Air Quality Monitoring in Jersey 2023

Report for the Government of Jersey

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1. EXECUTIVE SUMMARY

This report presents the results for 2023 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo Energy & Environment on behalf of the Natural Environment Department of the Government of Jersey.

The air quality monitoring programme in Jersey during 2023 consisted of the following:

- Automatic monitoring of nitrogen dioxide (NO_2).
- Automatic monitoring of particulate matter (PM_{10} and $PM_{2.5}$)
- Passive diffusion tube measurements for NO_2 and hydrocarbons.

An automatic monitoring station for (NO_2) has been located in the Central Market, Halkett Place, St Helier since January 2008. In November of 2021 this was re-located to a new position to measure NO_2 levels from traffic using Beresford Street. Particulate matter was monitored at two locations, Central Market and Howard Davis Park. In addition, non-automatic diffusion tube samplers were used for indicative monitoring of NO_2 at 23 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 tubes were supplied and analysed by Gradko International Ltd and changed by Technical Officers of Jersey's Natural Environment Department. The 2023 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

Since 2020, there has been a notable change in measurements of some pollutants as a results of COVID-19 Pandemic restrictions and their subsequent lifting. During 2023 the effects of the pandemic on this programme were felt less than previous years as there were no considerable changes to the diffusion tube calendar. All restrictions on the island were removed by the beginning of 2022, and as a result concentrations and patterns seen in this report illustrate the continual recovery from the pandemic.

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

Data capture at Beresford Street Market was over 97% in 2023, therefore achieving the 90% data capture required to create an annual average. The 2023 period mean from the automatic monitor at Beresford Street Market was 16 $\mu g\ m^{-3}$, showing a decrease in annual mean concentration compared to 2022. The annual mean NO_2 concentration measured at Beresford Street Market was within the EC Directive limit value and AQS objective of 40 $\mu g\ m^{-3}$ for annual mean NO_2 but was higher than the WHO annual guideline of 10 $\mu g\ m^{-3}$.

Annual mean concentrations of NO_2 did not exceed the EC Directive limit value of 40 $\mu g\ m^{-3}$ at any of the diffusion tube sites. However most sites recorded annual mean NO_2 concentrations greater than the WHO annual guideline of 10 $\mu g\ m^{-3}$. For comparison annual averages 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.

Data capture at Central Market Osiris and Howard Davis Park Osiris were both below the recommended 90% data capture required to create an annual average. Therefore no comparisons to limit values and objectives can be made.

The diurnal variation in NO_2 concentrations at Beresford Street Market showed some similarities to an urban site, showing an early and sharp peak at morning rush hour followed by a gentle but broad evening peak 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 use of the short term parking next to the site where drivers occasionally leave vehicles running.

The pattern of monthly averaged concentrations throughout the year showed that concentrations of NO_2 were typically highest in the winter months. Bivariate plots of NO_2 concentration indicated that nearby sources, such as vehicles using Beresford Street, were likely contributing factor of elevated NO_2 concentrations.

Diurnal variations of particulate matter concentrations at Central Market Osiris showed a broad morning peak followed by a smaller peak in the afternoon. Similar to NO_2 concentrations at Beresford Street, this is likely attributed to market operations and idling vehicles. Particulate matter concentrations measured at Howard Davis Park showed a similar trend to those measured at Central Market Osiris with a broad morning peak followed by a smaller afternoon peak, although to a lower magnitude due to this site being located in the centre of Howard Davis Park.

Analysis of bivariate plots of PM_{10} and $PM_{2.5}$ concentrations at Central Market Osiris and Howard Davis Park indicate that elevated particulate matter concentrations generally occur in unsettled conditions, particularly at high wind speeds from the southwest, in the direction of the port and marinas. Back trajectory analysis of particulate matter concentrations at both sites show that long range transport of polluted air masses from the continent are not likely to contribute to elevated concentrations.

Since 2000, there is shown to be an overall decreasing trend in NO_2 concentrations at long-running NO_2 diffusion tube monitoring locations. This decrease is likely linked to increased vehicle efficiency and cleaner fuels as well as the overall decline in the use of diesel vehicles in Jersey. Few sites have shown small increases in NO_2 concentrations in 2023 which is likely due to the continued reuptake in travel following the COVID-19 Pandemic restrictions imposed between 2020 and 2021.

Each of the hydrocarbon sites provided annual means below that required of the EC Directive limit value for benzene (5 µg m^{-3} as an annual mean, to be achieved by 2010). 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 [1]. The site at Harrington's Garage measured the highest annual mean benzene concentrations, of 0.7 µg m^{-3}, similar to the average at Faux Bie Terrace of 0.5 µg m^{-3}. Both of these sites represent relevant public exposure near to petrol stations. Concentrations at Faux Bie Terrace which has been in operation since 2009 have decreased since a stage 2 vapour recovery system was installed in 2016.

Hydrocarbon concentrations were generally similar when comparing 2023 to 2022, except for toluene concentrations at Faux Bie Terrace and Harrington's Garage where there were shown to be small increases in annual mean concentrations (although still significantly below occupational exposure levels). Over the long term, hydrocarbon concentrations have generally decreased at all sites that have been operational for 5 years or more. Long term trends at Rue de Pres and Beresford Street will be seen after these sites remain in operation for future years.

Please note, this version of the report had been reformatted to PDF to allow publication on the gov.je webpages. The original, interactive report can be found on the JerseyAir webpage here.

[1] UKPIA Statistical Review, 2018. Available at: https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf (Accessed 27th March 2024)

2. INTRODUCTION

2.1 BACKGROUND

Jersey is the largest of the Channel Islands at 45 square miles, with a population 111,300 [2]. Both air and sea transport links to the UK and France make it easy to travel to nearby destinations in less than an hour.

This report describes a programme of air quality monitoring carried out on the island of Jersey in 2023, undertaken by Ricardo Energy & Environment, on behalf of Jersey Government's Department of Infrastructure and Environment. The report presents and summarises the fully validated and quality controlled dataset for the period 1st January to 31st December 2023. This is the 26th 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 monitored in 2023 were nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$) and a range of hydrocarbon species (benzene, toluene, ethylbenzene and two xylene compounds). NO_2 was measured by an automatic monitor, situated at Beresford Street located next to the Central Market in St Helier. This was supplemented by indicative monitoring of NO_2 using low-cost passive samplers (Palmes type diffusion tubes). At the beginning of the year there were 23 locations, however in March 2023 two new sites were installed, meaning there were 25 sites in operation between March to December 2023. Particulate matter concentrations were measured by two automatic monitors, located at Central Market and Howard Davis Park. The suite of hydrocarbon species were monitored using 'BTEX' diffusion tubes at five sites during the year.

This report presents the 2023 air quality monitoring results 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 monitoring programmes from prior years.

Data in the annual report have been processed according to the rigorous quality assurance and quality control procedures used by Ricardo Energy & Environment. These ensure the data are reliable, accurate and traceable to UK national measurement standards.

In addition to this report, Jersey has daily access to provisional data from its monitoring sites via their own air quality monitoring page [3] and data from the UK's national air quality monitoring network, through the Defra UK Air Information Resource (UK-AIR) [4]. Data is also available via Ricardo's Jersey Air web page [5].

2.2 AIMS AND OBJECTIVES

Air quality monitoring during 2023 is the continuation of a survey that has been carried out since 1997. This report is the latest in a series of annual reports. As in previous years, the objective of this report 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).

The results of the monitoring are used to assess whether applicable national air quality objectives have been met, and how pollutant concentrations in the area have changed over time.

[2] Government of Jersey, 2022. *Population Estimates.* https://www.gov.je/StatisticsPerformance/Population/pages/population.aspx (Accessed 2nd April 2024)

[3] Government of Jersey, 2023. *Government of Jersey - Air Quality Monitoring.* https://www.gov.je/Environment/ProtectingEnvironment/Air/pages/airquality.aspx (Accessed 27th March 2024)

[4] Department for Environment, Food; Rural Affairs, 2023. *UK-AIR, Air Quality Information Resource.* http://uk-air.defra.gov.uk/ (Accessed 27th March 2024)

[5] Ricardo-AEA, 2023. *Air Pollution in Jersey.* http://jerseyair.ricardo-aea.com/ (Accessed 27th March 2024)

2.3 IMPACT OF COVID-19 RESTRICTIONS ON MONITORING

2020 and 2021 saw severe disruption to daily life for all of the world and Jersey was no different. The timeline of events relating to restrictions as a result of the COVID-19 Pandemic and the impacts this had on tourism in Jersey have been described in previous reports within this series. These reports also explained the disruption to the monitoring programme, mainly relating to deployment and collection of diffusion tubes.

In 2023 there were over 978,000 arrivals by air and sea combined [6]. This was an increase of roughly 14% compared to 2022, however still roughly only 83% of the 1.18 million air and sea arrivals in 2019 (pre-COVID-19). Therefore, it can be said that Jersey is continuing to recover from the effects of COVID-19 but there is an upward trend in recovery since 2021 which is expected to continue in 2024.

3. DETAILS OF THE MONITORING PROGRAMME

3.1 POLLUTANTS MONITORED

3.1.1 NO_x

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. NO_x is the term used to describe the mixture of oxides of nitrogen. 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 ($\mu g\ m^{-3}$). The earliest reports in this series used parts per billion (ppb). To convert from $\mu g\ m^{-3}$ to ppb for comparison with the earlier reports, if required, the following relationship should be used: 1 $\mu g\ m^{-3}$ = 0.523 ppb for nitrogen dioxide at 293 K (20 °C) and 1013 mb.

3.1.2 Particulate Matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The terms PM_{10} and $PM_{2.5}$ are used to describe particles with an effective size less than 10 µm and less than 2.5 µm respectively. Particulate matter in the atmosphere has many sources in Jersey, including combustion and road vehicle emissions. Similarly to NO_2, particulate matter can consist of both primary and secondary sources. Secondary particulate matter can be formed in the atmosphere from precursors such as nitrogen oxides, sulphur dioxide and ammonia. particulate matter can also be transported long distances, such as from the continent. Smaller particles are of greatest concern with regard to human health, as they are small enough to penetrate deep into the lungs. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface absorbed carcinogenic compounds into the lungs. Larger particles, meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation.

3.1.3 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).

[6] Government of Jersey - Open Data, 2023. https://opendata.gov.je/dataset/passenger-statistics (Accessed 27th March 2024)

A wide range of hydrocarbons are emitted from fuel storage, handling and combustion. It is not easy to measure all 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).

3.1.3.1 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 [7].

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).

3.1.3.2 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 [8], and a World Health Organisation (WHO) guideline of 260 µg m^{-3} for the weekly mean [9].

The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic [10]. 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 [11].

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).

3.1.3.3 Ethylbenzene

There are no limits for ambient concentrations of ethylbenzene. Although, there are occupational limits relating to workplace exposure [12], as discussed in previous reports, these are several orders of magnitude higher than typical outdoor ambient concentrations.

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[7] UKPIA Statistical Review, 2018. Available at: https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf (Accessed 27th March 2024)

[8] Health and Safety Executive, 2020. *EH40/2005 Workplace Exposure Limits.* https://www.hse.gov.uk/pubns/priced/eh40.pdf (Accessed 27th March 2024)

[9] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 27th March 2024)

[10] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 27th March 2024)

[11] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 27th March 2024)

[12] Health and Safety Executive, 2020. *EH40/2005 Workplace Exposure Limits.* https://www.hse.gov.uk/pubns/priced/eh40.pdf (Accessed 27th March 2024)

3.1.3.4 *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).

3.2 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.

3.2.1 World Health Organisation

The World Health Organisation (WHO) issued non-mandatory, advisory, guidelines for a variety of pollutants in 2005 using currently available scientific evidence on the effects of air pollution on human health [13]. New, updated, guidelines were introduced in September 2021 which significantly reduced the Annual mean limit of NO_2 from 40 µg m^{-3} to 10 µg m^{-3} and the 24 hour mean being reduced to 25 µg m^{-3} [14]. In light of the growing evidence of harm that PM_{10} and $PM_{2.5}$ can cause the Annual mean limits were reduced from 20 µg m^{-3} to 15 µg m^{-3} and 10 µg m^{-3} to 5 µg m^{-3} respectively.

3.2.2 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 [15]. 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 contains limit values for NO_2, PM_{10} and $PM_{2.5}$ as follows:

- 200 µg m^{-3} as an hourly mean of NO_2, 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 of NO_2, 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).
- 50 µg m^{-3} as a 24-hour mean, not to be exceeded more than 35 times per calendar year. To have been achieved by 1st January 2005.
- 40 µg m^{-3} as an annual mean of PM_{10}, to have been achieved by 1st January 2005.
- 20 µg m^{-3} as an annual mean of $PM_{2.5}$, to have been achieved by 1st January 2020.

[13] World Health Organisation, 2005. *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide, Global Update 2005.* http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=679FCD5CBEACDDD39B97F43A61C2FB14?sequence=1 (Accessed 27th March 2024)

[14] World Health Organisation, 2005. *WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide* https://www.who.int/publications/i/item/9789240034228 (Accessed 27th March 2024)

[15] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 27th March 2024)

The same Directive 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.

EU limit values are currently under review and are likely to be partially aligned with WHO air quality guideline limit values.

3.2.3 The UK Air Quality Strategy

The Environment Act 1995 required the UK to transpose the original EU Directive on Ambient Air Quality and Cleaner Air for Europe 2008/50/EC [16] and its update EU/1480 [17] into UK law. It also placed a requirement on the Secretary of State for the Environment to produce a national Air Quality Strategy (AQS) containing standards, objectives and measures for improving ambient air quality. The original AQS was published in 1997, and contained air quality objectives based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) regarding the levels of air pollutants at which there would be little risk to human health. The AQS has since undergone a number of revisions, and as of the Environment Act 2021 must be reviewed at least every 5 years. These revisions have reflected improvements in the understanding of air pollutants and their health effects. They also incorporated new European limit values, both for pollutants already covered by the Strategy and for newly introduced pollutants such as polycyclic aromatic hydrocarbons and $PM_{2.5}$ particulate matter. The latest version of the strategy was published by Defra in April 2023 [18]. With the UK's exit from the EU the UK's AQS is no longer tied to that of the EU, however the current objectives are at least as stringent as the EC limit values.

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

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[16] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 27th March 2024)

[17] Official Journal of the European Union, 2015. *COMMISSION DIRECTIVE (EU) 2015/ 1480 - of 28 August 2015 - Amending Several Annexes to Directives 2004/ 107/ EC and 2008/ 50/ EC of the European Parliament and of the Council Laying down the Rules Concerning Reference Methods, Data Validation and Location of Sampling Points for the Assessment of Ambient Air Quality (Text with EEA Relevance).* https://eur-lex.europa.eu/eli/dir/2015/1480/oj. (Accessed 27th March 2024)

[18] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 27th March 2024)

3.2.4 Jersey Air Quality Strategy

The most recent Jersey Air Quality Strategy was published in 2013 [19] and is largely based on the WHO [20], EU [21] and UK [22] policies described above and its limit values are the same. There is no legal requirement to implement the EU Directive in Jersey, as Jersey is not an EU member state. 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. Following the updated WHO guidelines the government policy concerning air quality limit values is under consideration. The Government of Jersey have also published the 'Common Strategy Policy - 2023-2026' in 2022 [23]. This highlights seven priorities for change of which the Environment is one. Within the Environment priority, aims for improvements to air quality are outlined.

3.3 MONITORING SITES AND METHODS

3.3.1 Automatic Methods

Oxides of nitrogen were monitored using a chemiluminescent analyser, located at the Central Market, St Helier, sampling from Beresford Street. This automatic monitoring site started operation in November 2021. The location descriptions of the site falls into the category "Roadside" as defined by the Defra Technical Guidance on air quality monitoring LAQM.TG(22) [24].

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.

Particulate matter concentrations have also been collected using Optical Scattering Instantaneous Respirable Dust Indication System (Osiris) monitors. Particulate matter concentrations were measured by these monitors at Halkett Place Roadside 2 (JER09) and Howard Davis Park Osiris (JER6). Halkett Place Roadside 2 will be referred to as Central Market Osiris throughout this report. Central Market Osiris is described as a "Roadside" site and Howard Davis Park Osiris is described as a "Urban Background" monitoring site.

The Osiris monitors uses an optical scattering technique to measure airborne particles. The air sample is continuously drawn into the instrument and data is recorded as 15-minute averages. Osiris monitors are defined as indicative, and carry a larger uncertainty in measurements and scaling. The overall uncertainty of the Osiris monitors is ± 50%.

Particulate matter analysers can undergo a testing regime run by the Environment Agency to ensure the quality and performance of PM analysers. If the testing requirements are met then the analyser will

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[19] States of Jersey, 2013. *Jersey Air Quality Strategy 2013.* https://statesassembly.gov.je/assemblyreports/2013/r.049-2013.pdf (Accessed 27th March 2024)

[20] World Health Organisation, 2005. *WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide* https://www.who.int/publications/i/item/9789240034228 (Accessed 27th March 2024)

[21] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 27th March 2024)

[22] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 27th March 2024)

[23] Government of Jersey, 2022. *Common Strategic Policy 2023 to 2026.* https://www.gov.je/government/planningperformance/governmentprogramme/commonstrategicpolicy/pages/commonstrategicpolicy2023to2026.aspx (Accessed 2nd April 2024)

[24] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 27th March 2024)

achieve MCERTS (Monitoring Certification Scheme) for PM certification [25]. Under MCERTS, instruments will either certify as reference equivalent (± 25% uncertainty) or indicative (± 50% uncertainty). Following QA/QC practices, data from indicative monitors can be used to provide qualitative assessment of pollution trends and identification of sources, and quantitative assessment of particulate matter concentrations with the defined uncertainty of ± 50%.

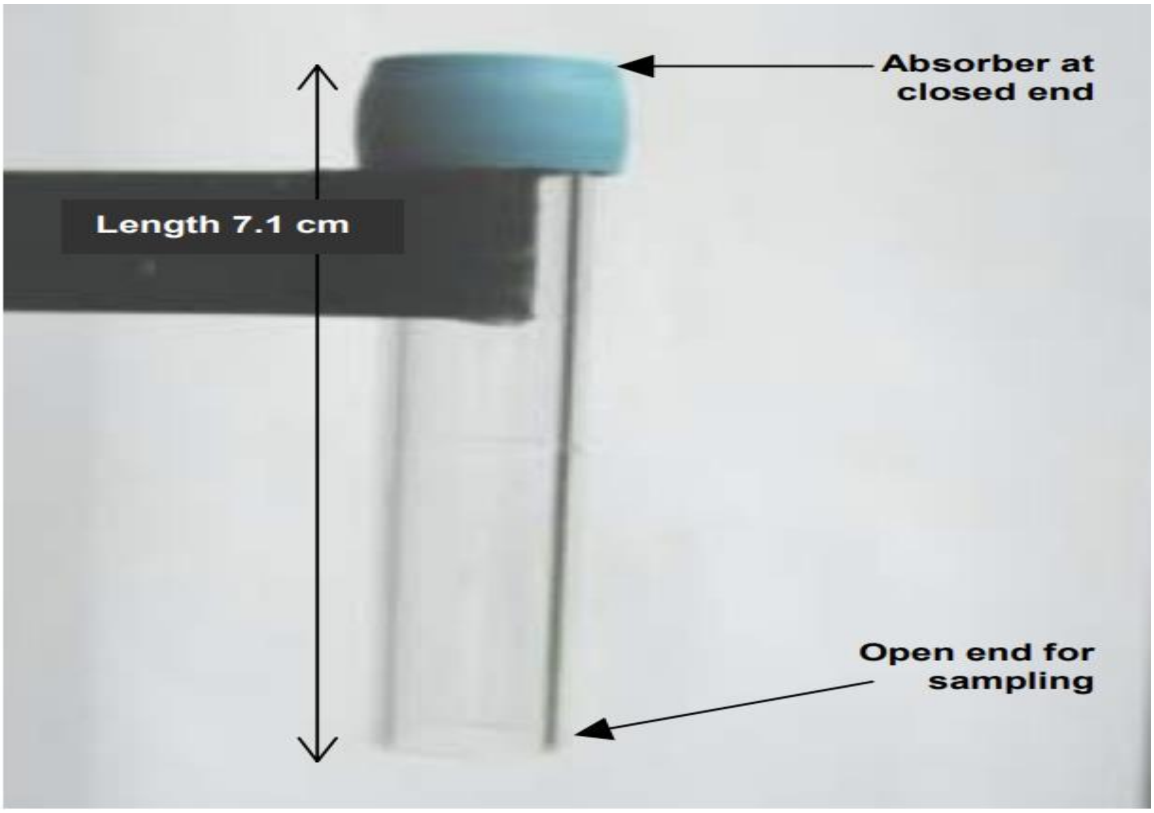
3.3.2 Diffusive Sampling of NO_2 and Hydrocarbons

The automatic monitoring site of Beresford Street Market 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 2m-4m above ground.

3.3.2.1 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.

Figure 1: NO_2 diffusion tube

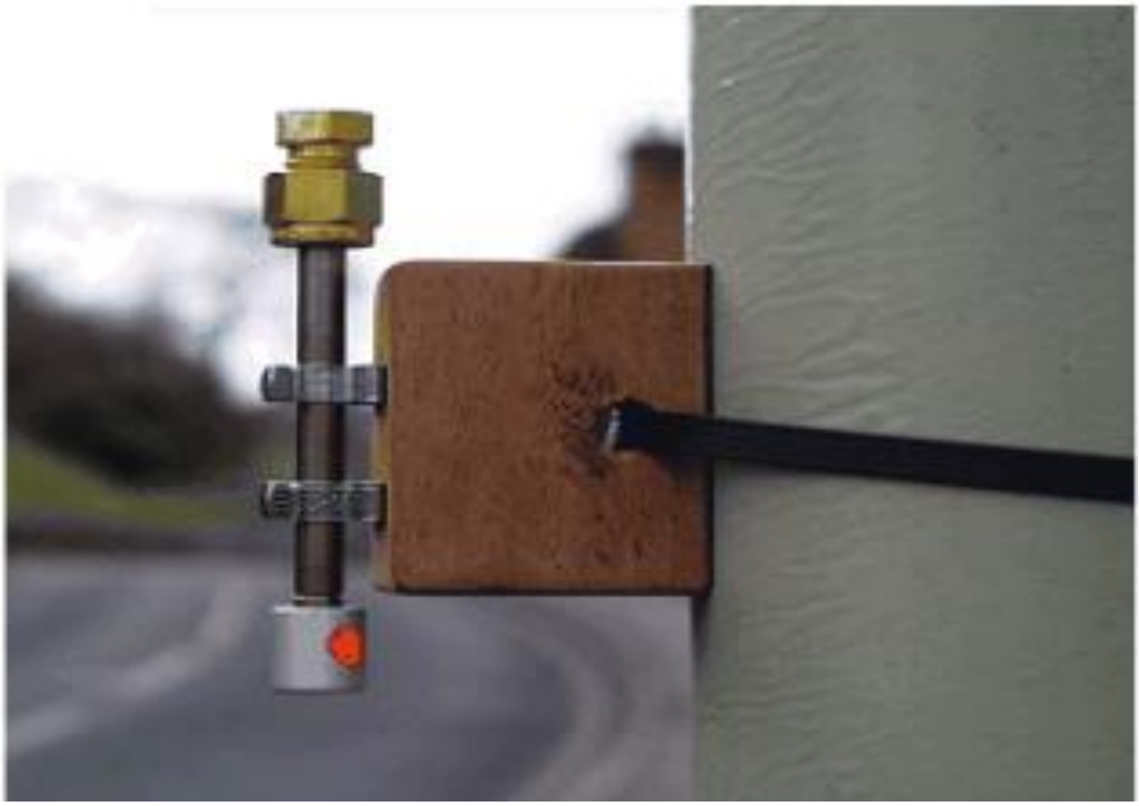


[25] CSA Group, 2024 *MCERTS Certified Products: Indicative Ambient Particulate Monitors* https://www.csagroup.org/en-gb/services/mcerts/mcerts-product-certification/mcerts-certified-products/mcerts-certified-products-indicative-ambient-particulate-monitors/ (Accessed 22nd April 2024)

3.3.2.2 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.

