Air quality monitoring in Jersey 2013

Report for States of Jersey

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Contact:

Nick Rand
Ricardo-AEA Ltd
Gemini Building, Harwell, Didcot, OX11 0QR
t: 01235 753484
e: nick.rand@ricardo-aea.com
Ricardo-AEA is certificated to ISO9001 and ISO14001

Author:

Alison Loader

Approved By:

Nick Rand

Date:

18 March 2014

Signed:

Ricardo-AEA reference:

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Executive summary

This report presents the results for 2013 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo-AEA on behalf of the Environmental Health Department of the States of Jersey.

An automatic monitoring station for nitrogen dioxide (NO_2) was located in the Central Market, Halkett Place, St Helier. In addition, non-automatic diffusion tube samplers were used for indicative monitoring of nitrogen dioxide (NO_2) at 12 sites, and a suite of four hydrocarbons (benzene, toluene, ethylbenzene and xylenes) at a further five sites. 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 2013 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

NO_2 and hydrocarbon diffusion tubes were exposed for twelve periods approximating to calendar months. The tubes were supplied and analysed by Gradko International Ltd, and changed by Technical Officers of Jersey's Environmental Health Section.

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

Annual mean concentrations of NO_2 at all twelve diffusion tube monitoring sites were within the EC Directive limit value. Annual means were generally comparable with the previous year’s results. Most sites showed a slight increase compared with concentrations measured in 2012, but this should be viewed in the context that most sites have shown overall decreases since monitoring began.

The diurnal pattern in concentrations of oxides of nitrogen at Halkett Place was similar to that observed in previous years. It showed a clear peak in the early morning (07:00 to 08:00), and very little afternoon rush-hour peak. This is thought to reflect the early morning activity of market retailers arriving to set up for the day, and of daily refuse collections.

All six hydrocarbon monitoring sites met the EC Directive limit value for benzene (5 $\mu g\ m^{-3}$ as an annual mean, to be achieved by 2010). The site at Faux Bie Terrace measured the highest annual mean benzene concentration, of 1.4 $\mu g\ m^{-3}$. Faux Bie Terrace represents the nearest relevant public exposure to a petrol station.

Hydrocarbon concentrations at most sites have decreased since monitoring started.

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Appendices

1 Introduction

1.1 Background

This report describes a programme of air quality monitoring undertaken by Ricardo-AEA, on behalf of the States of Jersey Public Health Services, on the island of Jersey in 2013. This is the seventeenth consecutive year in which an annual monitoring programme has been carried out: the first was undertaken in 1997. This ongoing monitoring programme has provided a long-term dataset of pollutant concentrations.

The pollutants measured were nitrogen dioxide (NO_2), and a range of hydrocarbon species (benzene, toluene, ethylbenzene and three xylene compounds). NO_2 was measured by an automatic monitor situated at Halkett Place, St Helier. This was supplemented by indicative monitoring of NO_2 at a total of 12 locations on the island (including Halkett Place), using low cost passive samplers (Palmes type diffusion tubes). The suite of hydrocarbon species was monitored using “BTEX” diffusion tubes at five sites.

This report presents the results obtained in the 2013 survey, and compares the data from Jersey with relevant air quality limit values, objectives and guidelines, data from selected UK monitoring stations and previous years' monitoring programmes.

1.2 Objectives

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

2 Details of monitoring programme

2.1 Pollutants monitored

2.1.1 NOx

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. This mixture of oxides of nitrogen is termed NOx. 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 have 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.

2.1.2 Hydrocarbons

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

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

2.1.2.1 Benzene

Of the organic compounds measured in this study, benzene is the one of most concern, as it is a known human carcinogen; long-term exposure can cause leukaemia. It is found in petrol and other liquid fuels, in small concentrations. In urban areas, the major source is vehicle emissions. In the UK, annual mean benzene concentrations in ambient air are typically less than 3 $\mu g\ m^{-3}$. In this report, concentrations of benzene are expressed in micrograms per cubic metre ($\mu g\ m^{-3}$). Some earlier reports in the series used parts per billion (ppb): to convert to ppb, if necessary, the following relationship should be used:

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

2.1.2.2 Toluene

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

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

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

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

2.1.2.3 Ethyl benzene

Again, there are no limits for ambient concentration of ethylbenzene, and although there are occupational limits relating to workplace exposure[2], as discussed in previous reports in this series, they are several orders of magnitude higher than typical outdoor ambient concentrations.

2.1.2.4 Xylene

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

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

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

2.2 Air quality limit values and objectives

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

2.2.1 World Health Organisation

In 2000, the World Health Organisation published revised air quality guidelines[4] for pollutants including NO_2. These were set using currently available scientific evidence on the effects of air pollutants on health and vegetation. The WHO guidelines are advisory only, and do not carry any mandatory status. They are summarised in Appendix 1. There are WHO guidelines for ambient NO_2 concentrations (hourly and annual means), benzene and toluene.

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

2.2.2 European Community

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

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

- 200 µg m^{-3} as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.

- 40 µg m^{-3} as an annual mean, for protection of human health. To have been achieved by 1st January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NOx), of 30 µg m^{-3}, for protection of vegetation (relevant in rural areas only).

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

2.2.3 UK Air Quality Strategy

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

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

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

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

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

2.3 Monitoring methodologies

2.3.1 Automatic methods

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

The chemiluminescent NOx analyser provides a continuous output, proportional to the pollutant concentration. This 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-AEA. Data are downloaded daily and uploaded onto the publicly available website www.jerseymet.gov.je

2.3.2 Diffusive sampling of NO_2 and hydrocarbons

The automatic monitoring site at Halkett Place was supplemented by indicative monitoring, using diffusion tubes, for NO_2 and BTEX hydrocarbons. Diffusion tubes are "passive" samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply.

2.3.2.1 NO_2 diffusion tubes

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

2.3.2.2 BTEX diffusion tubes

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

2.3.2.3 Preparation and analysis

Diffusion tubes were prepared and analysed by Gradko International Ltd. They were supplied to local Technical Officers of Jersey's Public Health Services, who carried out the tube changing. The tubes were supplied in sealed condition prior to exposure. The tubes were exposed at the sites for a set period of time. After exposure, the tubes were again sealed and returned to Gradko for analysis. The year was divided into twelve exposure periods approximating to calendar months. The duration of the exposure periods varied between four and five weeks.

The UK Local Air Quality Management Technical Guidance LAQM.TG(09)[6] states that when using diffusion tubes for indicative NO_2 monitoring, correction should be made where applicable for any systematic bias (ie over-read or under-read compared to the automatic chemiluminescent technique, which is the reference method for NO_2). By co-locating diffusion tubes with the automatic monitoring site at Halkett Place, it was possible to calculate a bias adjustment factor, which could then be applied to the annual mean diffusion tube measurements in this survey. The NO_2 diffusion tube results in this report are uncorrected except where clearly specified. BTEX diffusion tubes are not affected by the same sources of bias as NO_2 diffusion tubes, therefore the BTEX results have not been bias adjusted.

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

Gradko also retained one tube from each batch, in a sealed bag in their premises, as a “laboratory blank”.

The travel blank results for NO_2 were not used to apply any correction to the results from the exposed tubes – only to highlight possible contamination issues. BTEX results were blank corrected using the travel blank, or the laboratory blank where the analyst judged this to be appropriate.

2.3.2.4 Calendar of diffusion tube exposure periods

The calendar of exposure periods used for the NO_2 and BTEX diffusion tubes is shown in Table 2-1. They were intended to approximate to calendar months, while allowing for the tubes to be changed on a consistent day of the week.

Table 2-1: Diffusion tube exposure periods

Month	Start date	End date
January	02/01/2013	31/01/2013
February	31/01/2013	28/02/2013
March	28/02/2013	26/03/2013
April	26/03/2013	24/04/2013
May	24/04/2013	30/05/2013
June	30/05/2013	26/06/2013
July	26/06/2013	30/07/2013
August	30/07/2013	29/08/2013
September	29/08/2013	25/09/2013
October	25/09/2013	30/10/2013
November	30/10/2013	27/11/2013
December	27/11/2013	02/01/2014

2.4 Monitoring sites

Automatic monitoring of oxides of nitrogen was carried out at the Central Market, Halkett Place, in St Helier (Figure 2-1). This site represents a roadside site where levels of NO_2 were expected to be high, and where members of the public are regularly exposed for periods of one hour or more. The inlet funnel (circled) is just visible as a white tube protruding from the building façade above the hanging basket just beyond the yellow shop front. It is at a height of about 4 metres.

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

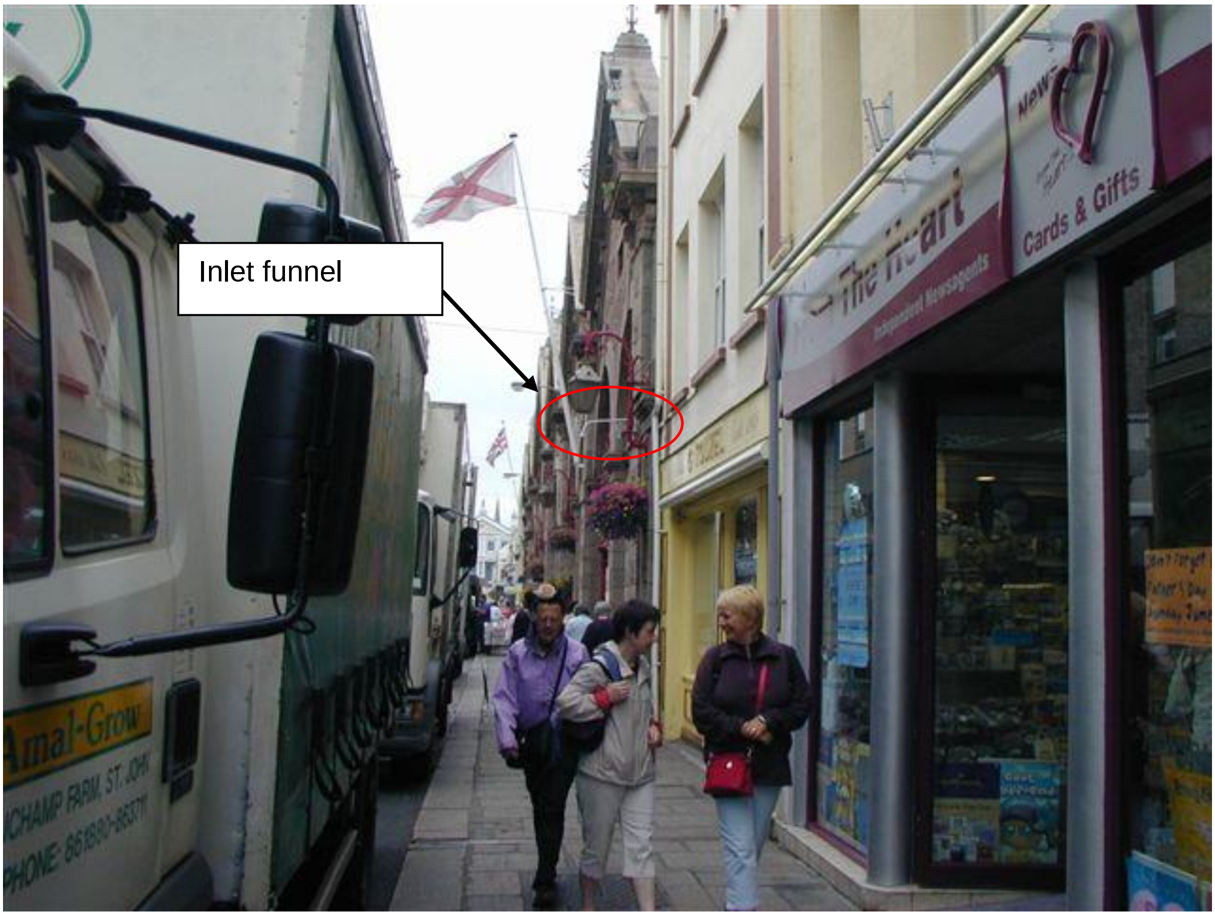


Figure 2-2 shows the chemiluminescent NOx analyser itself, which is located within the building. The analyser is calibrated monthly by the States of Jersey's Environmental Health Team. Details of the calibration procedure are provided in Appendix 2.

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

As explained in section 2.3, diffusion tubes were also used to monitor NO_2 at twelve sites in a range of different environments around Jersey. Table 2-2 lists the NO_2 diffusion tube sites, and Figure 2-3 and Figure 2-4 show their locations.

