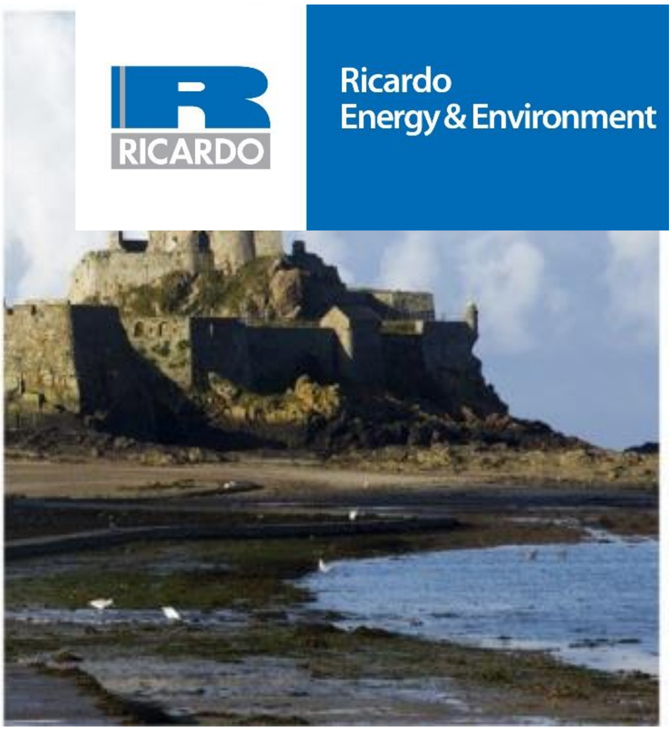

Ricardo Energy & Environment

Air Quality monitoring in Jersey 2020

Report for the Government of Jersey
ED12333 2020 Report

ED 12333 | Issue 2 2020 | Date 09/11/2021
Ricardo Energy & Environment

Customer:

Government of Jersey

Customer reference:

ED12333 2020

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09 November 2021

Ricardo Energy & Environment reference:

Ref: ED12333- 2020 Issue 3

Executive summary

This report presents the results for 2020 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo Energy & Environment on behalf of the Environmental Health Department of the Government of Jersey.

An automatic monitoring station for nitrogen dioxide (NO_2) has been located in the Central Market, Halkett Place, St Helier since January 2008. In addition, non-automatic diffusion tube samplers were used for indicative monitoring of NO_2 at 17 sites, and a suite of four hydrocarbons (benzene, toluene, ethylbenzene and xylenes) at a further five sites. Hydrocarbon monitoring sites included areas likely to be affected by specific emission sources (such as a petrol station and a paint-spraying process), as well as general background locations. The 2020 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

The Covid-19 pandemic affected the deployment and collection of NO_2 and hydrocarbon diffusion tubes. It is recommended that tubes are exposed for twelve periods approximating to calendar months, based on the UK's Defra diffusion tube calendar. Local restrictions meant that the March, August and November deployments were not collected within the recommended 4-5 week period, and that in order to realign with the calendar schedule the September exposure period was reduced. For the purpose of creating annual averages the results from these deployments were considered compromised and not included in calculations. The tubes were supplied and analysed by Gradko International Ltd and changed by Technical Officers of Jersey's Environmental Health Department.

The automatic monitoring site at Halkett Place met the EC Directive limit value (and AQS objective) for both the 1-hour mean NO_2 concentration (with 0 of 18 allowed 1-hour exceedances) and the annual mean NO_2 concentration.

The 2020 automatic monitors annual mean (19 $\mu g\ m^{-3}$) was 13.6% lower than that recorded in 2019 (22 $\mu g\ m^{-3}$).

Annual mean concentrations of NO_2 did not exceed the EC Directive limit value at any of the sites. For comparison time weighted averages of all deployment periods had a bias adjustment factor applied which gave lower annual averages for all sites. Diffusion tubes measure over a monthly period therefore, the results are an average and not applicable to measuring peaks or low levels of pollution at any specific time.

The diurnal pattern in concentrations of oxides of nitrogen at Halkett Place was similar to that observed in previous years. There was a clear peak in the early morning between 07:00 and 08:00, with another slight peak in the afternoon rush-hour. The morning peak is thought to reflect early activity of market retailers arriving to set-up for the day using refrigerated vehicles and daily refuse collections. These vehicles may need to be left with engines running whilst carrying out their operations, contributing to NO_2 levels.

Each of the hydrocarbon sites provided annual means below that required of the EC Directive limit value for benzene (5 $\mu g\ m^{-3}$ as an annual mean, to be achieved by 2010[4]). Since the introduction of catalytic converters in 1991 and the limiting of benzene concentrations in petrol to 1% in the year 2000, ambient measured concentrations have declined in the UK[8]. The sites at Faux Bie Terrace and Harrington's Garage measured the highest annual mean benzene concentrations, of 1 $\mu g\ m^{-3}$. Faux Bie Terrace represents the nearest relevant public exposure to a petrol station. Concentrations here have decreased since a stage 2 vapour recovery system was installed in 2016.

Overall hydrocarbons showed a decrease compared with 2019. Over the long term, hydrocarbon concentrations have generally decreased at La Bas Centre, Halkett Place and Hansford Lane. However, at the Faux Bie site concentrations had sharply increased until 2016 followed by substantial decreases between 2016 and 2020.

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1 Introduction

1.1 Background

This report describes a programme of air quality monitoring carried out on the island of Jersey in 2020, undertaken by Ricardo Energy & Environment, on behalf of the Government of Jersey Public Health Services. This is the 24th consecutive year in which an annual monitoring programme has been carried out; the first was undertaken in 1997. This ongoing monitoring programme has provided a long-term dataset of pollutant concentrations.

The pollutants measured were nitrogen dioxide (NO_2), and a range of hydrocarbon species (benzene, toluene, ethylbenzene and three xylene compounds). NO_2 was measured by an automatic monitor, situated at Halkett Place, St Helier. This was supplemented by indicative monitoring of NO_2 at 17 locations on the island (including Halkett Place), using low cost passive samplers (Palmes type diffusion tubes). The suite of hydrocarbon species were monitored using 'BTEX' diffusion tubes at five sites.

This report presents the results obtained in the 2020 survey and compares the data from Jersey with relevant air quality limit values, objectives and guidelines as well as data from selected UK monitoring stations and previous years' monitoring programmes.

1.2 Objectives

This year's monitoring is the continuation of a survey that has been carried out since 1997. This report is the latest in a series of annual reports[1]. The objective, as in previous years, was to monitor at sites where pollutant concentrations were expected to be high and compare these with background locations. The monitoring sites consisted of urban and rural background sites, in addition to locations where higher pollutant concentrations might be expected, such as roadside and kerbside sites, as well as locations close to specific emission sources (for example, a petrol station).

1.3 Impact of Covid-19 restrictions on monitoring

Covid-19 has had unprecedented impacts on daily life for all of the world and Jersey is no different. When looking at the temporal, especially seasonal, variations the impacts of the pandemic must be considered. On the 29th March 2020 Jersey announced a lockdown effective from the following morning with islanders only permitted to travel for fresh air and essential shopping. From the 3rd of April schools on the island were shut to all bar vulnerable children and children of essential workers. From the 11th May there was a gradual relaxation of the "stay at home rules" with the island moving into a Level system. Broad street in Saint Helier was closed to traffic in May 2020 to help with physical distancing. The most restrictive rules were lifted when the island moved to Level 2 on the 26th June and then to Level 1 on the 8th of August. Schools were reopened at the beginning of the September term. In order to combat a second wave of infections new restrictions were introduced on the 30th November and were tightened three days later and lasting into the new year.

Tourism is a major part of Jerseys economy and has an impact on the islands air quality, the variety of restrictions on travel over the course of the pandemic must also be considered when looking at the data from 2020. On the 14th of March travel into and from the island was restricted to essential travel only. Between 20th March and 1st July all travellers arriving on the island, other than essential workers, were required to self-isolate for 14 days. From the 3rd of July onwards, Jersey opened its borders to non-essential travel, but kept a variety of self-isolation and testing rules in place. In 2020 total arrivals by air and sea to the island dropped by 78.8% (929,363) from 1,179,113 to 249,750[12].

Covid-19 restrictions had a significant impact on almost all onsite activities, strict stay at home orders reduced the frequency of LSO site visits to the automatic instrument and of diffusion tube changes, while travel restrictions on visitors mean that no QA/QC audit or service took place during the summer of 2020.

With regards to diffusion tubes, they are to be exposed for a set period, with the year being divided into twelve approximating to calendar months. This results in the duration of the exposure periods varying between four and five weeks. However, due to the strict stay at home orders arising from the Covid-19 pandemic it was impossible for the collection and deployment schedule to be followed.

This resulted with two periods recording data for over 2000 hours each, tubes deployed in March and November which were collected in June 2020 and February 2021 respectively. In addition, the August sampling period was over 1200 hours and the September sampling period was only 288 hours. In these instances, the sampling period fell outside of the recommended 4-5 week period. Results from exposure periods outside this range must be considered compromised and non-representative of actual concentrations, as the rate of diffusion may not have been accurately defined.

It is recommended that for a local bias adjustment factor to be created a data capture rate of 75% is to be obtained. As 7 months of data are unreportable a data capture rate of 75% was not obtained and therefore local bias adjusted NO_2 data can't be reported.

Annual averages, unless otherwise stated, in this report only include the results from the 5 deployment periods with exposure periods between 4 and 5 weeks and are the results that we advise are used for any further comparison or work.

For the purpose of comparison and discussion within this report Table 4.2 states time weighted annual average NO_2 concentrations and a local bias adjusted value which were calculated using every available months results. However, these results are only indicative, and we do not advise their use due to their possible erroneous nature.

While Jersey is not bound to the requirements of LAQM.TG(16) it is worth noting that it advises that automatic monitors are serviced once every 6 months, within 3 weeks of a QA/QC audit. LSO calibrations are, for the site type of Halket place, to be carried out every 4 weeks. Travel restrictions meant that no audit or service was carried out at Halket place during 2020, while stay at home orders and staffing restrictions meant that the 4 weekly scheduled calibrations were not always able to be undertaken.

In order to evaluate the 2020 automatic data both the 2021 and 2019 audits and available LSO calibrations were thoroughly checked. On the establishment that both audits showed no faults with the instrument the data was thoroughly checked before being reviewed by an expert panel, who made the decision that the data could be marked valid.

2 Details of Monitoring Programme

2.1 Pollutants Monitored

2.1.1 NO_x

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. The mixture of oxides of nitrogen is termed NO_x. NO is subsequently oxidised to NO_2 in the atmosphere. NO_2 is an irritant to the respiratory system and can affect human health. Ambient concentrations of NO_2 are likely to be highest in the most built-up areas, especially where traffic is congested, or where buildings either side of the street create a 'canyon' effect, impeding the dispersion of vehicle emissions. The units used for NO_2 concentration in this report are micrograms per cubic metre (µg m^{-3}). The earliest reports in this series used parts per billion (ppb). To convert from µg m^{-3} to ppb for comparison with the earlier reports, if required, the following relationship should be used:

1 µg m^{-3} = 0.523 ppb for nitrogen dioxide at 293 K (20 °C) and 1013 mb.

2.1.2 Hydrocarbons

There are many sources of hydrocarbon emissions. Methane for example, is a naturally occurring gas, while xylene compounds are synthetic and used in many applications, for example as solvents in paint. A range of hydrocarbons are found in vehicle fuel and occur in vehicle emissions. In most urban areas, vehicle emissions constitute the major source of hydrocarbons, in particular benzene. There is the potential they may be released to the air from facilities where fuels are stored or handled (such as petrol stations).

A wide range of hydrocarbons are emitted from fuel storage, handling and combustion. It is not easy to measure all of these hydrocarbon species (particularly the most volatile) without expensive continuous monitoring systems. However, there are four species associated with fuels and vehicle emissions which, though not the largest constituent of such emissions, are easy to monitor using passive samplers due to their moderate volatility. These are benzene, toluene, ethylbenzene and xylene. Diffusion tubes are available for monitoring this group of organic compounds and are known as 'BTEX' tubes (BTEX being an acronym for the compounds measured).

2.1.2.1 Benzene

Of the organic compounds measured in this study, benzene is the one of most concern as it is a known human carcinogen; long-term exposure can cause leukaemia. It is found in small concentrations in petrol and other liquid fuels; for urban areas, the major source for benzene is vehicle emissions. In the UK, the annual mean concentrations for benzene in ambient air are typically less than 3 µg m^{-3} and have declined since the introduction of catalytic converters in 1991 and the limiting of benzene concentrations in petrol to 1% in the year 2000[8]. In this report, concentrations of benzene are expressed in micrograms per cubic metre (µg m^{-3}). Some earlier reports in the series used parts per billion (ppb). To convert to ppb, if necessary, the following relationship should be used:

1 µg m^{-3} = 0.307 ppb for benzene at 293 K (20 °C) and 1013 mb (only applicable to benzene).

2.1.2.2 Toluene

Toluene is found in petrol; it can be used as a solvent in paints and inks; it is also a constituent of tobacco smoke. There are no EU limit values for ambient toluene concentration, although there are occupational limits for workplace exposure[2], and a World Health Organisation (WHO) guideline of 260 µg m^{-3} for the weekly mean[3].

The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic[3]. Typical ambient concentrations are usually less than 5 µg m^{-3} in rural areas and in the range 5-150 µg m^{-3} in urban areas[3].

In this report, concentrations are expressed in micrograms per cubic metre (µg m^{-3}). Some earlier reports in the series used parts per billion (ppb). To convert to ppb, if necessary, the following relationship should be used:

1 µg m^{-3} = 0.261 ppb for toluene at 293 K (20 °C) and 1013 mb (only applicable to toluene).

2.1.2.3 Ethylbenzene

There are no limits for ambient concentrations of ethylbenzene. Although, there are occupational limits relating to workplace exposure[2], as discussed in previous reports, these are several orders of magnitude higher than typical outdoor ambient concentrations.

2.1.2.4 Xylene

Xylene exists in ortho (o), para (p) and meta (m) isomers. Occupational limits relating to workplace exposure are 100 ppm over 8 hours and 150 ppm over 10 minutes. Xylene, like toluene, can cause odour nuisance near processes where it is used (such as vehicle paint spraying).

In this report, concentrations of ethylbenzene and xylenes are expressed in micrograms per cubic metre (µg m^{-3}). Some earlier reports used parts per billion (ppb). To convert to ppb, if required, the following relationship should be used:

1 µg m^{-3} = 0.226 ppb for ethylbenzene or xylenes at 293 K (20 °C) and 1013 mb (applicable to ethylbenzene, m-, p- and o-xylene).

2.2 Air Quality Limit Values and Objectives

This report compares the results of the monitoring survey with air quality limit values and objectives applicable worldwide, in Europe and the UK. These are summarised in Appendix 1 and below.

2.2.1 World Health Organisation

The most recent World Health Organisation revised air quality guidelines[7] were published in 2005, for pollutants including NO_2. These were set using currently available scientific evidence on the effects of air pollutants on health and vegetation. The WHO guidelines are advisory only, and do not carry any mandatory status. They are summarised in Appendix 1. There are also WHO guidelines for ambient concentrations of, benzene and toluene[3].

The WHO non-mandatory guideline[7] for NO_2 is that the annual mean should not exceed 40 µg m^{-3}. For toluene, the WHO recommends a guideline[3] value of 0.26 mg m^{-3} (260 µg m^{-3}) for the weekly mean.

New WHO guidelines[13] for NO_2 were introduced in September 2021, the recommended annual mean limit being reduced to 10 µg m^{-3} and a 24 hour mean of 25 µg m^{-3}.

2.2.2 European Community

Throughout Europe, ambient air quality is regulated by the most recent EC Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC)[4]. This Directive (referred to as the Air Quality Directive) sets limit values, which are mandatory, and other requirements for the protection of human health and ecosystems. Both NO_2 and benzene are covered by this Directive. The Government of Jersey have agreed to meet the EU health limits.

The Air Quality Directive[4] contains limit values for NO_2 as follows:

- 200 µg m^{-3} as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.
- 40 µg m^{-3} as an annual mean, for protection of human health. To have been achieved by 1st January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NO_x), of 30 µg m^{-3}, for protection of vegetation (relevant in rural areas only).

The same Directive[4] also sets a limit of 5 µg m^{-3} for the annual mean of benzene, to have been achieved by 2010. Having achieved the limit values by the due dates, Member States must maintain compliance in future years.

2.2.3 UK Air Quality Strategy

The UK Air Quality Strategy (AQS)[5] contains standards and objectives for a range of pollutants including NO_2 and benzene. These are also summarised in Appendix 1. Only those objectives relating to the whole UK (as opposed to specifically England, Wales, etc.) are applicable to Jersey, and the AQS does not at present have mandatory status in the Government of Jersey.

The UK Air Quality Strategy's objectives for NO_2 are very similar to the EC Directive limits above, the only difference being that they had to be achieved by 31st December 2005.

The UK Air Quality Strategy[5] sets the following objectives for benzene:

- 16.25 µg m^{-3} (for the running annual mean), to have been achieved by 31st December 2003.
- 3.25 µg m^{-3} (for the calendar year mean in Scotland and Northern Ireland), to have been achieved by 31st December 2010.
- 5 µg m^{-3} (for the calendar year mean in England and Wales), to have been achieved by 31st December 2010.

Both the 2010 benzene objectives apply to specific parts of the UK only, so strictly speaking do not apply in Jersey. However, the objective of 5 µg m^{-3} applicable to England and Wales is the same as the EC Directive limit value, which is applicable in Jersey.

2.2.4 Jersey Air Quality Strategy

The most recent Jersey Air Quality Strategy was published in 2013[10] and is largely based on the WHO[7], EU[4] and UK[5] policies described above and its limit values are the same. As Jersey is not an EU member state there is no legal requirement to implement the EU Directive however, the Government of Jersey recognise the importance and relevance of the limit values to Jersey. The Jersey Air Quality Strategy works within the EU and UK limit values and puts in place a project plan and policies to ensure compliance. In light of reductions in concentrations and improvements in technology since the AQS was last published, now would be a good opportunity to review and potentially update the document.

2.3 Monitoring Methodologies

2.3.1 Automatic Methods

Oxides of nitrogen were monitored using a chemiluminescent analyser, located at the Central Market, Halkett Place, St Helier. This automatic monitoring site started operation in January 2008.