Figure 2: BTEX diffusion tube



3.3.2.3 Preparation and Analysis

Diffusion tubes were prepared and analysed by Gradko International Ltd. They were supplied to Jersey Government's Natural Environment Technical Officers, 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(22) [26] 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). A bias adjustment factor can be calculated due to the co-location of diffusion tubes with the automatic monitoring site at Beresford Street Market. This bias adjustment factor can 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 results have not been bias adjusted as BTEX diffusion tubes are not affected by the same sources of bias as NO_2 diffusion tubes.

Each monthly batch of diffusion tubes was accompanied by a 'travel blank' NO_2 and BTEX tube. 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 as they can easily be contaminated by exposure to

[26] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 27th March 2024)

solvents. These 'travel blank' 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.

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.

3.3.2.4 Calendar of Diffusion Tube Exposure Periods

The calendar of exposure periods used for the NO_2 and BTEX diffusion tubes is shown in Table 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. It was not always possible to stick to the intended dates, actual change over dates are also shown in the below Table 1.

Table 1: Diffusion tube exposure periods

Month	Intended Start Date	Intended End Date	Actual Start Date	Actual End Date
January	2023-01-04	2023-02-01	2023-01-04	2023-02-01
February	2023-02-01	2023-03-01	2023-02-01	2023-03-01
March	2023-03-01	2023-04-05	2023-03-01	2023-04-05
April	2023-04-05	2023-05-03	2023-04-05	2023-05-03
May	2023-05-03	2023-05-31	2023-05-03	2023-05-31
June	2023-05-31	2023-07-05	2023-05-31	2023-07-05
July	2023-07-05	2023-08-02	2023-07-05	2023-08-03
August	2023-08-02	2023-09-06	2023-08-03	2023-09-06
September	2023-09-06	2023-10-04	2023-09-06	2023-10-04
October	2023-10-04	2023-11-01	2023-10-04	2023-11-01
November	2023-11-01	2023-12-06	2023-11-01	2023-12-06
December	2023-12-06	2023-01-31	2023-12-06	2023-01-31

3.4 MONITORING SITES

Automatic monitoring of oxides of nitrogen was carried out at the Central Market, Beresford Street, in St Helier shown in Figure 3 between 1st January and 31st December 2023. This site represents a roadside location where NO_2 concentrations 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 located on a column at a height of approximately four meters. The chemiluminescent NO_x analyser itself shown in Figure 4 is located within the building. The analyser is calibrated by the Government of Jersey's Water and Air's Technical officers. Details of the calibration procedure is provided in Appendix 2.

Figure 3: Beresford Street Market air quality monitoring site

Figure 4: Automatic NO_x analyser at Beresford Street Market, St Helier

Diffusion tubes were used to monitor NO_2 at sites in a range of different environments around Jersey, as described above.

Diffusion tubes were also co-located with the automatic monitoring site at Beresford Street Market, and the results of this co-located monitoring have been 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 had single tubes deployed.

In March 2023, the diffusion tubes previously located at Le Bas Centre and Union Street were moved to two locations at St Luke's Primary School in St Saviour to aid monitoring of pollutant concentrations during the School Street Pilot Scheme. In April, these tubes were returned to Le Bas Centre and Union Street monitoring sites, and two new tubes were installed at St Luke's School Playground and St Luke's School Roadside sites. Details of these site specific changes are listed in Table 2.

Table 2: Diffusion tube & BTEX tube relocations in 2023

Site	Pollutant	Relocation Comment
La Bas Centre	NO2	Moved to St Lukes School Playground for March 2023
Union Street	NO2	Moved to St Lukes School Roadside for March 2023
St Lukes School Playground	NO2	Monitoring at this location began March 2023
St Lukes School Roadside	NO2	Monitoring at this location began March 2023
Le Bas Centre	NO2	Returned to Le Bas Centre for April 2023
Union Street	NO2	Returned to Union Street for April 2023

Automatic monitoring of particulate matter concentrations was carried out at two locations between 1st January and 31st December 2023, Central Market Osiris (JER09) and Howard Davis Park Osiris (JER6). The Central Market Osiris monitoring site is described as a roadside site and and is located at the Central Market in St Helier, as shown in Figure 5. The long-running automatic monitoring site located in the Howard Davis Park Osiris is classified as an urban background site and is located near the centre of the park, 77 metres from the nearest road and 330 metres from the beach at Havre Des Pas (Figure 6).

Figure 5: Central Market Osiris air quality monitoring site

Figure 6: Howard Davis Park Osiris air quality monitoring site

BTEX hydrocarbons were monitored at five sites during 2023 shown on Figure 7. The aim was to investigate sites likely to be affected by different emission sources and compare these with background sites.

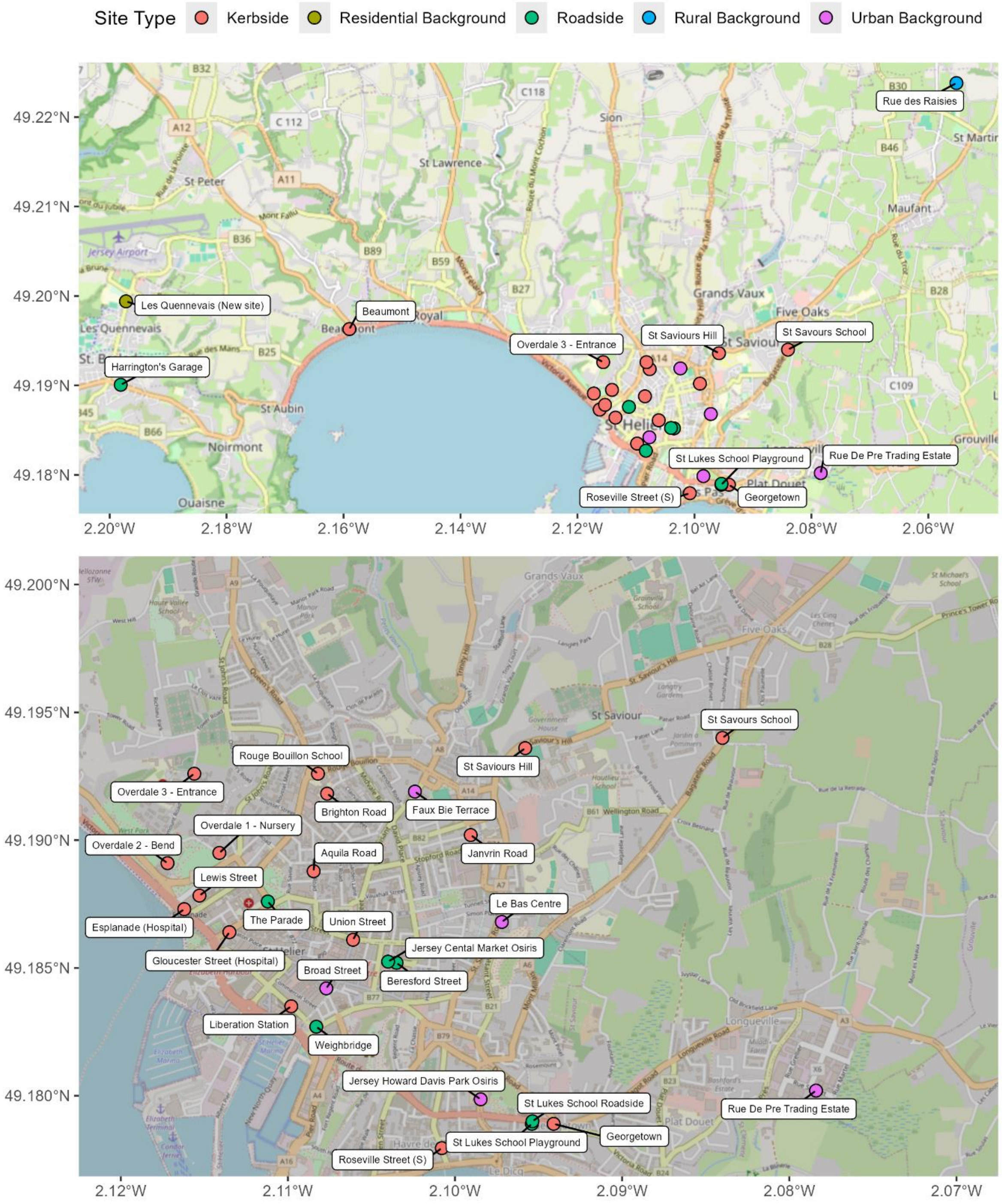
Le Bas Centre is intended to monitor hydrocarbon concentrations at an urban background location. Rue de Pres Trading Estate, in an industrial estate near to a paint spraying business. The Faux Bie site is located near a fuel filling station, a potential source of hydrocarbon emissions including benzene. This monitoring site is intended to represent public exposure to emissions from the filling station as it is located between a fuel filling station and a nearby block of flats. The fuel supplier uses a vapour recovery system to reduce emissions when filling the storage tanks and has done so since December 2003. A Stage 2 Vapour Recovery System was later installed at the fuel filling station in 2016, and the replacement of the fuel storage tanks took place during August 2017.

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 where there is no Vapour Recovery system currently in place. The BTEX tube is located on a down pipe attached to a domestic dwelling within the boundary of the petrol station.

Figure 7 shows a map of the locations of all monitoring sites used in this study. The map can be zoomed in and out and more information on the monitoring sites can be obtained from clicking on the marker. Note the following regarding site classifications:

- Kerbside: less than 1m from kerb of a busy road.
- Roadside: 1 - 5m from kerb of a busy road.
- Background: > 50m from the kerb of any major road.

Figure 7: Locations of the Jersey air monitoring sites.



3.4.1 Other Monitoring in Jersey

In addition to the monitoring sites detailed in this report, the Government of Jersey have also commissioned Ricardo to complete two short-term studies in 2023.

One study evaluated the effects of the implementation of the School Street pilot scheme at St Luke's Primary School, where temporary restrictions were implemented on motorised traffic access during school term drop off (07:30 – 09:30) and pick up (14:30 – 16:30) times. This study monitored NO_2, PM_{10} and $PM_{2.5}$ concentrations at St Luke's Primary School for five weeks prior to the implementation of the School Street pilot scheme and five weeks during the scheme. During the monitoring period, a low-cost automatic Clarity NO_2 and PM sensor was installed outside of St Luke's Primary School on Elizabeth Street and two non-automatic diffusion tubes were deployed, one of which was installed in St Luke's early years playground and the other was installed roadside of Route du Fort, on the exterior of the early years playground perimeter wall.

A second study was carried out to measure concentrations of pollutants at Rouge Bouillon School and Wellington Road, both located in St. Helier. This study employed a mobile Praxis Urban sensor to measure pollutant concentrations along four popular walking routes to St. Helier schools during morning drop-off and afternoon-pick up school times. Furthermore, a low-cost static Vortex IoT automatic monitoring sensor was installed at each location, to monitor NO_2, PM_{10} and $PM_{2.5}$ concentrations and determine if there were notable changes in concentrations at drop off and pick up times.

4. QUALITY ASSURANCE AND DATA CAPTURE

4.1 QUALITY ASSURANCE AND QUALITY CONTROL

A full intercalibration audit of the Beresford Street Market air quality monitoring site takes place annually, summarised in Table 3. The air intake sampling system is cleaned, and all other aspects of site infrastructure are checked in addition to standard checks of the instrument and calibration.

Table 3: Results of the July 2023 intercalibration audit

Species	Analyser Serial no	Zero Response	Zero uncertainty ppb	Calibration Factor	Factor uncertainty %	Converter eff. (%)
NOx	1,002	2.4	2.7	1.4303	3.5	98.8 (249ppb)
NO	1,002	0.5	2.7	1.4146	3.5	98.7 (116ppb)

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 4. These are given in ppb, the "native" unit of the automatic data.

Table 4: Estimated precision and accuracy of the data presented.

Pollutant	Precision	Accuracy
NO	± 5 ppb	± 15%
NO2	± 5 ppb	± 15%
PM10		± 10%
PM2.5		± 10%

5. RESULTS AND DISCUSSION

5.1 SUMMARY STATISTICS

Overall data capture statistics along with summary statistics for the three monitoring sites are provided in Table 5, Table 6 and Table 7 below. The percentage of valid data measured for the whole reporting period is represented by the data capture statistic. A data capture target of 90% is recommended in the European Commission Air Quality Directive [27] and Defra Technical Guidance is 85% LAQM.TG (22) [28], in order to assess annual data sets against long term targets.

In 2023, data capture for NO_2 at Beresford Street Market attained data capture of 97.6%, greater than 90% required from the European Commission Air Quality Directive. Data capture at Central Market Osiris and Howard Davis Park Osiris were both below the European Commission Air Quality Directive data capture target of 90%. The Osiris analysers at Central Market Osiris and Howard Davis Park Osiris had a data capture of 60.3% and 66.3% respectively, in 2023. Therefore, annual means are likely not representative of the entire year and should not be used for a comparison against limit values and objectives.

Significant data gaps for periods more than 6 hours for the Beresford Street Market are shown in Table 8.

Table 5: Summary statistics for NO2

Site	Annual mean	Annual data capture	Hourly maximum	99.8 percentile of hourly mean	98 percentile of hourly mean	Daily maximum	90 percentile of daily mean
Jersey Beresford Street Market	15.5	97.6%	105.5	71.1	50.5	43	23.3

Table 6: Summary statistics for PM10

Site	Annual mean	Annual data capture	Hourly maximum	99.8 percentile of hourly mean	98 percentile of hourly mean	Daily maximum	90 percentile of daily mean
Jersey Central Market Osiris	27.0	60.3%	199.9	147.6	101.9	126.5	54.1
Jersey Howard Davis Park Osiris	21.4	66.3%	225.6	150.7	86.2	115.4	41.3

[27] World Health Organisation, 2005. *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide, Global Update 2005.* http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=679FCD5CBEACDDD39B97F43A61C2FB14?sequence=1 (Accessed 27th March 2024)

[28] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 27th March 2024)

Table 7: Summary statistics for PM2.5

Site	Annual mean	Annual data capture	Hourly maximum	99.8 percentile of hourly mean	98 percentile of hourly mean	Daily maximum	90 percentile of daily mean
Jersey Central Market Osiris	11.9	60.3%	74.4	64.4	42.9	53.5	24.2
Jersey Howard Davis Park Osiris	9.6	66.3%	68.2	51.7	31.8	39.1	18.5

Table 8: Significant data gaps, 2023

Site	Pollutants	Start date	End date	No. of days	Reason
Jersey Howard Davies Park Osiris	PM10, PM2.5	2023-02-15	2023-02-20	5.01	Osiris heater fault
Jersey Howard Davies Park Osiris	PM10, PM2.5	2023-02-21	2023-02-21	0.34	Osiris heater fault
Jersey Howard Davies Park Osiris	PM10, PM2.5	2023-03-07	2023-03-11	4.01	Communications issue
Jersey Halkett Place Roadside 2	PM10, PM2.5	2023-05-05	2023-09-22	140.29	Analyser removed for routine calibration
Jersey Howard Davies Park Osiris	PM10, PM2.5	2023-06-30	2023-10-09	101.20	Analyser removed for routine calibration
Jersey Beresford Street Market	NO2	2023-07-04	2023-07-05	1.11	Audit and Service
Jersey Beresford Street Market	Site	2023-10-27	2023-11-03	6.90	Communications issue
Jersey Halkett Place Roadside 2	Site	2023-10-27	2023-10-31	4.31	Communications issue
Jersey Howard Davies Park Osiris	Site	2023-11-16	2023-11-28	12.40	Communications issue

5.2 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 are shown in Table 9. 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 0.491 μg m^{-3} to 0.636 μg m^{-3}. The limit of detection for benzene equated to an ambient concentration between 0.21 μg m^{-3} and 0.27 μg m^{-3}. The laboratory advises that there is a higher level of uncertainty for results lower than 10 times the limit of detection (LOD). For NO_2 diffusion tube monitoring sites, most ambient concentrations measured are well above this threshold, except for NO_2 measurements at Les Quennevais and Rue des Raisies. Therefore, the NO_2 concentrations 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 not the case for most measurements except for benzene, toluene and mp 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.

Table 9: Percentage uncertainty on the analysis of diffusion tubes

Uncertainty	NO2	Benzene	Toluene	Ethylbenzene	m/pXylene	oXylene
% Uncertainty	± 9.7	± 11	± 12	± 11	± 13	± 11

5.3 TIME SERIES PLOT

Below are hourly and daily time series plots of concentrations of NO_2 concentrations at Beresford Street Market as well as PM_{10} and $PM_{2.5}$ concentrations measured at Central Market Osiris and Howard Davis Park Osiris. It is possible to zoom in on a section of the graph using the sliders below the chart.

The highest hourly NO_2 concentration of 105.5 μg m^{-3} was recorded in January at Beresford Street Market. There is also shown to be periods of significant elevated data in January, February and December. At Central Market Osiris, highest hourly PM_{10} and $PM_{2.5}$ concentrations were recorded in March. There is also shown to be a period of elevated data for both PM_{10} and $PM_{2.5}$ in January. The highest hourly PM_{10} concentration was recorded in January at Howard Davis Park Osiris. In comparison, the highest hourly $PM_{2.5}$ concentration was recorded in March. For both PM_{10} and $PM_{2.5}$ concentrations at Howard Davis Park Osiris, there are shown to be periods of elevated data in January and February.

Figure 8: Time series plot of hourly average NO_2 concentration.

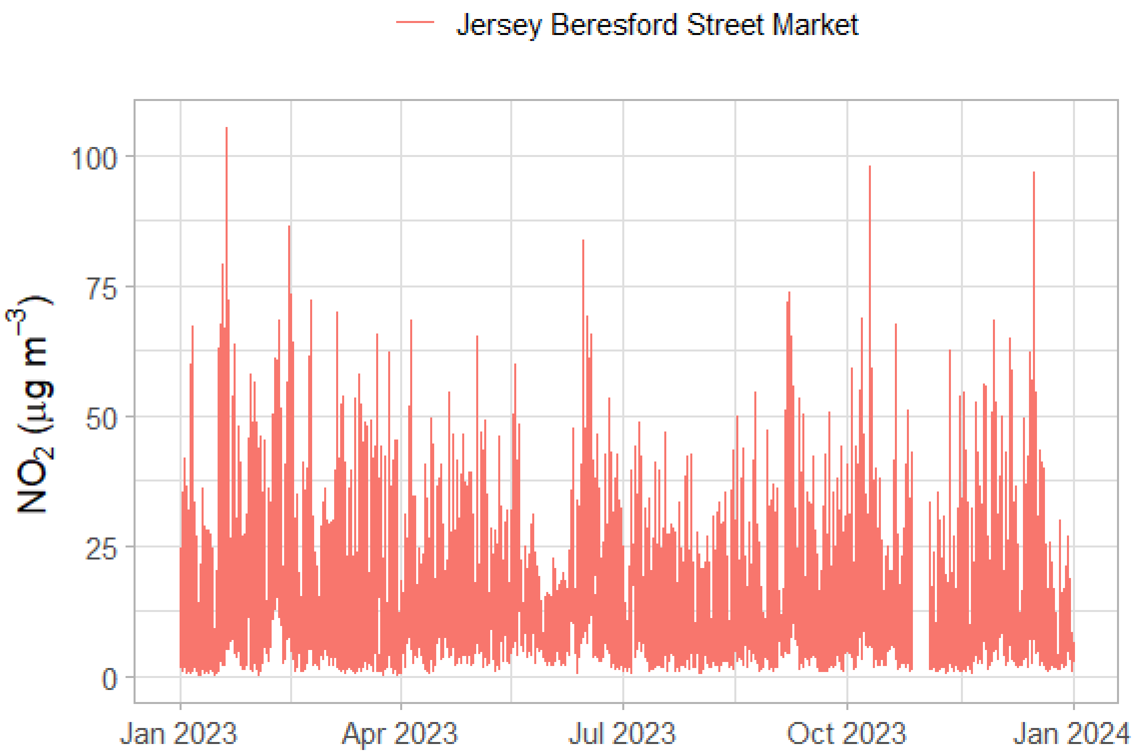


Figure 9: Time series plot of daily average NO_2 concentration.

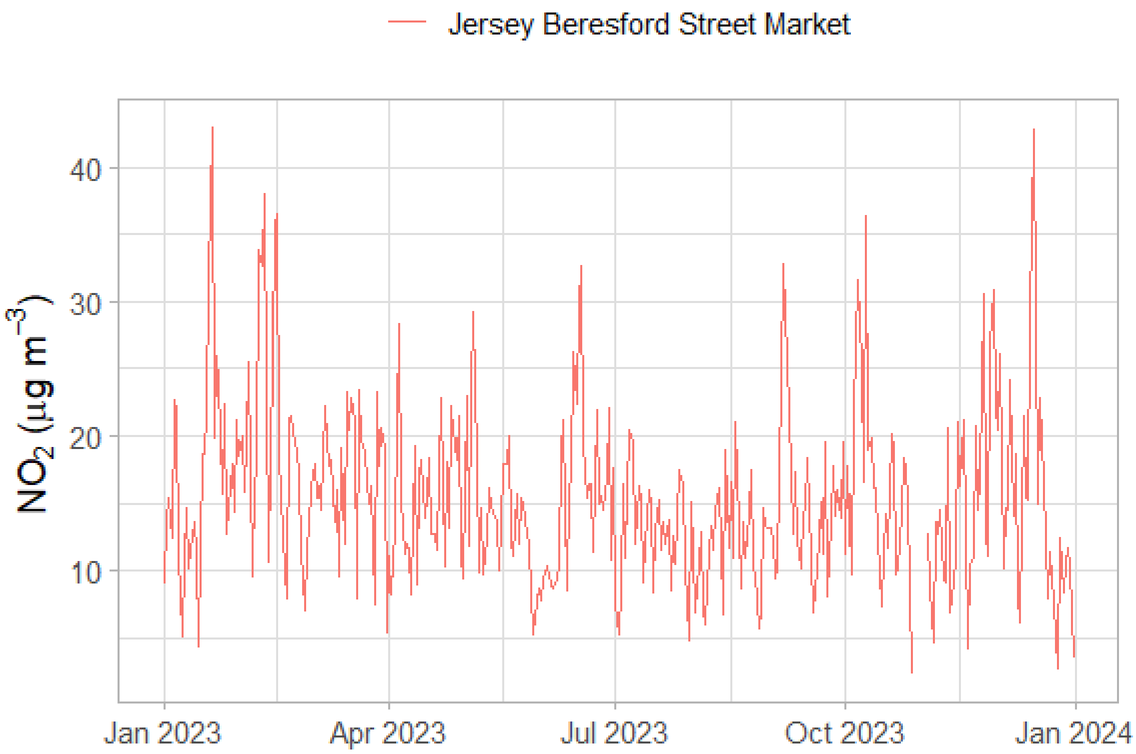


Figure 10: Time series plot of hourly average PM_{10} concentration.