Table 2-2: NO_2 monitoring sites in Jersey

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

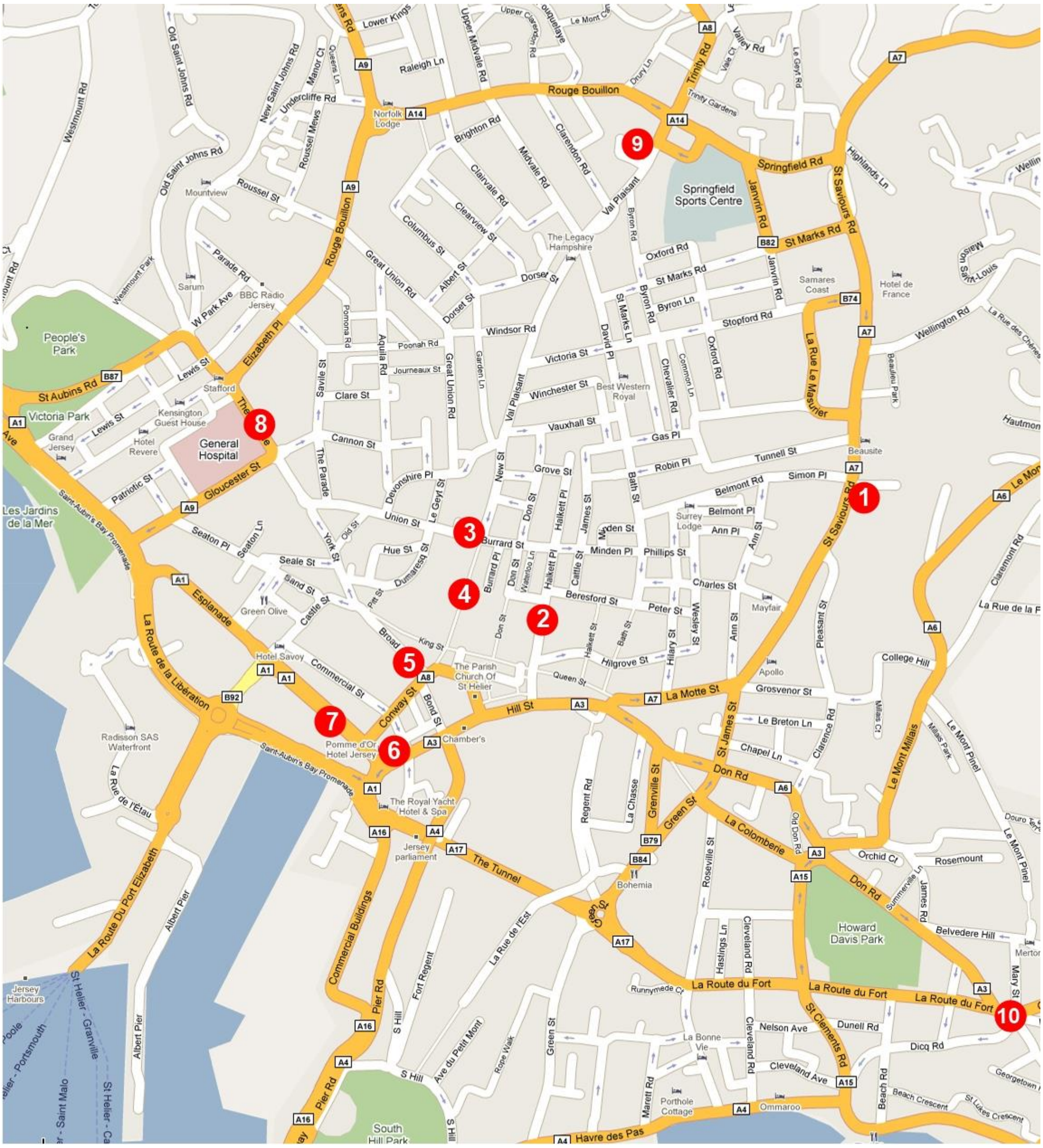
Kerbside: less than 1 m from kerb of a busy road.

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

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

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

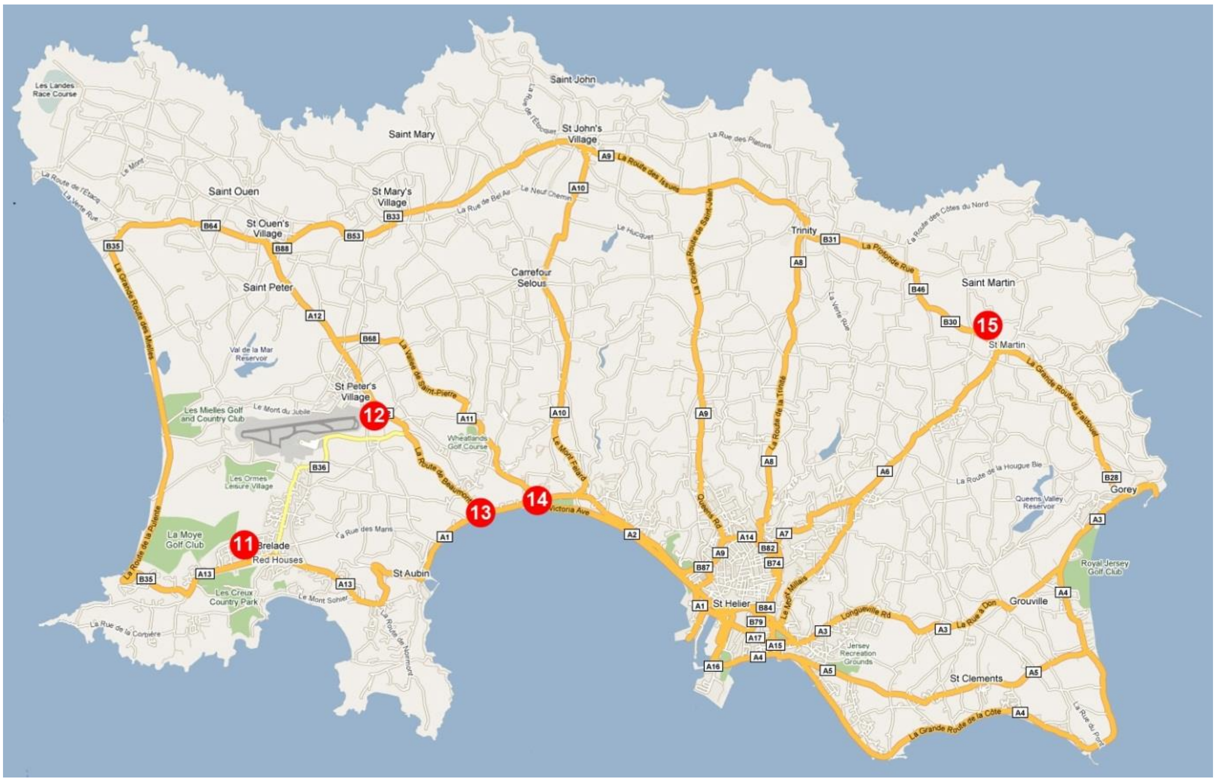
Figure 2-3: Site locations in St Helier town



Key:

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

Figure 2-4: Site locations outside St Helier



Key:

Number	Site name	Pollutants	Number	Site name	Pollutants
11	Les Quennevais	NO_2	14	Hansford Lane	BTEX
12	Airport Fence	BTEX	15	Rue Des Raisies	NO_2
13	Beaumont	NO_2			

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

BTEX hydrocarbons were monitored at five sites during 2013. These sites are shown in Table 2-3. The aim was to investigate sites likely to be affected by different emission sources, and compare these with background sites.

Table 2-3: BTEX diffusion tube monitoring sites

Site name	Grid reference	Description
Le Bas Centre	658 489	Urban background site which has operated since 1997.
Halkett Place	653 486	Urban roadside site which has operated since Sep 2011.
Airport Fence	512 598	Rural background site on the airport perimeter fence, in operation since Mar 2012.
Hansford Lane	633 499	Urban background site near a paint spraying process
Faux Bie	658 495	Urban background site, near fuel filling station. Represents the nearest public exposure to a petrol station.

Le Bas Centre was intended to monitor hydrocarbon concentrations at an urban background location.

Hansford Lane was close to a paint spraying process. This is a potential source of hydrocarbon emissions, especially toluene and xylenes.

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

The Airport Fence site was introduced as a replacement to the original Jersey Airport location, which had to be relocated.

3 Quality assurance and data capture

3.1 Quality assurance and quality control

A full intercalibration audit of the Jersey Halkett Place air quality monitoring site takes place annually. In addition to instrument and calibration standard checking, the air intake sampling system is cleaned and all other aspects of site infrastructure are checked.

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

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

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

3.2 Data capture

Overall data capture statistics for the monitoring site are given in Table 3-2. A data capture rate of 90 % or greater for ratified data is recommended in the Defra Technical Guidance LAQM.TG(09)[6]. The Halkett Place site achieved the data capture target of 90 %, with no major gaps in the data set.

Table 3-2: Jersey Halkett Place - Data capture statistics 2013

Site	NO	NO_2	NOx
Jersey Halkett Place	97.5 %	97.5 %	97.5 %

3.3 Diffusion tube uncertainty and detection limits

Diffusion tubes are an indicative technique, with greater uncertainty than more sophisticated automatic methods. The reported margins of uncertainty on the analysis only were typically ± 5.2 % (occasionally ± 7.8 %) for NO_2 and ± 9.6 % for BTEX hydrocarbons. However, uncertainties arising from the exposure phase also contribute to the overall uncertainty; it is usually estimated that the overall uncertainty on diffusion tube measurements is 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. Typically the detection limit for NO_2 in 2013 was equivalent to an ambient concentration of 0.34 µg m^{-3} assuming an exposure period of 28 days. For hydrocarbons, the limit of detection was 5 ng (total mass on tube). This equated to ambient concentration of around 0.3 µg m^{-3}. **The laboratory advises that results lower than 10 times the limit of detection will have a higher level of uncertainty. In the case of the NO_2 sites, ambient concentrations are well above this threshold. However, for BTEX hydrocarbons at Jersey, this was the case for most measurements with the exception of toluene, and of m+p xylenes at some sites. The BTEX hydrocarbon measurements are therefore likely to have overall uncertainty greater than ± 25 % and should be treated as indicative only**.

4 Results and discussion

4.1 Presentation of results

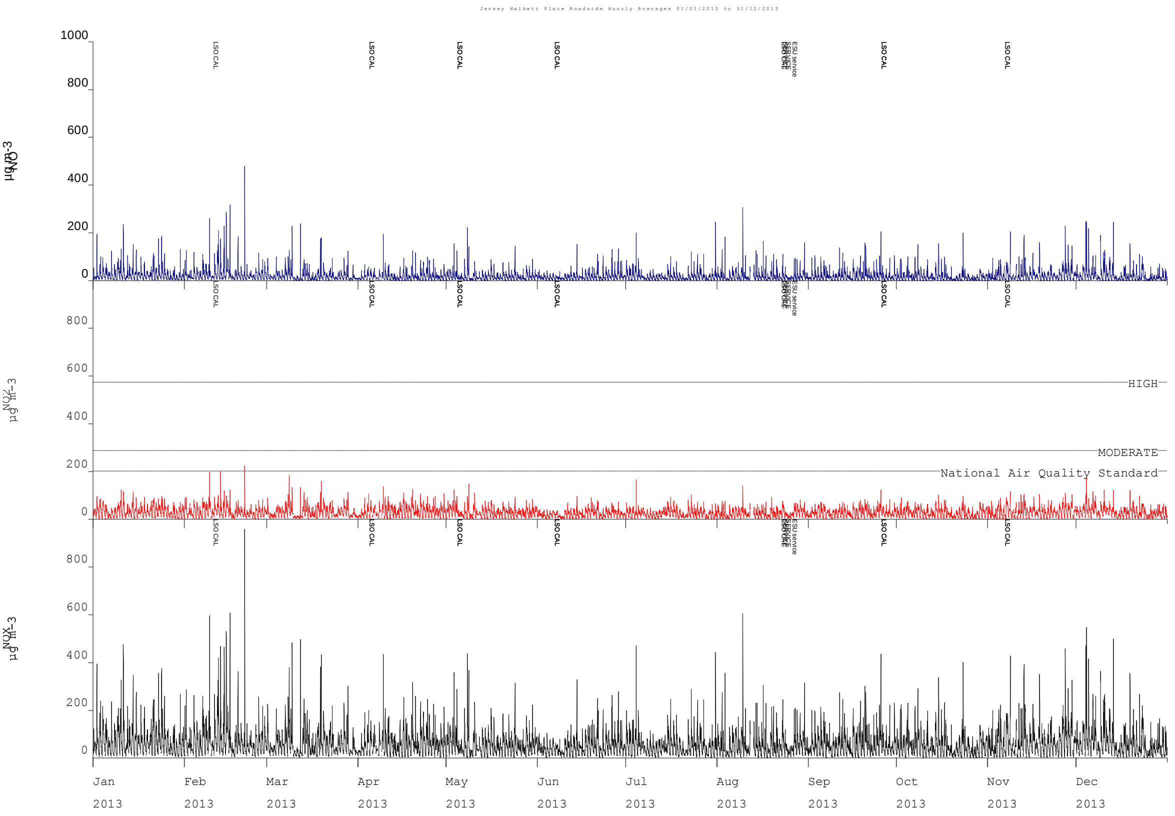
4.1.1 Automatic NO_2 monitoring results

Table 4-1 shows the key statistics for oxides of nitrogen measured by the automatic analyser at Halkett Place. Figure 4-1 shows time series plots of hourly mean NO, NO_2 and NOx concentrations. The purpose of these plots is to illustrate how concentrations of these pollutant species varied on a short-term timescale, and throughout the year. It also illustrates that there were no major gaps in the dataset.