The chemiluminescent NO_x analyser provides a continuous output, proportional to the pollutant concentration. The output is recorded and stored every 10 seconds and averaged to 15-minute average values by internal data loggers. The analyser is connected to a modem and interrogated by telephone to download the data to Ricardo Energy & Environment. Data are downloaded daily and uploaded onto the publicly available website: http://jerseyair.ricardo-aea.com

2.3.2 Diffusive Sampling of NO_2 and Hydrocarbons

The automatic monitoring site at Halkett Place was supplemented by indicative monitoring, using diffusion tubes, for NO_2 and BTEX hydrocarbons. Diffusion tubes are 'passive' samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply. They are located in places and heights of relevant exposure, usually attached to lampposts at approximately 3m-4m above ground.

2.3.2.1 NO_2 diffusion tubes

Palmes-type diffusion tubes were used for NO_2. These consist of a small plastic tube, approximately 7 cm long. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species (in this case NO_2) to be monitored. The tube is mounted vertically with the open end at the bottom. Ambient NO_2 diffuses up the tube during exposure and is absorbed as nitrite. The average ambient pollutant concentration for the exposure period is calculated from the amount of pollutant absorbed.

2.3.2.2 BTEX diffusion tubes

BTEX diffusion tubes are different in appearance from NO_2 tubes. They are longer, thinner, and made of metal rather than plastic. These tubes are fitted at both ends with brass Swagelok fittings. A separate 'diffusion cap' is supplied. Immediately before exposure, the Swagelok end fitting is replaced with the diffusion cap. The cap is removed after exposure and is replaced with the Swagelok fitting. BTEX diffusion tubes are very sensitive to interference by solvents.

2.3.2.3 Preparation and analysis

Diffusion tubes were prepared and analysed by Gradko International Ltd. They were supplied to the local Technical Officers of Jersey's Government, who carried out the tube changing. The tubes were supplied in a sealed condition prior to exposure. After exposure, the tubes were again sealed and returned to Gradko for analysis.

The UK Local Air Quality Management Technical Guidance LAQM.TG(16)[6] states that when using diffusion tubes for indicative NO_2 monitoring, correction should be made where applicable for any systematic bias (i.e. over-read or under-read compared to the automatic chemiluminescent technique; the reference method for NO_2). By co-locating diffusion tubes with the automatic monitoring site at Halkett Place, it is possible to calculate a bias adjustment factor, which could be applied to the annual mean diffusion tube measurements in this survey. The NO_2 diffusion tube results in this report are uncorrected except where clearly specified. BTEX diffusion tubes are not affected by the same sources of bias as NO_2 diffusion tubes, therefore the BTEX results have not been bias adjusted.

Each monthly batch of diffusion tubes was accompanied by a ‘travel blank’ NO_2 and BTEX tube. These tubes were taken with the exposure tubes to the site but were not exposed. They were returned to the site operator’s premises and were kept in a sealed bag in a cupboard. When the exposed tubes were collected, the ‘travel blank’ tubes were taken by the operator to the site. The travel blanks were sent with the exposed tubes for analysis. The purpose of these tubes was to indicate if any contamination of the tubes had occurred. This was particularly relevant in the case of the BTEX tubes because they can easily be contaminated by exposure to solvents.

Gradko also retained one tube from each batch, in a sealed bag in their premises, as a ‘laboratory blank’. The travel blank results for NO_2 were not used to apply any correction to the results from the exposed tubes – only to highlight possible contamination issues. BTEX results were blank corrected using the travel blank, or the laboratory blank where the analyst judged this to be appropriate.

2.3.2.4 Calendar of diffusion tube exposure periods

The calendar of exposure periods used for the NO_2 and BTEX diffusion tubes is shown in Table 2–1. They were intended to be an approximation to calendar months, while allowing for the tubes to be changed on a consistent day of the week. Due to complications caused by Covid-19 (See section 1.3) it was not always possible to stick to the intended dates, actual change over dates are also shown in the below Table 2-1.

Table 2–1: Diffusion tube exposure periods

Month	Intended start date	Intended end date	Actual start date	Actual end date
January	08/01/20	05/02/20	09/01/20	05/02/20
February	05/02/20	04/03/20	05/02/20	04/03/20
March	04/03/20	01/04/20	04/03/20	03/06/20
April	01/04/20	29/04/20	N/A	N/A
May	29/04/20	03/06/20	N/A	N/A
June	03/06/20	01/07/20	03/06/20	02/07/20
July	01/07/20	29/07/20	02/07/20	29/07/20
August	29/07/20	02/09/20	29/07/20	18/09/20
September	02/09/20	30/09/20	18/09/20	30/09/20
October	30/09/20	04/11/20	30/09/20	6/11/20
November	04/11/20	02/12/20	6/11/20	03/02/21
December	02/12/20	06/01/21	N/A	N/A

2.4 Monitoring sites

Automatic monitoring of oxides of nitrogen was carried out at the Central Market, Halkett Place, in St Helier (Figure 2-1). This site represents a roadside location where levels of NO_2 are expected to be high and where members of the public are regularly exposed for periods of one hour or more. The inlet funnel (circled) is just visible as a white tube protruding from the building façade above the hanging basket just beyond the yellow shop front. It is at a height of about four metres.

Figure 2-1: Automatic NO_x monitoring site, Halkett Place, St Helier

The chemiluminescent NO_x analyser itself, Figure 2-2, is located within the building. The analyser is calibrated by the Government of Jersey's Environmental Health Team. Details of complications caused by Covid-19 restrictions are outlined in section 1.3 and the calibration procedure is provided in Appendix 2.

Figure 2-2: Automatic NO_x analyser at Halkett Place, St Helier

As explained in section 2.3, diffusion tubes were used to monitor NO_2 at sites in a range of different environments around Jersey. Table 2–2 lists the 17 NO_2 diffusion tube sites used during 2020, Figure 2-3 to Figure 2-6 show their locations.

Table 2–2: NO_2 monitoring sites in Jersey

Kerbside: less than 1 m from kerb of a busy road.

Site name	Grid Reference	Method	Description
Halkett Place (Central Market)	653 486	Automatic analyser, diffusion tubes in triplicate	Central Market, Halkett Place, St Helier
Le Bas Centre	658 489	Diffusion tube	Urban background
Union Street	653 486	Diffusion tube	Kerbside in St Helier – corner of Union Street and New Street
St Saviours Hill	659 494	Diffusion tube	Kerbside in St Helier
Broad Street	652 486	Diffusion tube	Urban background
Weighbridge	651 483	Diffusion tube	Roadside at bus station near centre of St Helier
Liberation Station	652 485	Diffusion tube	Kerbside opposite entrance to new bus station
Georgetown	661 480	Diffusion tube	Kerbside on major road
The Parade	648 489	Diffusion tube	Roadside site at General Hospital
Les Quennevais	579 496	Diffusion tube	Residential background
Beaumont	597 516	Diffusion tube	Kerbside
Rue des Raisies	689 529	Diffusion tube	Rural background
Rouge Bouillon School	650 494	Diffusion tube	Kerbside
St Savours School	667 495	Diffusion tube	Kerbside
Gloucester Street (Hospital)	648 487	Diffusion tube	Kerbside
Kensington Place (Hospital)	646 486	Diffusion tube	Kerbside
Esplanade (Hospital)	645 485	Diffusion tube	Kerbside

Roadside: 1 – 5 m from kerb of a busy road.

Background: > 50 m from the kerb of any major road.

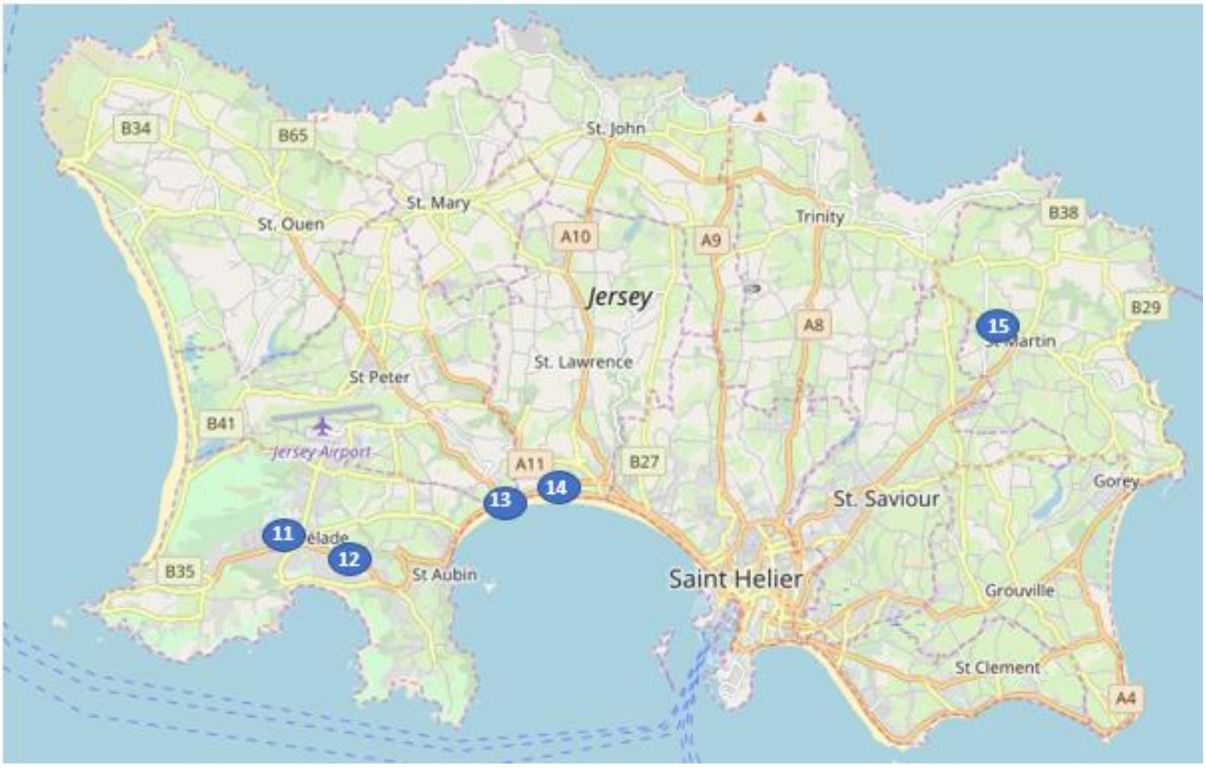
Note: all grid references are from OS 1:25000 Leisure Map of Jersey and are given to the nearest 100 m.

Figure 2-3: Site locations in St Helier town

Key:

Number	Site name	Pollutants	Number	Site Name	Pollutants
1	Les Bas Centre	NO_2. BTEX	7	The Parade	NO_2
2	Halkett Place (Central Market)	NO_2, BTEX, automatic NO_x (and automatic PM_{10} – locally managed)	8	Faux Bie	BTEX
3	Union Street	NO_2	9	Georgetown	NO_2
4	Broad Street	NO_2			
5	Weighbridge	NO_2	10	St Saviours Hill	NO_2
6	Liberation Station	NO_2			

Figure 2-4: Site locations outside St Helier



Key:

Number	Site name	Pollutants	Number	Site name	Pollutants
11	Les Quennevais	NO_2	14	Hansford Lane	BTEX
12	Harrington's Garage	BTEX	15	Rue Des Raisies	NO_2
13	Beaumont	NO_2			

Figure 2-5: Site locations near hospital

Key:

Number	Site name	Pollutants
16	Esplanade (Hospital)	NO_2
17	Kensington Place (Hospital)	NO_2
18	Gloucester Street (Hospital)	NO_2

Figure 2-6: Site locations near schools

Key:

Number	Site name	Pollutants
19	Rouge Bouillon School	NO_2
20	St Saviours School	NO_2

Diffusion tubes were also co-located with the automatic monitoring site at Halkett Place, and the results of this co-located monitoring are used to assess the precision and accuracy of the diffusion tubes, relative to the automatic chemiluminescent analyser, which is defined within Europe as the reference method for NO_2. The tubes at this site were exposed in triplicate, to allow assessment of precision. All other diffusion tube sites use single tubes.

BTEX hydrocarbons were monitored at five sites during 2020, shown in Table 2–3. The aim was to investigate sites likely to be affected by different emission sources and compare these with background sites.

Table 2–3: BTEX diffusion tube monitoring sites

Site name	Grid reference	Description
Les Bas Centre	658 489	Urban background site which has operated since 1997.
Central Market	653 486	Central Market, Halkett Place, St Helier
Harrington's Garage	585 489	Roadside site located on Rue de Genets.
Hansford Lane	633 499	Urban background site near a paint spraying process.
Faux Bie	658 495	Urban background site, near fuel filling station. Represents the nearest public exposure to a petrol station.

Le Bas Centre is intended to monitor hydrocarbon concentrations at an urban background location. Hansford Lane is close to a paint spraying process, a potential source of hydrocarbon emissions, especially toluene and xylenes.

The Faux Bie site is located near a fuel filling station, a potential source of hydrocarbon emissions including benzene. The monitoring site is between a fuel filling station and a nearby block of flats and is intended to represent public exposure to emissions from the filling station. The fuel supplier uses a vapour recovery system to reduce emissions when filling the storage tanks and has done so since December 2003.

The Harrington's Garage site was introduced as a replacement to the Airport Fence location and has been in operation since January 2019. The site is located on the A13 Rue de Genets, aiming to assess levels of BTEX from a typical garage with petrol and diesel storage and dispensing facilities.

3 Quality Assurance and Data Capture

3.1 Quality Assurance and Quality Control

A full intercalibration audit of the Jersey Halkett Place air quality monitoring site takes place annually, summarised in Table 3-1. In addition to instrument and calibration standard checking, the air intake sampling system is cleaned, and all other aspects of site infrastructure are checked. The 2020 audit and service were delayed until July 2021 due to Covid-19 restrictions, the implications of which are explained in section 1.3.

Table 3-1: Results of Jul 2021 intercalibration audit

Species	Analyser Serial no	Zero Response	Zero uncertainty ppb	Calibration Factor	Factor uncertainty %	Converter eff. (%)
NOx	16126	-0.2	2.7	1.3563	3.6	98.5
NO	16126	-0.3	2.7	1.3528	3.6	n/a

Following the instrument and calibration gas checking, and the subsequent scaling and ratification of the data, the overall accuracy and precision figures for the pollutants monitored at Jersey can be summarised as shown in Table 3–1. These are given in ppb, the “native” unit of the automatic data.

Table 3–1: Estimated accuracy and precision of the data presented

Pollutant	Precision	Accuracy
NO	± 5 ppb	± 15%
NO_2	± 5 ppb	± 15%

3.2 Data Capture

Overall data capture statistics for the monitoring site are given in Table 3–2. An annual data capture rate of 85% or greater for ratified data is recommended in the Defra Technical Guidance LAQM TG(16)[6] in order to assess annual data sets against long term targets. The Halkett Place site surpassed this target capture rate. There were no instances of data gaps (where data were rejected) over 24 hours.

Table 3–2: Jersey Halkett Place – Data capture statistics 2018

Site	NO	NO_2	NO_x
Jersey Halkett Place	96.6%	96.6%	96.6%

3.3 Diffusion Tube Uncertainty and Detection Limits

Diffusion tubes are an indicative technique, with greater uncertainty than more sophisticated automatic methods. The reported margins of uncertainty on the analysis was ± 9.7% for the NO_2 diffusion tubes ± 16.2% for the BTEX hydrocarbons. However, uncertainties arising from the exposure phase also contribute to the overall uncertainty; it is usually estimated that the overall uncertainty on diffusion tube measurements are approximately ± 25% for NO_2 and BTEX hydrocarbons.

The limits of detection in ambient air depend partly on the exposure time, and therefore vary to some extent from month to month. The analytical limit of detection was in the range 0.028 µg NO_2 to 0.031 µg NO_2: the ambient concentration that this equates to depends on the exposure period, but for the 4-week and 5-week periods used in this study, the limit of detection ranged from 0.458 µg m^{-3} to 0.636 µg m^{-3}. For benzene, the limit of detection equated to an ambient concentration between 0.12 µg m^{-3}

and 0.15 µg m^{-3}. The laboratory advises that results lower than 10 times the limit of detection, LOD, will have a higher level of uncertainty. In the case of the NO_2 sites, ambient concentrations are well above this threshold, apart from at Les Quennevais and Rue des Raisies. Therefore, the NO_2 measurements at these two sites are likely to have overall uncertainty greater than ± 25% and should be treated as indicative only. However, for BTEX hydrocarbons in Jersey, this was the case for most measurements except for toluene and m+p xylenes at some sites and other isolated measurements. The BTEX hydrocarbon measurements are therefore likely to have overall uncertainty greater that ± 25% and should be treated as indicative only.

4 Results and Discussion

4.1 Presentation of Results

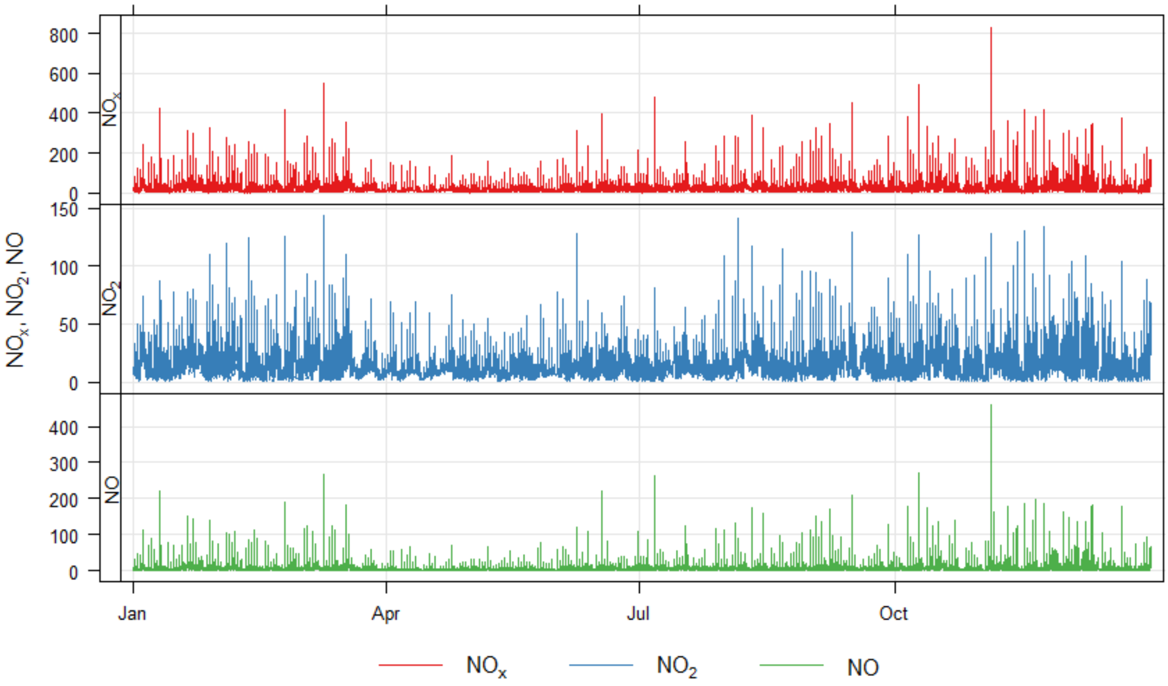
4.1.1 Automatic NO_2 Monitoring Results

Table 4-1 shows the key statistics for oxides of nitrogen measured by the automatic analyser at Halkett Place. Table 4-1 shows time series plots of hourly mean NO, NO_2 and NO_x concentrations. The purpose of these plots is to illustrate how concentrations of these pollutant species varied on a short time scale and throughout the year, Figure 4-1.