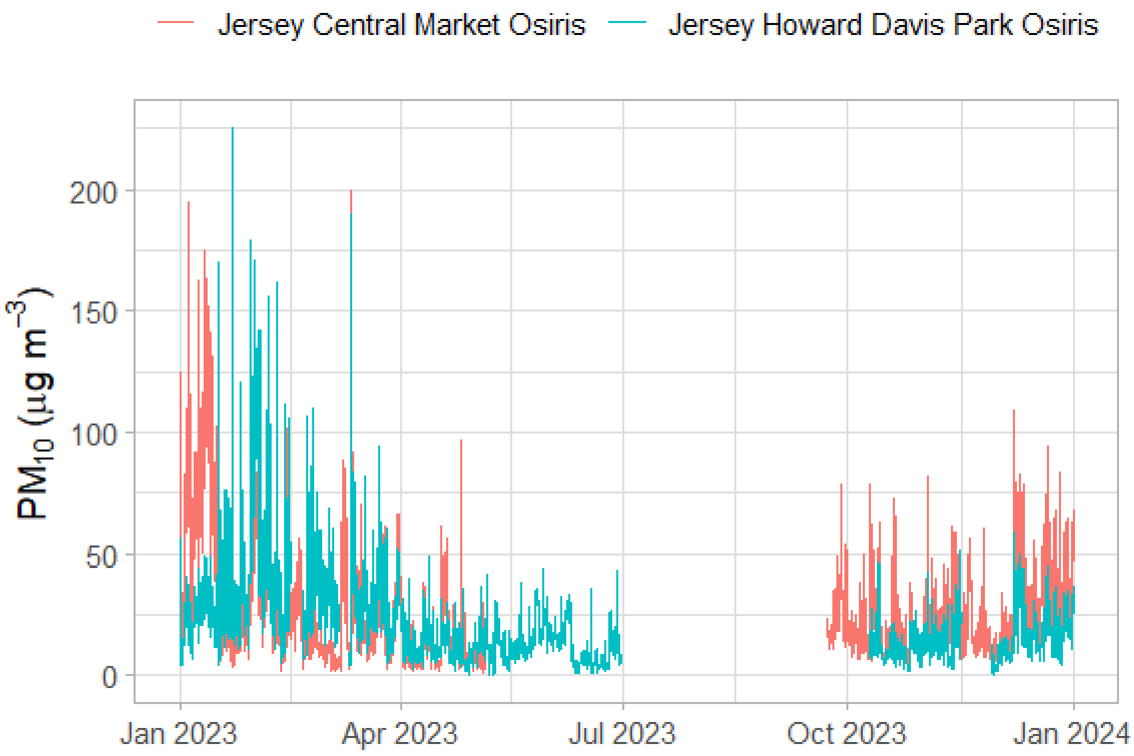


Figure 11: Time series plot of daily average PM_{10} concentration.

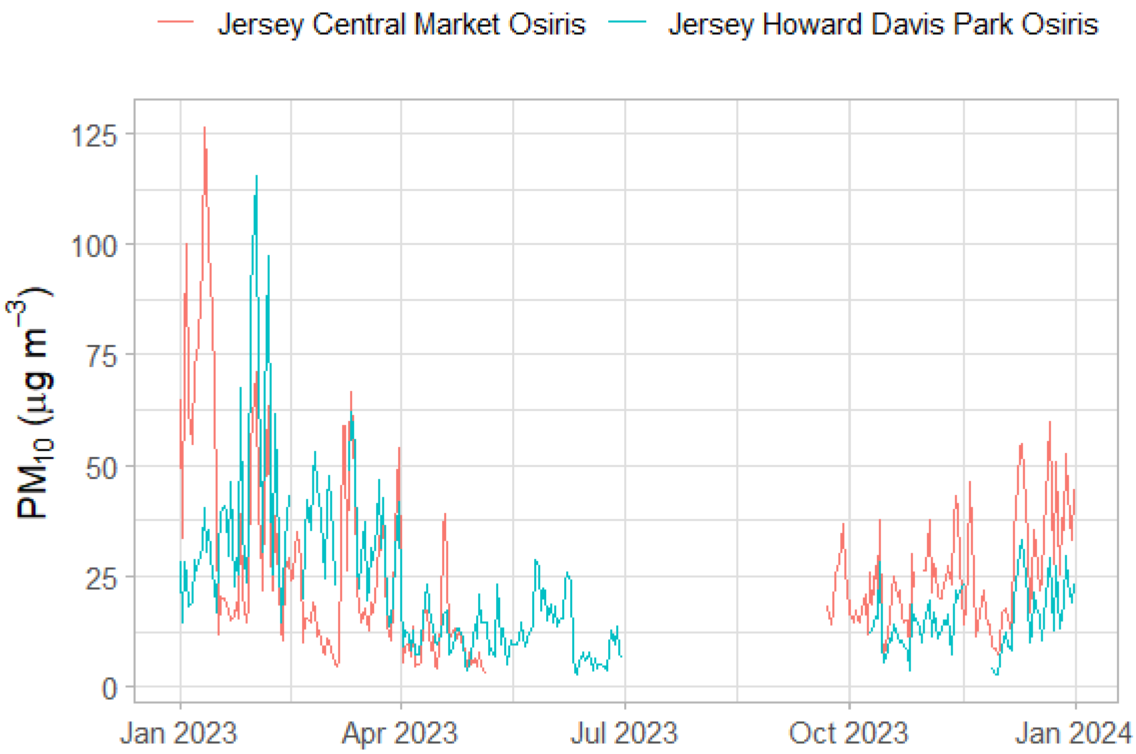
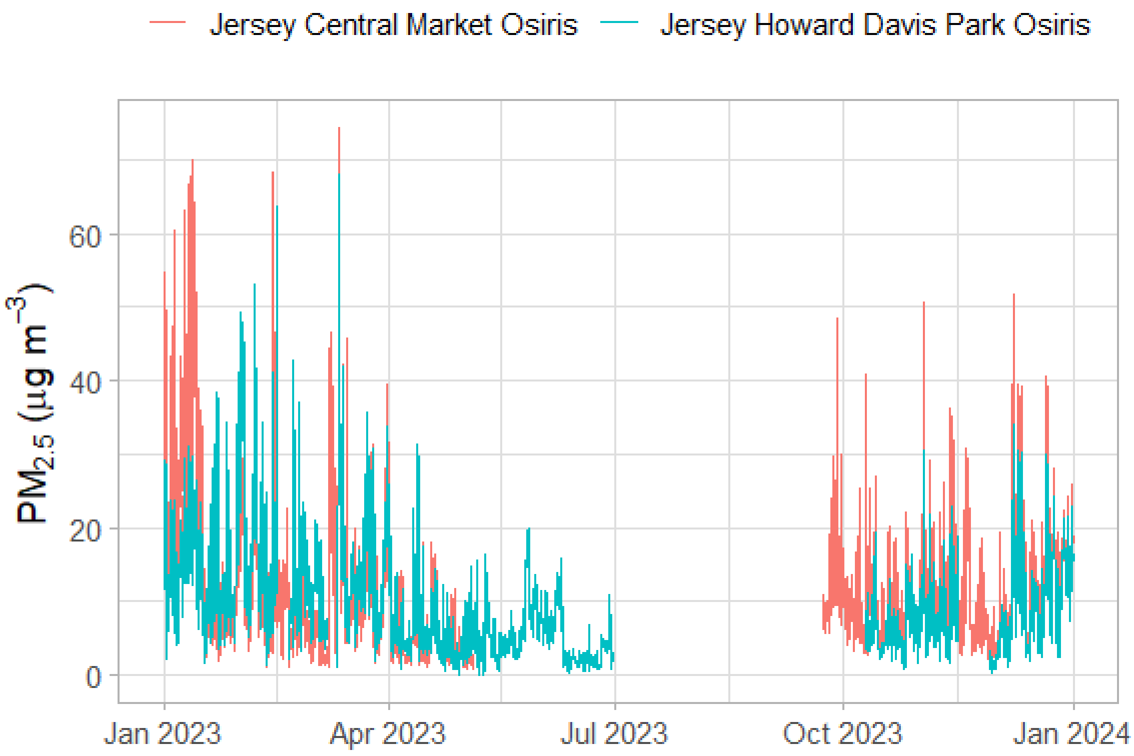
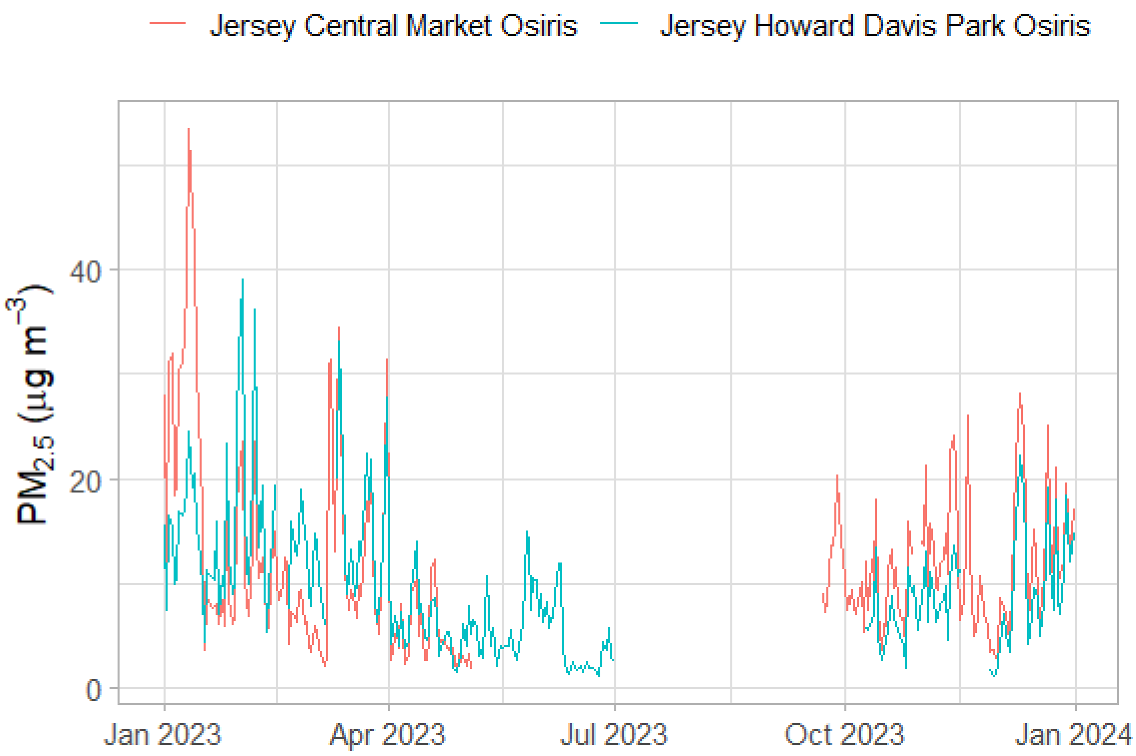


Figure 12: Time series plot of hourly average $PM_{2.5}$ concentration.



5.3.1 $PM_{2.5}$ Daily

Figure 13: Time series plot of daily average $PM_{2.5}$ concentration.



5.4 NO_2 DIFFUSION TUBE RESULTS

NO_2 diffusion tube results are presented in Table 10. Results are reported by the analyser to two decimal places, however in view of the estimated uncertainty of ± 25% on diffusion tube measurements, the monthly mean results reported here have been rounded to one decimal place. Details of site closures and openings during 2023 are given in section 2.4.

Diffusion tubes are affected by several artefacts, which can cause them to under-read or over-read with respect to the reference technique. It has therefore become common practice to calculate and apply a "bias adjustment factor" to annual mean NO_2 concentrations measured by diffusion tubes, using co-located diffusion tube and automatic analyser measurements. This bias adjustment factor is calculated as the ratio of the automatic analyser result to the diffusion tube result. This factor can then be used to correct the annual means measured at the other monitoring locations. The bias adjustment factor was calculated using unrounded values from all months. The bias adjustment factor for NO_2 diffusion results in 2023 was calculated to be 0.77.

Please note:

- Only the annual mean concentration (not individual monthly values) should be adjusted in this way. This is because diffusion tube bias can vary considerably from month to month due to meteorological and other factors.
- Even after application of a bias adjustment factor, diffusion tube measurements remain indicative only.

Table 10 includes monthly values from each site and Table 11 shows the raw 2023 annual mean and the bias adjusted 2023 annual mean. In 2023, annualisation of diffusion tube data was not necessary as all diffusion tube monitoring locations recorded a data capture greater than 75%. The annual mean for 2022 is 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 2.6 µg m^{-3} (in November at the Rue des Raises site) to 46.0 µg m^{-3} (in May at the Beaumont site). The annual mean for the majority of sites remained relatively consistent between 2022 and 2023 with most sites being within +/- 3 µg m^{-3}. For this report the annual mean will be used unless otherwise stated.

Table 12 lists the missing diffusion tube results throughout 2023, including outliers and missing tube results.

Table 10: NO2 diffusion tube results 2023, in µg m-3

	January	February	March	April	May	June	July	August	September	October	November	December
start date	04-01-2023	01-02-2023	01-03-2023	05-04-2023	03-05-2023	31-05-2023	05-07-2023	03-08-2023	06-09-2023	04-10-2023	01-11-2023	06-12-2023
end date	01-02-2023	01-03-2023	05-04-2023	03-05-2023	31-05-2023	05-07-2023	03-08-2023	06-09-2023	04-10-2023	01-11-2023	06-12-2023	03-01-2024
Aquila Road	12.0	12.6	11.9	9.2	9.5		8.6	8.7	10.4	11.3	9.1	8.4
Beaumont	29.5	33.1	26.5	30.8	35.4	27.5	22.4	25.2	27.4	21.8	21.7	19.3
Beresford Street (Central Market)	15.9	18.5	16.4	15.7	13.8	15.1	15.0	13.6	16.3	17.5	15.4	15.6
Brighton Road	11.5	10.4	9.2		9.2	8.5	7.3	7.9	9.0	9.8	10.5	8.5
Broad Street		13.4	14.0	11.1	10.4	12.0	12.2	11.0	13.2	14.2	12.5	12.3
Georgetown	25.9	31.2	25.8	26.1	25.8	22.5	21.4	21.6	25.5	22.8	24.4	20.2
Gloucester Street (Hospital)	22.8	24.1	22.5	21.5	19.6	20.5	22.5	19.6	23.2	23.5	22.5	19.4
Janvrin Road	11.9	11.8	10.9	7.9	7.8	7.8	8.2	7.6	8.9	10.2	9.5	9.7
Le Bas Centre	14.9	17.3		13.8	11.3	12.9	13.6	12.2	14.2	15.1	13.9	12.0

	January	February	March	April	May	June	July	August	September	October	November	December
Les Quennevais School	5.8	7.3	6.1	5.2	7.0	5.2	3.1	4.6	5.4	5.8	4.9	3.5
Lewis Street	11.1	13.4	11.1	10.4	10.1	11.0	8.8	10.0	12.2	12.2	9.5	8.3
Liberation Station	23.1	26.0	21.3	24.5	28.1	24.1	20.1	23.4	24.4	20.2	18.9	15.2
Overdale Bend	9.3	11.0	9.5	9.7	8.9	10.0	7.2	13.0	10.0	9.3	7.8	7.0
Overdale Entrance	6.4	8.4	7.9	6.0	7.5	6.1	5.1	5.4	8.0	7.7	6.6	6.1
Overdale Nursery	10.4	12.7	11.2	9.5	9.5	10.8	10.4	9.2	11.1	10.8	9.6	7.6
Roseville St (S)	13.5	15.5	12.6	12.1	12.0	11.9	11.7	11.8	15.2	12.0	11.6	10.9
Rouge Bouillon	19.7	22.4	15.3	14.7	19.0	15.8	14.1	16.1	18.2	16.9	15.9	13.6
Rue des Raisies	2.9	3.9	3.7	3.0	4.3	3.6	2.5	2.6	3.2	3.3	2.0	2.9
St Luke School Roadside (Rue de Fort)			30.0	29.2	23.4	26.2	26.8	25.7	29.9	31.7	25.6	23.6
St Lukes School Playground			19.1	17.1	13.4	15.7	13.5	14.1	18.0	16.8	14.1	14.3
St Saviours Hill	30.1	32.5	33.4	28.7	30.4	27.2	28.1	25.8	29.9	35.3	22.7	25.9
St Saviours School	11.8	13.9	12.3	11.0	11.1	12.5	9.4	9.6	12.2	13.1	11.1	9.1
The Parade	16.7	18.5	16.8	15.1	15.8	15.4	15.2	16.8	16.9	16.8	15.3	13.7
Union Street	19.3	20.8		16.2	16.9	15.5	12.5	13.9	16.9	16.1	14.3	13.2
Weighbridge	23.7	26.6	22.9	22.8	19.2	23.0	27.0	19.9	22.9	24.6	21.3	21.5

Table 11: Annual averages of the NO2 diffusion in 2023, in µg m-3

	2023 annual average	2022 annual average	2023 BIAS adjusted mean
Aquila Road	13.2	15.7	10.1
Beaumont	34.7	32.8	26.7
Beresford Street	20.4	21.7	15.7
Brighton Road	12.0	13.8	9.3
Broad Street	16.1	15.9	12.4
Georgetown	31.7	30.9	24.4
Gloucester Street (Hospital)	28.3	31.5	21.8
Janvrin Road	12.1	15.1	9.3
Le Bas Centre	17.9	18.5	13.8
Les Quennevais School	6.9	8.5	5.3
Lewis Street	13.9	17.9	10.7
Liberation Station	29.1	27.0	22.4
Overdale Bend	12.2	12.1	9.4
Overdale Entrance	8.8	14.3	6.8

	2023 annual average	2022 annual average	2023 BIAS adjusted mean
Overdale Nursery	13.3	13.9	10.2
Roseville Street (S)	16.3	19.7	12.6
Rouge Bouillon	21.8	20.6	16.8
Rue des Raisies	4.1	4.9	3.2
St Luke School Roadside (Rue de Fort)	35.4		27.2
St Lukes School Playground	20.3		15.6
St Saviours Hill	37.9	36.7	29.2
St Saviours School	14.8	15.2	11.4
The Parade	20.9	21.9	16.1

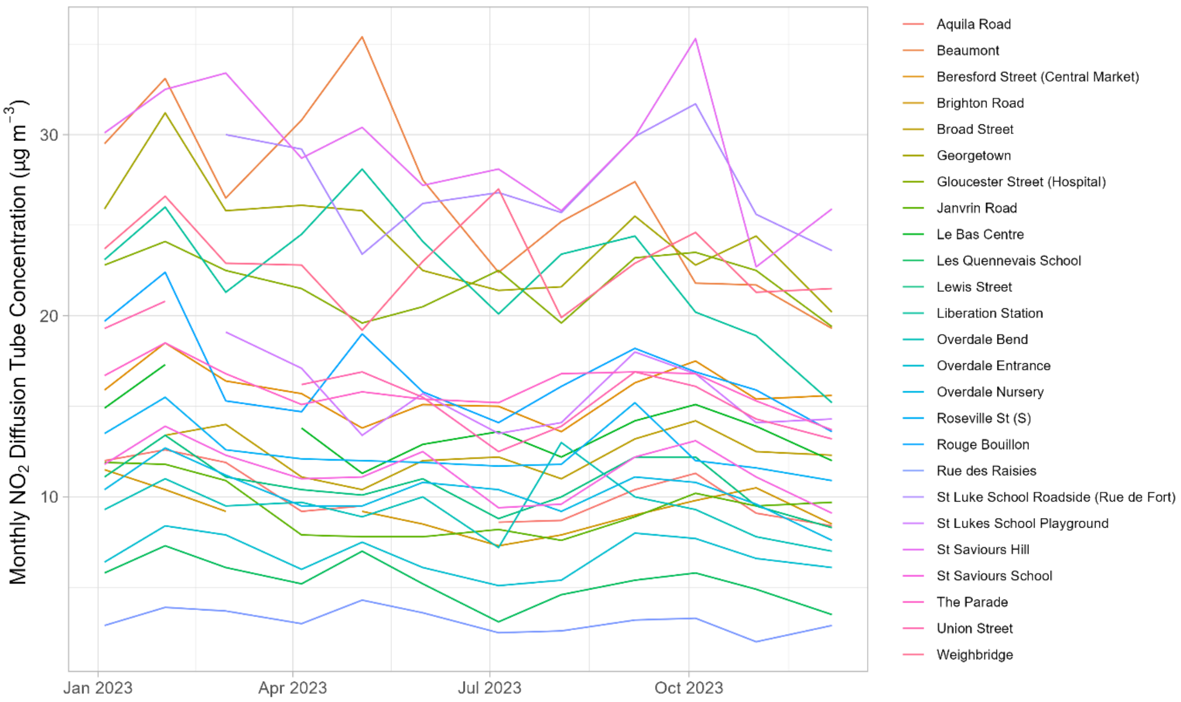
5.4.1 NO_2 Diffusion Tube Gaps

Table 12: Details of the missing or rejected NO2 diffusion tube results

Site	Month	Reason for rejection
Broad Street	January	Missing on collection
Brighton Road	April	Missing on collection
Aquila Road	June	Missing on collection
Beresford Street (Central Market)	July	Tube left at site for July and August in error
Beresford Street (Central Market)	August	Tube left at site for July and August in error

Figure 14 shows the highest concentrations were generally recorded in the winter months of February and March. This follows the expected pattern in NO_2 concentrations experienced in UK urban areas, with concentrations generally higher in the winter and lower in the summer. The spring and summer months between May and August had consistently average concentrations with very little variation. Overall, NO_2 concentrations were shown to be lowest in July and August. Sites with some of the highest concentrations include St Saviours Hill, Beaumont and St Lukes School Roadside, whilst Rue des Raisies consistently sits below all other sites.

Figure 14: Bias adjusted monthly mean NO2 diffusion tube results in 2023 in µg m-3



5.5 COMPARISON WITH AIR QUALITY GUIDELINES, LIMIT VALUES AND OBJECTIVES

Limit values, AQS objectives and WHO guidelines for all pollutants are described in earlier sections of this report. These are based on the hourly, 24-hour and annual means.

The 1-hour mean at the Beresford Street Market automatic monitoring sites did not exceed 200 µg m^{-3} in 2023. Therefore, this site met the EC Directive limit value and AQS objective for this parameter.

The period mean NO_2 concentration of 15.5 µg m^{-3} as measured by the automatic analyser at Beresford Street Market was well within the EC limit value of 40 µg m^{-3}.

The updated WHO guidelines introduced in 2021 advise an annual mean limit for NO_2 of 10 µg m^{-3}. NO_2 concentrations measured at Beresford Street Market would not meet this guideline in 2023.

Central Market Osiris and Howard Davis Park Osiris sites both had data capture less than 90%, therefore the annual means may not be representative of the entire year and are not directly comparable to limit values and objectives is not possible. When data capture is between 75% and 85%, it is possible to express concentrations as percentile values to approximate the number of limit value exceedances. However, as data capture for both Osiris monitors was less than 75%, this is not possible.

The 24-hour mean of 50 µg m^{-3} for PM_{10} concentrations was exceeded on 28 occasions at Central Market Osiris and on 12 occasions at Howard Davis Park Osiris during the monitoring period. Both sites are therefore shown to be below the allowed 35 exceedances. However, both Osiris monitors had low data capture and therefore the number of exceedances may have been greater if data capture been higher.

The annual mean PM_{10} concentrations measured at Central Market Osiris and Howard Davis Park were 27.0 µg m^{-3} and 21.4 µg m^{-3} respectively.

The annual mean $PM_{2.5}$ concentration measured at Central Market Osiris was 11.9 µg m^{-3} and the annual mean measured at Howard Davis Park was 9.6 µg m^{-3}.

All diffusion tube monitoring locations recorded annual means below the EC Directive limit value and AQS objective 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.

Seven diffusion tube monitoring locations recorded bias adjusted annual means lower than the 2021 WHO annual mean guideline for NO_2 of 10 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 3.2 µg m^{-3} at this rural site was well within the limit value.