Table 4-1: Oxides of nitrogen at Jersey Halkett Place - air quality statistics for 2013

Pollutant	NO µg m^{-3}	NO_2 µg m^{-3}	NOx µg m^{-3}
Maximum 15-minute mean	836	512	1454
Maximum hourly mean	480	225	959
Maximum running 8-hour mean	154	94	328
Maximum running 24-hour mean	78	61	173
Maximum daily mean	74	58	167
Average	20	29	59
Data capture	97.5 %	97.5 %	97.5 %

Figure 4-1: Time series plots of hourly mean pollutant concentrations at Halkett Place, 2013



4.1.2 NO_2 diffusion tube results

NO_2 diffusion tube results are presented in Table 4-2. Although reported by the analyst to two decimal places, the monthly mean results reported here have been rounded to the nearest integer, in view of the estimated uncertainty of ± 25 % on diffusion tube measurements. There are two exceptions - Les Quennevais and Rue des Raisies – where concentrations are typically less than 10 µg m^{-3}: these sites' results are given to one decimal place.

The July tube at Beaumont went missing; otherwise there was full data capture from all sites.

Individual monthly mean NO_2 results ranged from 5.1 µg m^{-3} (in October at the rural Rue des Raisies site), to 55 µg m^{-3} (in November at the roadside Liberation Station site).

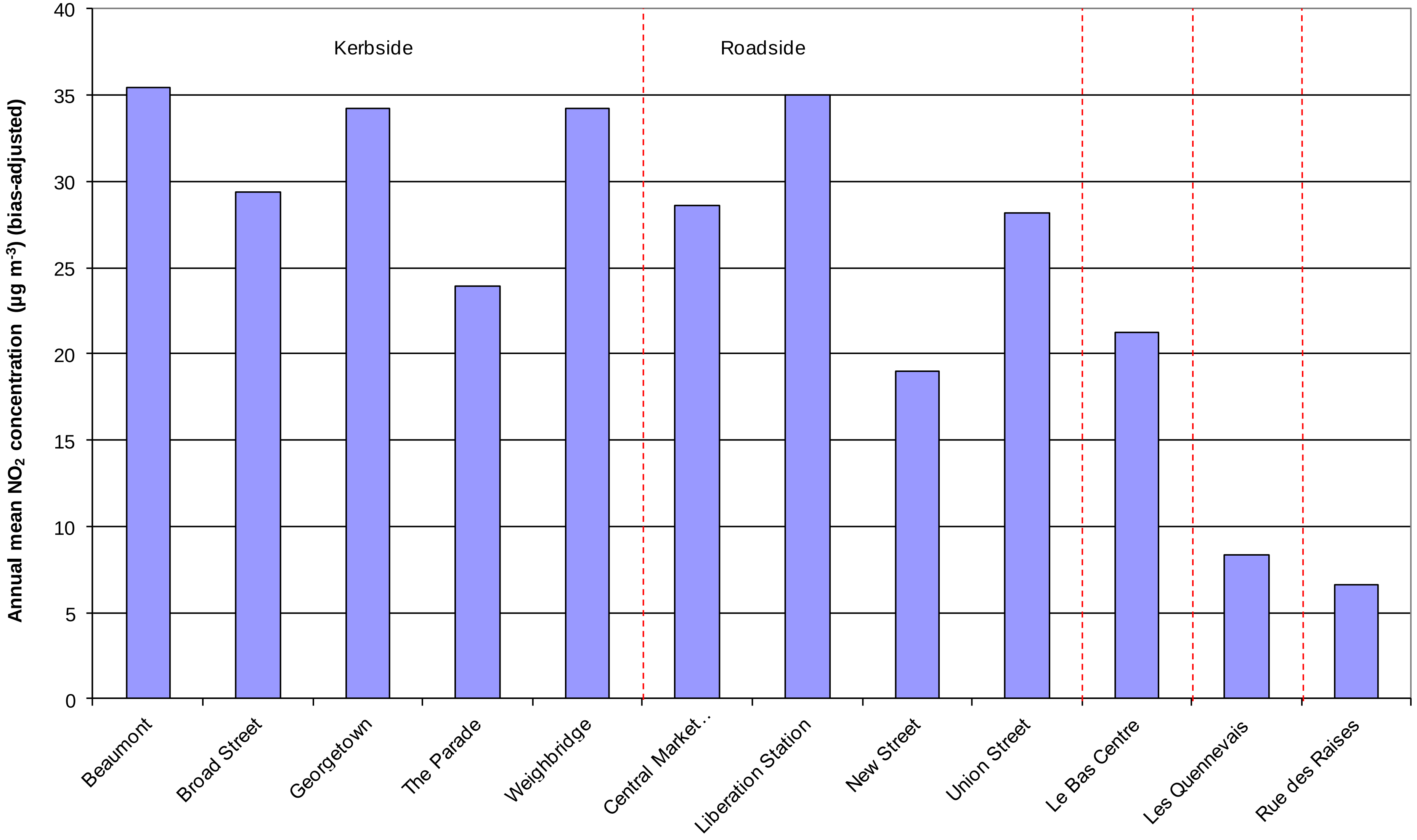
Results from the Halkett Place site (where diffusion tubes are co-located with an automatic analyser) were used to calculate a bias adjustment factor of 1.00 - see Appendix 3. Annual mean NO_2 concentrations (after application of this bias adjustment factor) ranged from 7 µg m^{-3} (at Rue des Raisies) to 35 µg m^{-3} at Beaumont and Liberation Station. (This is the first year in which Liberation Station has produced the highest annual mean).

Table 4-2: NO_2 diffusion tube results 2013, Jersey. Concentrations (rounded) in µg m^{-3}

Site	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Annual mean µg m^{-3}	Annual mean x BAF µg m^{-3}
Beaumont (K)	35	39	37	38	38	no data	38	36	39	31	31	29	35	35
Broad Street (K)	35	27	25	30	26	27	27	31	30	30	30	34	29	29
Georgetown (K)	35	36	34	39	25	30	37	28	40	41	44	21	34	34
The Parade (K)	29	25	26	25	22	21	22	23	24	23	23	24	24	24
Weighbridge (K)	39	33	35	36	30	32	29	32	37	38	33	35	34	34
Halkett Place tube 1	31	32	29	30	25	26	29	29	28	28	28	27	-	-
Halkett Place tube 2	31	35	28	30	26	25	30	28	29	27	28	28	-	-
Halkett Place tube 3	30	31	31	32	25	26	29	27	28	28	27	28	-	-
Halkett Place mean (R)	31	33	29	31	25	26	29	28	28	28	28	27	29	29
Liberation Station (R)	34	34	34	30	30	27	38	35	41	32	55	31	35	35
New Street (R)	26	20	22	18	16	13	18	17	17	19	20	22	19	19
Union Street (R)	36	27	30	31	23	23	25	28	28	28	28	31	28	28
Le Bas Centre (UB)	26	20	24	21	18	17	18	18	20	23	17	33	21	21
Les Quennevais (S)	11.1	11.2	11.2	8.9	6.5	9.2	8.4	5.8	5.7	7.5	6.7	8.5	8.4	8.4
Rue des Raisies (Ru)	8.9	8.3	7.6	6.3	5.7	6.8	7.5	5.6	5.2	5.1	6.0	6.1	6.6	6.6

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

Figure 4-2: Comparison of annual mean NO_2 concentrations at all Jersey sites, 2013 (bias adjusted)



4.1.3 Precision and accuracy of NO_2 diffusion tubes

Diffusion tubes are an indicative monitoring technique. Although they are economical and easy to use, they do not give the same level of precision and accuracy as more expensive automatic monitoring methods. For this reason, as explained in section 2.3 above, the Local Air Quality Management Technical Guidance LAQM.TG(09)[6] states that when using diffusion tubes for indicative NO_2 monitoring, correction should be made where applicable for any systematic bias (i.e. over-read or under-read) compared to the automatic chemiluminescent technique, which is the reference method for NO_2.

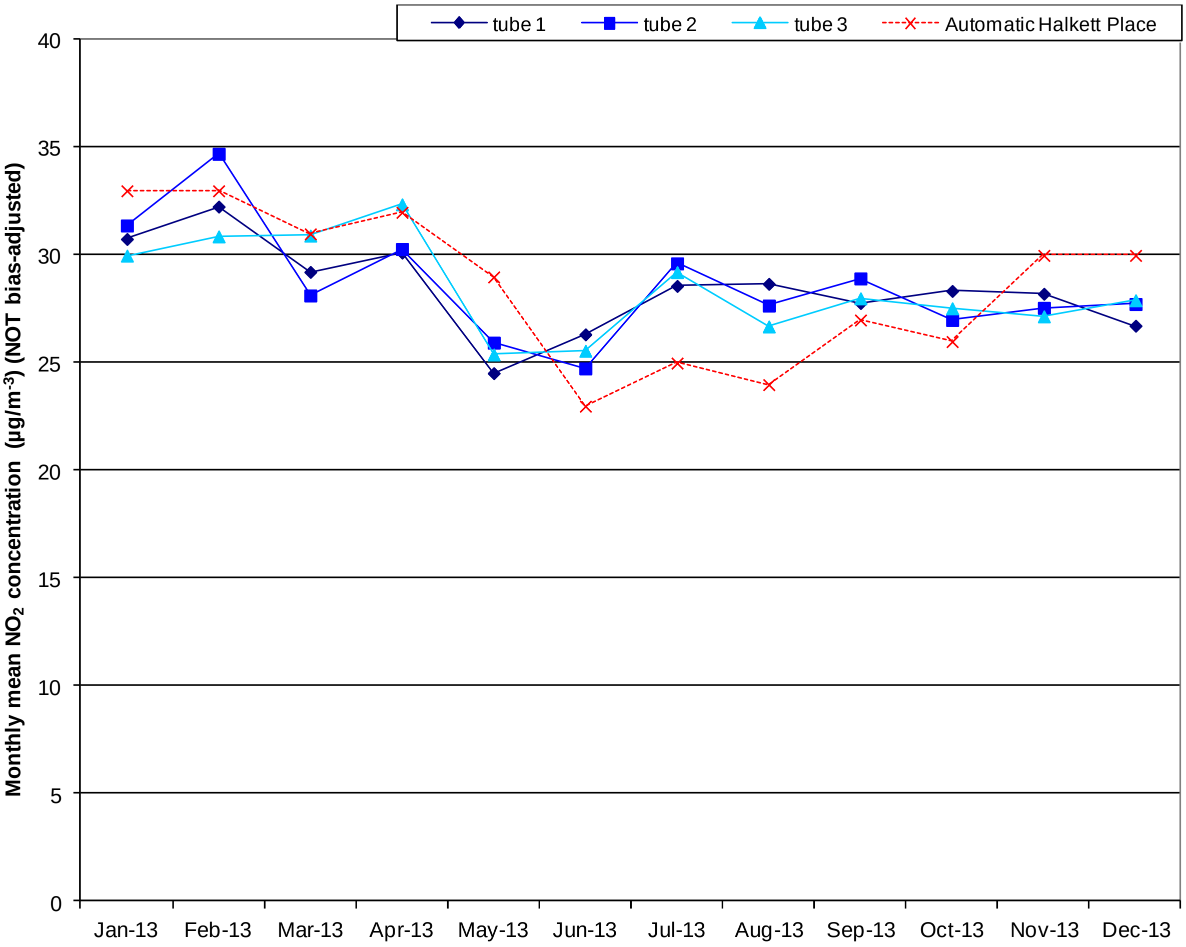
This is usually done by co-locating diffusion tubes with a chemiluminescent analyser and comparing the results of the two methods. The co-location site in this study was Halkett Place. By exposing diffusion tubes in triplicate at this site, it was possible to compare their precision and accuracy with that of the automatic monitor, and to calculate a “bias adjustment factor” which could be applied to the annual mean NO_2 concentrations measured at the other diffusion tube sites, in order to correct for any “bias”.

The mean NO_2 concentration as measured by the diffusion tubes was 29 $\mu g\ m^{-3}$ and by the reference automatic method was 29 $\mu g\ m^{-3}$, i.e. the diffusion tubes were (on average over the year) giving results in agreement with the reference method. The “bias adjustment factor” calculated for the whole year was therefore 1.0. The automatic monitor achieved at least 90 % data capture in each month.

Exposing tubes in triplicate allowed an investigation of diffusion tube precision. Precision may be expressed in terms of the coefficient of variation (CV) of the three replicate measurements. This parameter, also known as the relative standard deviation, is the standard deviation expressed as a percentage of the mean. For diffusion tubes exposed in triplicate, the CV is usually expected to be within 10 % on average. This is based purely on experience of what a competent laboratory is typically able to achieve, although it can be affected by conditions at the site. At Halkett Place, the CV of the monthly tube triplets ranged from 2 % to 6 %, with a mean of 3 %. This is a good result.

Figure 4-3 shows the monthly mean NO_2 concentrations, as measured by diffusion tubes and by the automatic analyser, at Halkett Place. Agreement between the two methods was good.