Table 4-1: Oxides of nitrogen at Jersey Halkett Place – air quality statistics for 2020

Pollutant	NO µg m^{-3}	NO_2 µg m^{-3}	NO_x µg m^{-3}
Maximum 15-minute mean	1078	262	1224
Maximum hourly mean	460	143	833
Maximum running 8-hour mean	108	66	232
Maximum running 24-hour mean	47	42	108
Maximum daily mean	45	40	104
Average	11	19	36
Data capture	96.6	96.6	96.6

Figure 4-1: Time series plots of hourly mean pollutant concentrations at Halkett Place, 2020 (µg m^{-3})



4.1.2 NO_2 Diffusion Tube Results

NO_2 diffusion tube results are presented in Table 4.2. Although reported by the analyser to two decimal places, the monthly mean results reported here have been rounded to the nearest integer, in view of the estimated uncertainty of ± 25% on diffusion tube measurements. There are two exceptions - Les Quennevais and Rue des Raisies – where concentrations are typically less than 10 µg m^{-3}: These sites' results are given to one decimal place.

No new sites were commissioned, or current sites shut down, during 2020.

Covid-19 restrictions led to difficulties in sticking to the deployment calendar and these are explained in section 1.3.

The following individual tubes are either absent or have not been included in the annual average:

- Rouge Bouillon School – February exposure "*Live spider in tube, removed*"
- Esplanade (Hospital) – February exposure "*Water drops in tube*"
- Gloucester Street (Hospital) – February exposure "*Missing from Feb 20 return*"
- Le Bas Centre – March "*Returned with Feb 20, not deployed*"
- St Saviours Hill – October "*Missing on collection*"
- Weighbridge – November "*Missing on collection*"
- Kensington Place (Hospital) – November "*Tube damaged and could not be analysed*"

Table 4.2 includes monthly values, the 2020 annual mean (only using sampling periods of 4-5 weeks) as well as time weighted annual and bias adjusted annual means (using all sampling periods). Both the time weighted annual mean and bias adjusted mean data are highly compromised and we recommend that the annual mean results are used. The annual mean and bias adjusted annual mean for 2019 are included for comparative purposes. Raw (not bias adjusted) monthly values are reported to allow for comparison against past data recorded before bias adjustment was introduced. Individual monthly mean NO_2 results ranged from 3.8 µg m^{-3} (in June and July at both the Rue des Raises site and the Les Quennevais site), to 46 µg m^{-3} (in January at the St Saviours Hill site). For this report the annual mean will be used unless otherwise stated.

All sites saw reduced annual means compared to 2019, except Le Bas Centre which stayed constant. The time weighted annual average for all sites was significantly lower than the 2019 annual means. Given the severe disruption caused by Covid-19 reduced annual averages are to be expected. Considering that in the annual mean calculation the months impacted most are not recorded its can be assumed that if all months had been recorded with standard exposure periods the annual average would lie somewhere between those calculated for this report.

Table 4–2: NO_2 diffusion tube results 2020, Jersey. Concentrations (rounded), µg m^{-3}.

Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	2020 Annual mean µg m^{-3}	2019 Annual mean µg m^{-3}	Time weighted annual mean µg m^{-3}	2020 Time weighted annual mean X BAF µg m^{-3}	2019 Annual mean X BAF µg m^{-3}
Le Bas Centre (UB)	23	20	-	-	-	16	15	18*	21*	19	10*	-	19	19	12	12	17
St Saviours Hill (R)	46	33	32*	-	-	40	34	36*	46*	-	18*	-	38	42	28	27	39
Union Street (R)	32	30	17*	-	-	23	22	22*	25*	24	13*	-	26	27	20	20	24
Halkett Place 1 (R)	26	22	16*	-	-	21	20	23*	25*	22	10*	-	22	24	18	18	22
Halkett Place 2 (R)	28	22	16*	-	-	21	19	21*	23*	22	10*	-	22	24	18	17	22
Halkett Place 3 (R)	25	23	15*	-	-	21	19	20*	24*	22	11*	-	22	24	18	17	22
Halkett Place Mean	27	22	16*	-	-	21	19	21*	24*	22	11*	-	22	24	18	17	22
Weighbridge (K)	33	33	17*	-	-	24	25	26*	28*	29	-	-	29	31	19	18	29
Liberation Station (R)	29	20	19*	-	-	23	23	28*	35*	25	14*	-	24	30	21	21	28
Broad Street (K)	30	26	15*	-	-	15	12	15*	17*	15	9*	-	19	26	15	15	23

Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	2020 Annual mean µg m^{-3}	2019 Annual mean µg m^{-3}	Time weighted annual mean µg m^{-3}	2020 Time weighted annual mean X BAF µg m^{-3}	2019 Annual mean X BAF µg m^{-3}
The Parade (K)	28	21	14*	-	-	19	17	21*	25*	21	10*	-	21	24	17	17	22
Les Quennevais (S)	8.6	4.1	5.4*	-	-	3.8	3.8	5.1*	6.4*	5.1	3.5*	-	5.1	5.7	4.8	4.6	5.2
Beaumont (K)	34	22	26*	-	-	26	28	28*	40*	25	14*	-	27	33	24	23	30
Rue des Raises (Ru)	6.8	4.1	4.0*	-	-	3.8	3.8	4.8*	5.6*	4.3	2.8*	-	4.6	5.0	4.1	3.9	4.5
Georgetown (K)	34	28	22*	-	-	28	27	30*	35*	25	15*	-	28	31	24	23	29
Rouge Bouillon School	27	17*	15*	-	-	16	13	16*	22*	17	11*	-	18	21	14	14	19

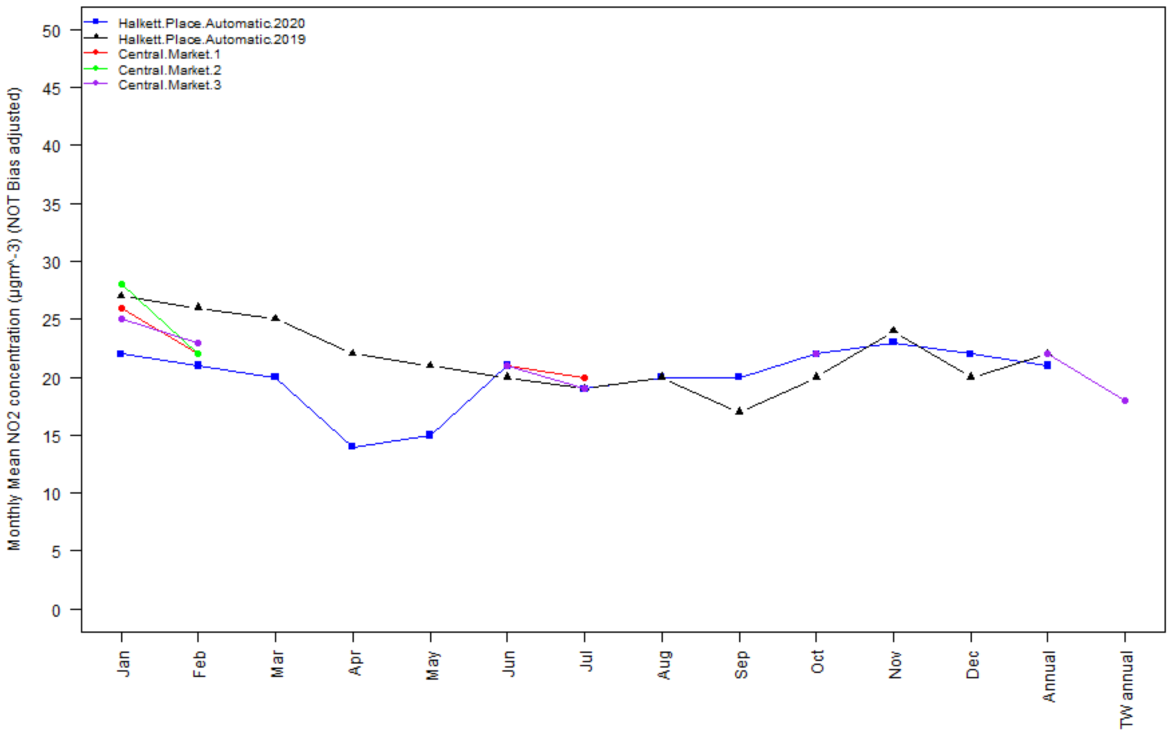
Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	2020 Annual mean µg m^{-3}	2019 Annual mean µg m^{-3}	Time weighted annual mean µg m^{-3}	2020 Time weighted annual mean X BAF µg m^{-3}	2019 Annual mean X BAF µg m^{-3}
St Savours School	20	14	13*	-	-	15	10	13*	19*	15	9*	-	15	16	13	12	15
Gloucester Street (Hospital) (K)	38	-	23*	-	-	28	24	29*	33*	27	14*	-	29	33	22	22	30
Kensington Place (Hospital) (K)	37	28	13*	-	-	25	22	24*	29*	28	-	-	28	28	18	17	25
Esplanade (Hospital) (R)	39	21*	26*	-	-	32	29	33*	39*	27	13*	-	32	37	24	23	34

K = kerbside, R = roadside, UB = urban background, S = suburban, Ru = rural. * Data not included in Annual mean.

Figure 4-2 shows the monthly mean NO_2 concentrations, as measured by diffusion tubes and by the automatic analyser, at Halkett Place for the same monitoring period. Agreement between the two methods were generally good. For several months, for instance October, measurements from 2 or more tubes and the automatic instrument tubes recorded the same values and so are overlain. The time weighted average (TW average) for all tubes and the automatic instrument were the same.

Due to the limited amount of data collected in 2020 the 2019 automatic data has also been included, this gives an indication of what levels could have been expected in a standard year.

Figure 4-2: Co-location results at Halkett Place, Jersey, 2020



4.2 Comparison with NO_2 Guidelines, Limit Values and Objectives

Limit values, AQS objectives and WHO guidelines for NO_2 are shown in Appendix 1. These are based on the hourly and annual means.

The Air Quality Directive[4] contains limit values for NO_2 as follows:

- 200 µg m^{-3} as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.
- 40 µg m^{-3} as an annual mean, for protection of human health. To have been achieved by 1st January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NO_x), of 30 µg m^{-3}, for protection of vegetation (relevant in rural areas).

The UK Air Quality Strategy[5] contains objectives for NO_2, which are very similar to the Directive limits above, the only difference being they had to be achieved by 31st December 2005.

The 1-hour mean at the Halkett Place automatic monitoring site did not exceeded the 200 µg m^{-3} in 2020. Therefore, this site met the EC Directive limit value and AQS objective for this parameter. The annual mean concentration of 19 µg m^{-3} as measured by the automatic analyser at Halkett Place was well within the EC limit value of 40 µg m^{-3}.

Due to the long sampling period of diffusion tubes, it is only possible to compare the results from the diffusion tube sites in this study against limit values relating to the annual mean. None of the three annual averages calculated in this report showed a site exceeding the annual mean limit value of 40 µg m^{-3}.

The 30 µg m^{-3} limit for protection of vegetation is only applicable at rural sites and is therefore only relevant to Rue des Raisies. The annual mean NO_2 concentration of 4.6 µg m^{-3} at this rural site was well within the limit value.

4.3 Temporal Variation in NO_2 Concentration

4.3.1 Temporal Variation in NO and NO_2 at Halkett Place 2020

Figure 4-3 shows how concentrations of nitric oxide (NO) and nitrogen dioxide (NO_2) typically varied over monthly, weekly, daily and hourly timescales, as measured by the automatic monitor at Halkett Place and averaged over the course of the year. Figure 4-4 shows individual monthly diurnal plots and figure 4-5 shows monthly average NO_2 for 2018 – 2020.

Figure 4-3: Temporal variation in concentrations of NO and NOx at Halkett Place, 2020

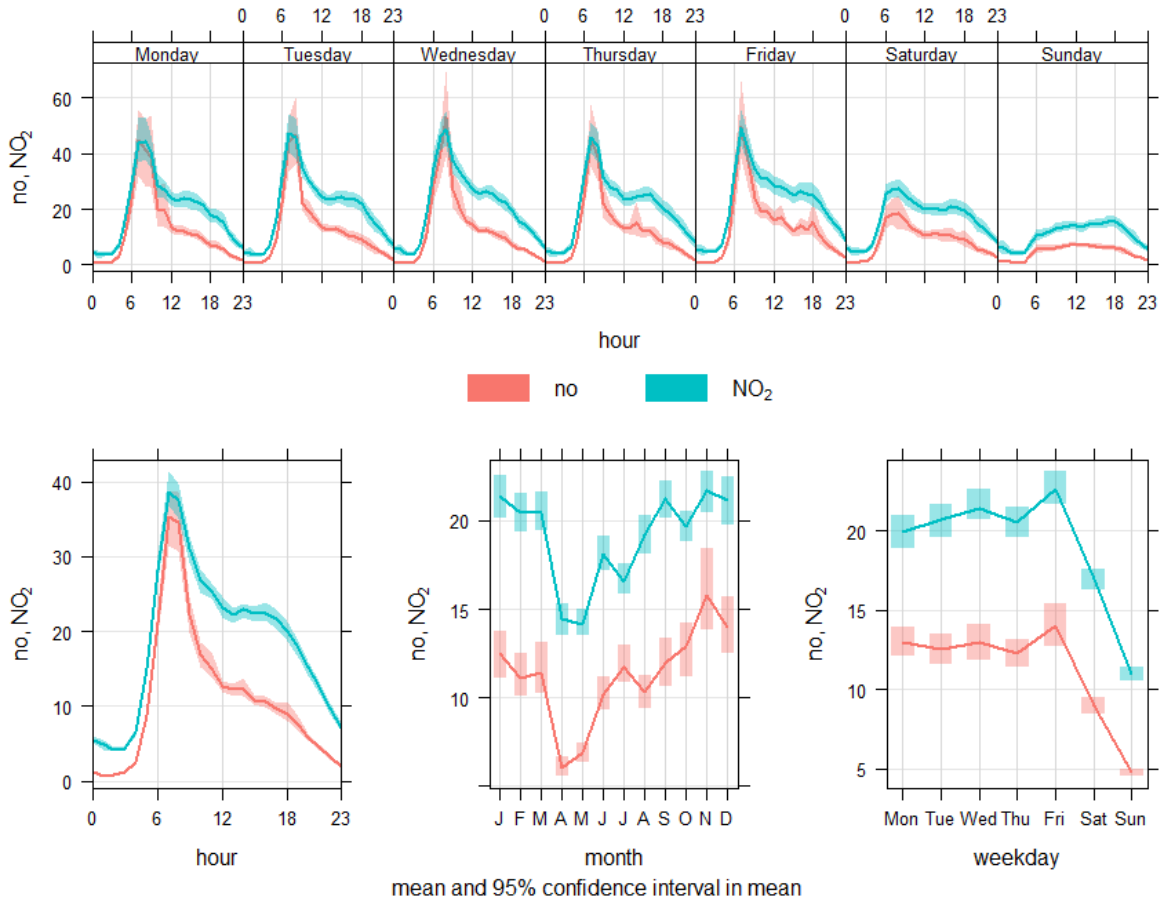


Figure 4-4: Hourly variation in concentrations of NO and NOx at Halkett Place for each month, 2020