5.6 TIME VARIATION PLOT

Figure 15, Figure 16 and Figure 17 below show the variation of monthly, weekly, daily and hourly pollutant concentrations during 2023 at the three automatic monitoring sites.

Seasonal variation

Seasonal variations can be observed in the ‘month’ plots of Figure 15. NO_2 concentrations follow the expected seasonal cycle, with lower concentrations observed in summer and elevated concentrations in winter, with the highest concentrations seen in January, February and October. This seasonal cycle is typical for urban areas when the highest levels of primary pollutants tend to occur in the winter months, when emissions may be higher, and periods of cold, still weather reduce pollutant dispersion.

Jersey has a significant tourism industry and pollutant concentrations can remain relatively high during the summer months. Figure 15 indicates that the highest monthly concentrations in 2023 to be in the winter months. However, NO_2 concentrations are shown to be elevated in June compared to other spring and summer months. The transition from winter to summer concentrations in 2023 is less harsh when compared to 2022, with concentrations gradually decreasing into the summer months. On average, NO_2 concentrations were shown to be lowest in August, this could likely be due to reduced traffic on the island during school holidays.

PM_{10} and $PM_{2.5}$ concentrations are shown to be highest in January and December at Central Market Osiris and highest in January and February at Howard Davis Park Osiris. This is likely due to unsettled meteorological conditions transporting polluted air masses. At Central Market Osiris, both PM_{10} and $PM_{2.5}$ concentrations are shown to be lowest in May. In comparison, particulate matter concentrations are shown to be lowest in June at Howard Davis Park Osiris, although concentrations are shown to be generally low throughout April to October.

Weekly variation

The analyses of each pollutants’ weekly variation showed that a similar type of diurnal patterns occur for all the days of the week except for Sunday.

NO_2 concentrations are shown to have an overall increasing trend through the week (Monday to Friday). The NO_2 early morning rush hour peaks are also more pronounced Monday to Friday and overall levels are lower over the weekend. Particularly Sundays when most shops are closed.

For particulate matter, concentrations are shown to be highest on Thursdays at both sites. Concentrations are shown to be low during the weekend at both sites which is likely due to less activity on these days as described above. Although weekend concentrations are shown to be low at Central Market Osiris, the days with lowest concentrations are shown to be Monday and Tuesday.

Diurnal variation

The diurnal variation analyses for the full year and individual days of the week can be viewed in the 'hour' plots in Figure 15. Both show typical urban area daily patterns for NO_2. Pronounced peaks can be seen during the morning, corresponding to rush hour traffic at around 07:00. The peak coincides with the time at which the market traders arrive and set up for the day, coinciding with the busier times of the day, just prior to the market opening at 07:30. It is likely vehicle emissions from these activities are responsible for the distinctively sharp morning pattern at Beresford Street Market.

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. This afternoon NO_2 rush hour peak is much lower than the magnitude of the morning rush hour peak and is similar to the afternoon peaks observed at many roadside UK AURN sites. 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 Beresford Street Market. 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.

Analysis of diurnal patterns in PM_{10} and $PM_{2.5}$ concentrations at Central Market Osiris shows concentrations begin to increase at 05:00 to a broad peak between 09:00 and 13:00. This peak in concentrations could be associated with market operations such as market traders and delivery vehicles, as well as idling vehicles using short term parking bays next to the site although there are anti-idling signs requesting drivers to not leave vehicles running. Particulate matter concentrations are then shown to decrease before showing a smaller less broad peak between 19:00 and 20:00. Particulate matter concentrations at Howard Davis Park Osiris show similar trends, although to a lower magnitude, than Central Market Osiris. These lower overall concentrations measured at Howard Davis Park Osiris are likely due to the location of the site, as it is located within Howard Davis Park and therefore likely indicates background particulate matter concentrations. There is shown to be a broad peak shown between 07:00 and 11:00, followed by another peak in concentrations between 18:00 to 20:00. As these peaks mostly coincide with rush hour times, it is likely that rush hour traffic is a contributing factor to elevated particulate matter concentrations at these times.

Figure 15: Temporal variation of NO_2 concentrations.

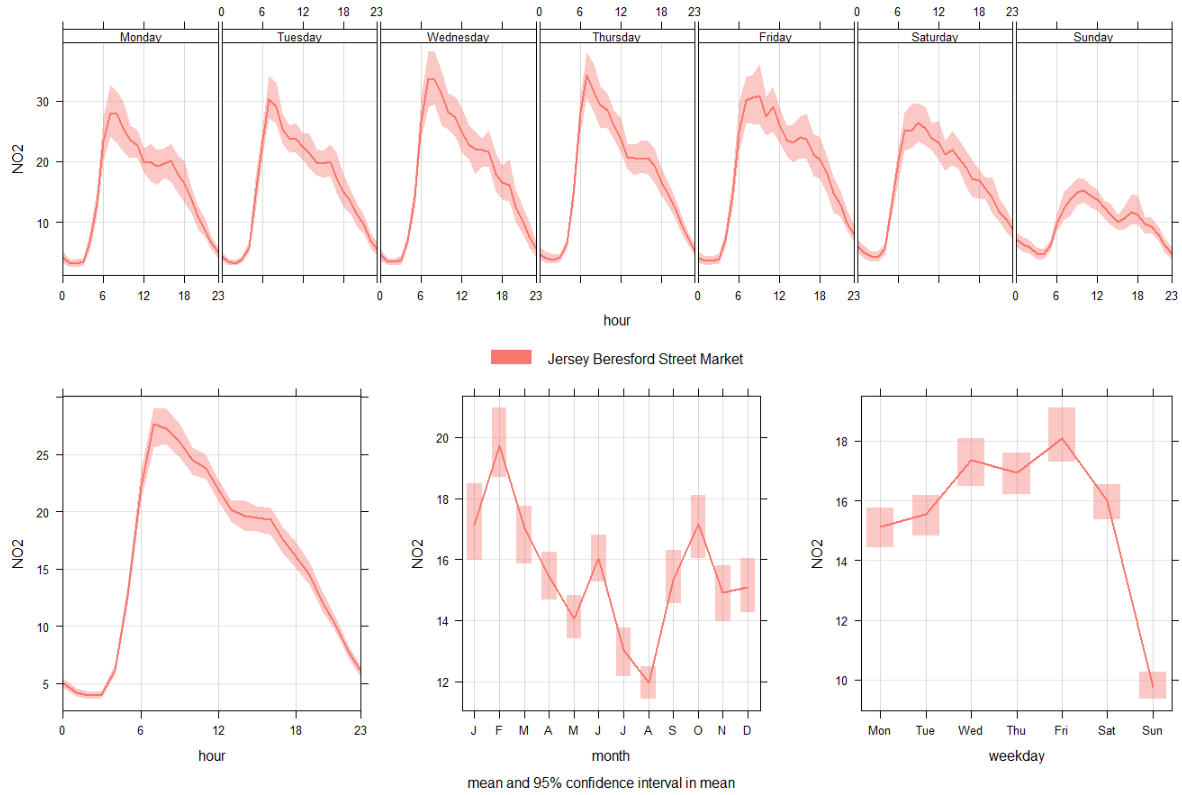
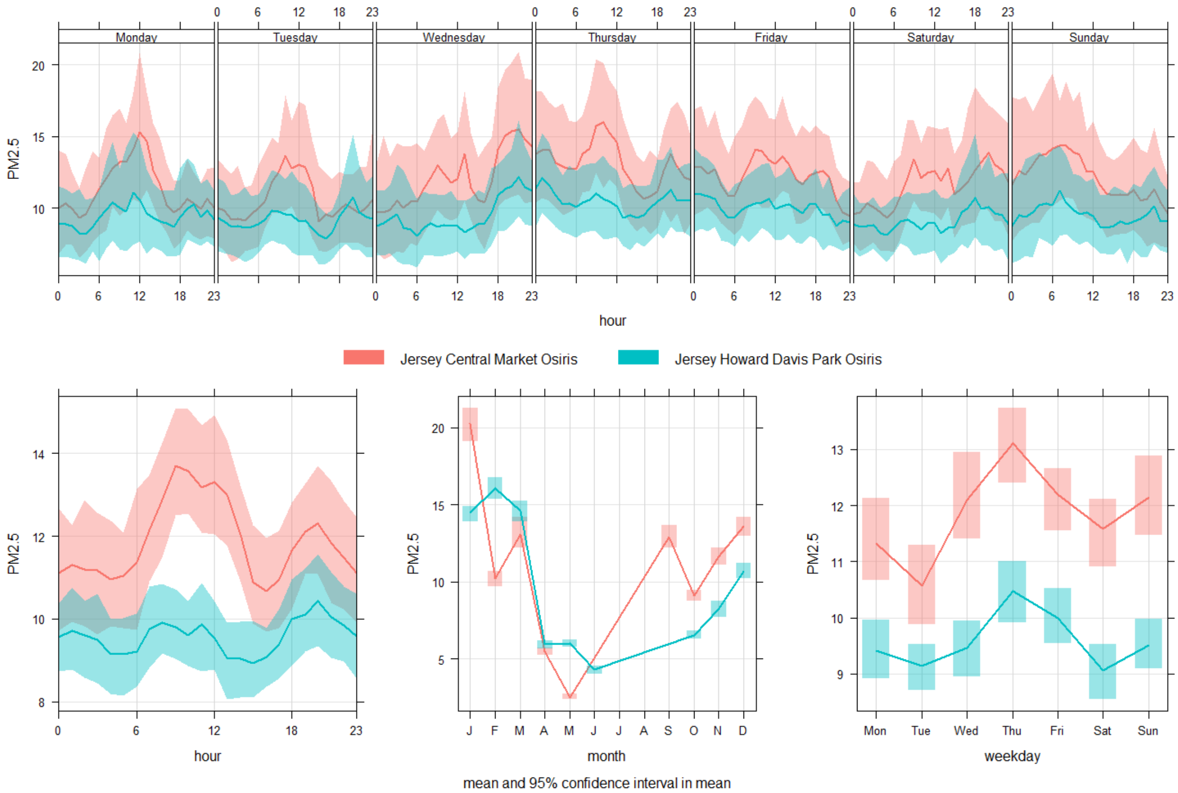


Figure 16: Temporal variation of PM_{10} concentrations.

Figure 17: Temporal variation of $PM_{2.5}$ concentrations.



5.7 SOURCE INVESTIGATION

In order to investigate the possible sources of air pollution being monitored around the three automatic monitoring sites, meteorological data measured at Jersey airport were 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 18 shows the measured wind speed and direction data for Jersey Airport. The length of each "spoke" against the concentric circles indicates the percentage of time during the year that the wind was measured from each direction. Each "spoke" is divided into coloured sections representing wind speed intervals of 2 ms^{-1}, followed by a final interval of 22.5 ms^{-1}. In 2023, the prevailing wind is shown to be from the west. The mean wind speed was 6.04 ms^{-1} and the maximum hourly measured wind speed was 28.5 ms^{-1}, which was recorded in November. Overall the month with highest wind speeds was also November 2023.

Figure 18: Wind rose showing the wind speed and directions at Jersey airport from 1st January to 31st December 2023

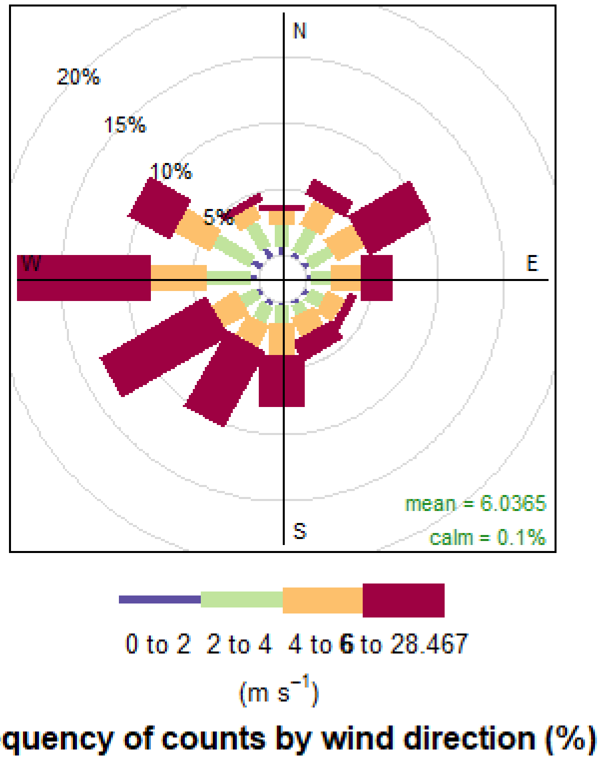


Figure 19, Figure 20, Figure 21 and Figure 22 show bivariate plots, "pollution roses" of hourly mean pollutant concentrations against the corresponding wind speed and wind direction. These plots should be interpreted as follows:

- The wind direction is indicated as in the wind rose below (north, south, east and west are indicated).
- The wind speed is indicated by the distance from the centre of the plot: the concentric 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 concentration varies 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 20 and Figure 19 show that elevated concentrations of NO and NO_2 occurred under calm and light wind conditions. Conditions such as these will allow 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 Beresford Street as a cut through or using the on-street parking location. Elevated NO_2 concentrations are also shown to occur under higher wind speeds from the southeast and southwest. There are multiple main roads that lie to the southwest of this site, including La Route du Fort, La Route de la Libération (A1) and Pier Road (A4), as well as smaller roads serving residents and local businesses. There is also the possibility of a street canyon effect which would allow concentrations of pollutants to build up when prevailing wind from the southeast blows across the top of the buildings. Other potential sources located to the southwest of the site include the port and marina as well as the A1, specifically near to the western end of the tunnel.

Figure 21 shows elevated PM_{10} concentrations under high wind speeds (25 ms^{-1} to 30 ms^{-1}) from the southwest at both Central Market Osiris and Howard Davis Park Osiris. At both sites there are also shown to be moderately elevated concentrations at all wind speeds from the southwest in the direction of the port and marinas. Other potential contributors to elevated particulate matter as higher wind speeds include sand and sea salt aerosols. At Central Market Osiris, there is also shown to be a strong signature at high wind speeds from the northwest and elevated concentrations are indicated at wind speeds between 5 ms^{-1} and 13 ms^{-1} from the northeast at Howard Davis Park Osiris.

$PM_{2.5}$ concentrations measured at Central Market Osiris and Howard Davis Park Osiris show similar trends to those seen in PM_{10} concentrations measured at both sites, as shown in Figure 22. Concentrations are shown to be elevated during unsettled conditions, with the highest concentrations occurring under high wind speeds from the southwest, in the direction of the port and marinas, and moderately elevated data occurring under all wind speeds also from the southwest. Elevated concentrations at Central Market may also be influenced from vehicle emissions from the busy road junction to Halkett Place that lies to the west of the site.

Figure 19: Pollution rose for NO at Beresford Street Market, 2023

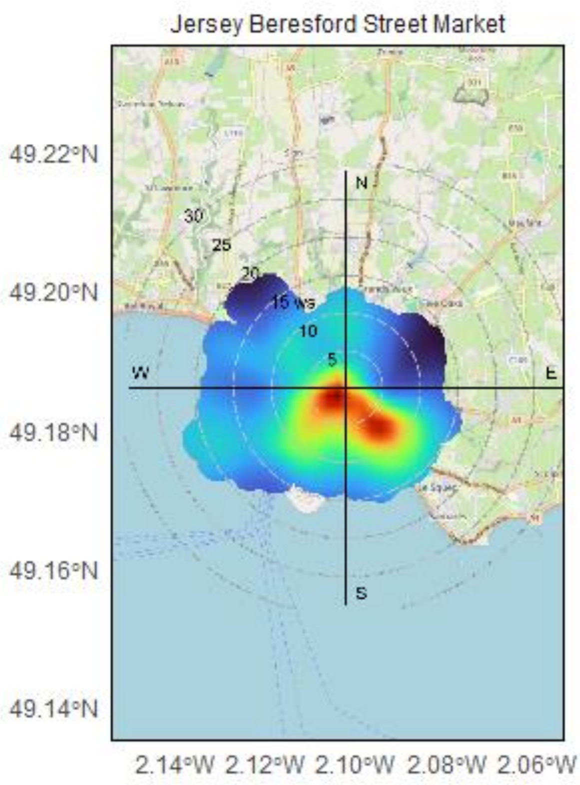


Figure 20: Pollution rose for NO2 at Beresford Street Market, 2023

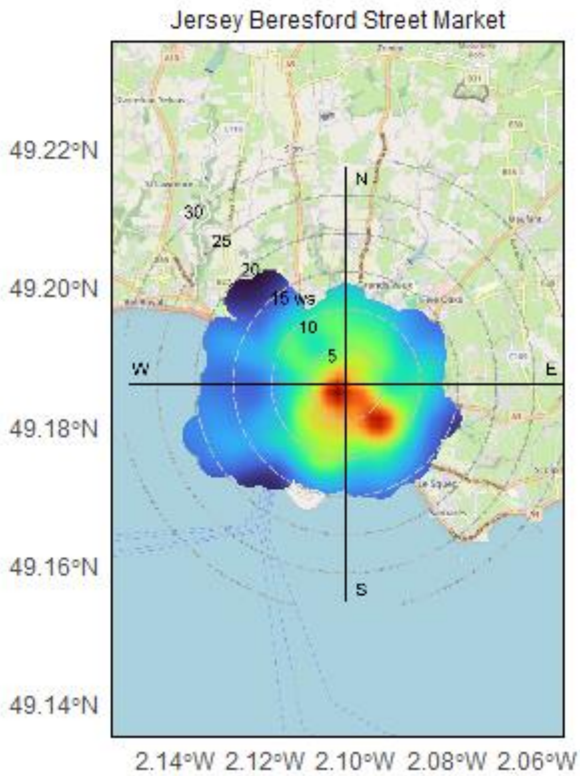


Figure 21: Pollution roses for PM_{10} at Central Market Osiris and Howard Davis Park Osiris, 2023

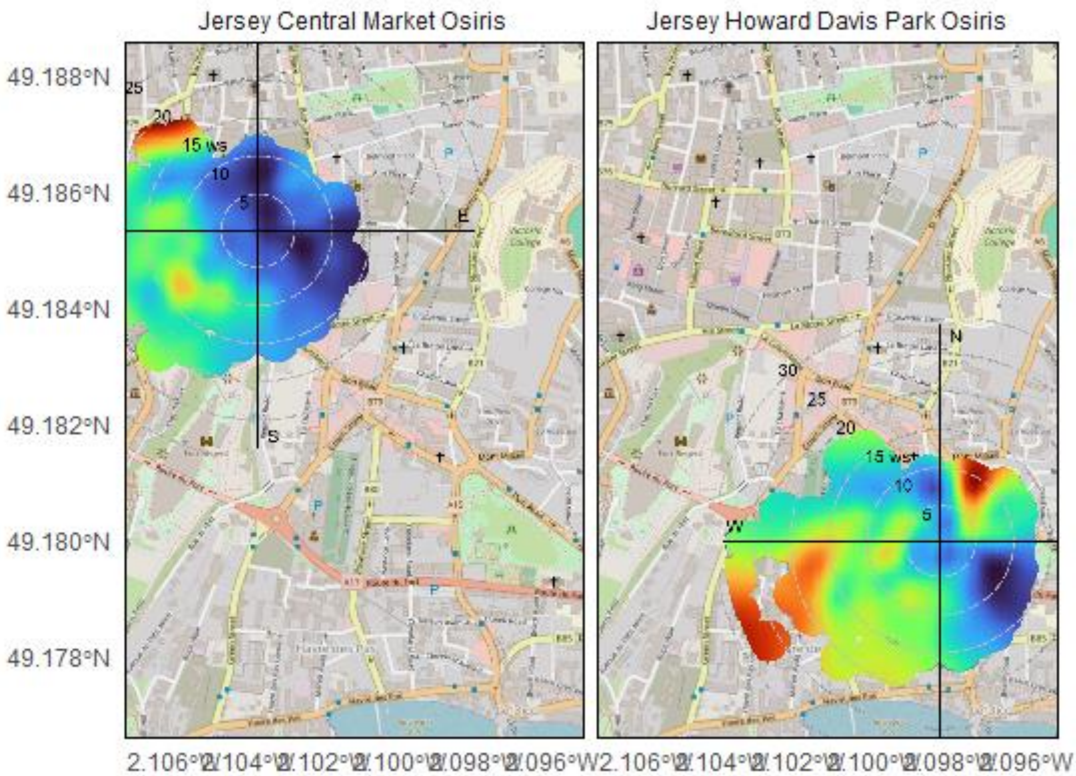
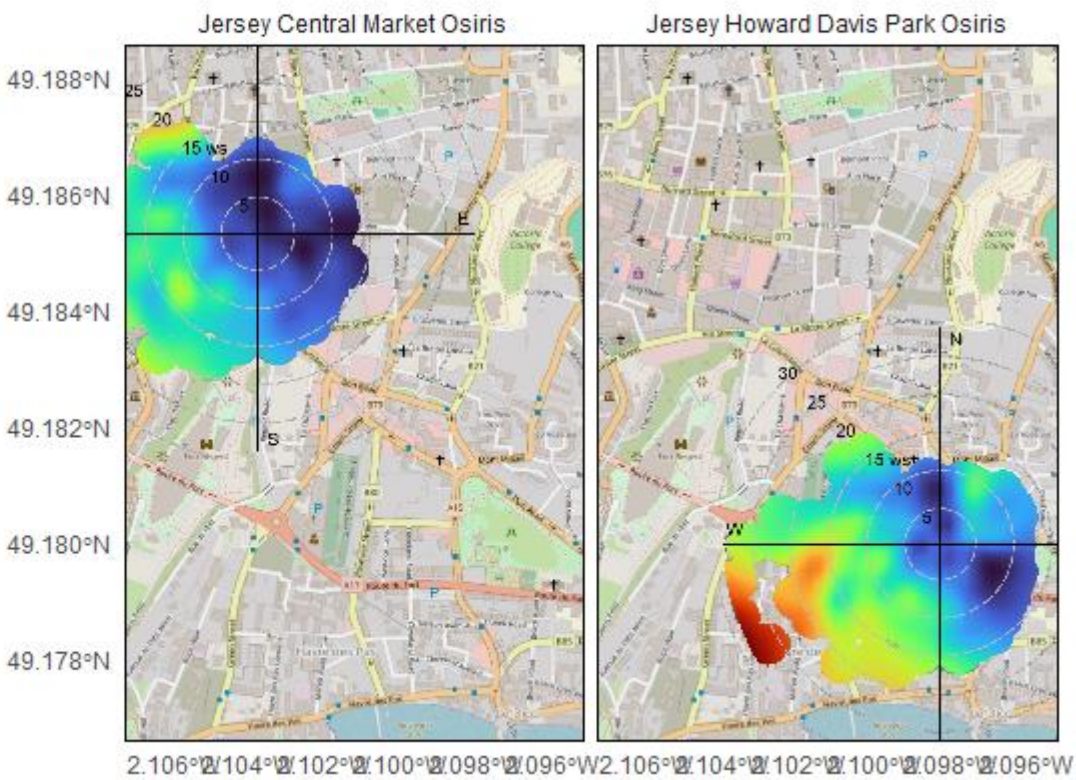


Figure 22: Pollution roses for $PM_{2.5}$ at Central Market Osiris and Howard Davis Park Osiris, 2023

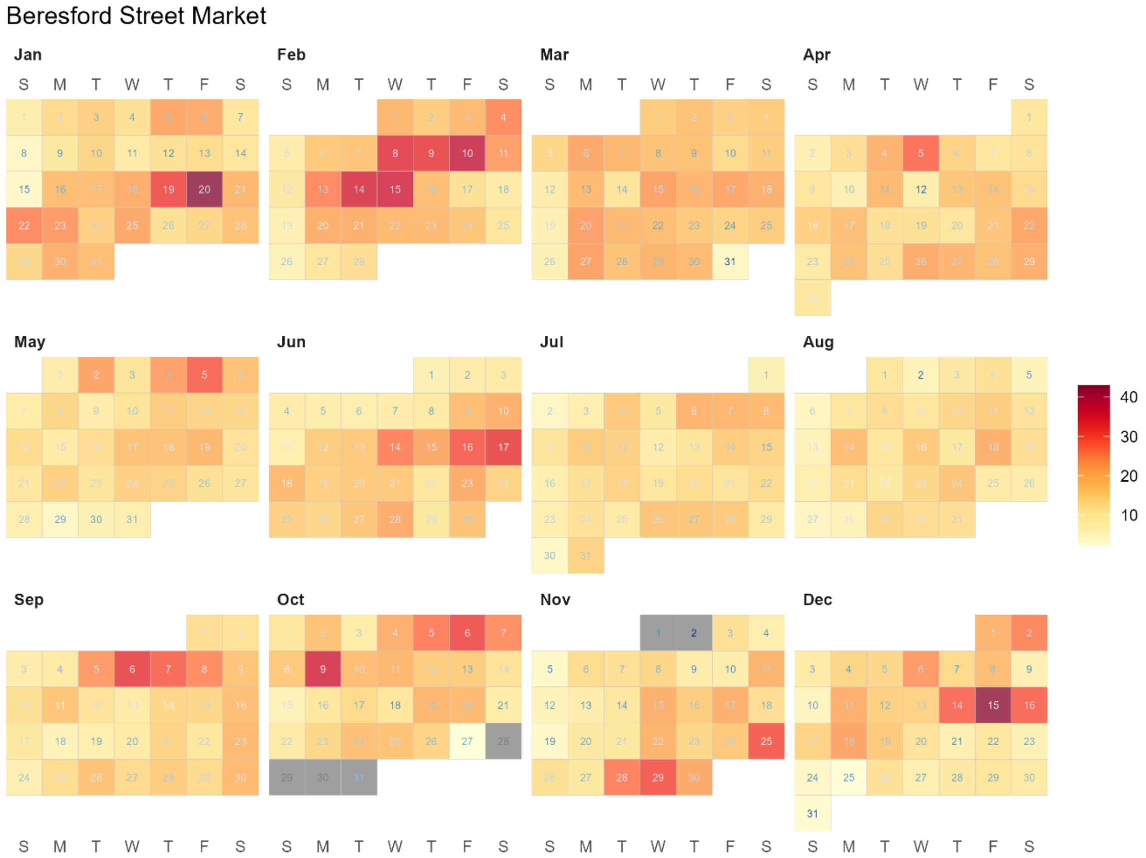


5.8 CALENDAR PLOT

Figure 23 to Figure 27 shows interactive versions of calendar plots. The date is coloured by the pollutant concentration (μg m^{-3}) for that day. The actual value can also be seen by hovering the mouse on the cell, along with the wind speed.