Figure 4-3: Co-location results at Halkett Place



4.2 Comparison with NO_2 guidelines, limit values and objectives

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

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

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

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

The 1-hour mean at the Halkett Place automatic monitoring site remained below 200 µg m^{-3} throughout 2013. Therefore this site met the EC Directive limit value and AQS objective for this parameter. The annual mean concentration of 29 µg m^{-3} as measured by the automatic analyser at Halkett Place was well within the EC limit value of 40 µg m^{-3}.

Because of 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. Annual mean NO_2 concentrations did not exceed 40 µg m^{-3} at any of the sites in 2013. Therefore, all diffusion tube sites met the limit value for annual mean NO_2 concentration.

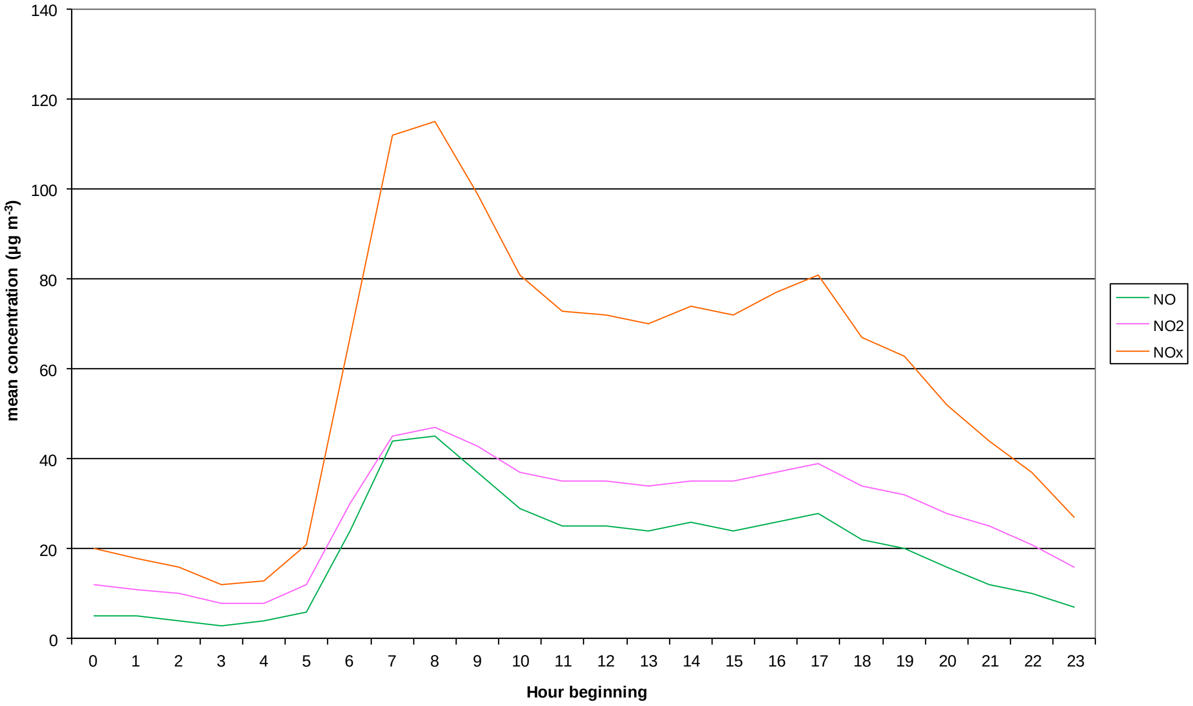
The 30 µg m^{-3} limit for protection of vegetation is only applicable at rural sites, and is therefore only relevant to Rue des Raisies. The annual mean NO_2 concentration of 7 µg m^{-3} at this rural site was well within the limit value.

4.3 Diurnal and seasonal variation in NO_2 concentration

4.3.1 Diurnal variation in NO_2 concentration at Halkett Place

Figure 4-4 shows how concentrations of nitrous oxide (NO), nitrogen dioxide (NO_2) and total oxides of nitrogen (NOx) typically varied over the course of the day during 2013, as measured by the automatic monitor at Halkett Place.

Figure 4-4: Diurnal variation in concentrations of NO, NO_2 and total NOx at Halkett Place, 2013



The curve for NO, which is a primary pollutant (i.e. directly emitted from source) emitted from road vehicles and other combustion sources, shows a sharp morning peak between 07:00 and 08:00. Concentrations then decrease during the late morning, remaining on a “plateau” for the rest of the afternoon, before they begin to fall again at around 17:00. There is barely any afternoon or evening rush hour peak.

For NO_2, which has both primary (directly emitted) and secondary (due to oxidation of NO) components, there is also an early morning peak, decreasing to a plateau through the rest of the morning and afternoon. There is a small peak at the time of the afternoon rush hour, but it is much less pronounced than that observed in the morning.

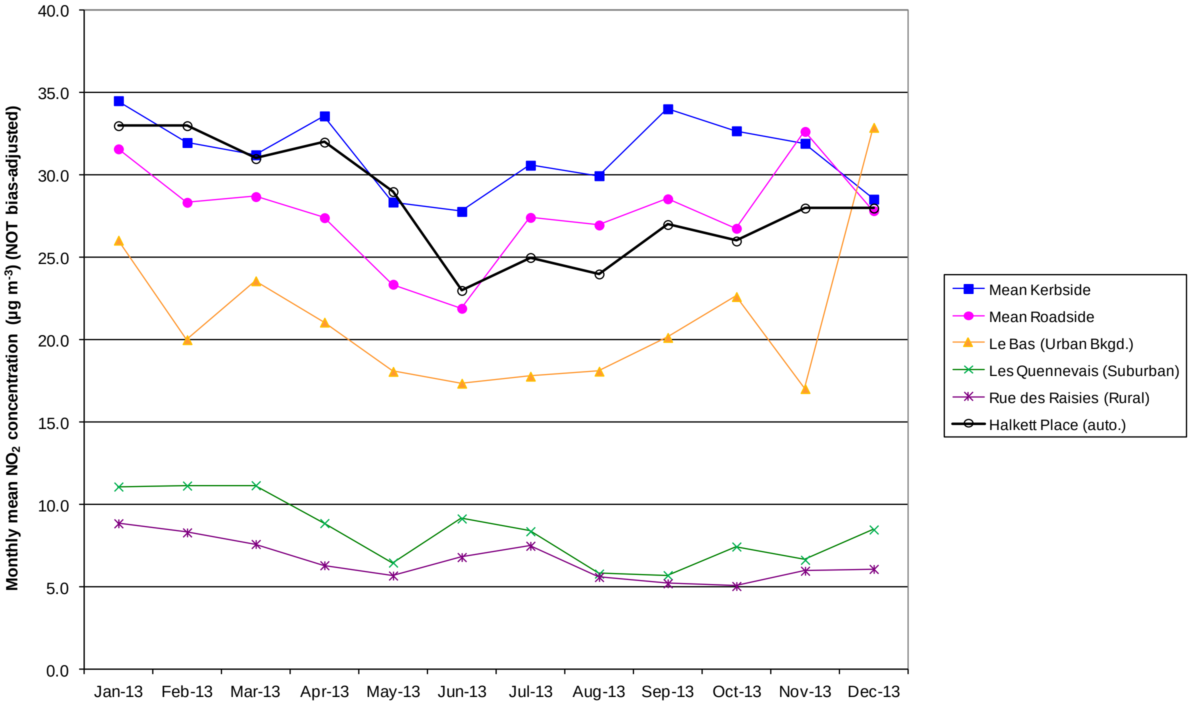
Based on Ricardo-AEA’s experience with data from the Automatic Urban and Rural Network (AURN), the morning peak in NO and NO_2 is typical for urban sites, reflecting the increased levels of these pollutants associated with morning rush hour traffic. However, at Halkett Place it is particularly early and particularly sharp. This may be explained by the fact that there is a market at Halkett Place every day except Sundays. The peak coincides with the time at which the market traders arrive and set up for the day. In addition, a skip lorry arrives at this time to collect the previous day's refuse. It is believed that vehicle emissions from these activities are responsible for the distinctive morning pattern at Halkett Place.

Halkett Place does not exhibit a substantial afternoon or evening rush hour peak (as observed at many roadside AURN sites). This is unusual for an urban site. In the afternoon, concentrations of oxidising agents in the atmosphere (particularly ozone) tend to increase, leading to enhanced oxidation of NO to NO_2. This typically causes the afternoon NO_2 peak at many urban sites to be higher than the morning NO_2 peak. However, this is not the case at Halkett Place. The likely reason is that there is no afternoon traffic rush hour in this area. Most traffic is associated with the market and with shoppers, and occurs during the morning. Afternoons are relatively quiet.

4.3.2 Seasonal variation in NO_2 concentration

Figure 4-5 shows monthly mean NO_2 concentrations measured at the diffusion tube sites and at Halkett Place. This shows the mean of the five kerbside sites, mean of the four roadside sites, and the monthly means measured at the single urban background site (Le Bas Centre), urban residential site (Les Quennevais) and rural site (Rue des Raisies – with the anomalous September result excluded). Monthly means (based on the same periods as the diffusion tube exposures) are also shown for the Halkett Place automatic site.

Figure 4-5: Monthly mean NO_2 concentrations (NOT bias adjusted) at diffusion tube sites and Halkett Place



The typical pattern in UK urban areas is for NO_2 concentrations to be generally higher in the winter and lower in the summer. Historically, the sites in Jersey have not shown this, or indeed any, consistent seasonal pattern. However, in 2013, urban concentrations were slightly higher in the winter months. The highest monthly mean for the kerbside sites was recorded in January, and the equal highest monthly means recorded by the automatic analyser were in January and February.

4.3.3 Comparison with UK NO_2 data

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

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

Table 4-3: Comparison of NO_2 in Jersey with UK automatic sites

Site	2013 Annual mean NO_2 concentration, µg m^{-3}
Brighton Preston Park	17
Exeter Roadside	32
Lullington Heath	8.5
Plymouth Centre	22
Yarner Wood	5.3
Halkett Place (automatic)	29

After bias adjustment, the annual mean NO_2 concentrations measured at the kerbside and roadside sites in Jersey (rounded to the nearest integer) ranged from 19 to 35 µg m^{-3}. The annual means at Exeter Roadside and Plymouth Centre (32 µg m^{-3} and 22 µg m^{-3} respectively) were within this range. The mean concentration measured at Exeter Roadside was higher than the annual mean of 29 µg m^{-3} measured by the automatic analyser at Halkett Place. The Jersey urban background site at Le Bas Centre had a (bias adjusted) annual mean NO_2 concentration of 21 µg m^{-3}, comparable with the annual means from the urban background site at Plymouth Centre. The residential background site at Les Quennevais had a bias-adjusted annual mean NO_2 concentration of 8.3 µg m^{-3}: this is a similar to the rural Lullington Heath site. The bias-adjusted annual mean of 6.5 µg m^{-3} at the Jersey rural background site, Rue des Raisies was lower than that measured at Lullington Heath, but higher than the more remote Yarner Wood site in Devon.

4.3.4 Trends in NO_2 at long-running sites

There are ten sites in the survey which have been in operation since 2005 or earlier and therefore have eight or more years' data. The annual mean NO_2 concentrations are shown in Table 4-4 and illustrated in Figure 4-6. These data are 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 are used in this section.

Annual mean NO_2 concentrations at the kerbside, roadside and urban background sites (Weighbridge, Georgetown, Beaumont, the Parade, Broad Street, and Le Bas) gave cause for concern in the early years of the study (2000 to 2003). Several exceeded the EC Directive limit value of 40 µg m^{-3}, and there was no sign of concentrations decreasing. However, from 2004 onwards, concentrations began to decrease, and all are now within the limit value, after application of the bias adjustment factor.