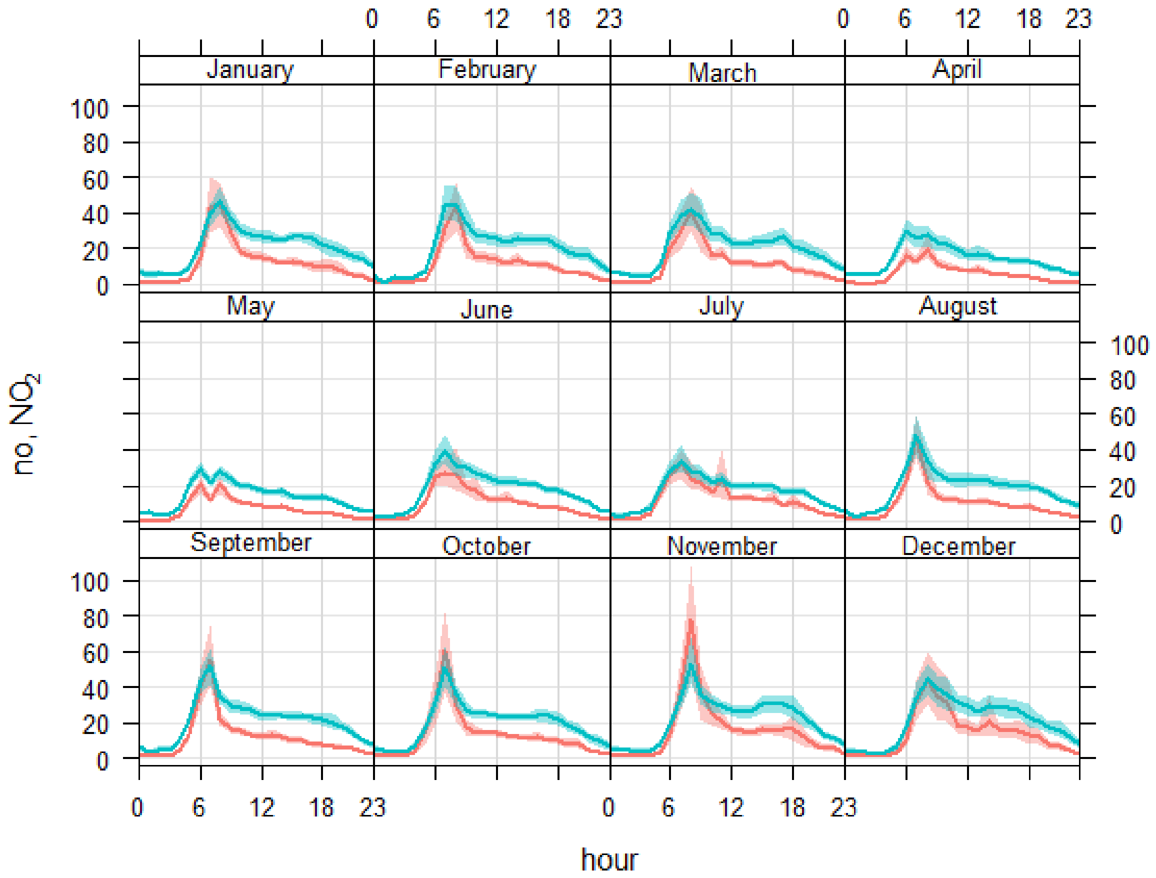
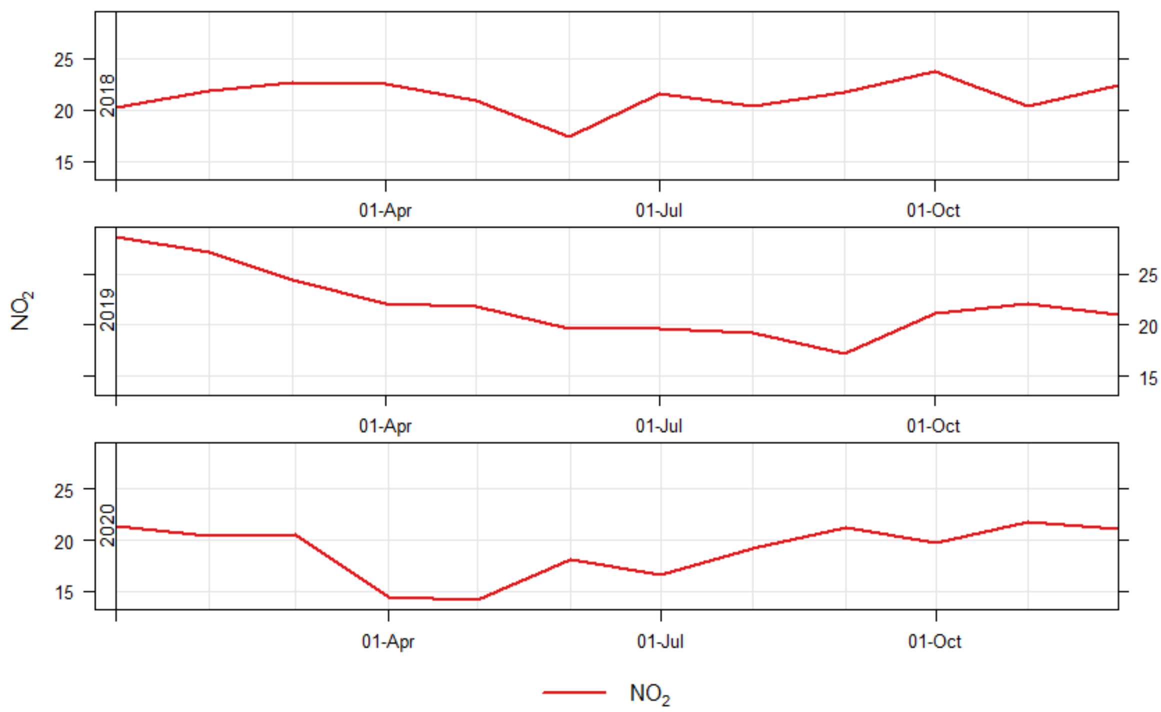


Figure 4-5: Average concentrations of NO_2 at Halkett Place for each month, 2018-2020



Seasonal variations are common for the pollutants measured at this site and can be observed in the 'month' plots of figure 4-3. General trends for all time measures continue much the same as in 2019, however figure 4-4 shows the clear impacts of local restrictions on the diurnal data trends and is discussed further below.

Clear seasonal variation can be seen in the NO and NO_2 concentrations. The autumn and winter months recorded higher levels when emissions may be higher with increased vehicle usage in poor weather. Periods of cold, still weather also reduce pollutant dispersion. The lowest levels of pollution also correspond with the strictest period of restrictions on the island in April and May, a further dip can be seen in December when some restrictions again came into force.

The analyses of each pollutants' weekly variation showed that the same type of diurnal patterns occur for all the days of the week except for Sunday. NO early morning and late afternoon rush hour peaks are, in general, much more pronounced Monday to Friday and overall levels are lower over the weekend. Particularly Sundays when most shops are closed.

The diurnal variation analyses for the full year can be viewed in the 'hour' plots in figure 4-3 and individual months in figure 4-4. Both show typical urban area daily patterns for NO and NO_2. Pronounced peaks can be seen for these pollutants during the morning, corresponding to rush hour traffic at around 07:00. However, at Halkett Place it is particularly early and sharp. This may be explained by the market at Halkett Place every day except Sundays. The peak coincides with the time at which the market traders arrive and set up for the day with refrigerated lorries making deliveries, just prior to the market opening at 07:30. In addition, a refuse lorry arrives at this time to collect the previous day's waste. It is believed vehicle emissions from these activities are responsible for the distinctive morning pattern at Halkett Place particularly considering the need for the refrigerated and refuse vehicles needing to keep their engines running to maintain temperatures and operate lifting equipment respectively. Concentrations tend to decrease during the middle of the day, with a much broader evening road traffic rush-hour peak, building up slightly from early afternoon. The market closes at 2PM on Thursdays, when looking at Figure 4-3 no significant change can be seen compared to the other days of the week, suggesting that the market does not have a significant impact on pollutant concentrations at this time of day.

Halkett Place exhibits a gentle afternoon NO_2 rush hour peak (as observed at many roadside UK AURN sites), however this is lower than the magnitude of the morning rush hour peak. In the afternoon, concentrations of oxidising agents in the atmosphere (particularly ozone) tend to increase, leading to enhanced oxidation of NO to NO_2. This typically causes the afternoon NO_2 peak at many urban sites to be higher than the morning NO_2 peak.

However, this is not the case at Halkett Place. The likely reason is that there is little afternoon rush hour traffic in this area. Most traffic is associated with the market and shoppers, occurring during the morning, afternoons are relatively quiet.

Figure 4-4 shows that during April and May there is a significantly reduced morning peak. During this time a strict stay at home order and other restrictions were in place, meaning that for a significant period the market and surrounding shops were closed/ not receiving deliveries. June and July also show relatively low morning peaks while businesses remained closed or in limited operation, while August again has a sharp, pronounced peak, which corresponds to the lifting of most restrictions and the reopening of many shops. Morning peak concentrations in November were higher than that in December, which corresponds to the tightening of restrictions over the winter.

As stated in section 1.3 Jersey has a significant tourism industry and pollutant concentrations can remain relatively high during the summer months. Figure 4-5 depicts the monthly averages for 2020 and the two years prior. As is to be expected the impact of covid restrictions on pollutant concentrations can be seen with the significant drop in April and May which is more pronounced than in prior years. NO_2 monthly average concentrations dropped 30% between March and April 2020. The April 2020 monthly mean concentration was 36% lower than that in 2019 and the May concentration was 28% lower. While concentrations increase slightly over the remaining summer months "normal" concentrations are only seen again starting in August after travel restrictions for visitors were relaxed starting in July. It must however be remembered that meteorology can't be ignored as it can have a significant impact on concentrations. Within Jersey's "COVID19 lockdown effects on air quality"[14] report a de-weather model was presented, this analysis removes the influence of meteorology and shows both a business as usual data set and actual 2020 measured data. Lower than expected concentrations of NO_2 were seen throughout April and May, as well as the impact of renewed restrictions at the end of the year into 2021.

4.3.2 Source investigation

In order to investigate the possible sources of air pollution being monitored around Halkett Place, meteorological data measured at Jersey airport was used to add a directional component to the air pollutant concentrations. Wind speed and direction data was gathered using data from the National Oceanic and Atmospheric Administration (NOAA) meteorological database.

Figure 4-6 shows the measured wind speed and direction data. The lengths of the “spokes” against the concentric circles indicate the percentage of time during the year that the wind was measured from each direction. The prevailing wind can be seen to be from the west. Each “spoke” is divided into coloured sections representing wind speed intervals of 2 ms^{-1}, followed by a final spoke of 13.9 ms^{-1} as shown by the scale bar in the plot. The mean wind speed was 6.06 ms^{-1}. The maximum measured wind speed was 19.9 ms^{-1}. The highest wind speeds were recorded in December and October 2020.

Figure 4-6: Wind rose showing the wind speeds and directions at Jersey airport, 2020

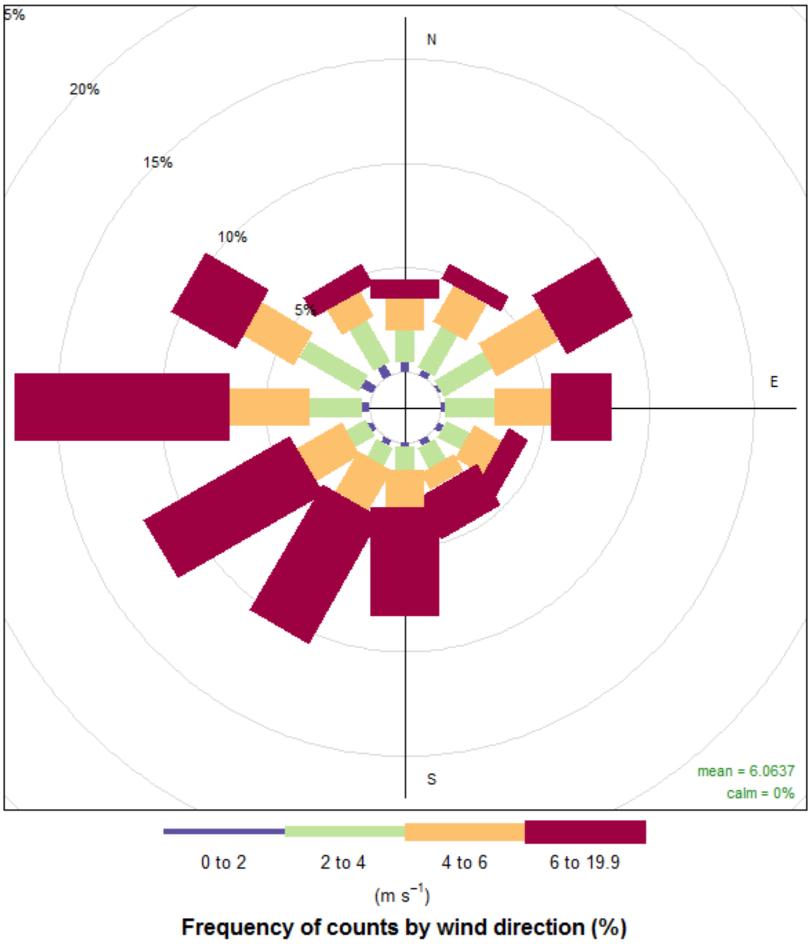


Figure 4-7 and Figure 4-8 show bivariate plots of hourly mean concentrations of NO and NO_2 at Halkett Place against wind speed and wind direction.

These plots should be interpreted as follows:

- The wind speed is indicated by the distance from the centre of the plot; the grey circles indicate wind speeds in 5 ms^{-1} intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentrations varied with wind direction and wind speed.

The plots do not show distance of pollutant emission sources from the monitoring site. However, in the case of primary pollutants such as NO, the concentrations at very low wind speeds are dominated by emission sources close by, while at higher wind speeds, effects are seen from sources further away.

Figure 4-7: Pollution rose for NO at Halkett Place, 2020

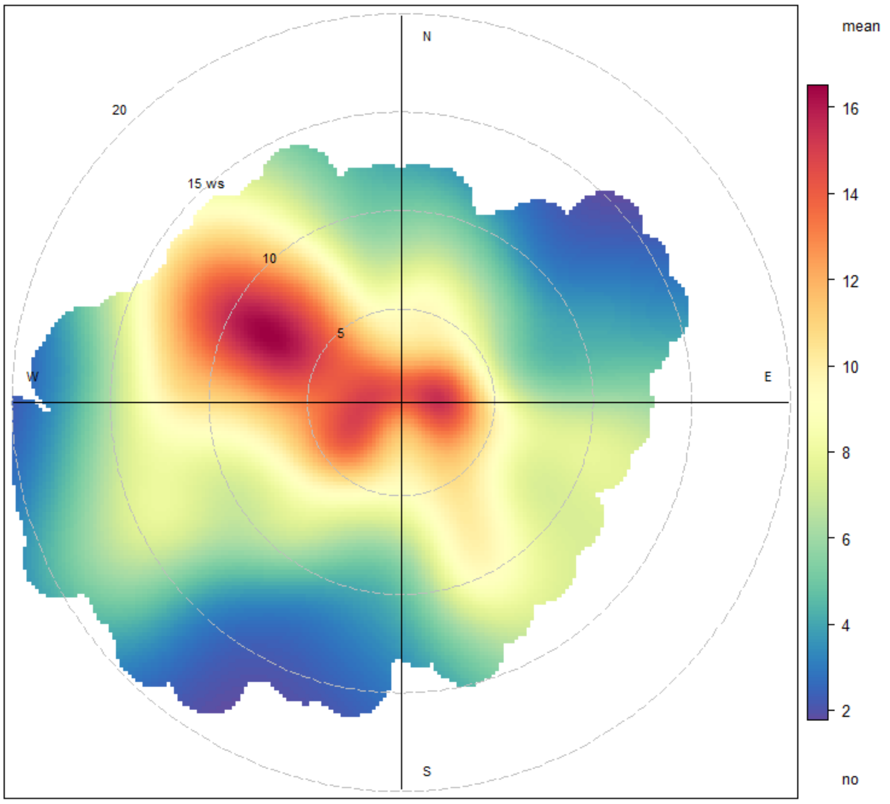
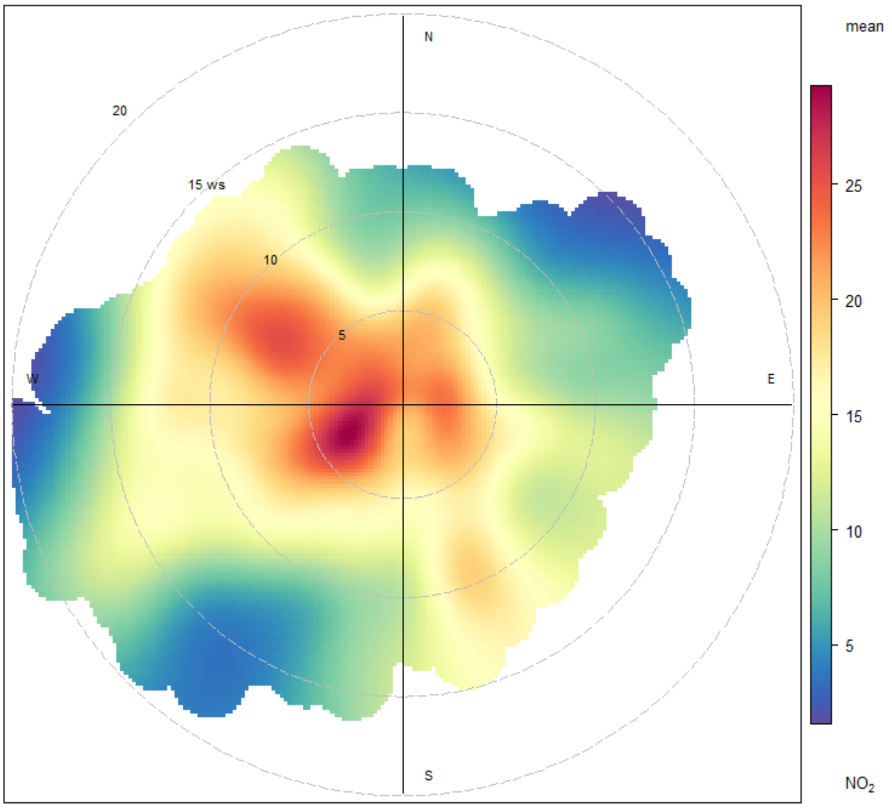


Figure 4-8: Pollution rose for NO2 at Halkett Place, 2020



Figures 4-7 and 4-8 show that high concentrations of NO occurred under calm and light wind conditions. Such conditions will have allowed NO and NO_2 emitted from nearby sources to build up, reaching higher concentrations. These sources are primarily vehicles on the surrounding streets and those using Halkett Place as a cut through or parking location. Delivery drivers to the market are advised not to leave engines idling in order to help reduce this however, refrigerated vehicles may not be able to abide by this.