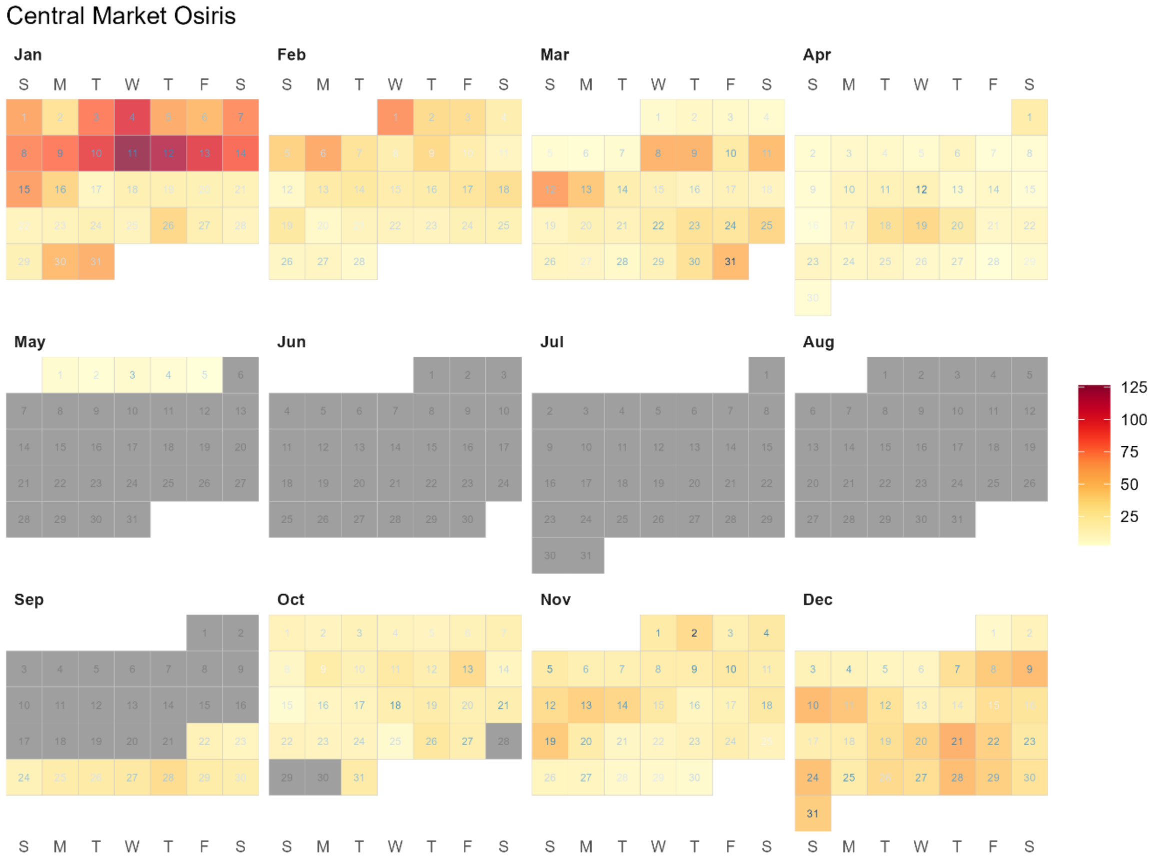
5.8.1 NO_2 Beresford Street Market

Figure 23: Calendar Plot for NO2 at Beresford Street Market, 2023



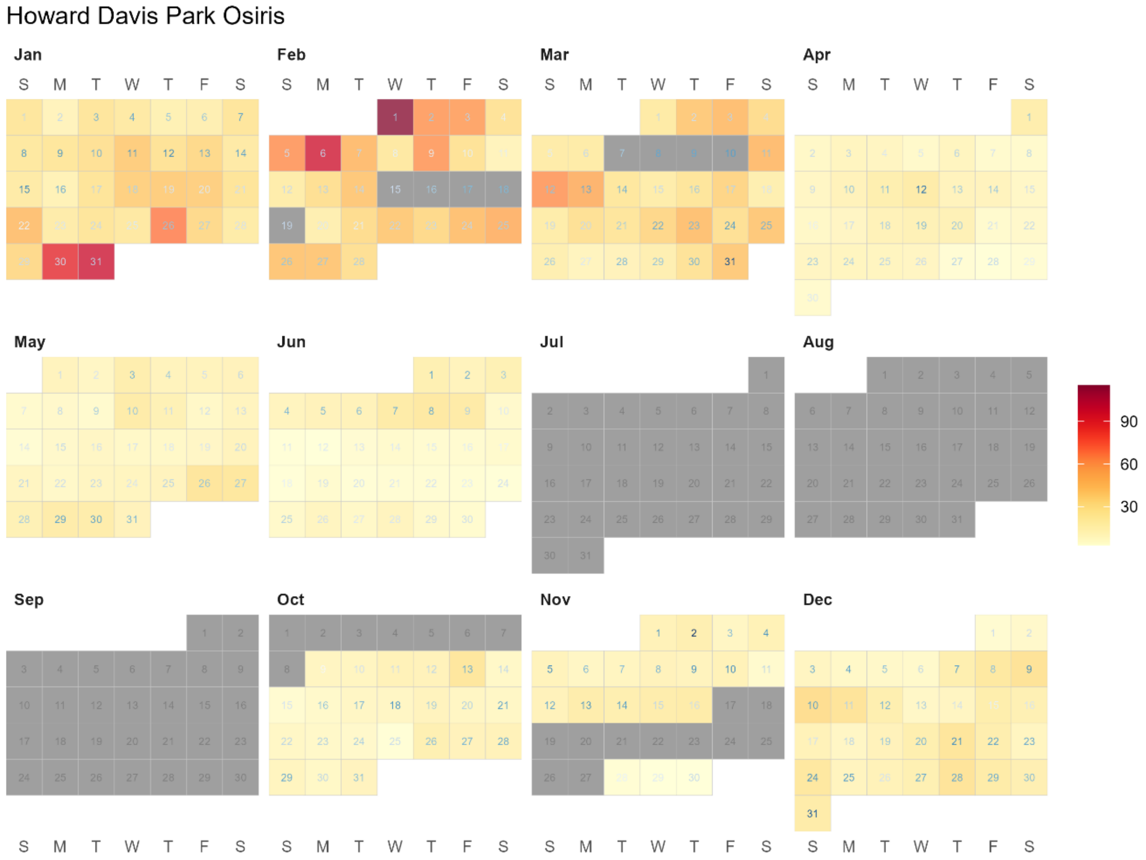
5.8.2 PM_{10} Central Market Osiris

Figure 24: Calendar Plot for PM10 at Central Market Osiris, 2023



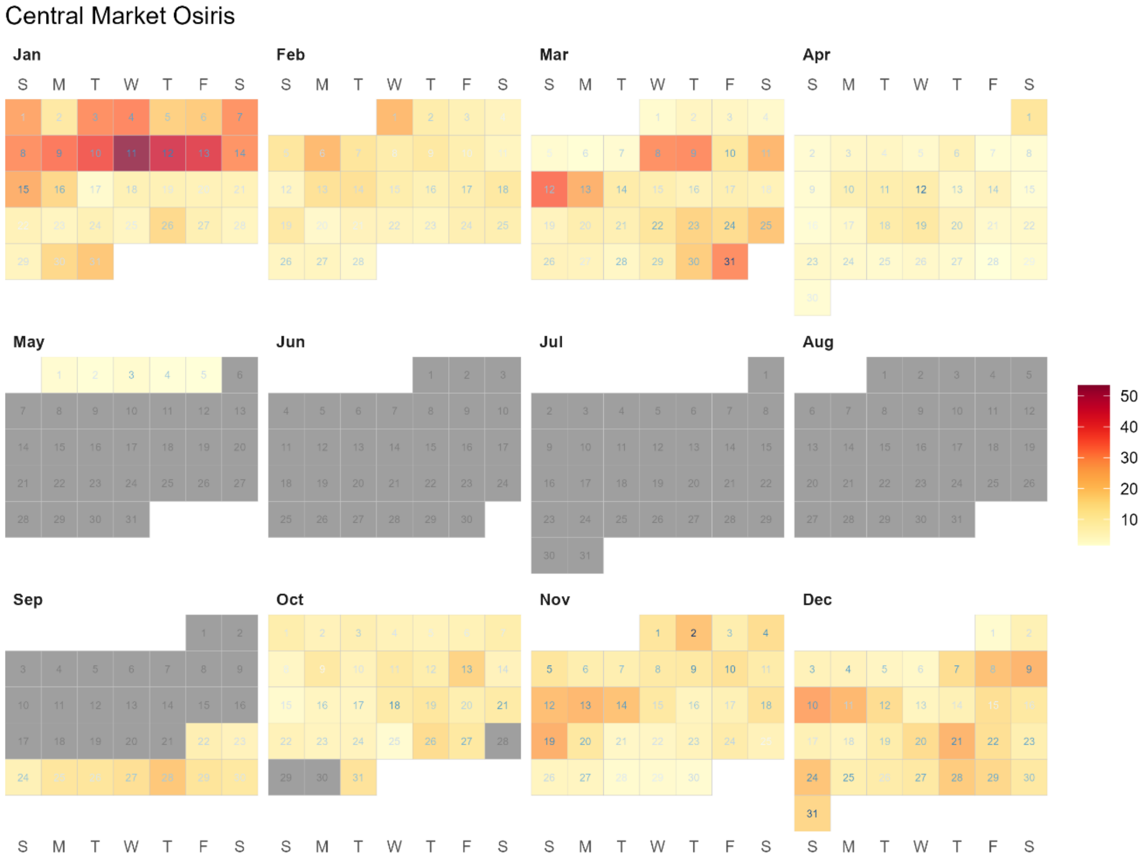
5.8.3 PM_{10} Howard Davis Park Osiris

Figure 25: Calendar Plot for PM10 at Howard Davis Park Osiris, 2023



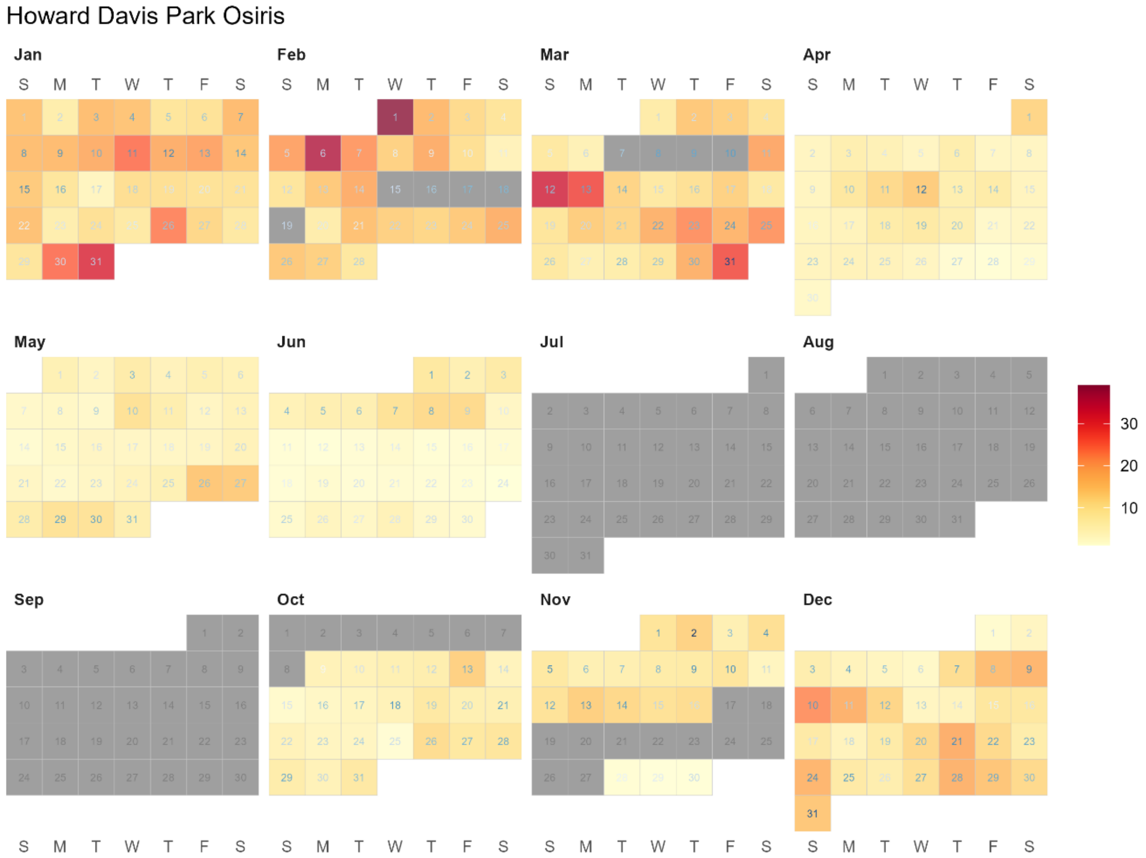
5.8.4 $PM_{2.5}$ Central Market Osiris

Figure 26: Calendar Plot for PM2.5 at Central Market Osiris, 2023



5.8.5 $PM_{2.5}$ Howard Davis Park Osiris

Figure 27: Calendar Plot for PM2.5 at Howard Davis Park Osiris, 2023



5.9 BACK TRAJECTORY ANALYSIS

Back trajectory plots show data from the HYSPLIT model [29] run in analysis mode. These show the air mass back trajectories for the period covered by the report. Two different types of plots are shown. One statistically groups the trajectories into similar clusters and shows the proportion of time during the report period that each represents Figure 28. This is useful to get an overview of air mass origins during the report period. Multiple plots of the back trajectories associated with the top 10 most polluted days for each pollutant are also presented in Figure 29 to Figure 33.

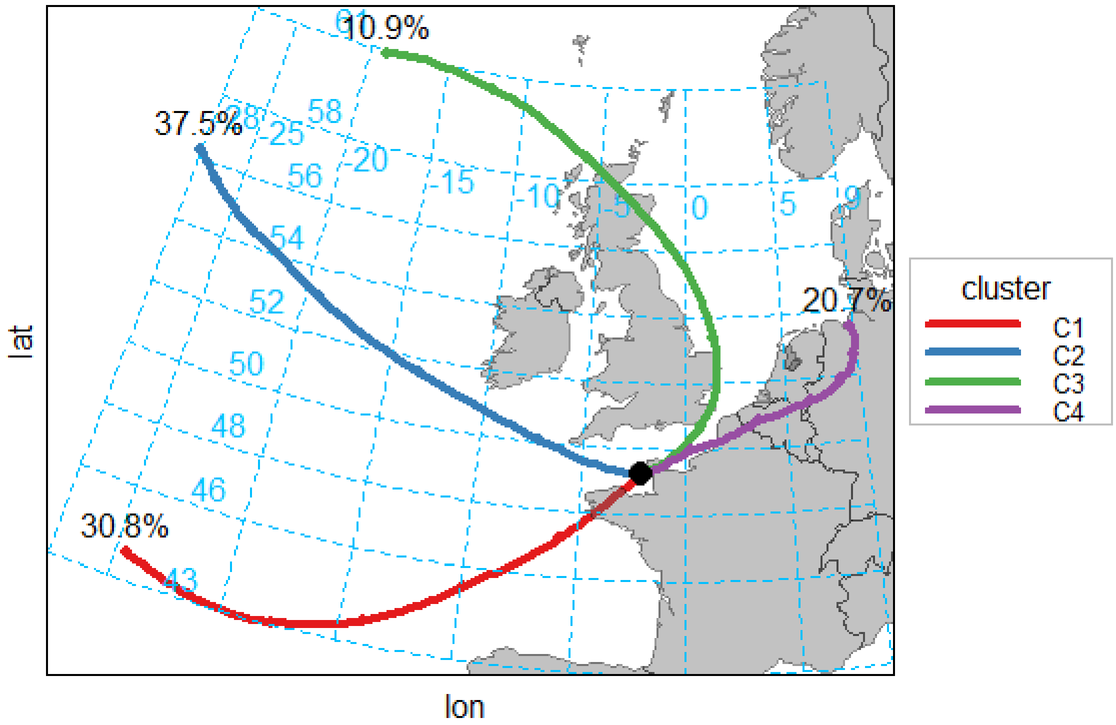
5.9.1 Trajectory Clusters

72-hour air mass back trajectories arriving at Jersey for the reporting period are grouped into 4 clusters, shown in Figure 28. This shows the approximate proportion of time air masses were arriving from each compass point during 2023.

Air mass back trajectories over these spatial scales do not vary locally so the receptor location used in this report has been selected from a range of national receptor locations maintained by Ricardo Energy & Environment. The receptor point used here is Jersey.

[29] National Oceanic and Atmospheric Administration, 2023. *HYSPLIT.* https://www.arl.noaa.gov/hysplit/ (Accessed 27th March 2024)

Figure 28: 72-hour air mass back trajectories arriving at Jersey during 2022

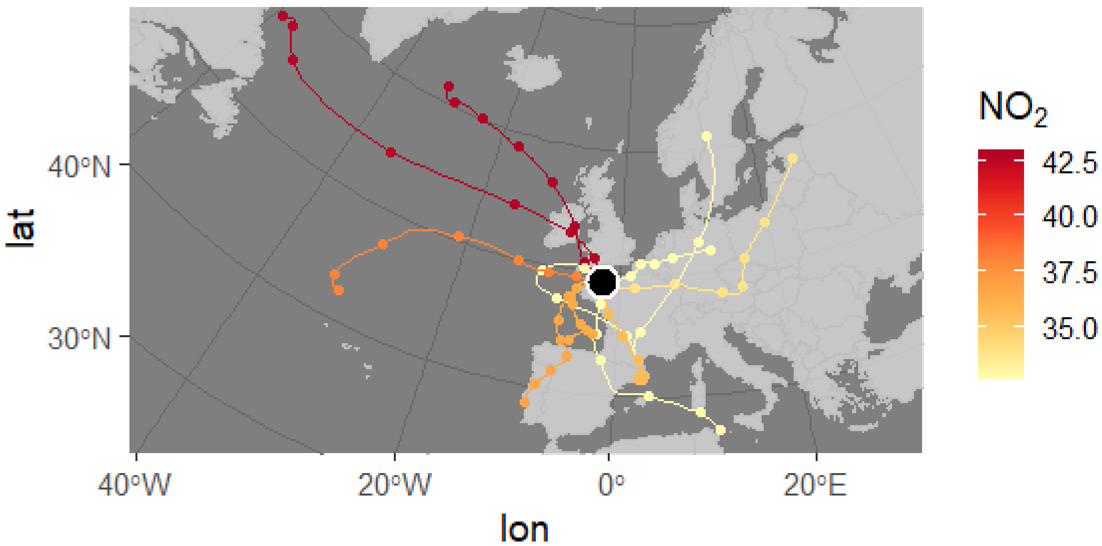


5.9.2 Trajectories Associated with Top Ten Most Polluted Days

Figure 29 shows that the top ten most polluted days for NO_2 concentrations originate from varying directions. This indicates that elevated NO_2 concentrations are likely associated with local factors, such as those described in section 4.6, and imported pollution is unlikely to be a major contributor.

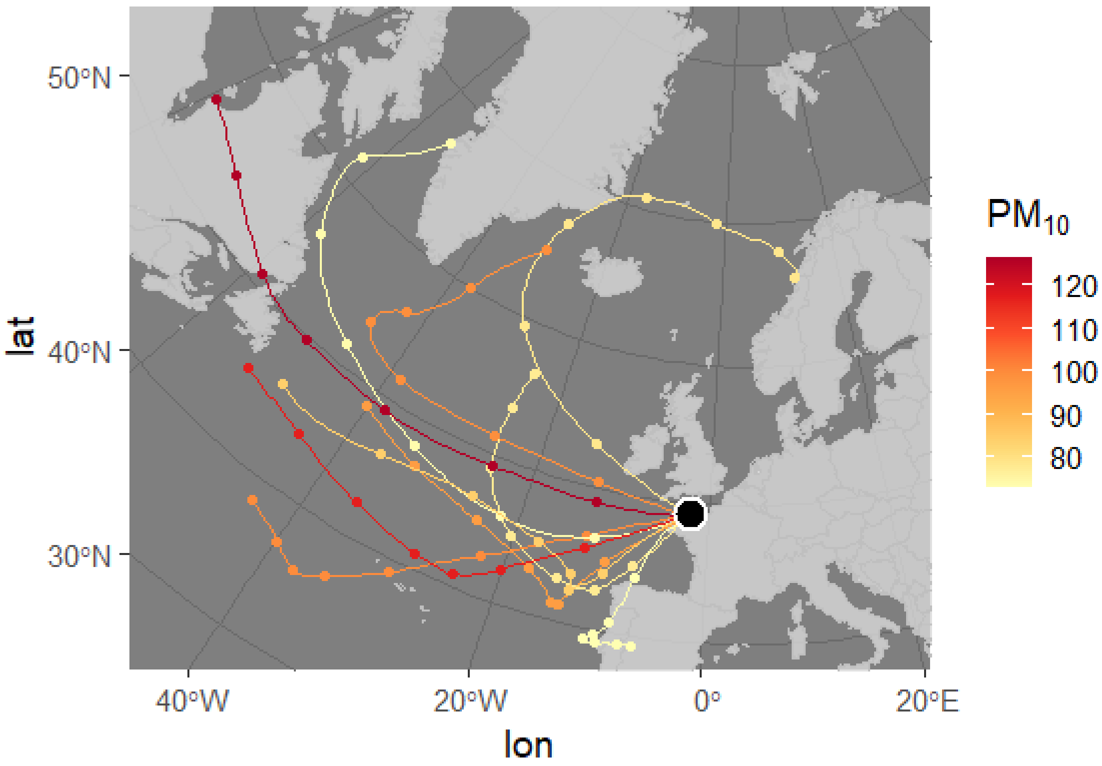
Figure 30 and Figure 31 show the top ten most polluted days in relation to PM_{10} and $PM_{2.5}$ at Central Market Osiris are predominantly associated with air masses originating from a westerly direction. Similarly, Figure 32 and Figure 33 indicate that the top ten most polluted days for PM_{10} and $PM_{2.5}$ at Howard Davis Park Osiris are also shown to be linked to air masses that originate from the west but also from the northeast. This indicates that the top ten most polluted days for PM_{10} and $PM_{2.5}$ are likely not associated with long range transport of polluted air masses from the continent.