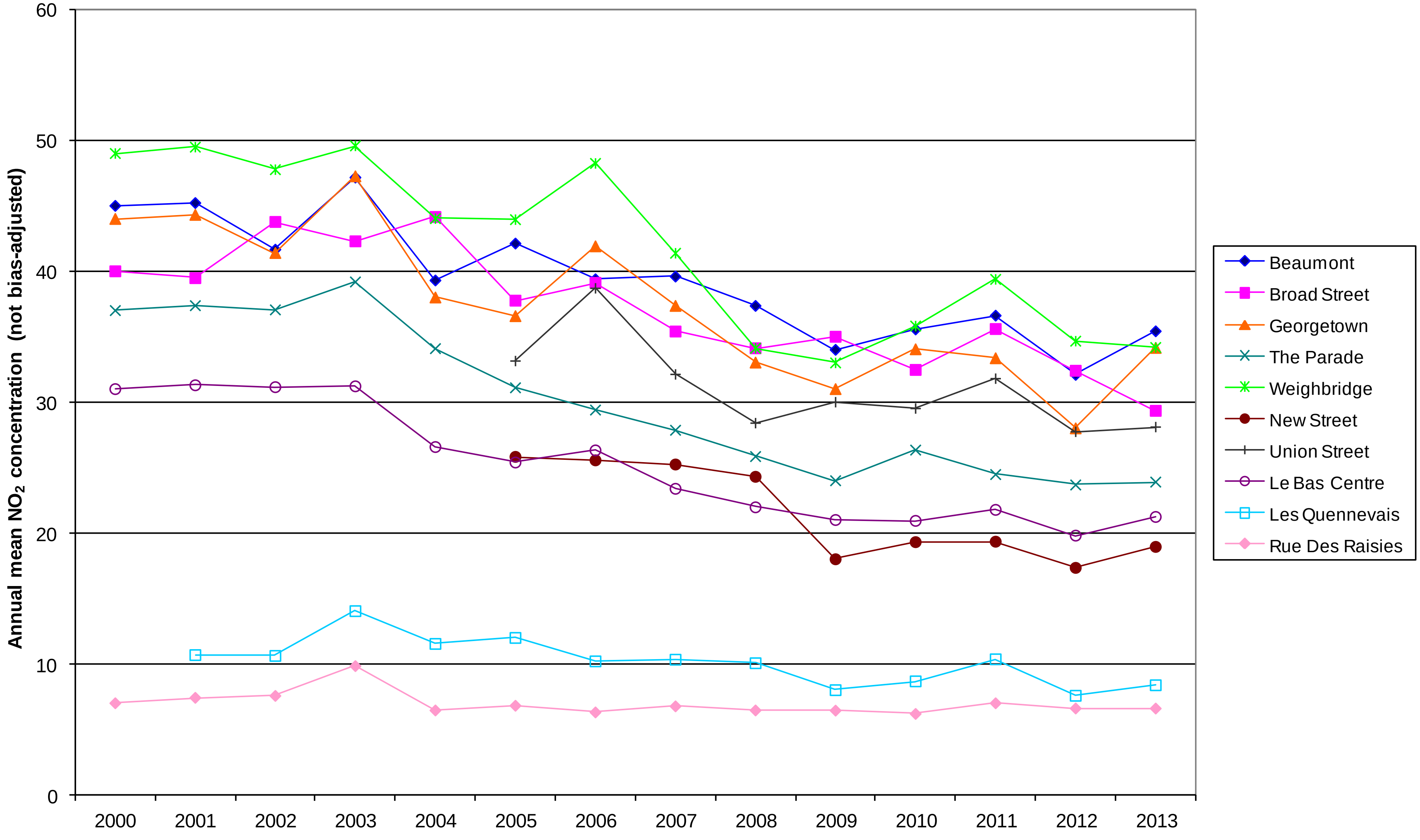
Figure 4-6 illustrates how annual mean concentrations remained stable from 2000 to 2003. This was followed by a period when NO_2 concentrations at the urban sites appeared to show some general decrease (though this was not consistent). NO_2 concentrations typically fluctuate from year to year due to meteorological and other factors.

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

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Beaumont (K)	45	45	42	47	39	42	39	40	37	34	36	37	32	35
Broad Street (K)	40	39	44	42	44	38	39	35	34	35	32	36	32	29
Georgetown (K)	44	44	41	47	38	37	42	37	33	31	34	33	28	34
The Parade (K)	37	37	37	39	34	31	29	28	26	24	26	24	24	24
Weighbridge (K)	49	49	48	50	44	44	48	41	34	33	36	39	35	34
Halkett Place (R)											31	30	27	29
Liberation Station (R)											33	34	30	35
New Street (R)						26	26	25	24	18	19	19	17	19
Union Street (R)						33	39	32	28	30	30	32	28	28
Le Bas Centre (UB)	31	31	31	31	27	25	26	23	22	21	21	22	20	21
Les Quennevais (S)		11	11	14	12	12	10	10.3	10.1	8.0	8.7	10.4	7.6	8.4
Rue Des Raisies (Ru)	7	7	8	10	6	7	6	6.8	6.5	6.4	6.2	7.0	6.6	6.6

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

Figure 4-6: Annual mean NO_2 concentrations (not adjusted for diffusion tube bias)



4.4 Hydrocarbons

Full monthly results of the hydrocarbon survey for the five BTEX sites are shown in Appendix 4, Tables A4-1 to A4-5. A summary of annual average hydrocarbon concentrations is shown in Table 4-5. There were numerous instances throughout the year when the reported results were less than the limit of detection, especially for benzene, ethylbenzene and o-xylene. Where this was the case, the value was treated as equal to the half limit of detection for the purposes of calculating the annual mean.

Travel blank values are included in Appendix 4, Table A4-6. These would usually be expected to give consistently lower results than the exposed tubes. However, this was not always the case in 2013 (as in previous years). Travel blank results were frequently comparable to exposed tube results or even higher.

Table 4-5: Summary of average hydrocarbon concentrations (μg m^{-3}), Jersey, 2013

Site	Benzene	Toluene	Ethyl-benzene	m+p xylene	o xylene
Le Bas Centre	0.7	2.4	0.8	2.0	0.7
Halkett Place	0.8	2.9	0.7	2.2	0.9
Airport Fence	0.4	1.0	0.2	0.4	0.2
Hansford Lane	0.4	2.6	1.9	5.2	1.8
Faux Bie	1.4	6.7	1.0	3.7	1.4
Travel blank	0.2	0.5	0.5	0.4	0.2

Highest annual mean concentrations of benzene and toluene were measured at Faux Bie, which is at the nearest housing to a petrol station. It is likely that the evaporation of these compounds from fuel, as it is stored or dispensed, is contributing to ambient levels.

As in previous years, the Hansford Lane site (near a paint spraying process) measured the highest concentration of m+p-xylene and o-xylene. The paint spraying process is not expected to be a significant source of benzene or toluene and the concentrations of these two hydrocarbons at Hansford Lane were similar to or lower than those at Le Bas and Halkett Place.

Graphical representations of monthly mean hydrocarbon concentrations are shown in Figure 4-7 to Figure 4-11. All five figures use identical y-axes, for ease of comparison.