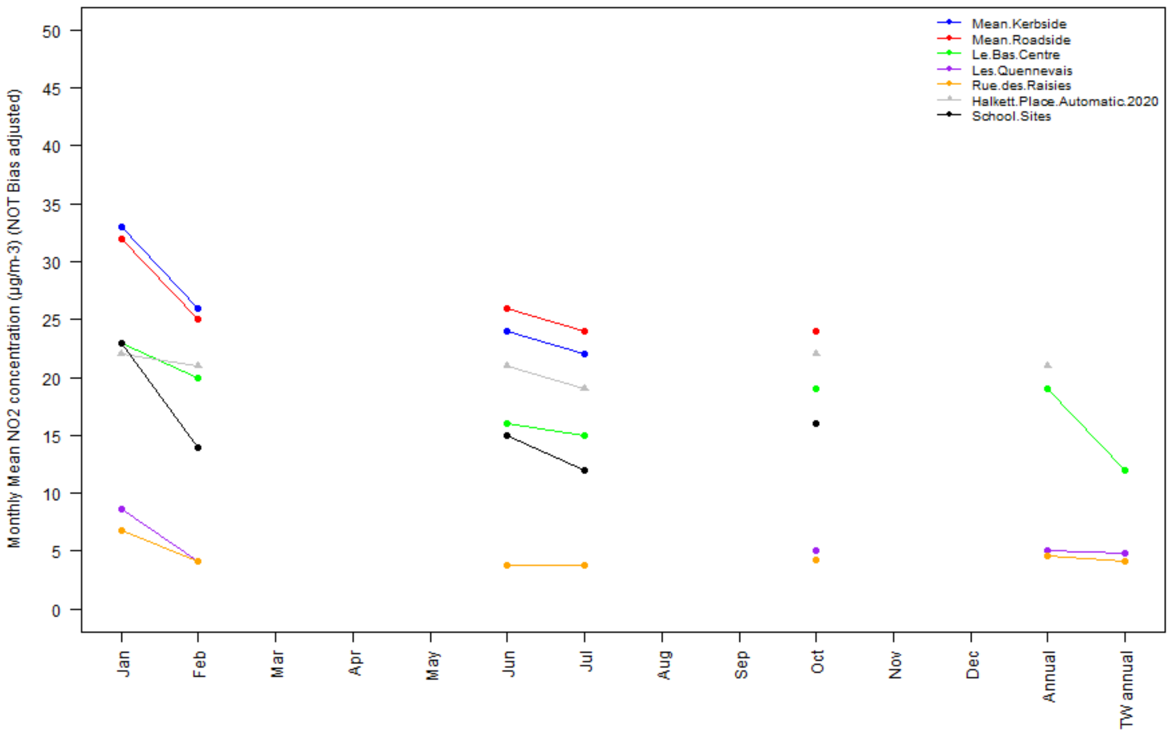
There is also evidence of higher concentrations of both pollutants seen under windier conditions from the North West and the South West, although not as high as in previous years, likely a consequence of reduced nearby activity due to Covid-19 restrictions. As in previous years this shows evidence of a source from the A9 and A2 main roads, Burrard Street, Waterloo Street and Don Street as well as the majority of the developed areas that lie to the North West of the monitoring site, all of which would account for increased concentrations. There is also the possibility of a street canyon effect which would allow concentrations of pollutants to build up when prevailing wind from the NW blows across the top of the buildings rather than along Halkett Place in its roughly NNE-SSW orientation. To the South West of the site lie the A1 and port. Warmer colours on the SSE edge of the polar plot indicate that higher levels of both pollutants can also be seen at higher windspeeds from the direction of the La Route du Fort tunnel.

4.3.3 Seasonal Variation in NO_2 Concentration

Figure 4-9 shows the monthly mean NO_2 concentrations, from months with a sample period of 4-5 weeks, measured at the diffusion tube sites and Halkett Place. Including:

- The mean of the eight kerbside sites.
- The mean of the four roadside sites.
- The monthly means measured at:
    - The single urban background site (Le Bas Centre).
    - The suburban residential site (Les Quennevais).
    - The rural site (Rue des Raisies).
    - The school sites (Rouge Bouillon School and St Savours School).
- The monthly means (based on the same periods as the diffusion tube exposures) for the Halkett Place automatic site.

Figure 4-9: Monthly mean NO_2 concentrations (NOT bias adjusted) at diffusion tube sites and Halkett Place, 2020



The typical pattern in UK urban areas is for NO_2 concentrations to be generally higher in the winter and lower in the summer. Historically, the sites in Jersey have not shown this, or indeed any, consistent seasonal pattern. The tube collections issues experienced in 2020 make the identification of any trend harder. However, the highest concentrations were recorded in January. The highest monthly mean out of all sets of sites were recorded in January at the roadside sites measuring an average of 33 µg/m^{-3}. Months with exposures outside the 4-5 week period, shown in Table 4-2, had significantly lower averages for March-June and November-February 2021, while these periods match the periods of restrictions on the island and so lower readings would be expected, due to the exposure periods we cannot have confidence in these results. The months of August and September had average concentrations similar than those seen in June and July. Previous years of this study have shown that these four months while having variation month to month largely stay within the same range, however again we cannot have confidence in these results.

Comparison with UK NO_2 data

Table 4–3 compares the annual NO_2 concentration measured at Halkett Place with those measured at a selection of UK air quality monitoring stations in the national Automatic Urban and Rural Network using automatic (chemiluminescent) NO_2 analysers. The sites used for comparison are listed below.

- Brighton Preston Park – an urban background site in Brighton, Sussex
- Exeter Roadside – a roadside site in the centre of Exeter, Devon
- Plymouth Centre – an urban centre site in the coastal city of Plymouth, Devon
- Yarner Wood – a rural moorland site in Devon.

Table 4–3: Comparison of NO_2 in Jersey with UK automatic sites, 2017 - 2020

Site	2020 Annual mean NO_2 concentration µg m^{-3}	Annual mean NO_2 concentration 2017-2019 µg m^{-3}
Brighton Preston Park	11	16
Exeter Roadside	10	28
Plymouth Centre	14	19
Yarner Wood	3	4
Jersey Halkett Place (automatic)	19	22

The annual mean NO_2 concentrations, from diffusion tubes with exposure periods between 4 and 5 weeks, measured at the kerbside and roadside sites in Jersey (rounded to the nearest integer) ranged from 19 to 38 µg m^{-3}. However, time weighted bias adjusted annual averages ranged from 15 to 27 µg m^{-3} which while lower is still elevated. Both calculations give levels higher than the annual means at Exeter Roadside and Plymouth Centre (10 µg m^{-3} and 14 µg m^{-3} respectively).

The mean concentration measured at Exeter Roadside, 10 µg m^{-3}, is lower than the 19 µg m^{-3} as measured by the automatic analyser at Halkett Place. The Jersey urban background site at Le Bas Centre had an annual mean NO_2 concentration of 19 µg m^{-3}, the same as that of the automatic analyser at Halkett Place. The residential background site at Les Quennevais had an annual mean NO_2 concentration of 5.1 µg m^{-3}, this is slightly higher than the rural Yarner Wood site in Devon. The annual mean of 4.6 µg m^{-3} at the Jersey rural background site, Rue des Raisies, was also slightly higher than that measured at the Yarner Wood site.

All sites showed a reduction in levels compared to the three year average from 2017 to 2019. Yarner wood is a rural site and is not expected to show a significant reduction due to covid restrictions given its isolated nature, however while Halkett Place did show a reduction it is less than the other three mainland sites, in particular Exeter. This could be due to the different time periods spent with restrictions in place, England entering into lockdown on the 16th of March, as compared to the 30th in Jersey, with a slower removal of restrictions over the summer. England also experienced tightening of restrictions in September with a new lockdown starting in early November and ending early December but retaining many restrictions while Jersey only began increasing restrictions in November.

4.3.4 Trends in NO_2 at Long-running Sites

There are ten sites in the survey which have been in operation since 2005 or earlier and therefore now have 15 years of data. The annual mean NO_2 concentrations are shown in Table 4-4 and illustrated in Figure 4-10. Broad Street became pedestrianised on the 23rd of May 2020 in order to allow greater social distancing for pedestrians, this is reflected in a 27% reduction in the annual mean concentrations.

Table 4–4The data is not adjusted for diffusion tube bias as there was no reliable information on which to carry out bias adjustment prior to 2002. Therefore, for consistency, unadjusted data is used in this section.

Annual mean NO_2 concentrations at historic kerbside, roadside and urban background sites (Weighbridge, Georgetown, Beaumont, The Parade, Broad Street, and Le Bas) from 2004 onwards have been shown to be decreasing. In 2020 all sites remained below 40 µg m^{-3}.

Figure 4-10 illustrates how since 2012 annual mean NO_2 concentrations at several of the sites have remained stable with typical fluctuations from year to year due to meteorological conditions and other factors.

As traffic volumes have increased since monitoring began, fluctuations in concentrations are likely linked to increased vehicle efficiency and cleaner fuels. A recent study into vehicle emissions in Jersey[9] found that newer petrol vehicles produce fewer NO_x emissions. It also found that there is an increase in newer petrol cars compared to a decline in diesel on the island. Plans to introduce MOT style testing are currently being implemented with full implementation expected to be in place from 2022. This will further increase visibility of emissions and potentially reduce the number of heavily polluting vehicles on the roads, in turn contributing to a continued reduction in ambient concentrations.

As a more focused example of the differences between site locations; it is interesting to note the lower trend of readings from the now discontinued New Street site compared to Union Street. The two locations were very close with the Union Street tube located on the corner of Union Street and New Street which run perpendicular to each other. New Street is access only and therefore, carries much lower traffic volumes. As the prevailing wind is from the West with the least wind coming from the North, very little of the pollution from Union Street is carried to the more southerly New Street location. This indicates how localised NO_2 distribution can be with certain mitigating factors. Broad Street became pedestrianised on the 23rd of May 2020 in order to allow greater social distancing for pedestrians, this is reflected in a 27% reduction in the annual mean concentrations.

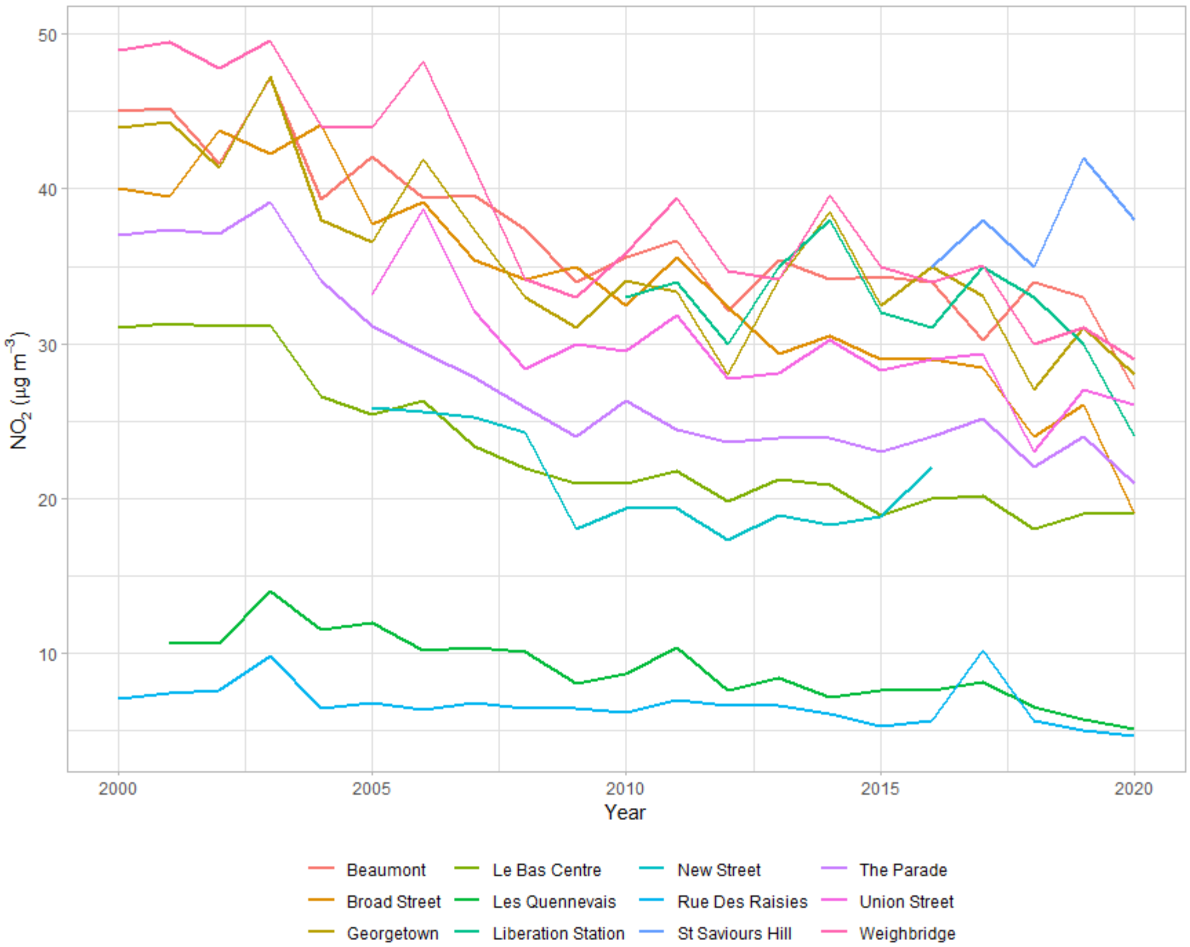
Table 4–4: Annual mean NO_2 concentrations at the diffusion tube sites, µg m^{-3} (NOT bias adjusted)

Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beaumont (K)	45	45	42	47	39	42	39	40	37	34	36	37	32	35	34	34	34	30	34	33	27
Broad Street (K)	40	39	44	42	44	38	39	35	34	35	32	36	32	29	30	29	29	28	24	26	19
Georgetown (K)	44	44	41	47	38	37	42	37	33	31	34	33	28	34	39	32	35	33	27	31	28
The Parade (K)	37	37	37	39	34	31	29	28	26	24	26	24	24	24	24	23	24	25	22	24	21
Weighbridge (K)	49	49	48	50	44	44	48	41	34	33	36	39	35	34	40	35	34	35	30	31	29
Rouge Bouillon School (K)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	18
St Savours School (K)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	15
Gloucester Street (Hospital) (K)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	29
Kensington Place (Hospital) (K)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	28
Esplanade (Hospital (K)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37	32
New Street (R)	-	-	-	-	-	26	26	25	24	18	19	19	17	19	18	19	22	-	-	-	-
Union Street (R)	-	-	-	-	-	33	39	32	28	30	30	32	28	28	30	28	29	29	23	27	26

Le Bas Centre (UB)	31	31	31	31	27	25	26	23	22	21	21	22	20	21	21	19	20	20	18	19	19
Les Quennevais (S)	-	11	11	14	12	12	10	10.3	10.1	8.0	8.7	10.4	7.6	8.4	7.1	8	7.6	8.1	6.5	5.7	5.1
Rue Des Raisies (Ru)	7	7	8	10	6	7	6	6.8	6.5	6.4	6.2	7.0	6.6	6.6	6.1	5	5.6	10.1	5.6	5.0	4.6
Liberation Station (R)	-	-	-	-	-	-	-	-	-	-	33	34	30	35	38	32	31	35	33	30	24
St Saviours Hill (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	38	35	42	38

K = kerbside, R = roadside, UB = urban background, S = suburban, Ru = rural

Figure 4-10: Annual mean NO_2 concentrations (NOT adjusted for diffusion tube bias)



4.4 Hydrocarbons

Full monthly results of the hydrocarbon survey for the five BTEX sites and a summary of the annual average hydrocarbon concentrations are shown in Appendix 4. Travel blank values are included in Appendix 4. These gave consistently lower results than the exposed tubes.

For BTEX tubes monthly data is displayed in Figures 4-11 to 4-15. However, these do not include months with exposure periods outside of 4-5 weeks. Table 4-5 shows the annual means only using results from months with exposure periods between 4 and 5 weeks. For the purpose of comparison Table 4-6 shows the time weighted annual mean using all recorded results.

Table 4–5 Summary of average hydrocarbon concentrations (µg m^{-3}), Jersey, 2020

Site	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
Le Bas Centre	0.7	2.7	0.6	1.8	0.7
Halkett Place (Central Market)	0.6	2.4	0.8	2.7	1.1
Harrington's Garage	1	8.5	1.6	5.3	1.9
Hansford Lane	0.3	1.7	0.6	2	0.6
Faux Bie Terrace	1	5.8	1	3.2	1.2
Travel blank	0.1	0	0	0.1	0

Table 4–6 Summary of time weighted average hydrocarbon concentrations (µg m^{-3}), Jersey, 2020

Site	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
Le Bas Centre	0.6	2.3	0.5	1.6	0.6
Halkett Place (Central Market)	0.6	2.1	0.6	1.8	0.8
Harrington's Garage	0.8	5.2	0.9	2.9	1.1
Hansford Lane	0.3	1.4	0.4	1.4	0.5
Faux Bie Terrace	0.9	5.5	0.9	3.0	1.1

Highest annual mean concentrations of benzene in 2020 were measured at Faux Bie, which is between a petrol station and the nearest housing to it (12m from flats), and Harrington's Garage which also recorded the highest annual mean for each of the other 4 hydrocarbon species and it is likely that the evaporation of benzene and toluene, from fuel as it is stored or dispensed, is contributing to ambient levels at both locations. It is important to note that, despite the higher concentrations at these two sites compared to other Jersey sites, the annual mean of 1 µg m^{-3} for Benzene is still well below the annual limit value of 5 µg m^{-3}.

Concentrations at Faux Bie Terrace, for all species, increased year on year, particularly between 2012 and 2016. However, after a Stage 2 Vapour Recovery System was installed at the fuel filling station in 2016 and the replacement of the fuel storage tanks during August 2017, these increases have reversed with all hydrocarbon pollutants having decreased at this location. Concentrations over the last three years have remained relatively flat.

The Hansford Lane site has in the past measured relatively high concentrations of m+p-xylene and o-xylene while not thought to be a significant source of benzene or toluene. The site location was initially chosen due to its proximity to a paint spraying business, however, this closed in 2019 and was replaced by an electric bike storage unit which likely explains the reduced concentrations recorded. In light of this the diffusion tube location was closed and moved in 2021.