Figure 29: Trajectory plot for top ten highest daily NO_2 concentrations measured at Beresford Street Market.



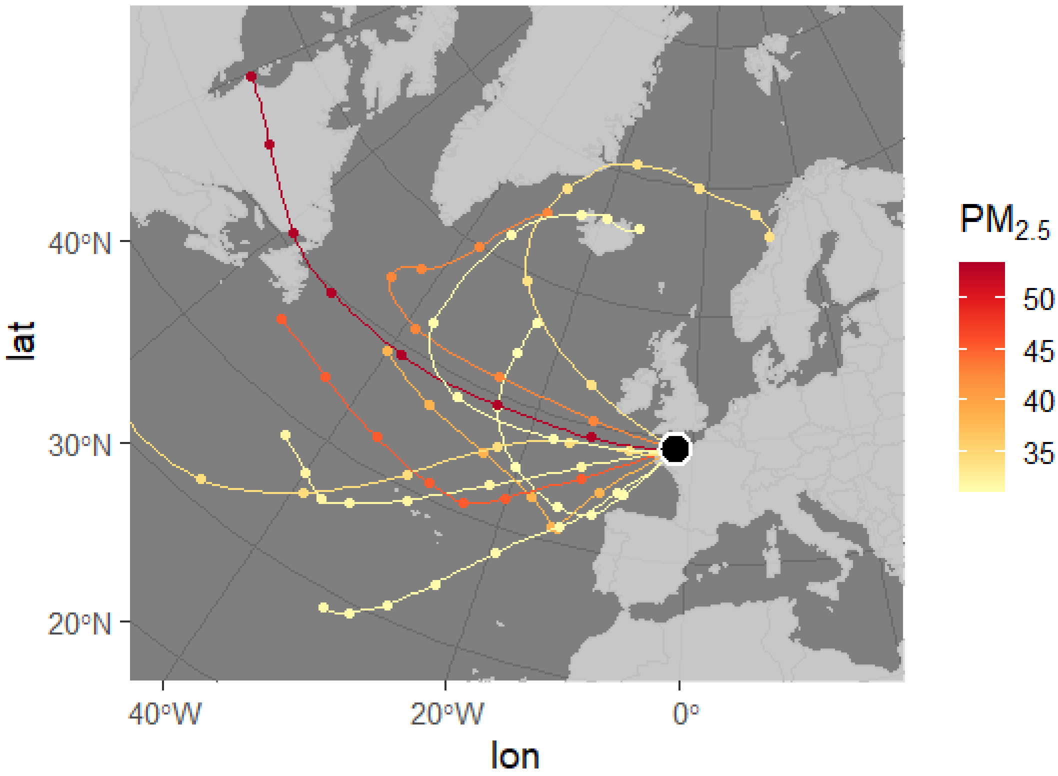
5.9.2.1 PM_{10} Central Market Osiris

Figure 30: Trajectory plot for top ten highest daily PM_{10} concentrations measured at Central Market Osiris.



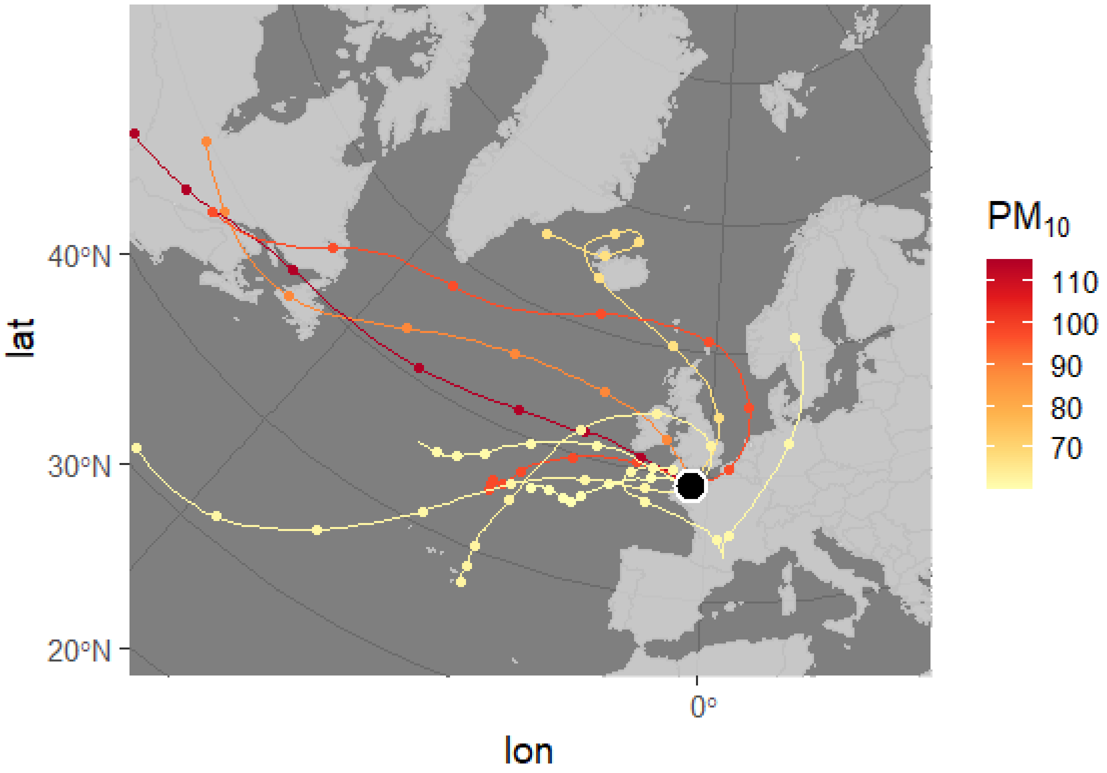
5.9.2.2 $PM_{2.5}$ Central Market Osiris

Figure 31: Trajectory plot for top ten highest daily $PM_{2.5}$ concentrations measured at Central Market Osiris.



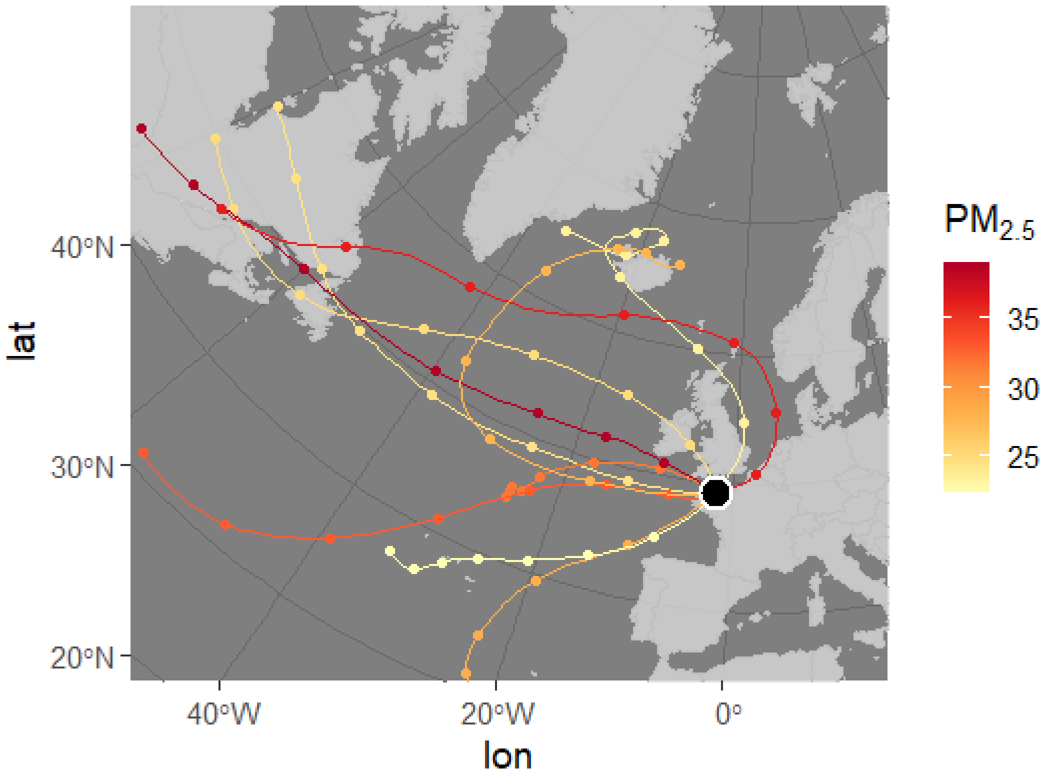
5.9.2.3 *PM_{10} Howard Davis Park Osiris*

Figure 32: Trajectory plot for top ten highest daily PM_{10} concentrations measured at Howard Davis Park Osiris.



5.9.2.4 $PM_{2.5}$ Howard Davis Park Osiris

Figure 33: Trajectory plot for top ten highest daily $PM_{2.5}$ concentrations measured at Jersey Howard Davis Park Osiris.



5.10 COMPARISON WITH UK NO_2 DATA

Table 13 compares the annual NO_2 concentration measured at Beresford Street Market with those measured at a selection of UK air quality monitoring stations in the national Automatic Urban and Rural Network and in Guernsey, using automatic (chemiluminescent) NO_2 analysers. The sites used for comparison are listed below:

- Bournemouth – an urban background site in the coastal city of Bournemouth.
- Guernsey Bulwer Avenue - a roadside site in the northeast of Guernsey.
- Exeter Roadside – a roadside site in the centre of Exeter, Devon.
- Plymouth Centre – an urban centre site in the coastal city of Plymouth, Devon.
- Plymouth Tavistock Road - an urban traffic site in the coastal city of Plymouth, Devon.
- Yarner Wood – a rural moorland site in Devon.

The mean concentrations measured at Exeter Roadside and Plymouth Centre are both shown to be within 1 µg m^{-3} of the annual mean measured at Beresford Street Market of 15 µg m^{-3}. A comparison between 2023 averages for Beresford Street Market and Guernsey Bulwer Avenue show that mean concentrations measured at Beresford Street were slightly higher than the those measured at the Guernsey Bulwer Avenue. However, both are well within the 40 µg m^{-3} annual limit set by the European Union. Further investigation shows that the majority of these sites showed an overall decrease in annual mean NO_2 concentrations between 2022 and 2023, except Plymouth Tavistock Road and Guernsey Bulwer Avenue, of which both showed small increases.

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 9 to 38 µg m^{-3}. However, bias adjusted annual averages ranged from 7 to 29 µg m^{-3}. The Jersey urban background site at Le Bas Centre had an annual mean NO_2 concentration of 18 µg m^{-3}, which is higher than the annual mean of 15 µg m^{-3} measured by the automatic analyser at Beresford Street Market. The residential background/school site at Les Quennevais measured an annual mean NO_2 concentration of 7 µg m^{-3}, which is higher than the annual mean at the rural Yarner Wood site in Devon. At the Jersey rural background site, Rue des Raisies, the annual mean NO_2 concentration of 4.1 µg m^{-3} (3.2 µg m^{-3} when bias adjusted) was slightly higher than that measured at the Yarner Wood site.

Table 14 and Table 15 compare PM_{10} and $PM_{2.5}$ concentrations measured by the Osiris analysers at Central Market Osiris and Howard Davis Park Osiris against those measured by FIDAS analysers at a selection of UK air quality monitoring stations in the national Automatic Urban and Rural Network and in Guernsey. The 2022 annual mean PM_{10} and $PM_{2.5}$ concentrations for Central Market Osiris and Howard Davis Park Osiris have been included but did not undergo the QA/QC process [30]. The sites used for comparison are described below:

- Guernsey Bulwer Avenue - a roadside site in the northeast of Guernsey.
- Honiton – a urban background site in the centre of Exeter, Devon.
- Plymouth Centre – an urban centre site in the coastal city of Plymouth, Devon.

The annual mean PM_{10} concentrations measured at Central Market Osiris and Howard Davis Park Osiris are shown to be higher than those measured at Honiton, Plymouth Centre and Guernsey Bulwer Avenue. Similarly, $PM_{2.5}$ concentrations measured at Central Market Osiris and Howard Davis Park Osiris are also shown to be higher but to a lesser extent. Howard Davis Park Osiris and Guernsey Bulwer Avenue are shown to be the closest in annual mean concentrations of PM_{10} and $PM_{2.5}$.

Table 13: Comparison of NO2 in Jersey with UK automatic sites, 2022-2023

Site	2023 Annual mean NO2 concentration ug m-3	2022 Annual mean NO2 concentration (ug m-3)
Exeter Roadside	16	18
Bournemouth	8	10
Plymouth Tavistock Road	17	16
Plymouth Centre	15	16
Yarner Wood	2	3
Jersey Beresford Street Market	15	17
Guernsey Bulwer Avenue	14	13

Table 14: Comparison of PM10 in Jersey with UK automatic sites, 2022-2023

Site	2023 Annual mean PM10 concentration (ug m-3)	2022 Annual mean PM10 concentration (ug m-3)
Honiton	10	11

[30] Government of Jersey, 2022. *Report on Turnkey Osiris Particle Results at the Market/Beresford Street and Howard Davis Park Sites in Jersey for 2022* https://www.gov.je/Government/Pages/StatesReports.aspx (Accessed 22nd April 2024)

Site	2023 Annual mean PM10 concentration (ug m-3)	2022 Annual mean PM10 concentration (ug m-3)
Plymouth Centre	16	17
Jersey Central Market Osiris	27	22
Jersey Howard Davis Park Osiris	21	21
Guernsey Bulwer Avenue	19	21

Table 14: Comparison of PM10 in Jersey with UK automatic sites, 2022-2023

Site	2023 Annual mean PM2.5 concentration (ug m-3)	2022 Annual mean PM2.5 concentration (ug m-3)
Honiton	6	6
Plymouth Centre	8	8
Jersey Central Market Osiris	12	11
Jersey Howard Davis Park Osiris	10	10
Guernsey Bulwer Avenue	9	10

5.11 TRENDS IN NO_2 AT LONG-RUNNING SITES

The annual mean NO_2 concentrations for diffusion tube sites which had over 75% data capture are illustrated in Figure 34. The 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.

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 in 2020. This was followed by subsequent decreases in 2021 and 2022 to 17 µg m^{-3} and 16 µg m^{-3} respectively. In 2023, the annual concentration is similar to that measured in 2022.

From 2004 onwards, annual mean NO_2 concentrations at historic kerbside, roadside and urban background sites (Weighbridge, Georgetown, Beaumont, The Parade, Broad Street, and Le Bas Centre) show an overall decreasing trend. In 2023, all sites remained below 40 µg m^{-3}. Some sites saw concentrations increase compared to 2022, which is likely a result of the continued reuptake in travel following the COVID-19 Pandemic restrictions that were imposed in 2020 and 2021.

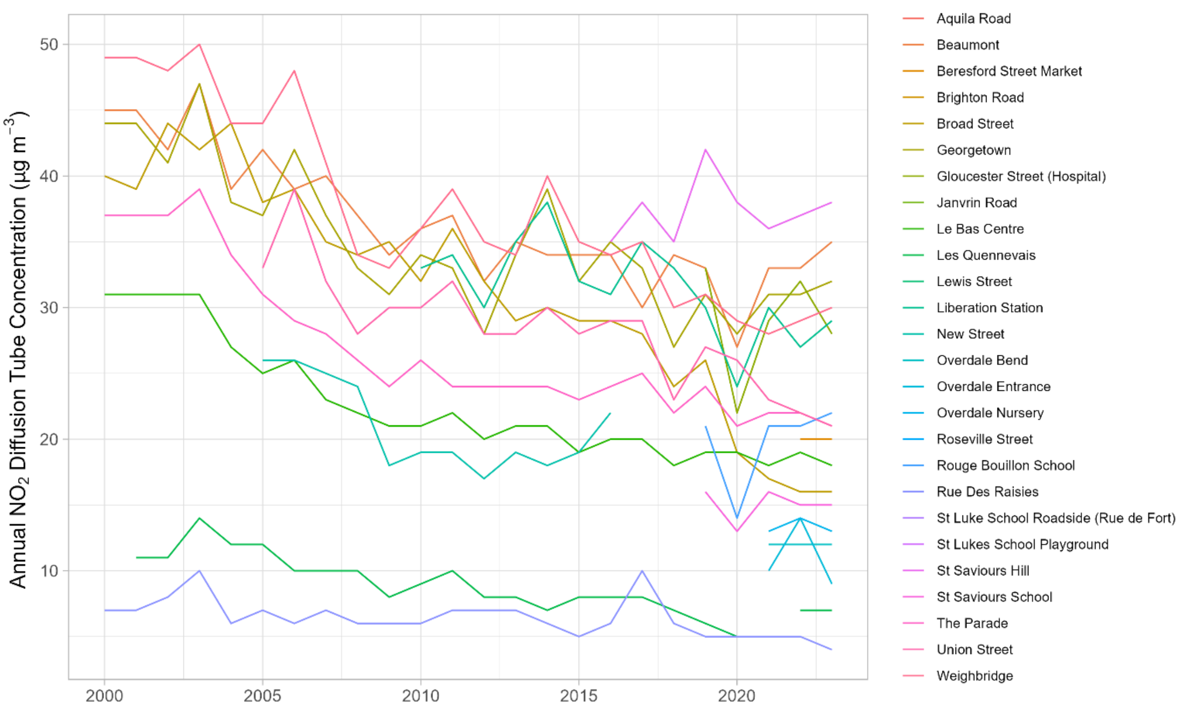
Table 16 illustrates annual mean NO_2 concentrations at several of the sites have remained stable with typical fluctuations from year to year due to meteorological conditions and other factors since 2012.

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

[31] found that newer petrol vehicles produce fewer NO_x emissions. It also found that there has been an overall decline in diesel vehicles on the island and an increase in newer petrol cars. There are also plans to introduce MOT style testing to Jersey in the future which 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.

A focused example of the differences between closely located site locations indicates how localised NO_2 distribution can be with certain mitigating factors. A comparison between the now discontinued New Street site and Union Street shows New Street generally measured lower concentrations than Union Street. These sites 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. Furthermore, very little pollution from Union Street is carried to New Street, located to the South, as the prevailing wind is from the West with the least wind coming from the North.

Figure 34: Figure 34: Annual mean NO_2 concentrations (NOT adjusted for diffusion tube bias)



5.12 HYDROCARBONS

Full monthly results of the hydrocarbon survey for the five BTEX sites and a summary of the annual average hydrocarbon concentrations are shown below. Travel blank values gave consistently lower results than the exposed tubes which the exception of most pollutants in June and November 2023 which had elevated levels in the Travel Blank. The following exposures were noted to have loose end caps and it is therefore possible that the elevated concentrations reported were influenced by this:

- February 2023 - Beresford Street & Harrington's Garage
- November 2023 - Harrington's Garage, Rue de Pres Trading Estate & Travel Blank

[31] Ricardo Energy & Environment, 2017 *Vehicle Emissions Remote Sensing in Jersey.* https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Vehicle%20emissions%20remote%20sensing%20in%20Jersey%2020180816%20DM.pdf (Accessed 27th March 2024)

- December 2023 - Faux Bie Terrace.

For most of the deployments listed above these corresponded with elevated concentrations by the BTEX tubes, therefore these measurements should be treated with caution. Results of BTEX monitoring at Beresford Street in February and Faux Bie Terrace in December have been rejected as they were significant outliers and are likely erroneous due to loose end caps following exposure.

Table 17 lists the missing BTEX tube results throughout 2023, including outliers and missing tube results.

Table 17: Details of the missing or rejected BTEX tube results

Site	Month	Reason for rejection
Beresford Street	February	Significant outlier likely due to the loose end cap following exposure
Rue de Pres	February	Missing on collection
Le Bas Centre	June	Tube left at site for June and July in error
Le Bas Centre	July	Tube left at site for June and July in error
Faux Bie Terrace	November	Missing on collection
Faux Bie Terrace	December	Significant outlier likely due to the loose end cap following exposure

5.12.1 Hydrocarbons Results

Monthly hydrocarbon results for each of the five sites are shown in Table 18. Table 19 shows the highest annual mean concentrations of benzene and toluene were measured at Harrington's Garage in 2023, which is located by a fueling station with no Vapour Recovery system. Rue de Pres Trading Estate recorded the highest average concentrations of ethylbenzene and the highest annual means for mp-xylene and o-xylene were recorded at Faux Bie Terrace. Despite the higher concentrations at these sites compared to other Jersey sites, the annual mean of 0.7 µg m^{-3} for benzene is still well below the annual limit value of 5 µg m^{-3}.