Figure 4-7: Monthly mean hydrocarbon concentrations at Le Bas Centre, 2013

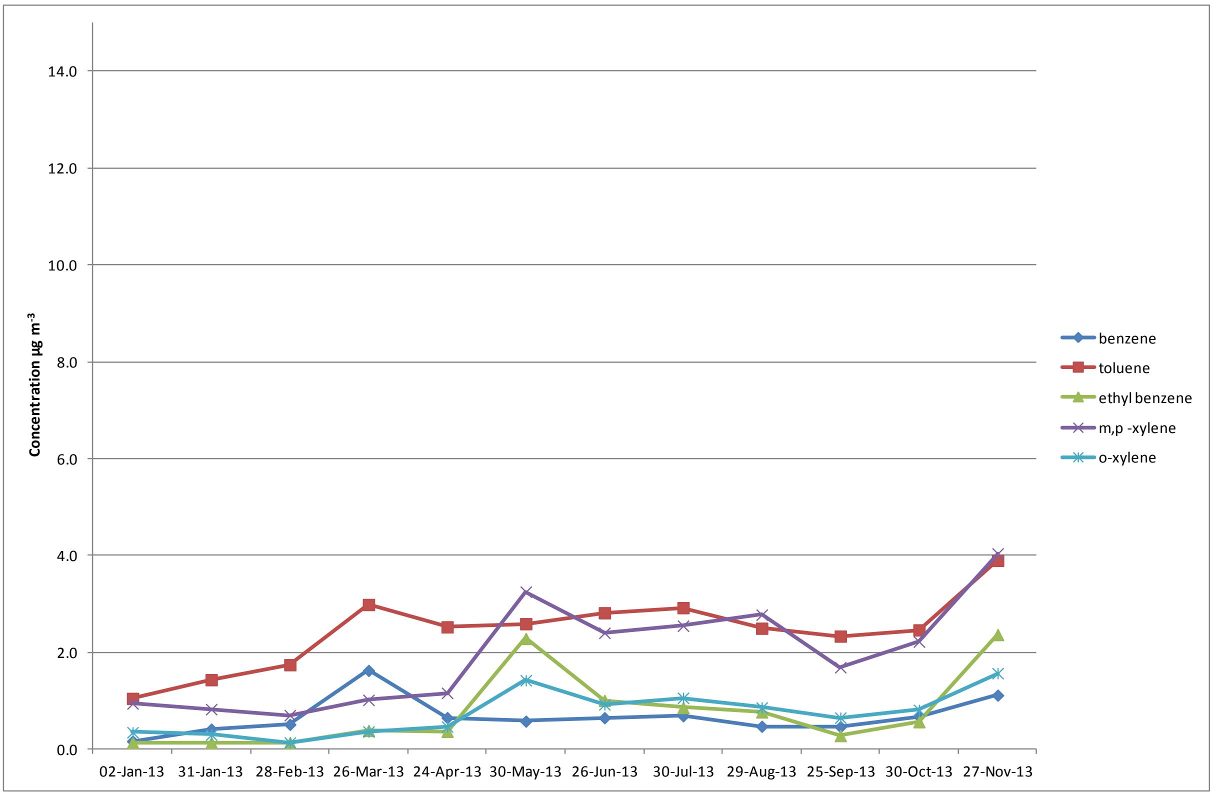


Figure 4-8: Monthly mean hydrocarbon concentrations at Halkett Place, 2013

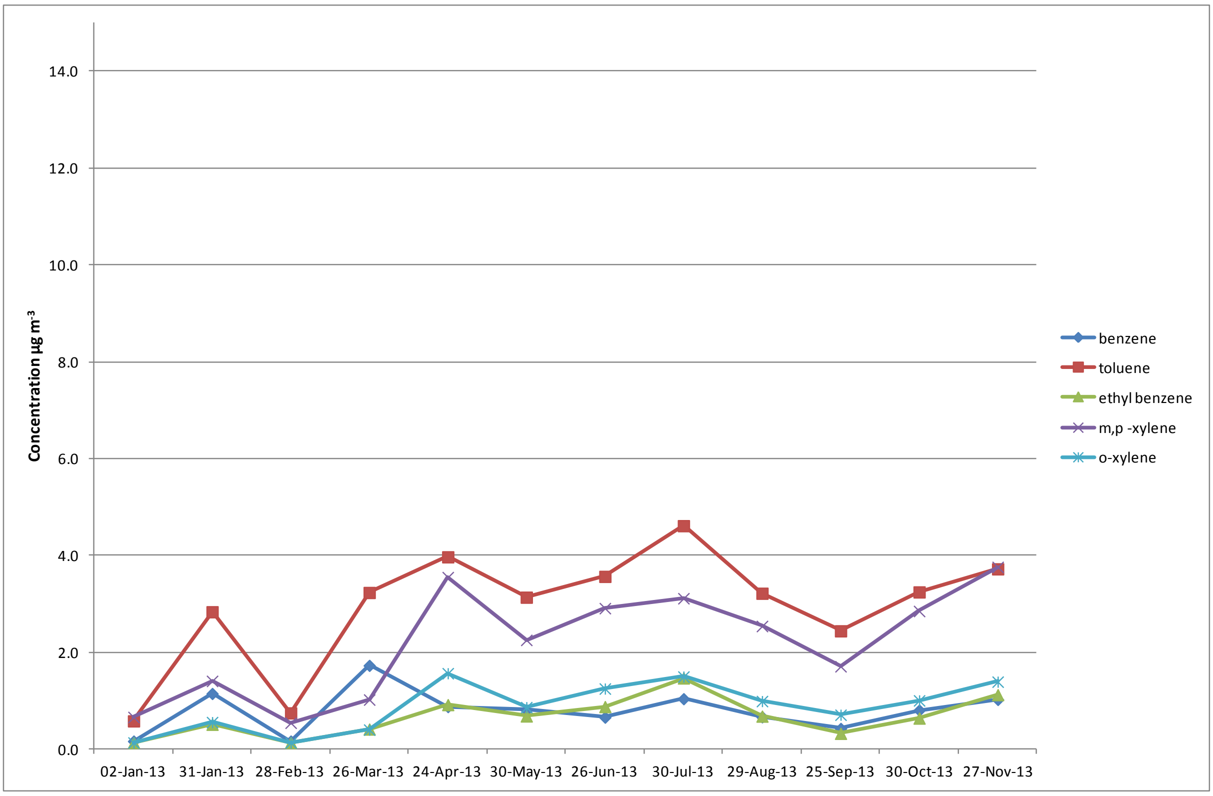


Figure 4-9: Monthly mean hydrocarbon concentrations at Airport Fence, 2013

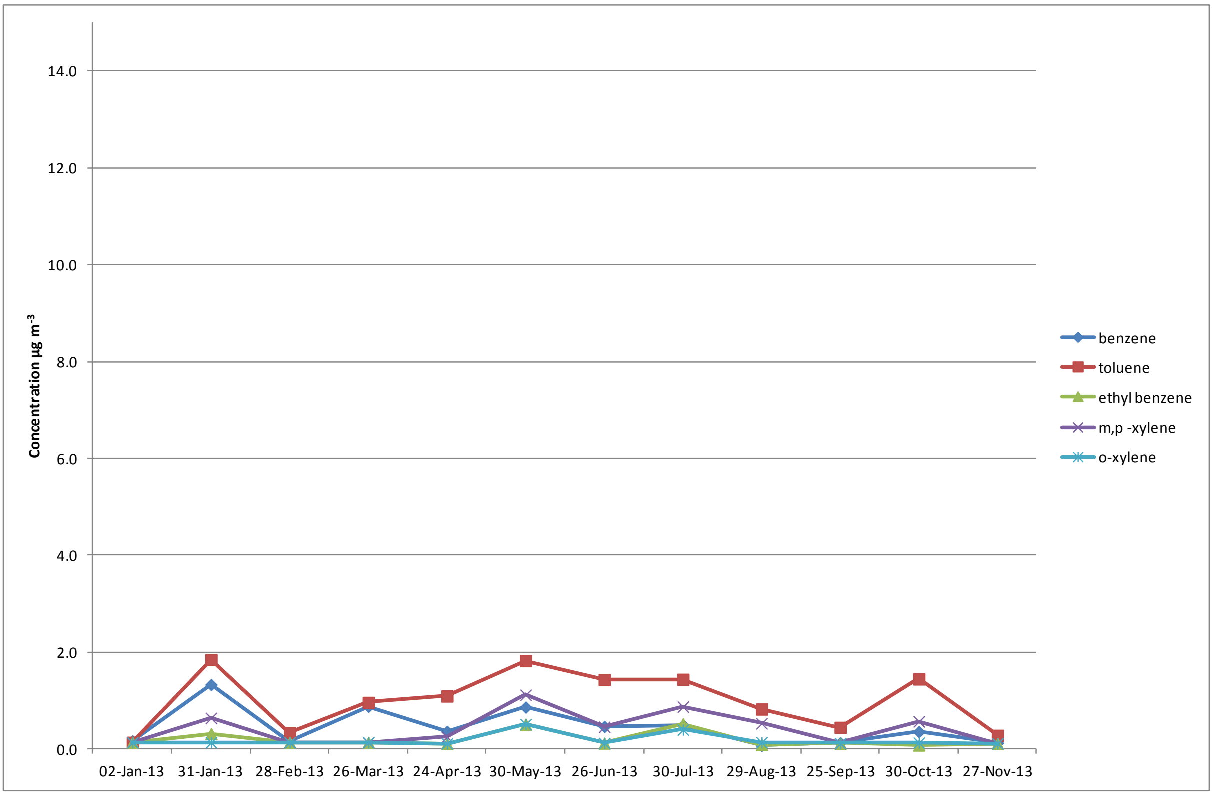


Figure 4-10: Monthly mean hydrocarbon concentrations at Hansford Lane, 2013

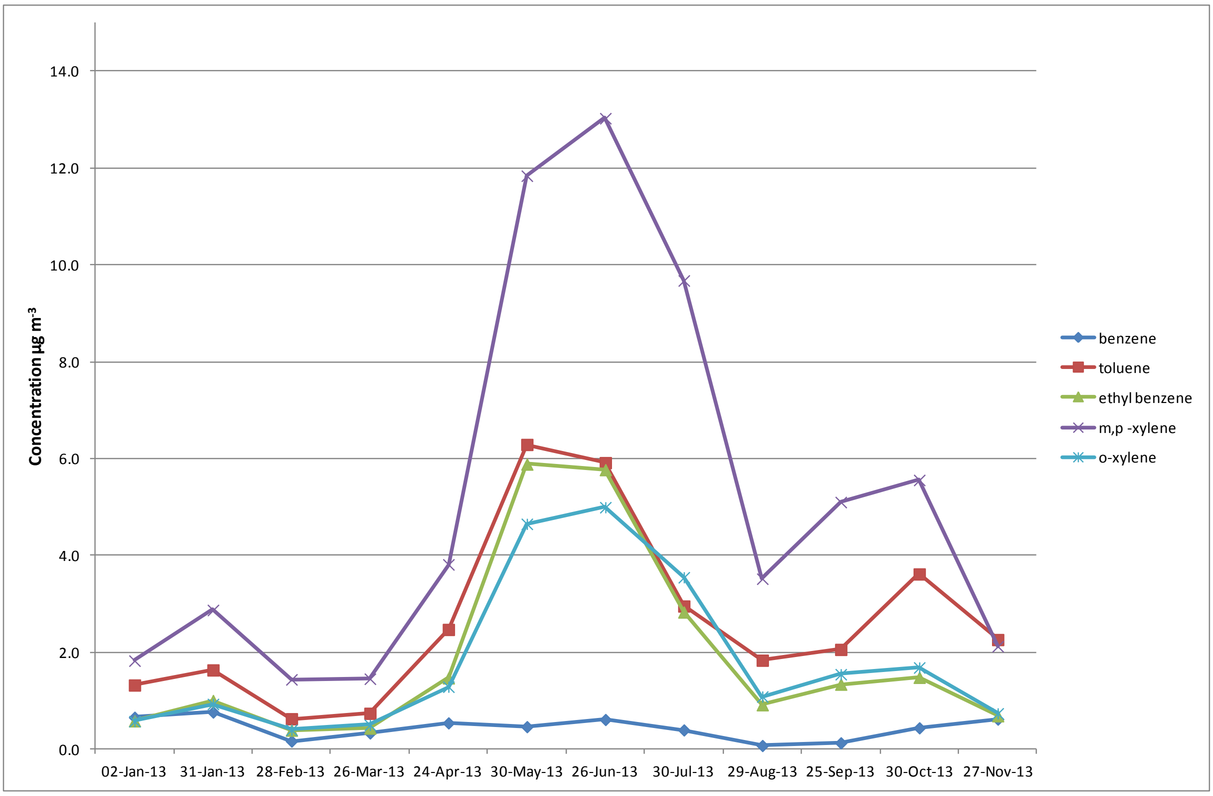
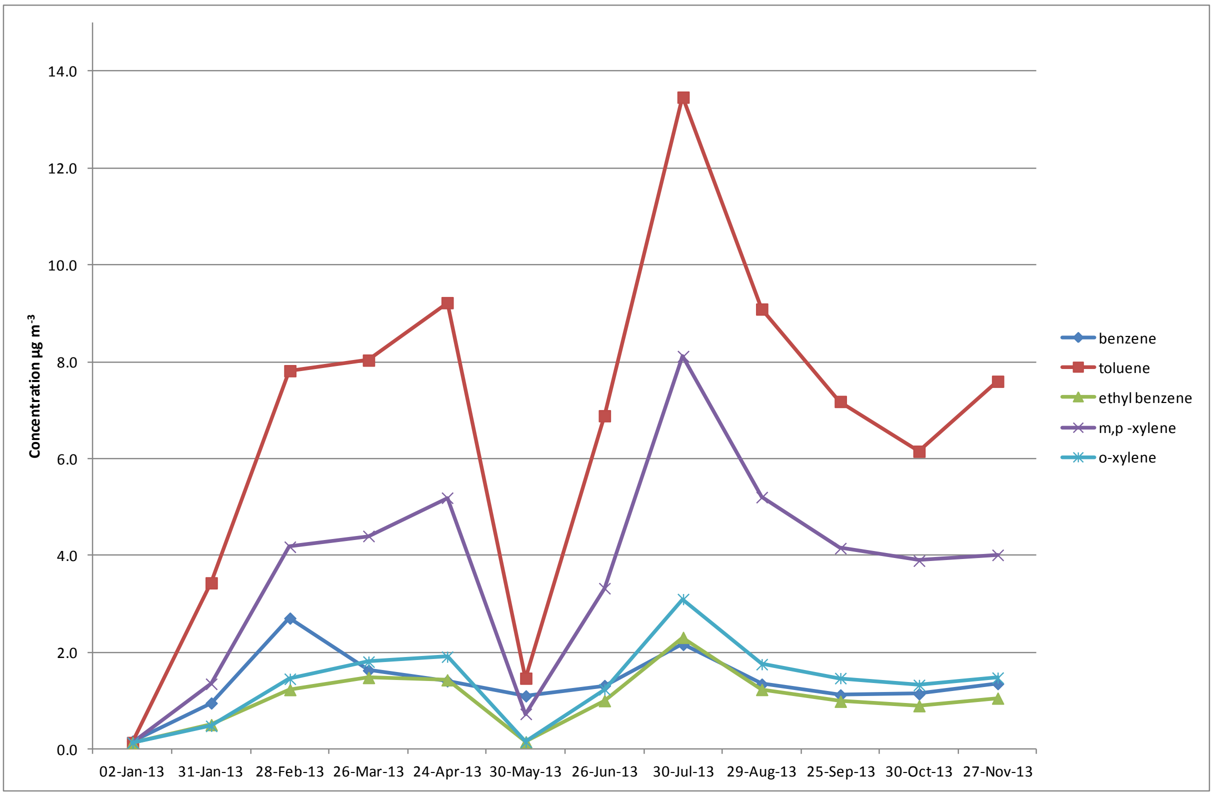


Figure 4-11: Monthly mean hydrocarbon concentrations at Faux Bie, 2013



The charts clearly show the differences in hydrocarbon concentrations between each one. Airport Fence site recorded the lowest concentrations of all the BTEX hydrocarbons, frequently below the detection limit, particularly for ethylbenzene.

4.4.1 Comparison with limit values and objectives

Of the hydrocarbon species monitored, only benzene is the subject of any applicable air quality standards. The Air Quality Directive[4] sets a limit of 5 µg m^{-3} for annual mean benzene, to be achieved by 2010. All sites met this limit in 2013, and have done so since 1999 (or since they started operation).

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

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

These AQS objectives are not at present mandatory in Jersey.

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

4.4.2 Comparison with previous years' hydrocarbon results

Figure 4-12 to Figure 4-16 show how annual mean hydrocarbon concentrations at the five Jersey sites have changed over the years of monitoring. These data are also provided in tabular form in Appendix 4.

It is important to remember that pollutant concentrations are expected to show considerable year-to-year variation, due to meteorological and other factors. Year-to year changes are therefore of less importance than the observation of long-term trends, which are discussed below.

Figure 4-12: Time Series of benzene concentrations

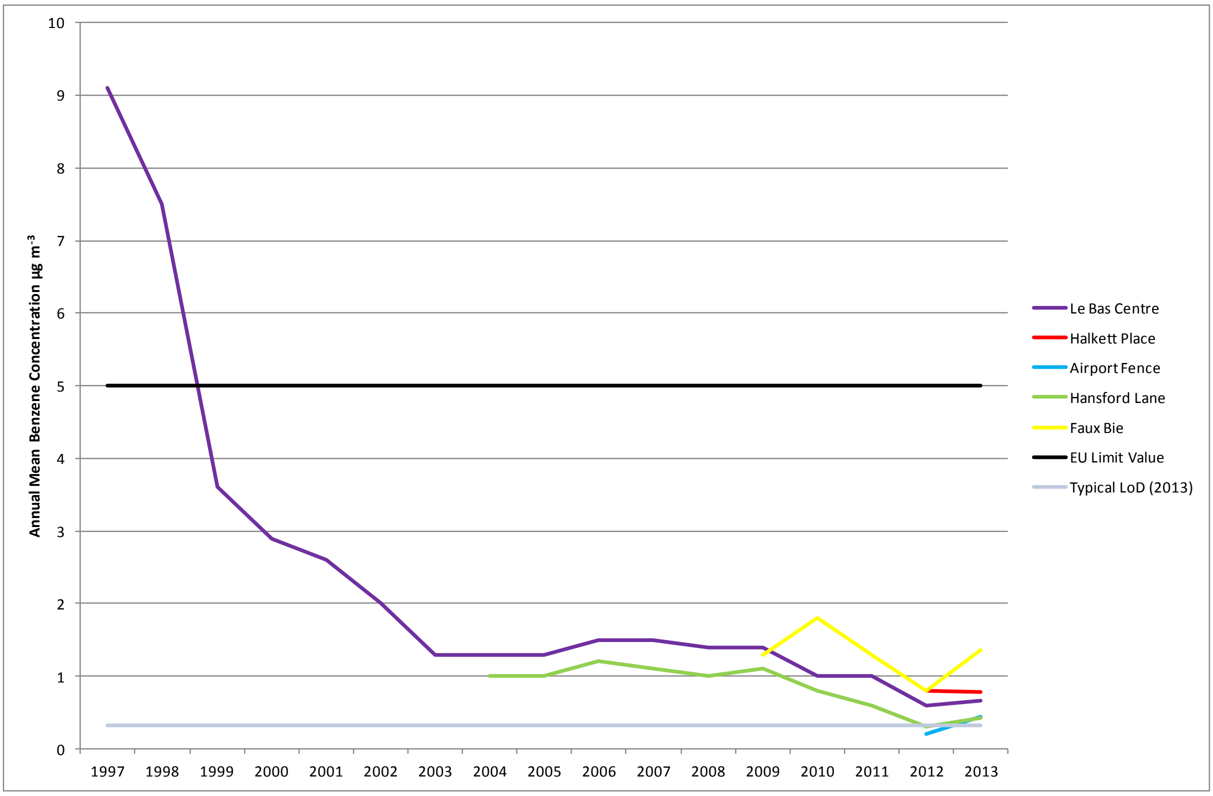


Figure 4-12 shows annual mean benzene concentrations. It includes the EU limit value of 5 µg m^{-3}, shown as a black line, and the typical LoD equivalent concentration (shown as a grey line). Le Bas Centre has been in operation since 1997. Annual mean concentrations of benzene at this very long-running site showed a marked drop in 2000 due to the maximum permitted benzene content of petrol sold in the UK being reduced from 2 % in unleaded (5 % in super unleaded), to 1 % as of 1st January 2000. This site has shown a further modest decrease since around 2009, as has Hansford Lane. Annual mean concentrations at all sites except Faux Bie are now less than 1 µg m^{-3}.