Figure 4-11: Monthly mean hydrocarbon concentrations at Le Bas Centre, 2020

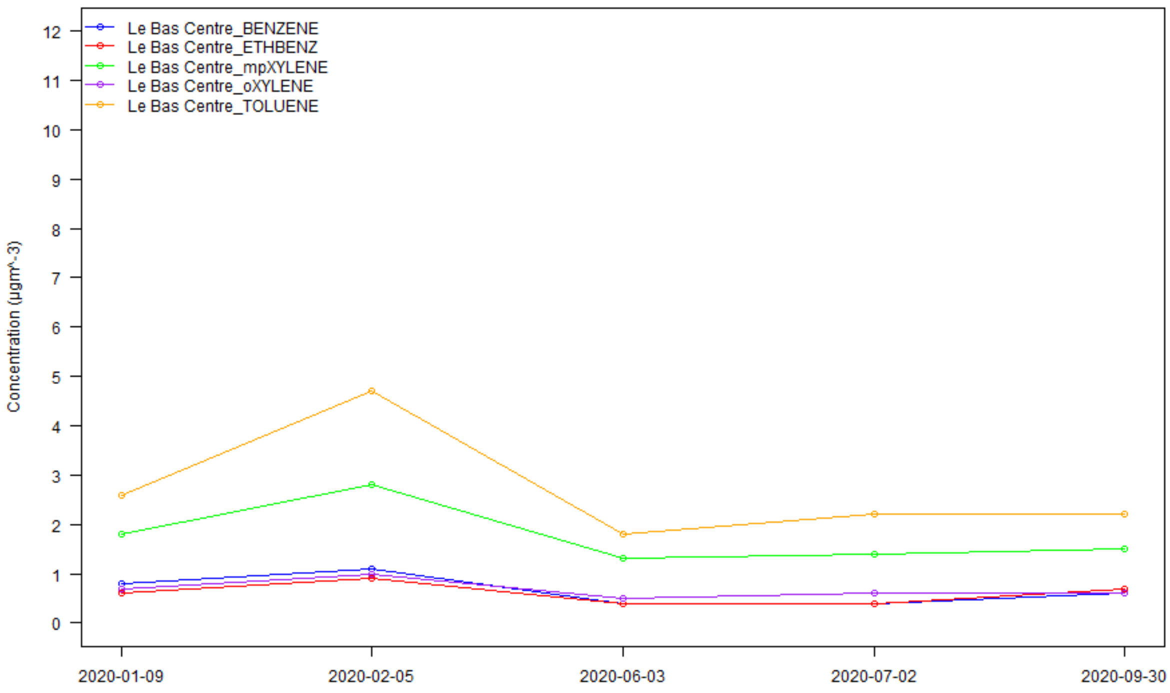


Figure 4-12 Monthly mean hydrocarbon concentrations at Halkett Place, 2020

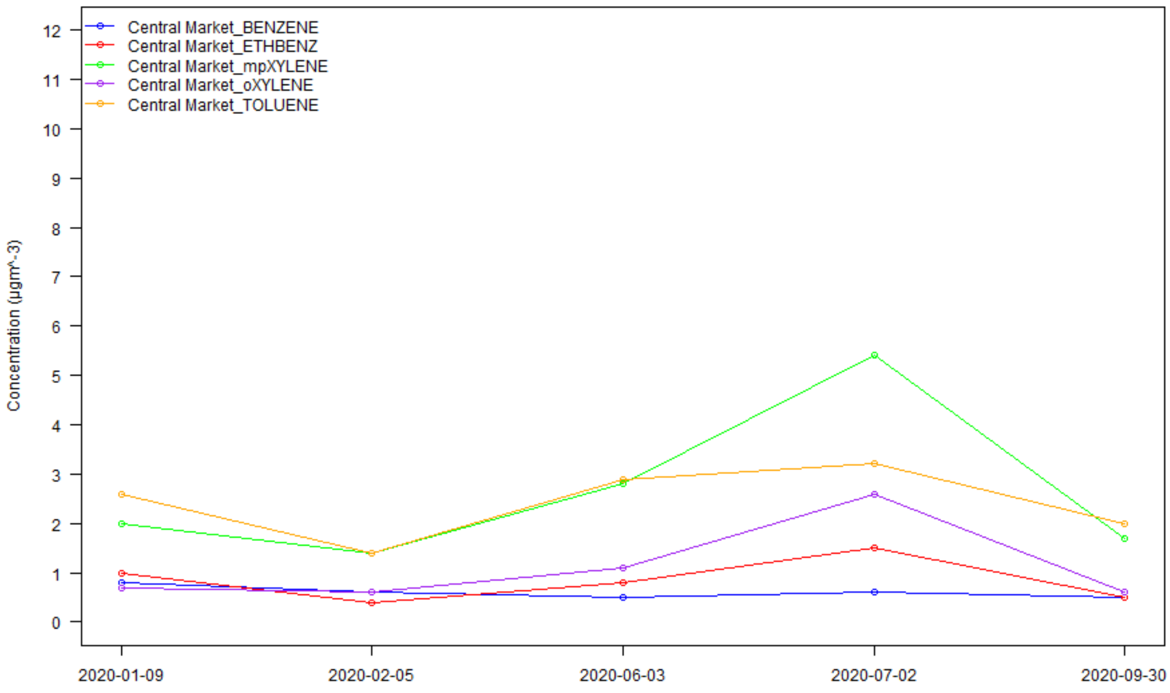


Figure 4-13: Monthly mean hydrocarbon concentrations at Harrington's Garage, 2020

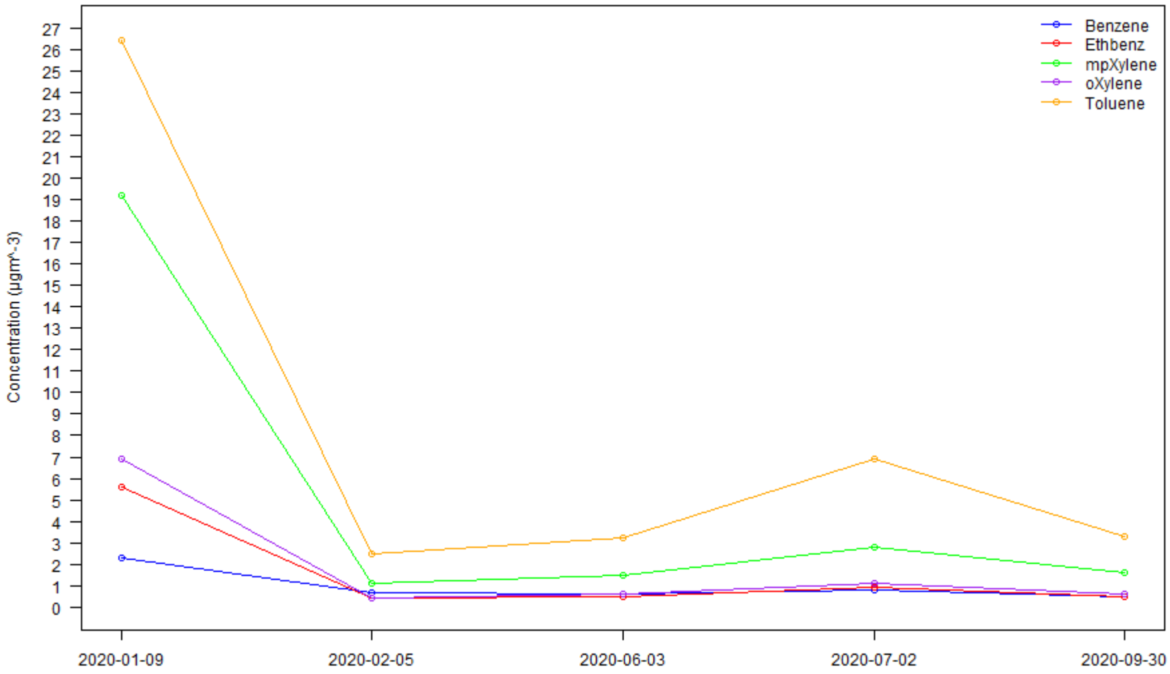


Figure 4-14: Monthly mean hydrocarbon concentrations at Hansford Lane, 2020

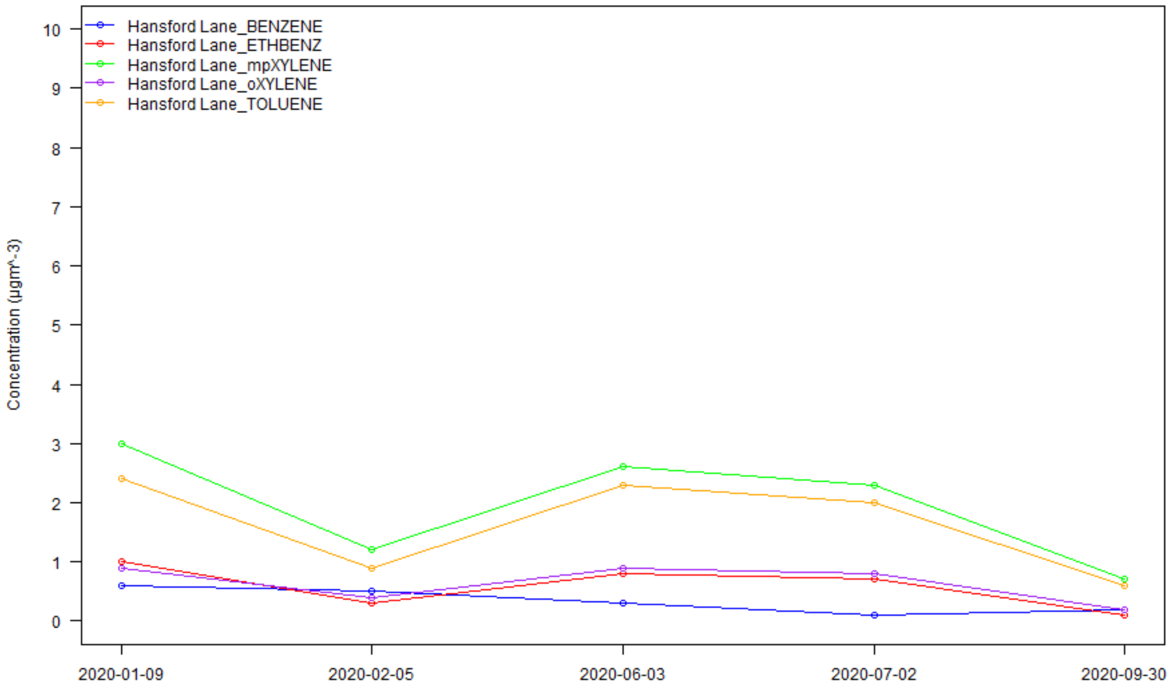
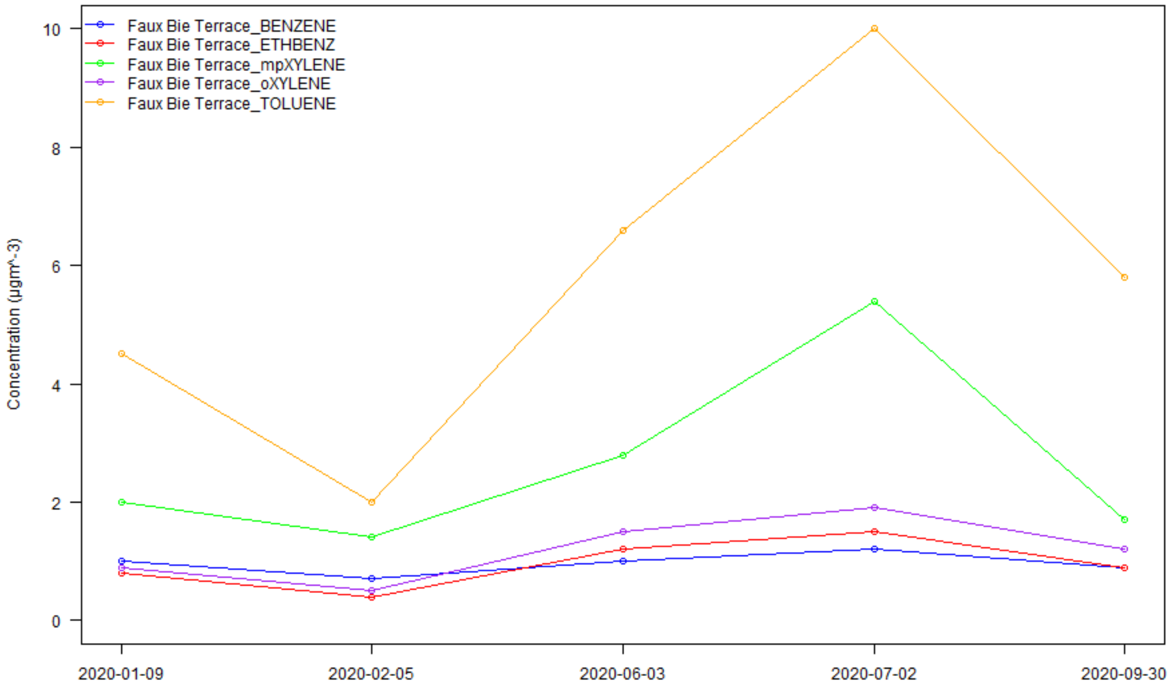


Figure 4-15: Monthly mean hydrocarbon concentrations at Faux Bie, 2020



The charts clearly show the differences in hydrocarbon concentrations between each location. The Hansford lane and Le Bas Centre sites had the lowest concentrations of BTEX hydrocarbons, Hansford lane recording one month below the detection limit for Benzene and another for Ethylbenzene.

4.4.1 Comparison with Limit Values and Objectives

Of the hydrocarbon species monitored, only benzene is the subject of any applicable air quality standards. The Air Quality Directive[4] sets a limit of 5 µg m^{-3} for the annual mean of benzene, to be achieved by 2010. All sites met this limit in 2020 and have done so since 1999 (or since they started operation).

The UK Air Quality Strategy[5] sets the following objectives for benzene:

- 16.25 µg m^{-3} (for the running annual mean), to have been achieved by 31st December 2003.
- 5 µg m^{-3} (for the calendar year mean), to have been achieved by 31st December 2010 in England and Wales. This is the same as the EC limit value.
- 3.25 µg m^{-3} (for the calendar year mean), to have been achieved by 31st December 2010 in Scotland and Northern Ireland.

These AQS objectives are not at present mandatory in Jersey.

The annual mean benzene concentration (which can be considered a good indicator of the running annual mean) was well within the 2003 objective of 16.25 µg m^{-3} at all the Jersey sites. The calendar year mean benzene concentration was below 3.25 µg m^{-3} at all Jersey sites. Therefore, these sites meet the tightest AQS objectives for benzene (those applying to Scotland and Northern Ireland).

4.4.2 Comparison with Previous Years' Hydrocarbon Results

Figure 4-16 to Figure 4-20 show how the annual mean hydrocarbon concentrations at the five Jersey sites have changed over the years of monitoring. The data is also provided in tabular form in Appendix 4.

It is important to remember that pollutant concentrations are expected to show considerable year-to-year variation mainly due to meteorological variations and other factors. Covid-19 restrictions impacted the deployment of BTEX tubes in 2020, see section 1.3, which has resulted in several months being considered compromised. It is likely that the reduction in NO_2 that has been explored earlier in this report would be somewhat mirrored in BTEX pollutants as they share many of the same emission sources. While the time weighted annual averages are expected to be lower than the annual averages, due to them including periods of restrictions, results from months with a non-standard exposure periods will not be included in the annual averages shown in Figures 4-16 to 4-20. Year-to year changes are therefore of less importance than the observation of long-term trends, which are discussed below.

Figure 4-16: Time series of benzene concentrations

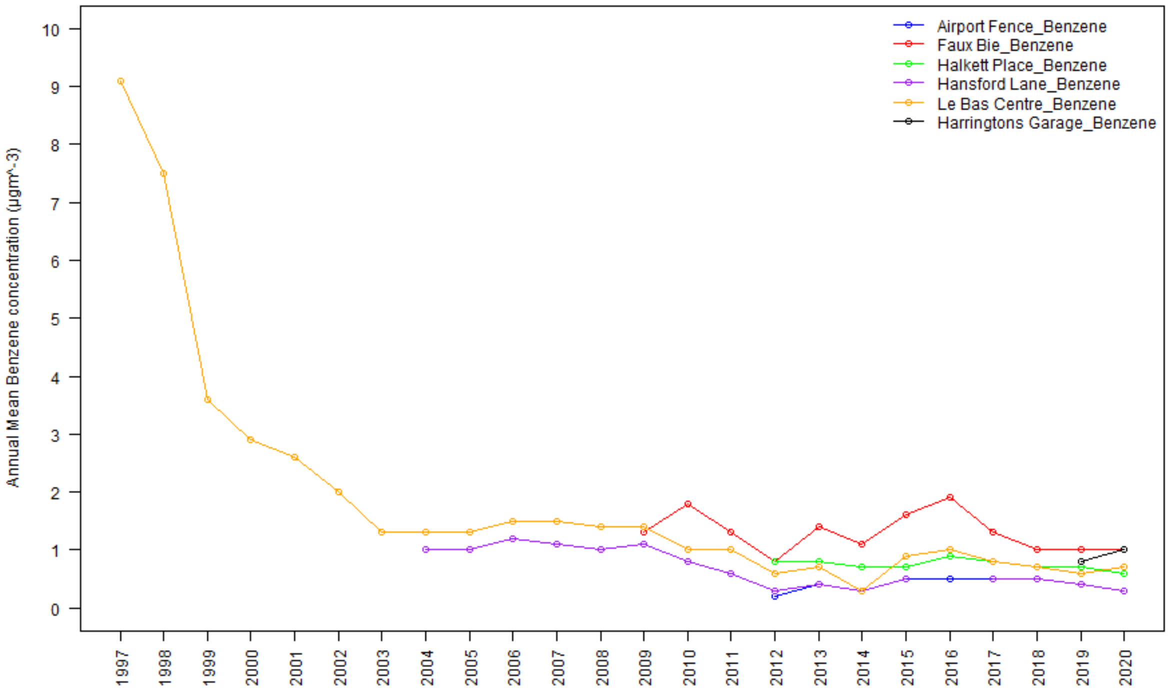


Figure 4-6 shows the annual mean benzene concentrations. The EU limit value is 5 µg m^{-3} and the Typical LoD as concentration equivalent is 0.097 µg m^{-3}. Le Bas Centre has been in operation since 1997 and the annual mean concentrations of benzene show a marked drop over the years running to the year 2000 due to the maximum permitted benzene content of petrol sold in the UK being reduced from 2% in unleaded (5% in super unleaded), to 1% as of 1st January 2000. This site has shown a further modest decrease between 2009 and 2012, as has Hansford Lane. Annual mean concentrations at all sites were equal to or lower than 1 µg m^{-3} in 2020 and represent a similar annual average to concentrations measured in 2019.