Table 18: Jersey BTEX tube results in 2023 in µg m-3

Pid	start date	end date	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
BENZENE	2023-01-04	2023-02-01	0.4	0.5	0.6	0.4	0.3	0.1
BENZENE	2023-02-01	2023-03-01		0.6	0.7	0.5		0.1
BENZENE	2023-03-01	2023-04-05	0.3	0.5	2.1	0.4	0.3	0.0
BENZENE	2023-04-05	2023-05-03	0.2	0.4	0.7	0.6	0.2	0.1
BENZENE	2023-05-03	2023-05-31	0.3	0.4	0.6	0.3	0.2	0.2
BENZENE	2023-05-31	2023-07-05	0.4	0.5	0.6		0.2	0.2

Pid	start date	end date	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
BENZENE	2023-07-05	2023-08-02	0.6	0.9	0.6		0.2	0.2
BENZENE	2023-08-02	2023-09-06	0.3	0.5	0.7	0.2	0.2	0.2
BENZENE	2023-09-06	2023-10-04	0.3	0.5	0.9	0.6	0.3	0.1
BENZENE	2023-10-04	2023-11-01	0.4	0.6	0.7	0.4	0.2	0.1
BENZENE	2023-11-01	2023-12-06	0.4		0.2	0.4	0.3	0.2
BENZENE	2023-12-06	2024-01-03	0.4		0.4	0.5	0.3	0.0
ETHBENZ	2023-01-04	2023-02-01	0.3	0.3	0.5	0.3	0.3	0.0
ETHBENZ	2023-02-01	2023-03-01		0.5	0.5	0.3		0.0
ETHBENZ	2023-03-01	2023-04-05	0.2	0.5	0.5	0.2	3.7	0.0
ETHBENZ	2023-04-05	2023-05-03	0.3	0.4	0.6	0.3	0.3	0.0
ETHBENZ	2023-05-03	2023-05-31	0.3	0.3	0.5	0.3	0.3	0.0
ETHBENZ	2023-05-31	2023-07-05	0.4	0.7	0.5		0.2	3.8
ETHBENZ	2023-07-05	2023-08-02	0.4	0.5	0.4		0.3	0.3
ETHBENZ	2023-08-02	2023-09-06	0.2	0.6	0.7	0.2	0.2	0.1
ETHBENZ	2023-09-06	2023-10-04	0.3	0.6	0.7	0.5	0.3	0.1
ETHBENZ	2023-10-04	2023-11-01	0.3	0.7	0.6	0.3	0.3	0.0
ETHBENZ	2023-11-01	2023-12-06	0.2		0.2	0.2	0.7	9.0
ETHBENZ	2023-12-06	2024-01-03	0.3		0.3	0.3	0.3	0.0
mpXYLENE	2023-01-04	2023-02-01	0.5	0.8	1.7	0.5	0.3	0.0

Pid	start date	end date	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
mpXYLENE	2023-02-01	2023-03-01		1.6	1.4	0.8		0.1
mpXYLENE	2023-03-01	2023-04-05	0.5	1.6	1.5	0.7	3.3	0.0
mpXYLENE	2023-04-05	2023-05-03	0.3	1.3	1.8	0.5	0.4	0.0
mpXYLENE	2023-05-03	2023-05-31	0.3	1.0	1.1	0.4	0.3	0.1
mpXYLENE	2023-05-31	2023-07-05	1.0	1.5	1.1		0.4	3.7
mpXYLENE	2023-07-05	2023-08-02	1.1	1.4	0.9		0.3	0.3
mpXYLENE	2023-08-02	2023-09-06	0.4	2.0	2.1	0.3	0.6	0.2
mpXYLENE	2023-09-06	2023-10-04	0.4	1.6	1.6	1.3	0.8	0.1
mpXYLENE	2023-10-04	2023-11-01	0.4	1.4	1.6	0.3	0.3	0.1
mpXYLENE	2023-11-01	2023-12-06	0.4		0.4	0.4	1.1	7.8
mpXYLENE	2023-12-06	2024-01-03	0.6		0.7	0.7	0.4	0.0
oXYLENE	2023-01-04	2023-02-01	0.3	0.3	0.7	0.3	0.3	0.0
oXYLENE	2023-02-01	2023-03-01		0.6	0.6	0.3		0.0
oXYLENE	2023-03-01	2023-04-05	0.2	0.7	0.6	0.2	1.2	0.0
oXYLENE	2023-04-05	2023-05-03	0.3	0.5	0.7	0.3	0.3	0.0
oXYLENE	2023-05-03	2023-05-31	0.3	0.4	0.4	0.3	0.3	0.0
oXYLENE	2023-05-31	2023-07-05	0.4	0.6	0.5		0.2	1.6
oXYLENE	2023-07-05	2023-08-02	0.5	0.6	0.4		0.3	0.3
oXYLENE	2023-08-02	2023-09-06	0.2	0.8	0.8	0.2	0.2	0.2

Pid	start date	end date	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
oXYLENE	2023-09-06	2023-10-04	0.3	0.7	0.6	0.5	0.3	0.0
oXYLENE	2023-10-04	2023-11-01	0.3	0.6	0.6	0.3	0.3	0.0
oXYLENE	2023-11-01	2023-12-06	0.2		0.3	0.2	0.4	3.7
oXYLENE	2023-12-06	2024-01-03	0.3		0.3	0.3	0.3	0.0
TOLUENE	2023-01-04	2023-02-01	0.8	1.9	3.6	0.8	1.1	0.0
TOLUENE	2023-02-01	2023-03-01		3.7	4.0	1.4		0.1
TOLUENE	2023-03-01	2023-04-05	0.7	2.9	3.9	0.9	0.7	0.1
TOLUENE	2023-04-05	2023-05-03	0.5	2.1	4.0	0.8	0.3	0.1
TOLUENE	2023-05-03	2023-05-31	0.6	2.1	3.6	0.9	0.7	0.0
TOLUENE	2023-05-31	2023-07-05	1.5	4.1	4.5		0.7	0.3
TOLUENE	2023-07-05	2023-08-02	1.6	5.1	3.6		0.5	0.2
TOLUENE	2023-08-02	2023-09-06	0.7	4.1	5.6	0.8	0.9	0.5
TOLUENE	2023-09-06	2023-10-04	1.2	4.5	7.2	2.2	0.9	0.1
TOLUENE	2023-10-04	2023-11-01	1.1	4.0	0.5	1.2	0.5	0.1
TOLUENE	2023-11-01	2023-12-06	0.9		0.2	1.0	0.8	0.3
TOLUENE	2023-12-06	2024-01-03	0.8		1.7	1.1	0.5	0.0

Table 19: Summary of average hydrocarbon concentrations in Jersey, 2023, in µg m-3

Pid	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
BENZENE	0.4	0.5	0.7	0.4	0.2	0.1
ETHBENZ	0.3	0.5	0.5	0.3	0.6	1.1

Pid	Beresford Street	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	Travel Blank
TOLUENE	0.9	3.4	3.5	1.1	0.7	0.1
mpXYLENE	0.5	1.4	1.3	0.6	0.7	1.0
oXYLENE	0.3	0.6	0.5	0.3	0.4	0.5

5.12.2 Hydrocarbons by Pollutant

Monthly BTEX tubes concentrations by pollutant are displayed in Figure 35 to Figure 39.

Figure 35: Monthly mean Benzene concentrations at each BTEX site in µg m-3

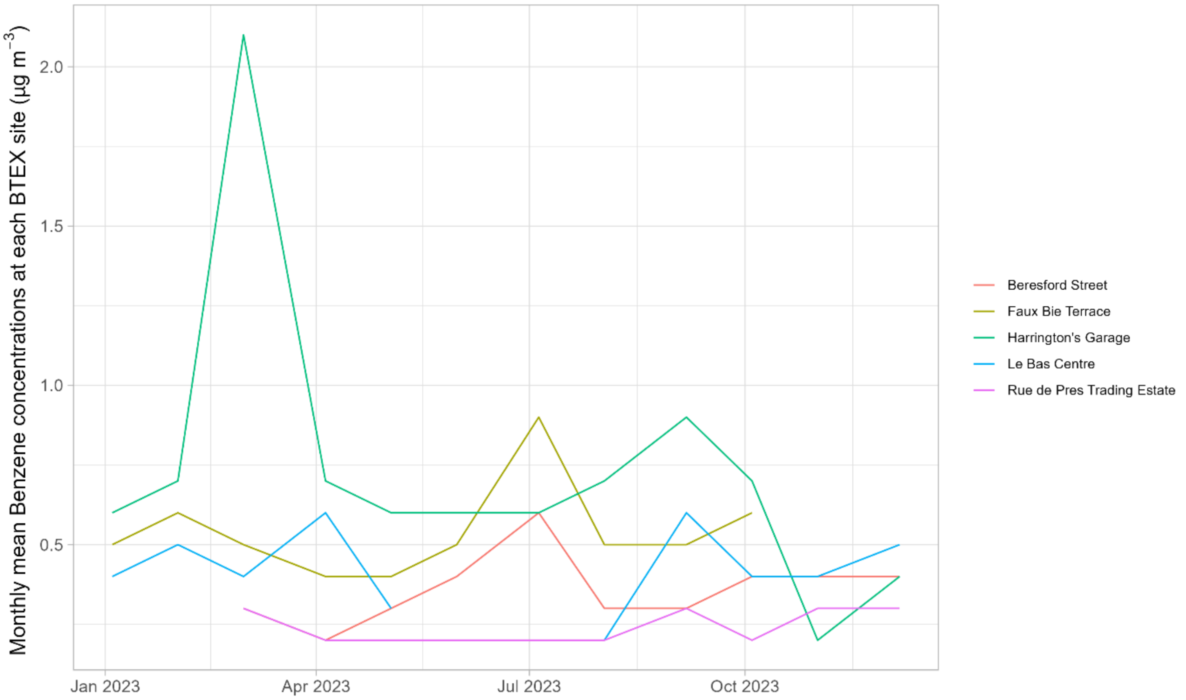


Figure 36: Monthly mean Toluene concentrations at each BTEX site in µg m-3

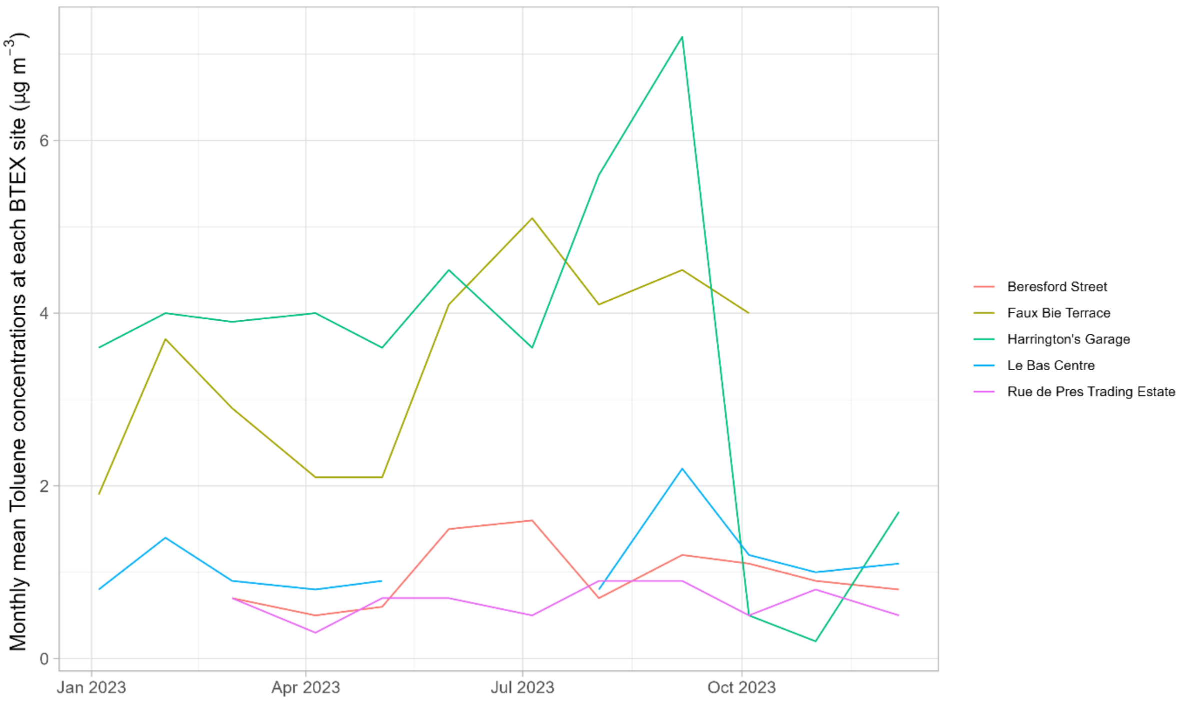


Figure 37: Monthly mean Ethylbenzene concentrations at each BTEX site in µg m-3

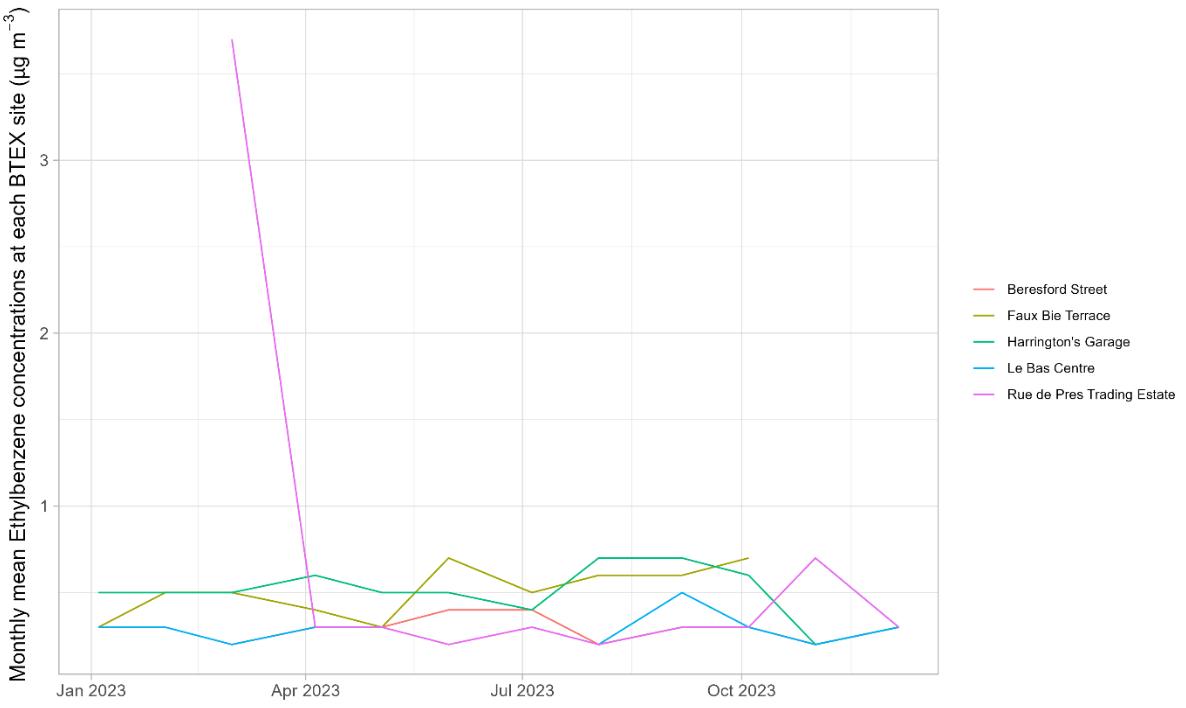


Figure 38: Monthly mean mp-xylene concentrations at each BTEX site in µg m-3

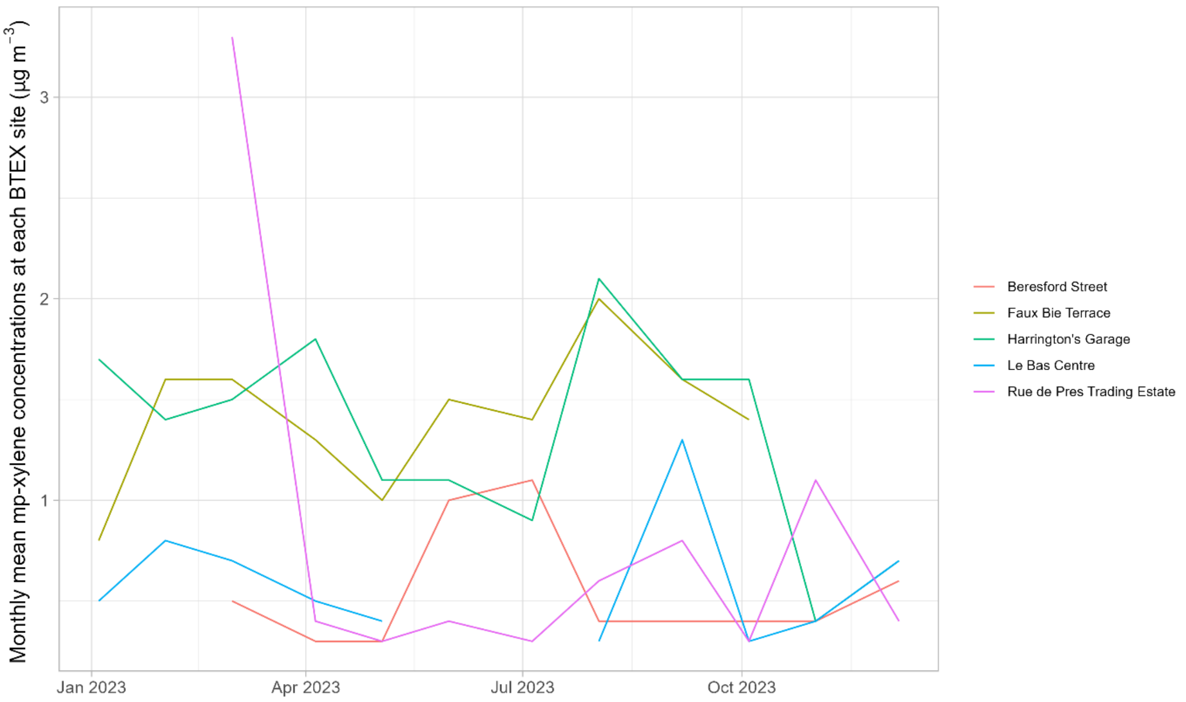
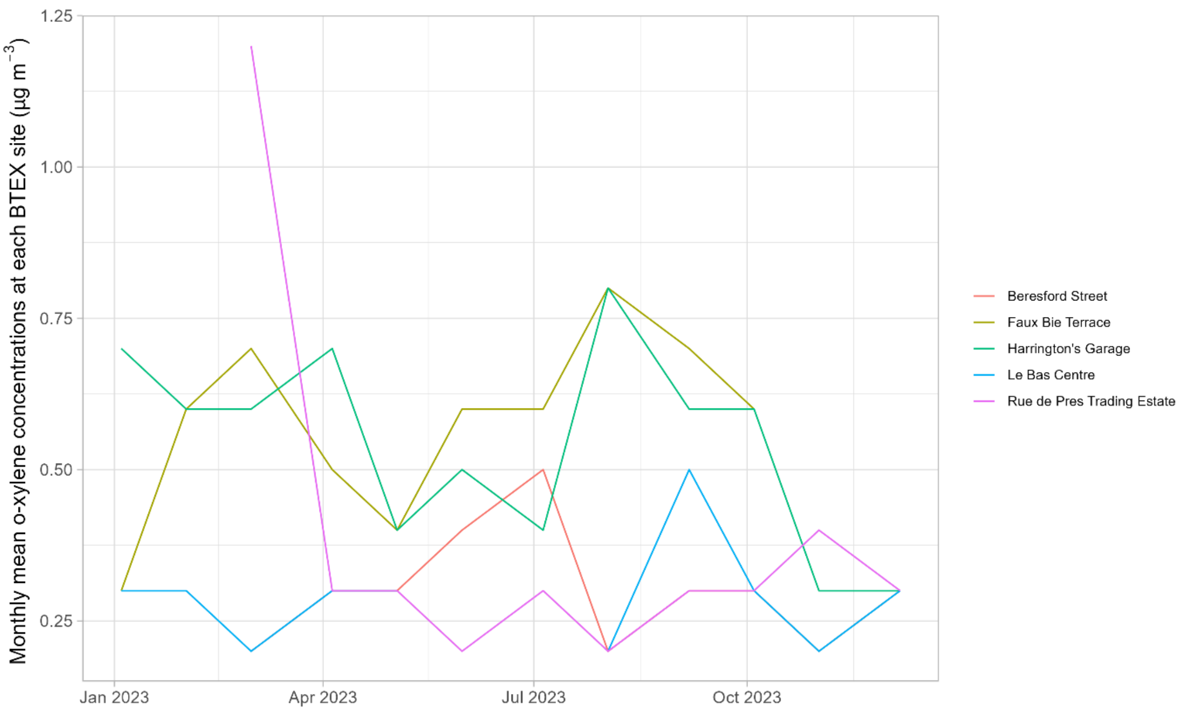


Figure 39: Monthly mean o-xylene concentrations at each BTEX site in µg m-3



5.12.3 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 [32] 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 2023 and have done so since 1999 (or since they started operation).

The UK Air Quality Strategy [33] 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 mandatory in Jersey at present.

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 5 µg m^{-3} and 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).

5.12.4 Comparison with Previous Years' Hydrocarbons Results

Figure 40 to Figure 44 show how the annual mean hydrocarbon concentrations at the five Jersey sites have changed over the years of monitoring. Historic sites are also included for comparison and include Airport Fence, Hansford Lane and Central Market. 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.

When compared to 2022, the majority of sites showed a decreased in BTEX concentrations, although some sites showed a small increase or no change. The increase in concentrations at some monitoring locations could be contributed by easing of COVID-19 Pandemic restrictions allowing increased activity on the island in 2023, particularly more use of fuel filling stations. It is however important to note that annual concentrations of all pollutants measured by the BTEX tubes remain low, below the limit value for benzene and occupational exposure limits for other pollutants.

At Faux Bie Terrace 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, all hydrocarbon pollutants have shown a general decreasing trend.

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[32] World Health Organisation, 2005. *WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide* https://www.who.int/publications/i/item/9789240034228 (Accessed 27th March 2024)

[33] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 27th March 2024)

Figure 40: Time series of annual mean benzene concentrations in µg m-3

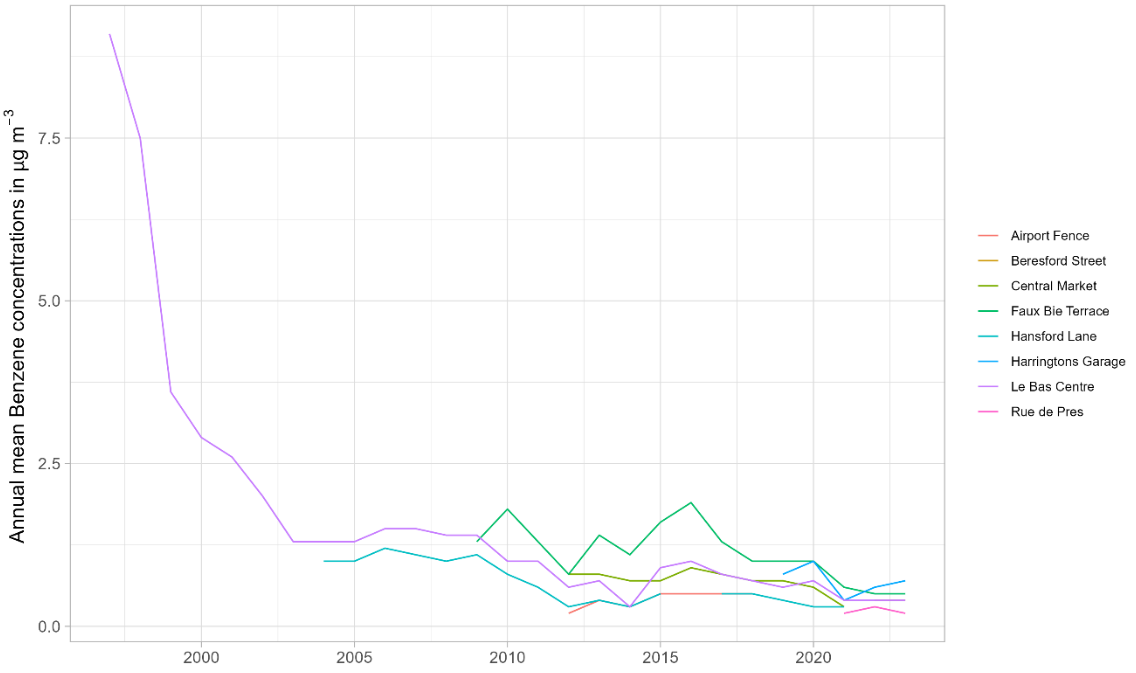


Figure 40 shows the annual mean benzene concentrations. All sites are shown to be well below the EU limit value is 5 µg m^{-3}. The maximum permitted benzene content of petrol sold in the UK reduced from 2% in unleaded (5% in super unleaded), to 1% as of 1st January 2000. This is highlighted by the marked decrease in benzene concentrations measured at Le Bas Centre between 1997, when operation of the site began, and 2000. This site has shown a further modest decrease between 2009 and 2012, as has Hansford Lane. Annual mean concentrations at all sites were shown to be equal to or lower than 0.7 µg m^{-3} in 2023 and have remained similar to concentrations measured in 2022.