Figure 4-13 shows toluene concentrations. Again, the ambient concentration equivalent to the typical LoD for toluene is shown as a grey line for comparison. The two longest-running sites, Le Bas Centre and Hansford Lane, show general decreases over the past ten years, though these are not consistent. There is no apparent trend observable at Faux Bie so far.

The pattern for ethylbenzene (Figure 4-14) is similar.

Concentrations of xylenes (Figure 4-15 and Figure 4-16) are now generally lower than in the early years of the survey. At Hansford Lane (near the paint spraying process), concentrations of m- +p-xylene and of o-xylene have fluctuated considerably from year to year. However, overall concentrations are low.

Figure 4-13: Time Series of toluene concentrations

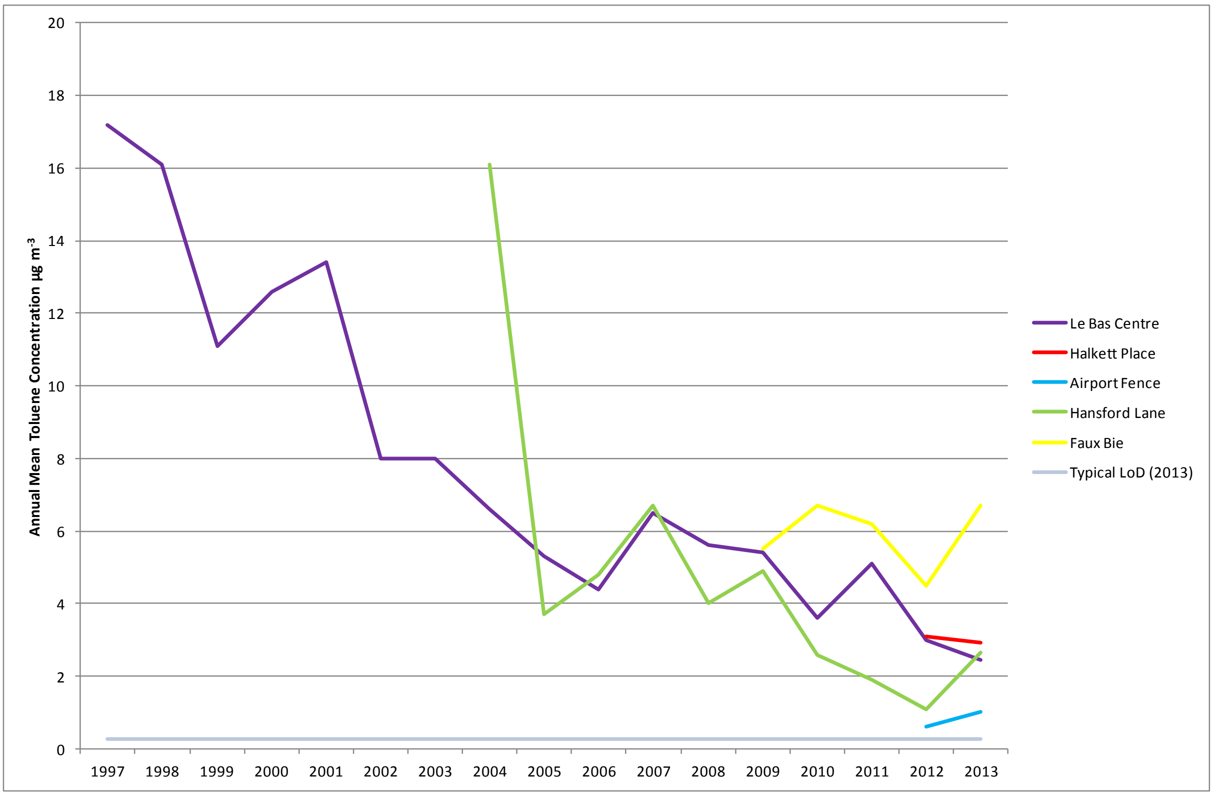


Figure 4-14: Time Series of ethylbenzene concentrations

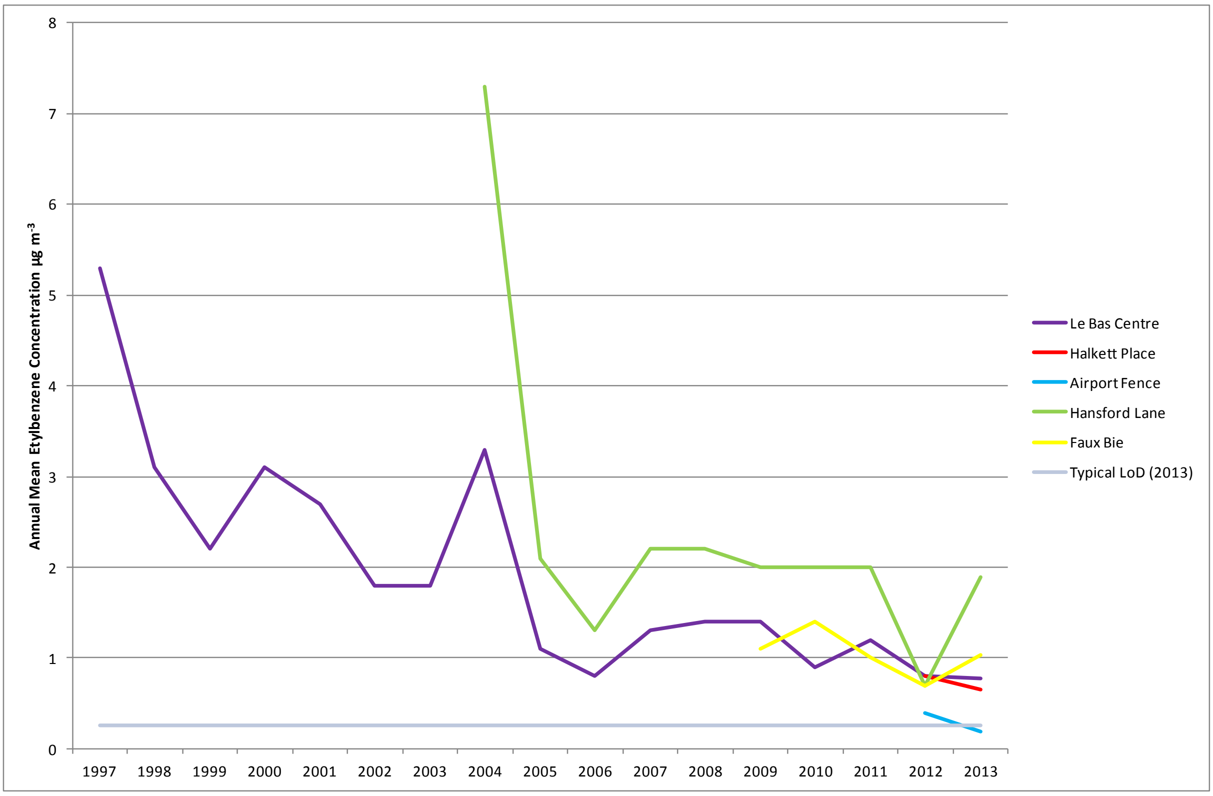


Figure 4-15: Time Series of m+p- xylene concentrations

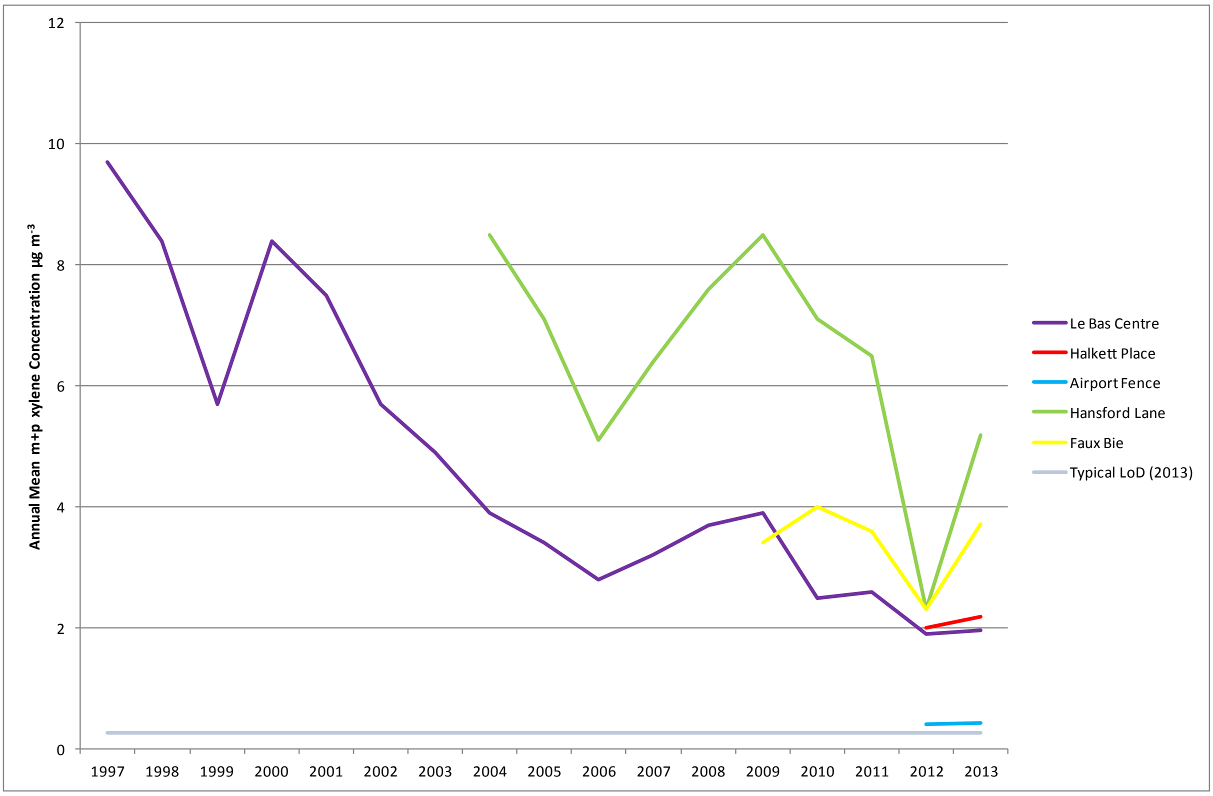
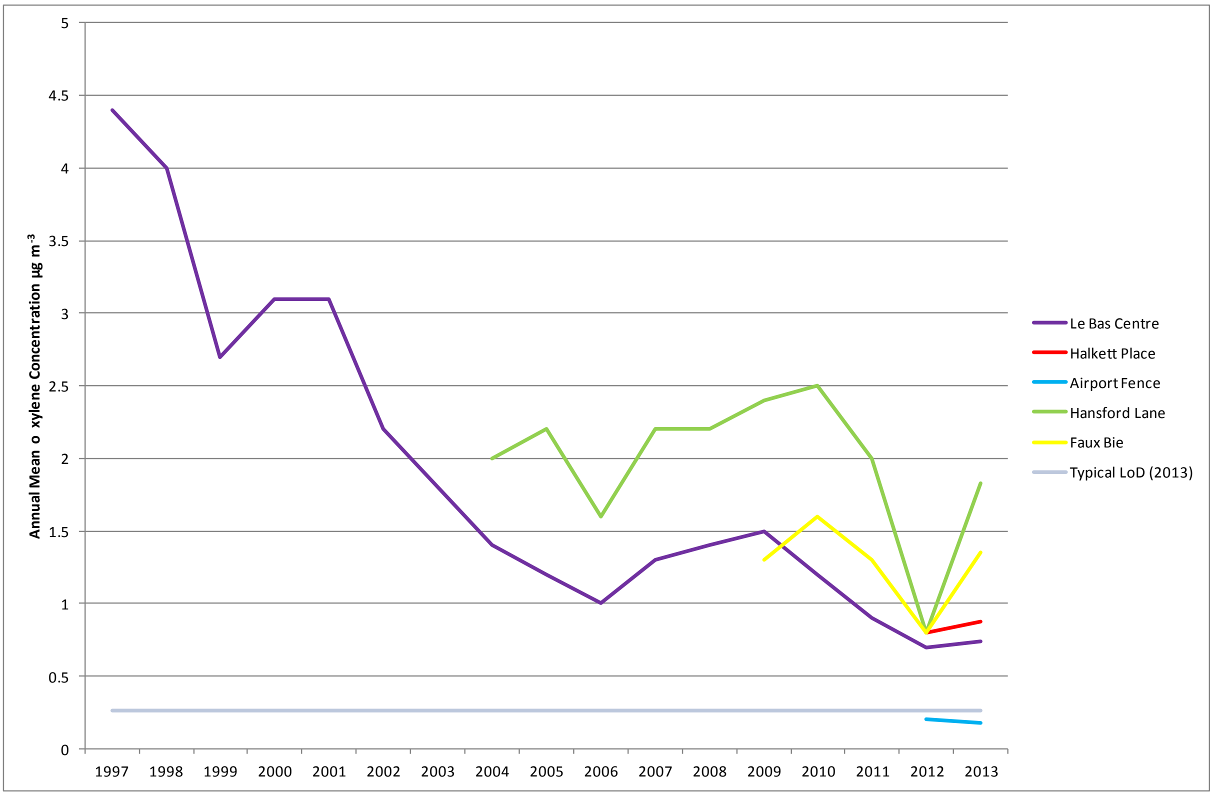


Figure 4-16: Time Series of o-xylene concentrations



It is also important to note how low current hydrocarbon concentrations now are, compared to the LoD equivalent concentration (typically around 0.3 µg m^{-3} for benzene, 0.27 µg m^{-3} for the other hydrocarbons). In the case of the Airport Fence site, annual mean concentrations of ethylbenzene and o-xylene are now typically below the LoD.