Figure 4-17: Time series of toluene concentrations

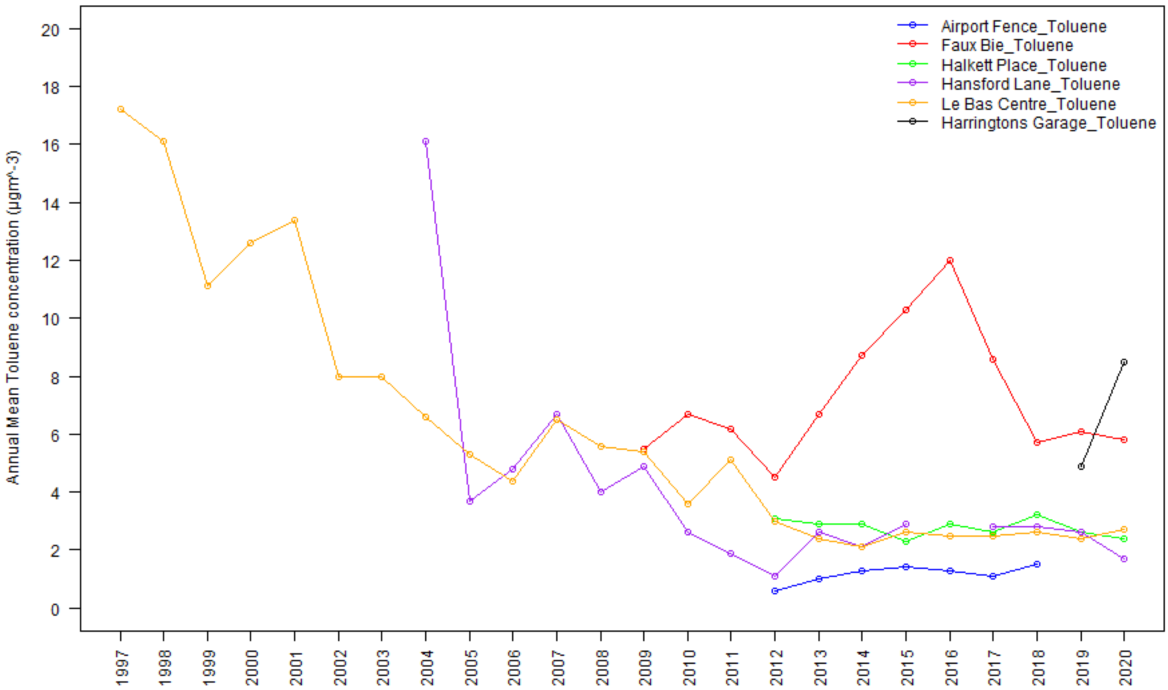
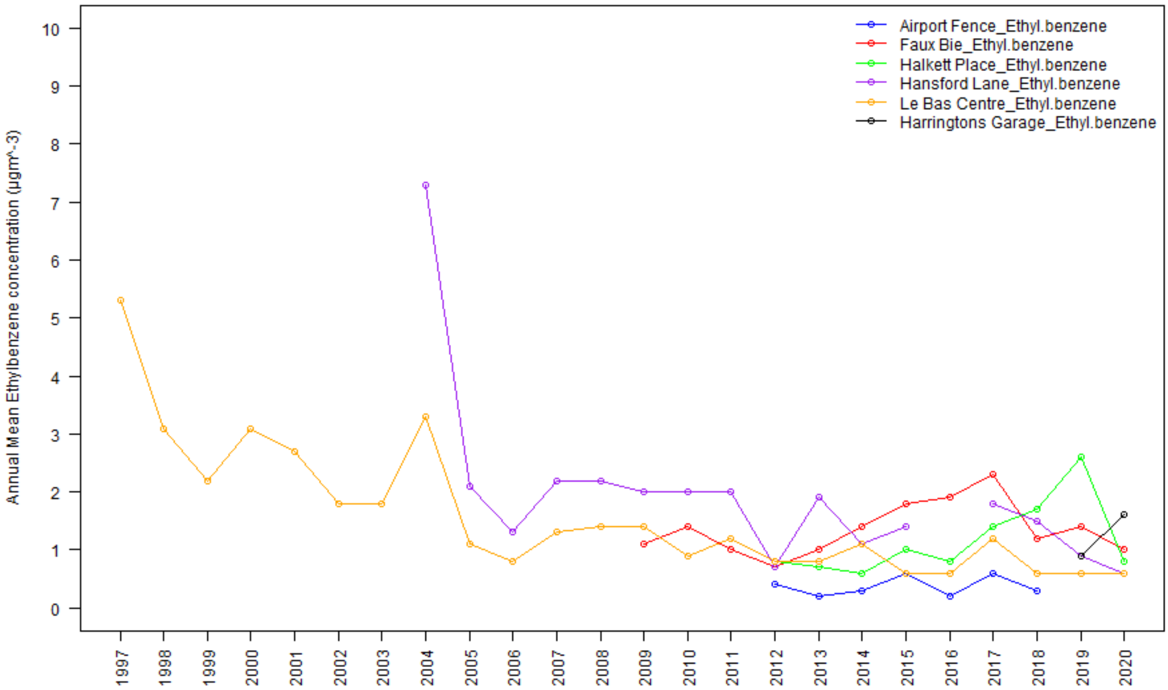


Figure 4-7 shows toluene concentrations. The ambient concentration equivalent to the typical LoD for toluene is 0.11 µg m^{-3}. The two longest-running sites, Le Bas Centre and Hansford Lane, show general decreases over the past twelve years, though these are not consistent. All sites have had relatively stable yearly averages since 2012 except for concentrations at the Faux Bie site which increased year on year between 2012 and 2016. However, concentrations decreased considerably after filling station upgrades in 2016 and 2017. 2020 average concentrations at Harrington's Garage increased to 8.5 µg m^{-3}, the highest recorded at any site since 2017. The average is however skewed by very high readings (for all species) in the January deployment.

Figure 4-18: Time series of ethylbenzene concentrations



The pattern for ethylbenzene, Figure 4-8, generally show that all sites have reduced their annual averages over the past 3 to 4 years. The exception to this is Harrington's Garage which saw a modest increase from the previous year, again impacted by a high January result. This illustrates that a longer time period is required to establish a trend that isn't influenced by short term events or meteorological conditions.

Figure 4-19 Time series of m+p-xylene concentrations

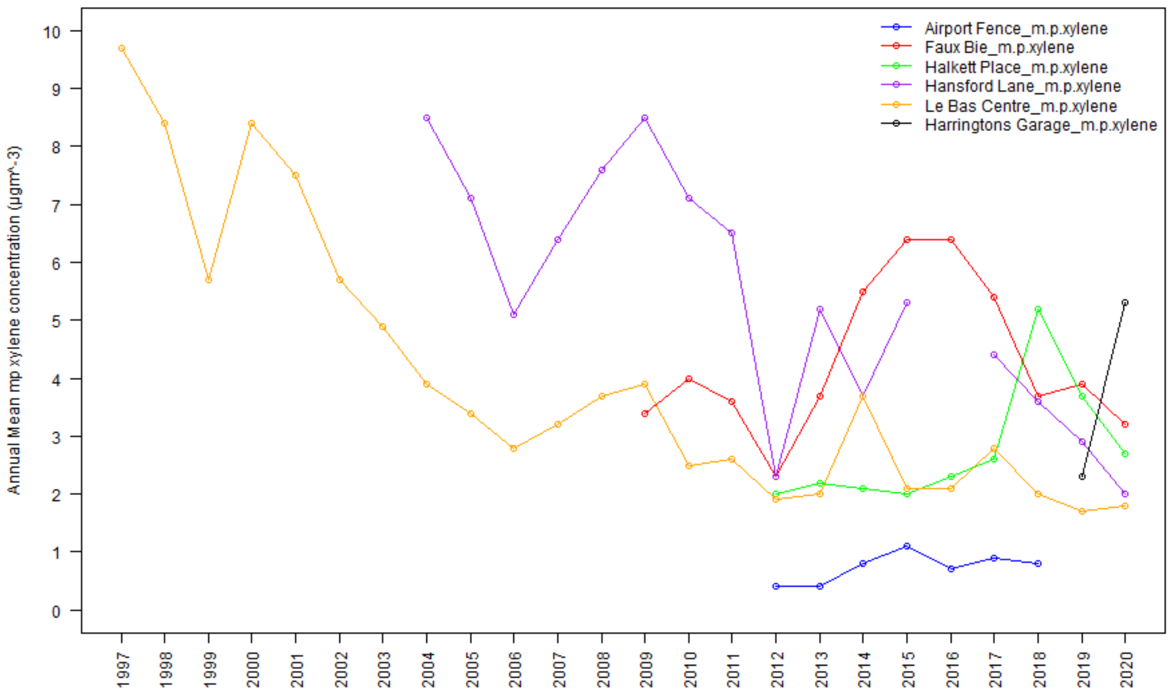
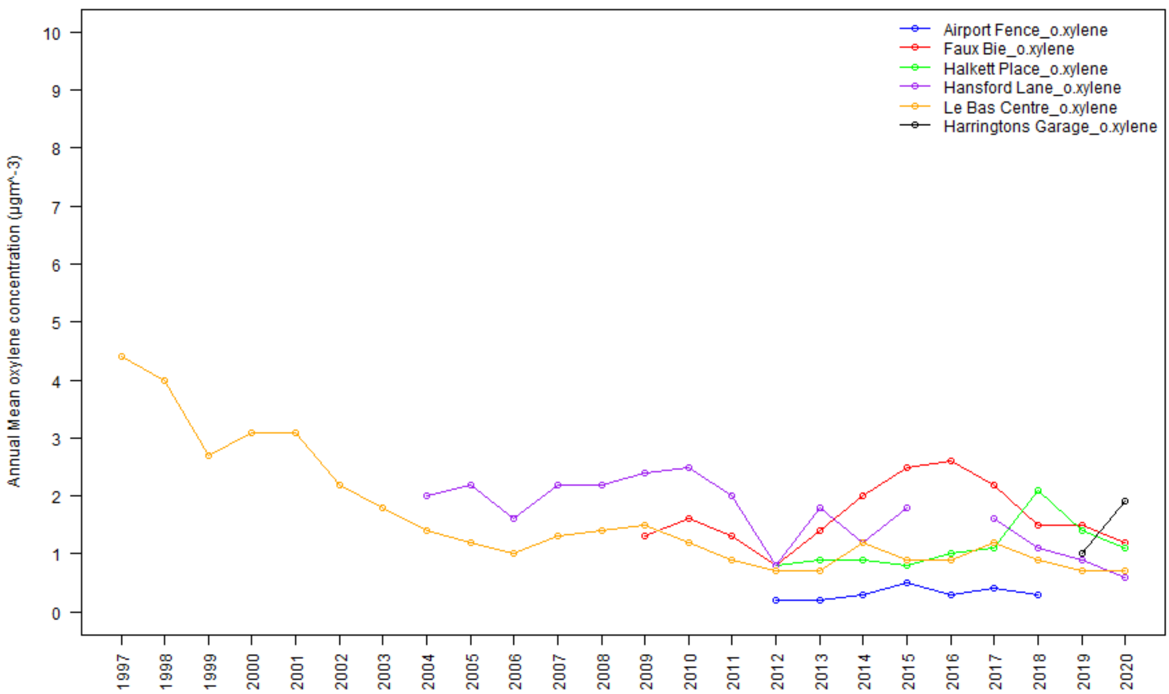


Figure 4-20 Time series of o-xylene concentrations



Concentrations of xylenes (Figure 4-19 and Figure 4-20) have generally decreased since monitoring began with the exception of Faux Bie which saw a steady increase since 2012, though this has reversed since filling station upgrades in 2016 and 2017. At Hansford Lane (near the paint spraying process), concentrations of m+p-xylene and of o-xylene have fluctuated considerably from year to year; however, overall concentrations are low and the general trend is one that is decreasing.

M+pxylene and oxylene concentrations in 2020 at Harrington's Garage increased to 5.3 µg m^{-3} and 1.9 µg m^{-3} respectively, a further detailed analysis of annual concentrations at this site will be made as multiple years of data are obtained.

It is also important to note how low current hydrocarbon concentrations are, compared to the LoD equivalent concentration (in 2020, typically around 0.15 µg m^{-3} for benzene, 0.15 µg m^{-3} for toluene and 0.12 µg m^{-3} for the other hydrocarbons).

5 Conclusions and Recommendations

Ricardo Energy & Environment has continued the ongoing air quality monitoring programme in Jersey during 2020, on behalf of the Government of Jersey. This was the 24th year of monitoring. Oxides of nitrogen were monitored at one automatic monitoring station, located in a roadside position at the Central Market, Halkett Place in St Helier. Diffusion tubes were also co-located (in triplicate) with the automatic site at Halkett Place. This was supplemented by diffusion tubes for indicative monitoring of NO_2 at an additional 16 sites around the island.

The Covid-19 pandemic and related restrictions have had an impact on both the data itself and its collection. This can be seen in the delayed QA/QC audit and service of the automatic instrument along with difficulties in keeping the diffusion tubes aligned with the deployment calendar. Due to the length of exposure falling outside of the recommended 4-5 week period several deployments have had to be marked as compromised. The periods of greatest restrictions have likely coincided with the periods of lowest concentrations which is reflected in the, compromised, time weighted annual averages being lower than the annual averages. In this report annual averages for diffusion tubes have been reported only including results from months with exposure periods between 4 and 5 weeks. For comparison however time weighted annual averages have also been reported.

Hydrocarbons (benzene, toluene, ethylbenzene and xylenes, collectively termed BTEX) were measured at five sites, using diffusion tubes. The sites were located at a range of different locations on the island, one of which has been in operation since 1997.

5.1 NO_2 Results

1. The annual mean NO_2 concentration measured by the automatic analyser at Halkett Place was 19 µg m^{-3}. This is within the EC Directive limit value and AQS objective of 40 µg m^{-3} for annual mean NO_2. Having achieved compliance by 2010 as required by all European Union member states the Government of Jersey are advised to continue to demonstrate ongoing compliance as has been done since 2010.
2. The 2020 automatic instrument annual mean shows a 13.6% reduction compared to the 2019 mean. A 30% drop in concentrations was seen between the March 2020 and April 2020 monthly means.
3. The monthly mean of the automatic instrument showed a 36% drop in concentrations between April 2019 and April 2020, while May showed a 28% drop.
4. The EC Directive limit value (and AQS objective) for 1-hour mean NO_2 concentration is 200 µg m^{-3}, with 18 exceedances permitted per calendar year. There were no hourly means greater than this value measured at Halkett Place. Therefore, Halkett Place met the limit value objective.
5. Diffusion tubes exposed in triplicate alongside the automatic analyser gave an annual mean of 22 µg m^{-3}. The time weighted annual mean gave a result of 18 µg m^{-3}.
6. Annual mean NO_2 concentrations at all diffusion tube monitoring sites were within the EC limit value.
7. The diurnal variation in oxide concentrations of nitrogen at Halkett Place were generally typical of an urban site but had a particularly early (and sharp) morning rush hour peak, with a slight afternoon rush hour peak. This is thought to be due to traffic patterns around the site; this being early morning traffic associated with the market and waste collection from the previous day. Refrigerated and refuse lorries are commonly left with engines running to allow them to cool and lift bins respectively.
8. Seasonal variations in monthly mean NO_2 concentrations at the diffusion tube sites are harder to see than in recent years however, the highest concentrations in 2020 were measured in January and the lowest concentrations recorded in June and July.
9. Annual mean NO_2 concentrations at Jersey's urban sites appear to have generally decreased between 2003 and 2012. Since then, concentrations have remained largely stable at most sites, with a slight decrease occurring in 2020.
10. Broad Street became pedestrianised in May 2020 and saw a 27% drop in annual mean concentration compared to 2019.

11. Annual mean NO_2 concentrations at all of Jersey's diffusion tube monitoring sites were lower in 2020 compared with 2019, despite the likely lowest months not being included, the compromised time weighted annual averages being lower still. Pollutant concentrations are expected to fluctuate from year to year, due to meteorological and other factors, the COVID-19 pandemic being the obvious major one for 2020 and beyond.

5.2 Hydrocarbon Diffusion Tube Results

1. Annual mean benzene concentrations at all four sites with annual averages were within the EC Directive limit value of 5 µg m^{-3}. Having achieved compliance by 2010 as required, the Government of Jersey must continue to demonstrate ongoing compliance.
2. The Hansford Lane site recorded the lowest concentrations of all the BTEX hydrocarbons (with the exception of m+p-xylene), and several results were below the limit of detection of the method. In 2019 the paint spraying business at Hansford lane closed and was replaced by an electric bike storage unit.
3. Annual mean concentrations of BTEX hydrocarbons were slightly lower than those measured in recent years, except for Harrington's Garage which saw high levels of all the BTEX hydrocarbons in the January deployment which raised the annual mean to above that of 2019. However as this is only the second year of monitoring at the site no long trend can be identified, and the impact of meteorological, COVID-19 and other factors must be considered.

5.3 Recommendations

It is recommended that the monitoring programme be continued as part of Jersey's Air Quality Strategy[10].

Measured concentrations of BTEX hydrocarbons at most of the sites were very low. The results should therefore only be taken as indicative measurements, for the purpose of confirming that benzene concentrations at the sites are within relevant limit values. However, if accurate measurement of hydrocarbons are required, it may be appropriate to consider installation of pumped-tube sampling at key sites, as used at UK mainland Non-Automatic Hydrocarbon Network sites. It is recommended that the Handsford Lane site is discontinued with a new site identified if required, this is because benzene concentrations sit at only 8% of the limit value and have been low for a number of years now.

A review of the diffusion tube network is recommended to assess any sites that no longer represent relevant exposure and can be removed or relocated.

The diffusion tube results indicate no sites breaching or close to the annual average NO_2 limit values. As such, an expansion of the automatic NOx monitoring network is not recommended at this time. Based on the 2019 Clean Air Strategy[11] and its emphasis on $PM_{2.5}$ reduction the Government of Jersey may wish to install reference equivalent analysers in an aim to expanding their particulate monitoring network and demonstrating compliance with the annual WHO $PM_{2.5}$ guideline of 5 µg m^{-3}.

With ongoing reductions in concentrations and improvements in technology since the AQS was last published in 2013, now would be a good opportunity to review and potentially update the document.

6 Acknowledgements

Ricardo Energy & Environment gratefully acknowledges the help and support of the staff of the Government of Jersey Environmental Health in this monitoring study.