Figure 41: Time series of annual mean toluene concentrations in µg m-3

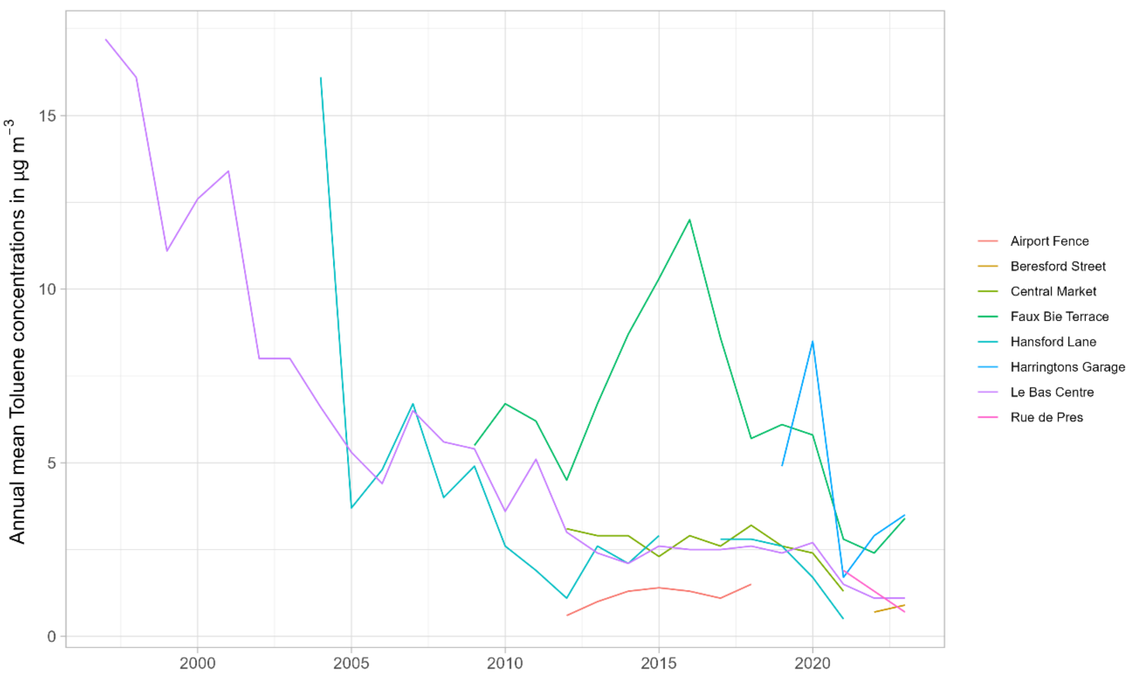


Figure 41 shows toluene concentrations. The ambient concentration equivalent to the typical LoD for toluene is 0.11 µg m^{-3}. Le Bas Centre and Hansford Lane (closed from 2021) are the two longest-running sites and have shown a general decreasing trend over the past twelve years, though these are not consistent. Since 2012, yearly averages at all sites have been relatively stable except for concentrations at the Faux Bie site which showed increases year on year between 2012 and 2016. Concentrations then decreased considerably after filling station upgrades in 2016 and 2017. Faux Bie now presents similar concentrations to the Harrington’s Garage site, both of which are located near to fuel filling stations. Beresford Street Market, Harrington’s Garage and Faux Bie terrace all show a small increase, less than 1 µg m^{-3}, when compared to 2022. Rue de Pres has shown a steady decrease in annual mean toluene concentrations since monitoring began at this location.

Figure 42: Time series of annual mean ethylbenzene concentrations in µg m-3

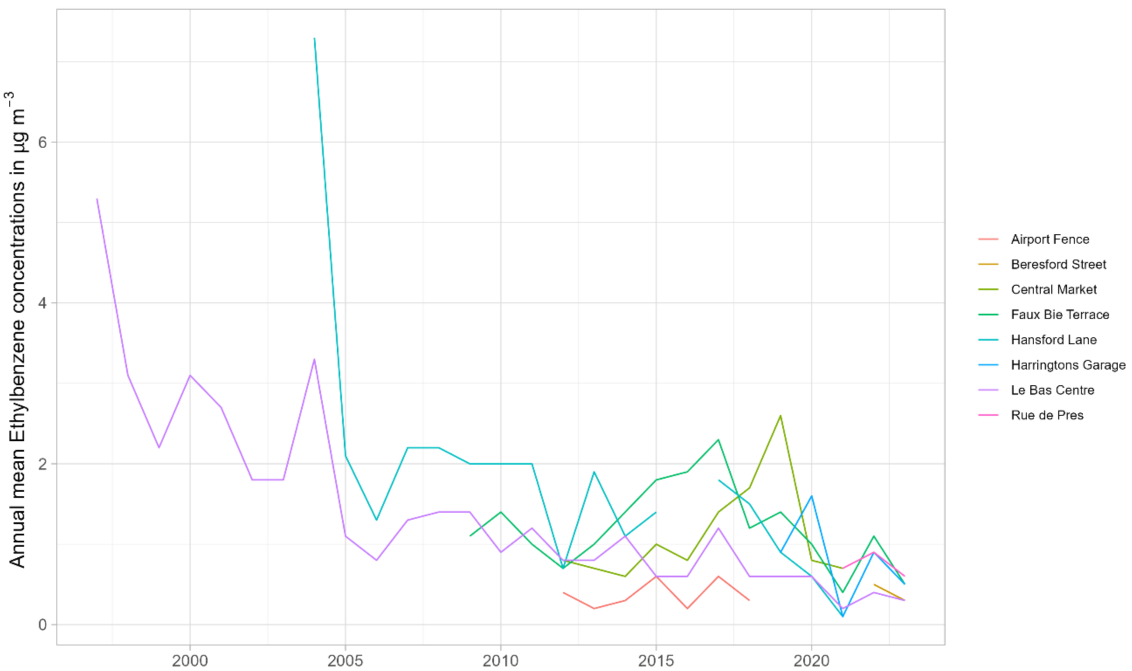
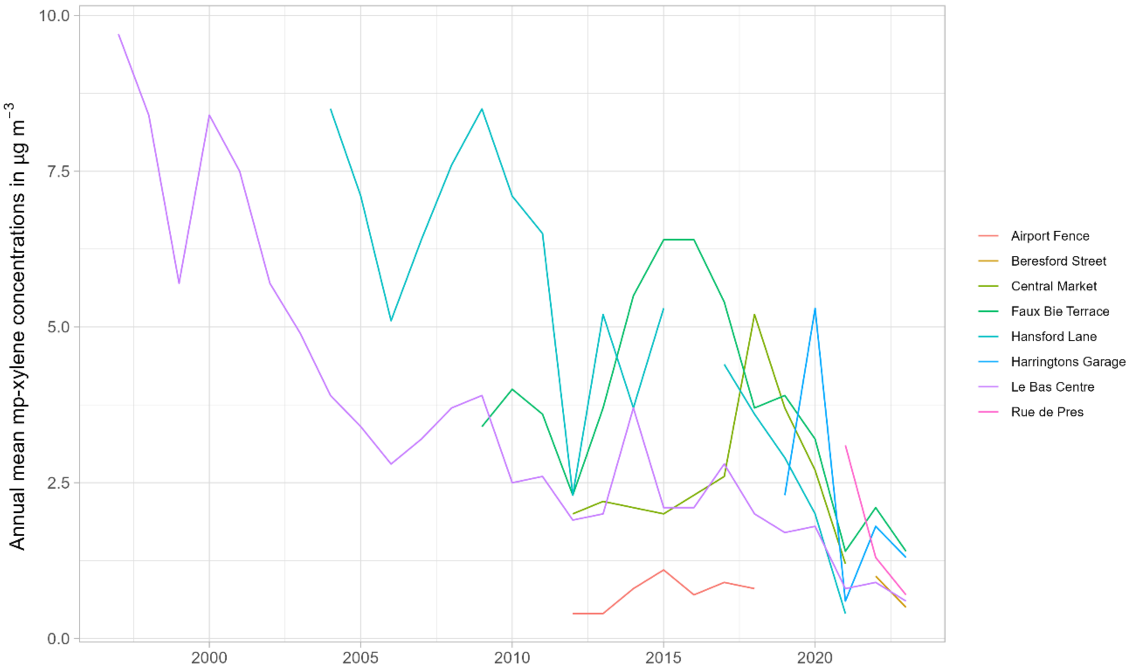


Figure 42 illustrates that ethylbenzene concentrations were shown to decrease at all sites in 2023 compared to 2022 where all sites had previously shown an increase in concentrations. Annual mean ethylbenzene concentrations were shown to decrease most significantly at Faux Bie Terrace, from 1.1 µg m^{-3} in 2022 to 0.5 µg m^{-3} in 2023. Overall, there is a general decreasing trend in ethylbenzene concentrations at long-running sites but a longer time period is required to assess trends in concentrations at newer sites such as Beresford Street and Faux Bie Terrace to establish a trend that isn’t influenced by short term events or meteorological conditions.

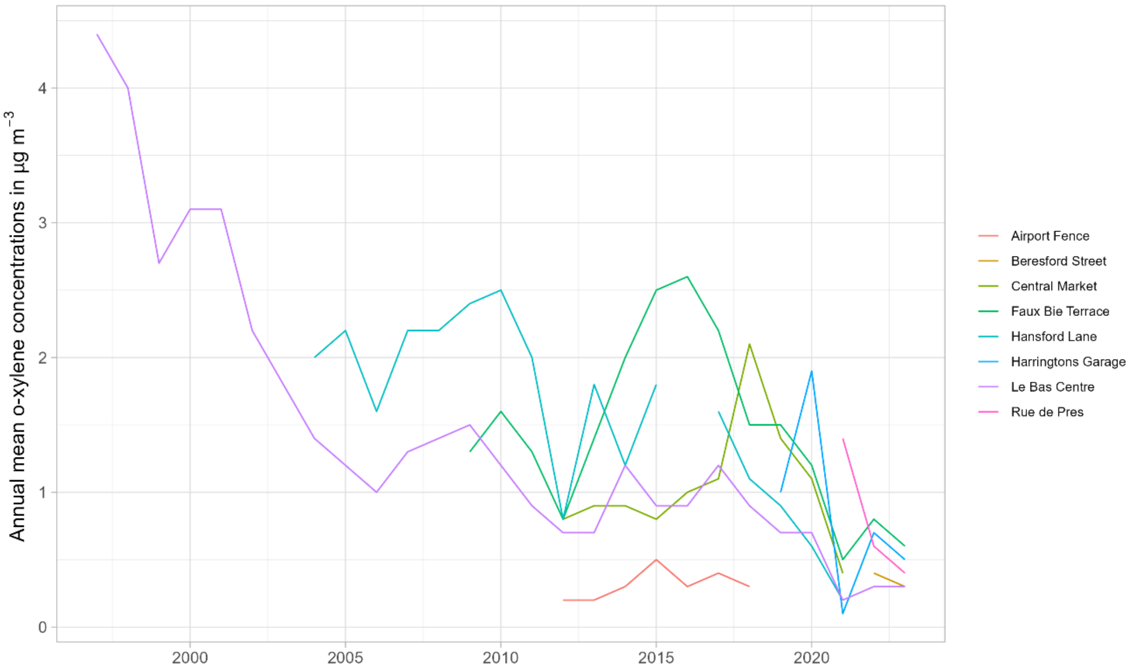
Figure 43: Time series of annual mean mp-xylene concentrations in µg m-3



Concentrations of xylenes (Figure 43 and Figure 44) have generally decreased since monitoring began except for Faux Bie which saw a steady increase between 2012 and 2016. Concentrations have since decreased following filling station upgrades in 2016 and 2017. Concentrations of mp-xylene and of o-xylene at Hansford Lane have fluctuated considerably from year to year. However, since 2019, overall xylene concentrations and other BTEX species have shown a large drop since the closure of the paint spraying business. In 2023, mp-xylene and o-xylene concentrations were shown to remain similar to those measured in 2022 or show a decrease at all sites. Further detailed analysis of annual concentrations at Rue de Pres and Beresford Street Market 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, which were typically around 0.21 µg m^{-3} for benzene, 0.22 µg m^{-3} for toluene and 0.27 µg m^{-3} for the other hydrocarbons, in 2023.

Figure 44: Time series of annual mean o-xylene concentrations in µg m-3



Concentrations of xylenes (Figure 43 and Figure 44) have generally decreased since monitoring began except for Faux Bie which saw a steady increase between 2012 and 2016. Concentrations have since decreased following filling station upgrades in 2016 and 2017. Concentrations of mp-xylene and of o-xylene at Hansford Lane have fluctuated considerably from year to year. However, since 2019, overall xylene concentrations and other BTEX species have shown a large drop since the closure of the paint spraying business. In 2023, mp-xylene and o-xylene concentrations were shown to remain similar to those measured in 2022 or show a decrease at all sites. Further detailed analysis of annual concentrations at Rue de Pres and Beresford Street Market 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, which were typically around 0.21 µg m^{-3} for benzene, 0.22 µg m^{-3} for toluene and 0.27 µg m^{-3} for the other hydrocarbons, in 2023.

6. CONCLUSIONS AND RECOMMENDATIONS

Ricardo Energy & Environment has continued the ongoing air quality monitoring programme in Jersey during 2023, on behalf of the Government of Jersey. This was the 26th year of monitoring. Oxides of nitrogen were monitored at one automatic monitoring station which changed location in November 2021 from a roadside position at the Central Market, Halkett Place in St Helier to a roadside position at the Central Market, Beresford Street, St Helier. Diffusion tubes were also co-located (in triplicate) with the automatic site at this location. This was supplemented by diffusion tubes for indicative monitoring of NO_2 at an additional 24 sites around the island.

Particulate matter was monitored by two Osiris monitors at Central Market Osiris and Howard Davis Park Osiris.

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.

6.1 NO_2 RESULTS

1. The period mean NO_2 concentration measured by the automatic analyser at Beresford Street Market was 16 µg m^{-3} (rounded to the nearest integer). This site recorded 97.6% data capture for the 2023 calendar year, above the limit required to report an annual mean. This is therefore 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 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 the Beresford Street Market automatic site, the highest hourly value measured was 105.5 µg m^{-3}. Therefore, this site met the limit value objective.
3. NO_2 diffusion tubes exposed in triplicate alongside the automatic analyser at Beresford Street Market measured a 20 µg m^{-3} annual mean.
4. Annual mean NO_2 concentrations at all diffusion tube monitoring sites were within the EC limit value of 40 µg m^{-3}.
5. The updated WHO guidelines introduced in 2021 advise an annual mean limit for NO_2 of 10 µg m^{-3}. Beresford Street Market would not meet this guideline during 2023.
6. Seven diffusion tube monitoring locations measured annual mean NO_2 concentrations lower than the 2021 WHO annual mean NO_2 guideline of 10 µg m^{-3}
7. NO_2 concentrations at Beresford Street Market were shown to be lower in 2023 compared to 2022. 2023 is the second full calendar year of monitoring at Beresford Street Market, therefore it is difficult to make direct comparisons between this site and others. Jersey is also continuing its recovery from the COVID-19 Pandemic, therefore making comparisons between previous years difficult. It is recommended that monitoring is continued at Beresford Street Market for further years to enable these comparisons.
8. Seasonal variations in monthly mean NO_2 concentrations at the diffusion tube sites are generally shown to be highest in February and March whilst lower concentrations were seen between July and August.
9. The diurnal variation in NO_2 concentrations at Beresford Street Market showed a similar pattern to an urban site. The expected morning peak is particularly early and sharp, followed by a broad evening peak at rush hour. This is likely a result of traffic patterns around the site, particularly traffic associated with market operations, such as market traders and delivery vehicles.
10. Annual mean NO_2 concentrations at Jersey's urban sites have shown a general decreasing trend between 2023 and 2012. Since then, concentrations have been shown to remain largely stable at the majority of sites.
11. Annual mean NO_2 concentrations at all of Jersey's diffusion tube monitoring sites were generally similar in 2023 compared with 2022, with . 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.

6.2 PM_{10} AND $PM_{2.5}$ RESULTS

1. The period mean PM_{10} concentration measured at Central Market Osiris and Howard Davis Park Osiris were 27 µg m^{-3} and 21 µg m^{-3} respectively (rounded to the nearest integer). Central Market Osiris recorded a data capture of 60.3% and Howard Davis Park Osiris recorded 66.3% data capture. This is below the recommended 90% data capture required to report an annual mean and compare to limit values and objectives.
2. The diurnal variation in PM_{10} and $PM_{2.5}$ concentrations at Central Market Osiris show a broad morning peak followed by a smaller peak in the evening. This pattern is likely attributed to traffic

patterns around the site, particularly those associated with market operations as well as general public use.

3. The diurnal variation in PM_{10} and $PM_{2.5}$ concentrations at Howard Davis Park Osiris shows concentrations are lower at this site compared to Central Market Osiris, likely due to the location of the site in the centre of the park. There is shown to be a broad morning peak followed by a smaller peak in the evening to which rush hour traffic is a contributing factor.
4. Investigation of particulate matter concentrations with wind speed and wind direction show that elevated concentrations of PM_{10} and $PM_{2.5}$ primarily occurred under unsettled conditions, particularly high wind speeds from the southwest, in the direction of the port and marinas.
5. Back trajectories from the top ten most polluted days for PM_{10} and $PM_{2.5}$ indicate that elevated concentrations were predominantly associated with wind directions from the west. This shows that elevated concentrations are not likely associated with long range transport of polluted air masses from the continent.

6.3 HYDROCARBON DIFFUSION TUBE RESULTS

1. Annual mean benzene concentrations at all five sites 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. All sites measured relatively low annual mean concentrations of each pollutant. However, Harrington's Garage and Faux Bie Terrace showed slightly higher average measurements than the other three sites for benzene and toluene, possibly as a result of their proximity to fuel filling stations. Rue de Pres Trading Estate recorded the highest average concentrations for ethylbenzene and Faux Bie Terrace recorded the highest annual mean mp-xylene and o-xylene concentrations.
3. Annual mean concentrations of benzene were shown to be similar or lower than those measured in 2022 at all sites expect Harrington's Garage, which showed a small increase in concentrations. Toluene concentrations at three monitoring sites were similar or lower than those measured in 2022, however toluene concentrations at Harrington's Garage and Faux Bie Terrace both showed small increases compared to 2022.
4. Annual mean concentrations of ethylbenzene, mp-xylene and o-xylene were shown to decrease at all BTEX monitoring sites in 2023 when compared to those measured in 2022.

6.4 RECOMMENDATIONS

It is recommended that the monitoring programme be continued as part of Jersey's Air Quality Strategy and that quality assurance and quality control (QAQC) practices are continued for all analysers including the Osiris monitors located at Central Market and Howard Davis Park.

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. As BTEX concentrations at the current monitoring sites have remained low for numerous years, a review of the current VOC network is recommended to identify any sites which may be suitable for relocation to new monitoring locations. Locating a BTEX tube close to the La Collette Terminal is recommended to monitor BTEX concentrations that may be associated with the fuel farm. To further reduce VOC emissions from petrol stations and Jersey's fuel farm it is recommended that the States of Jersey consider developing vapour recovery legislation.

Continual 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 results outlined in this report indicate that no sites have breached the annual average NO_2 limit values. As such, an expansion of the automatic NO_x monitoring network is not required, although it is recommended that monitoring continues at the Beresford Street Market urban roadside location. Monitoring at Beresford Street allows better comparison between the other roadside and kerbside diffusion tube sites and enables an appropriate co-location for diffusion tubes used for annual BIAS adjustment. It also ensures that Jersey's monitoring network aligns with the strategy stated in LAQM.TG(22) whereby monitoring sites are "sufficiently close to the dominant pollution source (i.e. in the vast majority of cases, at roadside sites)"[34]. If the Government of Jersey would like to expand the network, monitoring at a background site would be beneficial to "determine long-term trends, as such sites are less likely to be affected by variations in local sources, for example, changes in traffic on a particular road" [35].

Continuation of quality assurance and quality control (QAQC) practices for measured data from the Osiris monitors is recommended

Based on the 2019 UK Clean Air Strategy [36] 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 Jersey Air Quality Strategy was last published in 2013, now would be a good opportunity to review and potentially update the document. Ricardo understands that with a recent restructure during 2021, with Air Quality monitoring moving to a dedicated scientific team, and Government Plan funding allocation, the Government of Jersey have moved to prioritise the development of the existing Air Quality monitoring programme to meet new and existing environmental challenges.

7. APPENDIX I - AIR QUALITY OBJECTIVES

Table 20: UK air quality objectives for protection of human health, July 2007

Pollutant	Metric	Type	Legal value
NO2	1-hr	LV	200 µg m-3 (18 allowed)
NO2	Annual mean	LV	40 µg m-3
PM10	24-hr	LV	50 µg m-3 (35 allowed)
PM10	Annual mean	LV	40 µg m-3
PM2.5	Annual mean	LV (stage 1)	25 µg m-3
PM2.5	Annual mean	LV (stage 2)	20 µg m-3
SO2	1-hr	LV	350 µg m-3 (24 allowed)
SO2	24-hr	LV	125 µg m-3 (3 allowed)
CO	8-hr mean	LV	10 mg m-3
Ozone	Maximum daily running 8-hour mean	LV	100 µg m-3 (10 allowed)
Ozone	Maximum daily running 8-hour mean	LTO	120 µg m-3

[34] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 27th March 2024)

[35] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 27th March 2024)

[36] Department for Environment, Food; Rural Affairs, 2019. *Clean Air Strategy.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (Accessed 27th March 2024)

Pollutant	Metric	Type	Legal value
Benzene	Annual mean	LV	5.0 µg m-3
Benzo[a]pyrene	Annual mean	TV	1.0 ng m-3
Arsenic	Annual mean	TV	6.0 ng m-3
Cadmium	Annual mean	TV	5.0 ng m-3
Nickel	Annual mean	TV	20.0 ng m-3
Lead	Annual mean	LV	0.5 µg m-3

Table 21: Air pollution bandings and descriptions

Banding	Index	Accompanying health messages for at-risk individuals*	Accompanying health messages for the general population
Low	1,2,3	Enjoy your usual outdoor activities.	Enjoy your usual outdoor activities.
Moderate	4,5,6	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.	Enjoy your usual outdoor activities.
High	7,8,9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

Table 22: Air pollution bandings and descriptions

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	PM2.5 Particles (EU Reference Equivalent)	PM10 Particles (EU Reference Equivalent)
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour mean	
		ugm-3				
Low	1	0-33	0-67	0-88	0-11	0-16
Low	2	34-66	68-134	89-177	45261	17-33
Low	3	67-100	135-200	178-266	24-35	34-50

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	PM2.5 Particles (EU Reference Equivalent)	PM10 Particles (EU Reference Equivalent)
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour mean	
		ugm-3				
Moderate	4	101-120	201-267	267-354	36-41	51-58
Moderate	5	121-140	268-334	355-443	42-47	59-66
Moderate	6	141-160	335-400	444-532	48-53	67-75
High	7	161-187	401-467	533-710	54-58	76-83
High	8	188-213	468-534	711-887	59-64	84-91
High	9	214-240	535-600	888-1064	65-70	92-100
Very High	10	241 or more	601 or more	1065 or more	71 or more	101 or more

8. APPENDIX II - MONITORING APPARATUS AND TECHNIQUES

The analyser at Beresford Street Market is calibrated monthly by officers from the Natural Environment Department. 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. 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. Osiris monitors are sent away annually to the UK for calibration, service and testing at the manufacturer workshop. At the time of the annual QA/QC visit in July, both Osiris monitors were away for calibration and therefore it was not possible to perform further independent QA/QC flow test.