7 References

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Appendices

Appendix 1: Air quality limit values, objectives and guidelines

Appendix 2: Calibration procedures for automatic analyser

Appendix 3: Nitrogen dioxide diffusion tubes: Bias adjustment factor

Appendix 4: BTEX diffusion tubes: Monthly dataset and annual means 1997 - 2019

Appendix 1 - Air quality limit values, objectives and guidelines

Air pollution guidelines used in this report

UK and International Ambient Air Quality Limit Values, Objectives and Guidelines

Table A1- 1 Nitrogen Dioxide

Guideline set by	Description	Criteria based on	Value[1]/µg m^{-3} (ppb)
The Air Quality Strategy[2]	Objective for Dec. 31st 2005, for protection of human health	1-hour mean	200 (105) Not to be exceeded more than 18 times per calendar year.
Set in regulations[3] for all UK:	Objective for Dec. 31st 2005, for protection of human health	Annual mean	40 (21)
Not intended to be set in regulations:	Objective for Dec. 31st 2000, for protection of vegetation.	Annual mean NO_x (NO_x as NO_2)	30 (16)
ED Directive on Ambient Air Quality and Cleaner Air for Europe[4]	Limit Value for protection of human health. To be achieved by Jan. 1st 2010	1 hour mean	200 (105) not to be exceeded more than 18 times per calendar year
	Limit Value for protection of human health. To be achieved by Jan. 1st 2010	Calendar year mean	40 (21)
	Limit Value (total NO_x) for protection of vegetation. To be achieved by Jul. 19th 2001	Calendar year mean	30 (16)
World Health Organisation[5] (Non-Mandatory Guidelines)	Health Guideline	1-hour mean	200
	Health Guideline	Annual mean	40

[1] Conversions between µg m^{-3} and ppb are as used by the EC, i.e. 1 ppb NO_2 = 1.91 µg m^{-3} at 20 °C and 1013 mB.
[2] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. March 2011.
[3] Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265).
[4] Council Directive 2008/50/EC.
[5] WHO Air Quality Guidelines for Europe (2000).

Table A1- 2 Benzene

Guideline set by	Description	Criteria based on	Value[6]/µg m^{-3} (ppb)
The Air Quality Strategy[7,8] All UK	Objective for Dec. 31st 2003	Running annual mean	16.25 (5)
England[9] & Wales[10] only:	Objective for Dec. 31st 2010	Annual mean	5 (1.54)
Scotland[11] & Northern Ireland	Objective for Dec. 31st 2010	Running annual mean	3.25 (1.0)
ED Directive on Ambient Air Quality and Cleaner Air for Europe [12]	Limit Value. To be achieved by Jan 1st 2010	Annual calendar year mean	5 (1.5)

Table A1- 3 Toluene

Guideline set by	Description	Criteria based on	Value[1]/µg m^{-3} (ppb)
World Health Organisation[13] (Non-Mandatory Guideline)	Health Guideline	1-week mean	260 µg m^{-3} or 0.26 mg m^{-3}

[6] Conversions between µg m^{-3} and ppb are as used by the EC, i.e. 1 ppb NO_2 = 1.91 µg m^{-3} at 20 °C and 1013 mB.
[7] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
[8] Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
[9] Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043).
[10] Air Quality (Amendment) (Wales) Regulations 2002 (SI 2002/3182 (W298)).
[11] Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297).
[12] Council Directive 2008/50/EC.
[13] WHO Air Quality Guidelines for Europe (2000).

Appendix 2 - Calibration procedures for automatic analyser

The analyser at Halkett Place is calibrated monthly by the Environmental Health team. Standard gas calibration mixtures are used to check the instrument's span, and chemically scrubbed air is used to check the instrument's zero. All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards from the Gas Standards Calibration Laboratory at Ricardo Energy & Environment. The calibration laboratory operates within a specific and documented quality system and has UKAS accreditation for calibration of the gas standards used in this survey.

An important aspect of QA/QC procedures is the annual intercalibration and audit check usually undertaken every 12 months, please see section 1.3 for the impacts of Covid19 on the 2020 audit. This audit has two principal functions, firstly to check the instrument and the site infrastructure, and secondly to recalibrate the transfer gas standards routinely used on-site, using standards recently checked in the calibration laboratory. Ricardo Energy & Environment's audit calibration procedures are UKAS accredited to ISO 17025.

At these visits, the essential functional parameters of the monitors, such as noise, linearity and, for the NO_x monitor, the efficiency of the NO_2 to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked. In 2020 this exercise was delayed to the summer of 2021 and was followed by a full service of the analyser and sampler pump. A second visit is planned for November 2021 before resuming the normal schedule in 2022.

Appendix 3 - Nitrogen dioxide diffusion tubes: Bias adjustment factor

The precision and accuracy of the diffusion tubes in this study were quantified by exposing them in triplicate alongside the automatic NO_x analyser at Halkett Place. The percentage by which the diffusion tubes over- or under-estimate with respect to the automatic chemiluminescent analyser (defined within the European Community as the reference method for NO_2) is calculated as follows.

Percentage bias B = 100 x (D - C) / C

Where D = the average NO_2 concentration as measured using diffusion tubes; and

C = the average NO_2 concentration as measured using the automatic analyser.

The diffusion tube annual mean concentrations measured at the other (non-co-located) sites can be adjusted for the diffusion tube over/under-read by application of a bias adjustment factor, calculated as follows.

Bias adjustment factor = C / D

Where D and C are the annual mean NO_2 concentrations as measured using diffusion tubes and the automatic analyser respectively, as above.

These calculations were carried out using a spreadsheet tool developed by Ricardo Energy & Environment (at that time trading as AEA Energy & Environment): Figure A3- 1, see below. This spreadsheet shows the diffusion tube concentrations to one decimal place as reported by the analyst – but given the uncertainty on diffusion tube measurements, it is only considered valid to report to the nearest integer in the report, except at the sites with lowest concentrations.

Figure A3- 1 Precision and bias spreadsheet showing Halkett Place dataset

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm⁻³	Tube 2 μgm⁻³	Tube 3 μgm⁻³	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	09/01/2020	05/02/2020	26.5	27.9	25.4	27	1.3	5	3.1	22	97.2	Good	Good
2	05/02/2020	04/03/2020	22.4	22.1	22.6	22	0.2	1	0.6	21	95.8	Good	Good
3	04/03/2020	03/06/2020	16.3	16.4	15.5	16	0.5	3	1.2	16	97.6	Good	Good
4	N/A	N/A											
5	N/A	N/A											
6	03/06/2020	02/07/2020	21.5	21.0	20.9	21	0.3	2	0.8	18	96	Good	Good
7	02/07/2020	29/07/2020	19.6	19.4	18.9	19	0.4	2	0.9	16	97.2	Good	Good
8	29/07/2020	18/09/2020	22.6	20.8	20.0	21	1.3	6	3.3	20	96.6	Good	Good
9	18/09/2020	30/09/2020	24.8	23.4	23.9	24	0.7	3	1.8	20	95.2	Good	Good
10	30/09/2020	06/11/2020	22.3	21.5	22.0	22	0.4	2	1.0	20	95.7	Good	Good
11	06/11/2020	03/02/2021	10.2	10.5	11.4	11	0.7	6	1.6	22	96.6	Good	Good
12	N/A	N/A											
13													
It is necessary to have results for at least two tubes in order to calculate the precision of the measurements											Overall survey -->	Good precision	Good Overall DC

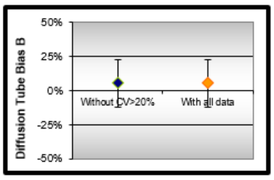
Site Name/ ID:

Precision: 9 out of 9 periods have a CV smaller than 20%

(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval)	
without periods with CV larger than 20%	
Bias calculated using 9 periods of data	
Bias factor A	0.96 (0.82 - 1.15)
Bias B	5% (-13% - 22%)
Diffusion Tubes Mean:	20 μgm⁻³
Mean CV (Precision):	3
Automatic Mean:	19 μgm⁻³
Data Capture for periods used:	96%
Adjusted Tubes Mean:	20 (17 - 23) μgm⁻³

Accuracy (with 95% confidence interval)	
WITH ALL DATA	
Bias calculated using 9 periods of data	
Bias factor A	0.96 (0.82 - 1.15)
Bias B	5% (-13% - 22%)
Diffusion Tubes Mean:	20 μgm⁻³
Mean CV (Precision):	3
Automatic Mean:	19 μgm⁻³
Data Capture for periods used:	96%
Adjusted Tubes Mean:	20 (17 - 23) μgm⁻³



Jaume Targa, for AEA
Version 04 - February 2011

Appendix 4 - BTEX diffusion tubes: Monthly dataset and annual means 1997 - 2020

Figures in red are results less than the analytical limit of detection. They have been treated as ½ LoD for calculation purposes. Results are supplied in units of parts per billion (ppb) and converted.

* Data was not used to create the annual mean

Table A4- 1 Monthly mean hydrocarbon concentrations, µg m^{-3} – Le Bas Centre

Le Bas Centre	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	0.83	2.59	0.61	1.77	0.67
05/02/2020	1.14	4.69	0.87	2.79	1.04
04/03/2020	0.54*	2.00*	0.48*	1.57*	0.61*
03/06/2020	0.41	1.83	0.42	1.33	0.52
02/07/2020	0.38	2.17	0.42	1.43	0.59
29/07/2020	0.44*	2.40*	0.47*	1.54*	0.60*
18/09/2020	0.22*	0.25*	0.30*	0.30*	0.30*
30/09/2020	0.55	2.15	0.67	1.54	0.60
06/11/2020	0.73*	2.37*	0.47*	1.50*	0.62*
Annual mean (Only exposures between 4 and 5 weeks)	**0.7**	**2.7**	**0.6**	**1.8**	**0.7**
Time weighted Annual average (All months	**0.6**	**2.3**	**0.5**	**1.5**	**0.6**

Table A4- 2 Monthly mean hydrocarbon concentrations, µg m^{-3} – Halkett Place

Halkett Place	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	0.79	2.55	0.98	1.96	0.74
05/02/2020	0.55	1.43	0.43	1.37	0.56
04/03/2020	0.48*	1.50*	0.37*	1.13*	0.44*
03/06/2020	0.50	2.86	0.81	2.78	1.13
02/07/2020	0.60	3.18	1.46	5.45	2.60
29/07/2020	0.46*	2.39*	0.51*	1.78*	0.70*
18/09/2020	0.22*	0.25*	0.30*	0.30*	0.30*
30/09/2020	0.50	2.04	0.45	1.71	0.64
06/11/2020	0.71*	2.15*	0.48*	1.61*	0.61*
Annual mean (Only exposures between 4 and 5 weeks)	**0.6**	**2.4**	**0.8**	**2.7**	**1.1**
Time weighted Annual average (All months	**0.6**	**2**	**0.6**	**2**	**0.9**

Table A4- 3 Monthly mean hydrocarbon concentrations, µg m^{-3} – Harrington's Garage

Harrington's Garage	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	2.29	26.45	5.58	19.20	6.92
05/02/2020	0.74	2.49	0.40	1.12	0.41
04/03/2020	0.50*	2.43*	0.44*	1.37*	0.51*
03/06/2020	0.56	3.21	0.47	1.54	0.56
02/07/2020	0.83	6.92	0.90	2.84	1.08
29/07/2020	0.90*	6.60*	0.83*	2.71*	1.01*
18/09/2020	0.85*	3.60*	0.30*	1.70*	0.67*
30/09/2020	0.52	3.31	0.45	1.59	0.57
06/11/2020	0.60*	2.89*	0.37*	1.20*	0.49*
Annual mean (Only exposures between 4 and 5 weeks)	**1**	**8.5**	**1.6**	**5.3**	**1.9**
Time weighted Annual average (All months	**0.9**	**6.4**	**1.1**	**3.7**	**1.4**

Table A4- 4 Monthly mean hydrocarbon concentrations, µg m^{-3} – Hansford Lane

Hansford Lane	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	0.55	2.42	0.96	3.02	0.87
05/02/2020	0.48	0.93	0.31	1.20	0.40
04/03/2020	0.37*	1.85*	0.49*	1.65*	0.52*
03/06/2020	0.26	2.34	0.82	2.61	0.87
02/07/2020	0.11	2.00	0.70	2.30	0.79
29/07/2020	0.20*	1.24*	0.32*	1.08*	0.36*
18/09/2020	0.22*	0.25*	0.30*	0.30*	0.30*
30/09/2020	0.21	0.58	0.10	0.68	0.23
06/11/2020	0.40*	0.68*	0.15*	0.51*	0.21*
Annual mean (Only exposures between 4 and 5 weeks)	**0.3**	**1.7**	**0.6**	**2**	**0.6**
Time weighted Annual average (All months	**0.3**	**1.4**	**0.5**	**1.5**	**0.5**

Table A4- 5 Monthly mean hydrocarbon concentrations, µg m^{-3} – Faux Bie

Faux Bie	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	1.03	4.48	0.76	2.41	0.93
05/02/2020	0.66	2.01	0.45	1.38	0.54
04/03/2020	0.70*	3.77*	0.68*	2.16*	0.82*
03/06/2020	0.99	6.64	1.19	4.06	1.50
02/07/2020	1.20	10.04	1.45	5.00	1.89
29/07/2020	1.19*	9.76*	1.50*	5.10*	1.89*
18/09/2020	0.67*	3.34*	0.30*	1.38*	0.30*
30/09/2020	0.92	5.81	0.93	3.22	1.20
06/11/2020	0.88*	4.56*	0.69*	2.34*	0.90*
Annual mean (Only exposures between 4 and 5 weeks)	**1**	**5.8**	**1**	**3.2**	**1.2**
Time weighted Annual average (All months	**0.9**	**5.6**	**0.9**	**3**	**1.1**

Table A4- 6 Monthly mean hydrocarbon concentrations, µg m^{-3} – Travel blank

Travel blank	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
09/01/2020	0.06	0.02	0.02	0.03	0.02
05/02/2020	0.03	0.02	0.05	0.13	0.06
04/03/2020	0.02*	0.02*	0.01*	0.01*	0.00*
03/06/2020	0.05	0.02	0.01	0.04	0.02
02/07/2020	0.06	0.02	0.03	0.11	0.01
29/07/2020	0.02*	0.01*	0.01*	0.02*	0.01*
18/09/2020	0.11*	0.43*	0.13*	0.14*	0.06*
30/09/2020	0.06	0.01	0.02	0.01	0.02
06/11/2020	0.02*	0.01*	0.01*	0.05*	0.00*
Annual mean (Only exposures between 4 and 5 weeks)	**0.1**	**0**	**0**	**0.1**	**0**
Time weighted Annual average (All months	**0**	**0.1**	**0**	**0.1**	**0**

Table A4- 7 Comparison of hydrocarbon concentrations, Jersey, 1997 – 2020

	Benzene µg m-3	Toluene µg m-3	Ethylbenzene µg m-3	m+p-xylene µg m-3	o-xylene µg m-3
Le Bas Centre					
1997	9.1	17.2	5.3	9.7	4.4
1998	7.5	16.1	3.1	8.4	4
1999	3.6	11.1	2.2	5.7	2.7
2000	2.9	12.6	3.1	8.4	3.1
2001	2.6	13.4	2.7	7.5	3.1
2002	2	8	1.8	5.7	2.2
2003	1.3	8	1.8	4.9	1.8
2004	1.3	6.6	3.3	3.9	1.4
2005	1.3	5.3	1.1	3.4	1.2
2006	1.5	4.4	0.8	2.8	1
2007	1.5	6.5	1.3	3.2	1.3
2008	1.4	5.6	1.4	3.7	1.4
2009	1.4	5.4	1.4	3.9	1.5
2010	1	3.6	0.9	2.5	1.2
2011	1	5.1	1.2	2.6	0.9
2012	0.6	3	0.8	1.9	0.7
2013	0.7	2.4	0.8	2.0	0.7
2014	0.5	2.1	0.5	1.7	0.6
2015	0.9	2.6	0.6	2.1	0.9
2016	1	2.5	0.6	2.1	0.9
2017	0.8	2.5	1.2	2.8	1.2
2018	0.7	2.6	0.6	2	0.9
2019	0.6	2.4	0.6	1.7	0.7
2020	0.7	2.7	0.6	1.8	0.7
Halkett Place					
2012	0.8	3.1	0.8	2	0.8
2013	0.8	2.9	0.7	2.2	0.9
2014	0.7	2.9	0.6	2.1	0.9
2015	0.7	2.3	1.0	2.0	0.8
2016	0.9	2.9	0.8	2.3	1
2017	0.8	2.6	1.4	2.6	1.1
2018	0.7	3.2	1.7	5.2	2.1
2019	0.7	2.6	2.6	3.7	1.4
2020	0.6	2.4	0.8	2.7	1.1
Harrington's Garage					
2019	0.8	4.9	0.9	2.3	1.0
2020	1	8.5	1.6	5.3	1.9

Table A4- 8 (Continued) Comparison of hydrocarbon concentrations, Jersey, 1997 – 2020

	Benzene µg m^{-3}	Toluene µg m^{-3}	Ethylbenzene µg m^{-3}	m+p-xylene µg m^{-3}	o-xylene µg m^{-3}
Hansford Lane					
2004	1	16.1	7.3	8.5	2
2005	1	3.7	2.1	7.1	2.2
2006	1.2	4.8	1.3	5.1	1.6
2007	1.1	6.7	2.2	6.4	2.2
2008	1	4	2.2	7.6	2.2
2009	1.1	4.9	2	8.5	2.4
2010	0.8	2.6	2	7.1	2.5
2011	0.6	1.9	2	6.5	2
2012	0.3	1.1	0.7	2.3	0.8
2013	0.4	2.6	1.9	5.2	1.8
2014	0.3	2.1	1.1	3.7	1.2
2015	0.5	2.9	1.4	5.3	1.8
2016	N/A	N/A	N/A	N/A	N/A
2017	0.5	2.8	1.8	4.4	1.6
2018	0.5	2.8	1.5	3.6	1.1
2019	0.4	2.6	0.9	2.9	0.9
2020	0.3	1.7	0.6	2	0.6
Faux Bie					
2009	1.3	5.5	1.1	3.4	1.3
2010	1.8	6.7	1.4	4	1.6
2011	1.3	6.2	1	3.6	1.3
2012	0.8	4.5	0.7	2.3	0.8
2013	1.4	6.7	1.0	3.7	1.4
2014	1.1	8.7	1.4	5.5	2.0
2015	1.6	10.3	1.8	6.4	2.5
2016	1.9	12	1.9	6.4	2.6
2017	1.3	8.6	2.3	5.4	2.2
2018	1	5.7	1.2	3.7	1.5
2019	1	6.1	1.4	3.9	1.5
2020	1	5.8	1	3.2	1.2

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