5 Conclusions and recommendations

Ricardo-AEA has continued the ongoing air quality monitoring programme in Jersey during 2013, on behalf of the States of Jersey Public Health Services. This was the seventeenth year of monitoring. Oxides of nitrogen were monitored at one automatic monitoring station, located in a roadside position at the Central Market, Halkett Place in St Helier. Diffusion tubes were also co-located (in triplicate) with the automatic site at Halkett Place. This was supplemented by diffusion tubes for indicative monitoring of NO_2 at an additional 11 sites around the island.

Hydrocarbons (benzene, toluene, ethylbenzene and xylenes, collectively termed BTEX) were measured at five sites, also 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.

The main conclusions of the monitoring programme are summarised below.

5.1 NO_2 results

1. The annual mean NO_2 concentration measured by the automatic analyser at Halkett Place was 29 µg m^{-3}. This is well 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, the States of Jersey must continue to demonstrate ongoing compliance.
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. The maximum hourly mean reported by this site was within this value, and there were no exceedances. Therefore Halkett Place met the limit value and objective.
3. Diffusion tubes exposed in triplicate alongside the automatic analyser gave an annual mean of 29 µg m^{-3} – the same as the automatic annual mean of 29 µg m^{-3}.
4. Annual mean NO_2 concentrations at all 12 diffusion tube monitoring sites were within the EC limit value, and were generally comparable with previous years' results.
5. The diurnal variation in concentrations of oxides of nitrogen at Halkett Place was generally typical of an urban site, but with a particularly early (and sharp) morning rush hour peak, and barely any afternoon rush hour peak. This is thought to be due to traffic patterns around the site: there is early morning traffic associated with the market and with waste collection from the previous day.
6. Monthly mean NO_2 concentrations at the diffusion tube sites showed a slight seasonal pattern, with highest concentrations in the winter months. While this is typical of many urban locations, it is not typical in Jersey which has not historically shown the typical seasonal pattern.
7. Annual mean NO_2 concentrations at Jersey's urban sites appear to have decreased over the last 10 years, though most sites do not show a consistent downward trend. Pollutant concentrations are expected to fluctuate from year to year, due to meteorological and other factors.

5.2 Hydrocarbon diffusion tube results

1. Annual mean benzene concentrations at all five sites were well within the EC Directive limit value of 5 µg m^{-3}. Having achieved compliance by 2010 as required, the States of Jersey must continue to demonstrate ongoing compliance.
2. The Airport Fence site recorded the lowest concentrations of all the BTEX hydrocarbons, and for some species the majority of results were below the limit of detection of the method.

3. Annual mean concentrations of BTEX hydrocarbons were comparable with those measured in recent years.

5.3 Recommendations

It is recommended that the monitoring programme be continued, to demonstrate continuing compliance with air quality limit values and objectives. Also, consideration should be given to aligning the monitoring programme with the requirements of Jersey's Air Quality Strategy.

Measured concentrations of BTEX hydrocarbons at most of the sites are very low, and in some cases typically below the limit of detection. 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 is 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.

6 Acknowledgements

Ricardo-AEA gratefully acknowledges the help and support of the staff of the States of Jersey Environmental Health Services in this monitoring study.

7 References

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5. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07

6. Part IV of the Environment Act 1995. Local Air Quality Management. Technical Guidance LAQM.TG(09) February 2009. Produced by Defra.

Appendices

Appendix 1 – Air quality limit values, objectives and guidelines

Air pollution guidelines used in this report

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

Table A1-1: Nitrogen dioxide

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

(1) Conversions between µg m^{-3} and ppb are as used by the EC, ie 1 ppb NO_2 = 1.91 µg m^{-3} at 20 °C and 1013 mB.

(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

(3) Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265).

(4) Council Directive 2008/50/EC.

(5) WHO Air Quality Guidelines for Europe (2000).

Table A1-2: Benzene

Guideline Set By	Description	Criteria Based On	Value(1) / µgm^{-3} (ppb)
The Air Quality Strategy(2,3) **All UK**	Objective for Dec. 31st 2003	Running annual mean	16.25 (5)
England(4) & Wales(5) only:	Objective for Dec. 31st 2010	Annual mean	5 (1.54)
Scotland(6) & Northern Ireland	Objective for Dec. 31st 2010	Running annual mean	3.25 (1.0)
ED Directive on Ambient Air Quality and Cleaner Air for Europe (7)	Limit Value. To be achieved by Jan 1st 2010	Annual calendar year mean	5 (1.5)

(1) Conversions between µg m^{-3} and ppb are those used by the EC, ie 1 ppb benzene = 3.25 µg m^{-3} at 20°C and 1013 mB.

(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).

(4) Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043).

(5) Air Quality (Amendment) (Wales) Regulations 2002 (SI 2002/3182 (W298)).

(6) Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297).

(7) Council Directive 2008/50/EC.

Table A1-3: Toluene

Guideline Set By	Description	Criteria Based On	Value(1) / µgm^{-3} (ppb)
World Health Organisation(8) **(Non-Mandatory Guideline)**	Health Guideline	1-week mean	260 µgm^{-3} or 0.26 mgm^{-3}

(8) WHO Air Quality Guidelines for Europe (2000).

Appendix 2 – Calibration procedures for automatic analyser

The analyser at Halkett Place is calibrated monthly by the Environmental Health team. Standard gas calibration mixtures are used to check the instrument’s span, and chemically scrubbed air is used to check the instrument’s zero. All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards from the Gas Standards Calibration Laboratory at Ricardo-AEA. 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 12-monthly intercalibration and audit check 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-AEA’s audit calibration procedures are UKAS accredited to ISO 17025.

Full intercalibration audits take place annually. At these visits, the essential functional parameters of the monitors, such as noise, linearity and, for the NOx monitor, the efficiency of the NO_2 to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked. In 2013 this exercise was combined with a full service of the analyser and sampler pump. The same is planned for the 2014 scheduled visit.

Appendix 3 - Nitrogen dioxide diffusion tubes: Bias adjustment factor

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

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

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

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

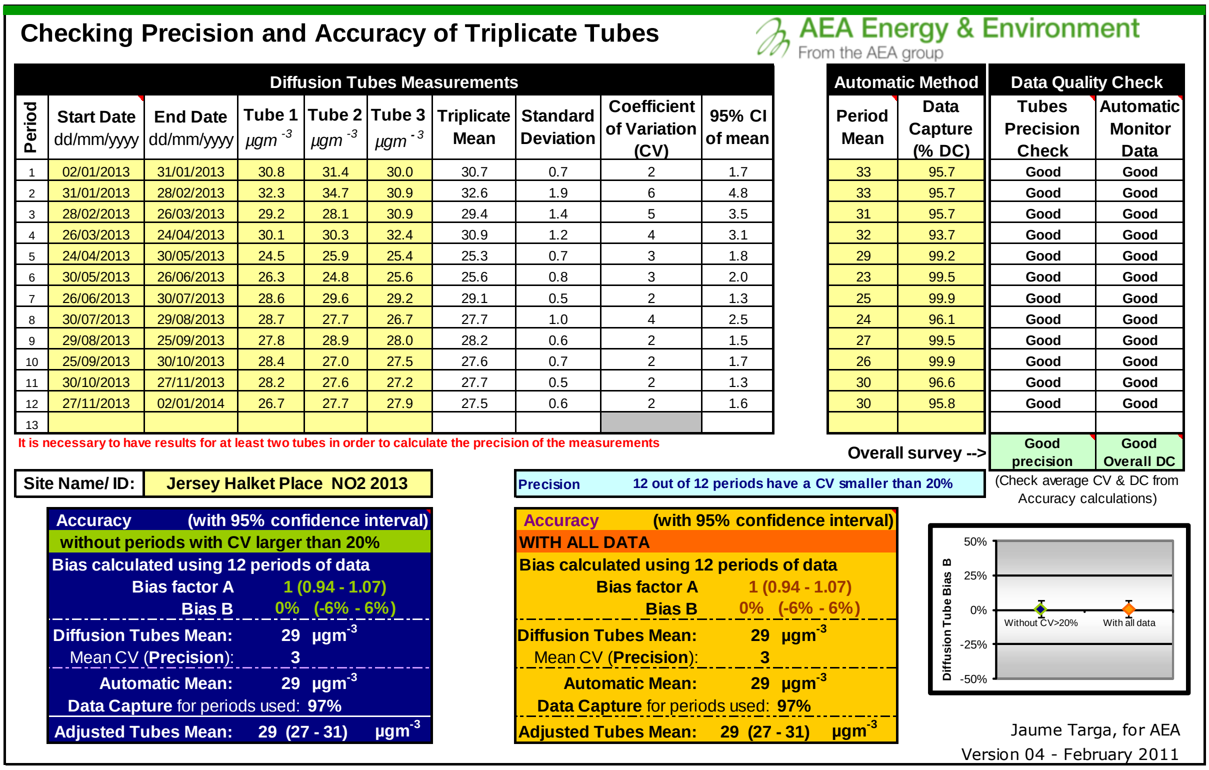
The diffusion tube annual mean concentrations measured at the other (non-co-located) sites can be adjusted for the diffusion tube over- / under-read by application of a bias adjustment factor, calculated as follows.

Bias adjustment factor = C / D

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

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

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



Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

	Diffusion Tubes Measurements									Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 µgm⁻³	Tube 2 µgm⁻³	Tube 3 µgm⁻³	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	02/01/2013	31/01/2013	30.8	31.4	30.0	30.7	0.7	2	1.7	33	95.7	Good	Good
2	31/01/2013	28/02/2013	32.3	34.7	30.9	32.6	1.9	6	4.8	33	95.7	Good	Good
3	28/02/2013	26/03/2013	29.2	28.1	30.9	29.4	1.4	5	3.5	31	95.7	Good	Good
4	26/03/2013	24/04/2013	30.1	30.3	32.4	30.9	1.2	4	3.1	32	93.7	Good	Good
5	24/04/2013	30/05/2013	24.5	25.9	25.4	25.3	0.7	3	1.8	29	99.2	Good	Good
6	30/05/2013	26/06/2013	26.3	24.8	25.6	25.6	0.8	3	2.0	23	99.5	Good	Good
7	26/06/2013	30/07/2013	28.6	29.6	29.2	29.1	0.5	2	1.3	25	99.9	Good	Good
8	30/07/2013	29/08/2013	28.7	27.7	26.7	27.7	1.0	4	2.5	24	96.1	Good	Good
9	29/08/2013	25/09/2013	27.8	28.9	28.0	28.2	0.6	2	1.5	27	99.5	Good	Good
10	25/09/2013	30/10/2013	28.4	27.0	27.5	27.6	0.7	2	1.7	26	99.9	Good	Good
11	30/10/2013	27/11/2013	28.2	27.6	27.2	27.7	0.5	2	1.3	30	96.6	Good	Good
12	27/11/2013	02/01/2014	26.7	27.7	27.9	27.5	0.6	2	1.6	30	95.8	Good	Good
13													
											Overall survey -->	Good precision	Good Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

(Check average CV & DC from Accuracy calculations)

Site Name/ ID: Jersey Halket Place NO2 2013

Precision 12 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 12 periods of data
Bias factor A 1 (0.94 - 1.07)
Bias B 0% (-6% - 6%)
Diffusion Tubes Mean: 29 µgm⁻³
Mean CV (Precision): 3
Automatic Mean: 29 µgm⁻³
Data Capture for periods used: 97%
Adjusted Tubes Mean: 29 (27 - 31) µgm⁻³

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 12 periods of data
Bias factor A 1 (0.94 - 1.07)
Bias B 0% (-6% - 6%)
Diffusion Tubes Mean: 29 µgm⁻³
Mean CV (Precision): 3
Automatic Mean: 29 µgm⁻³
Data Capture for periods used: 97%
Adjusted Tubes Mean: 29 (27 - 31) µgm⁻³

Jaume Targa, for AEA
Version 04 - February 2011

If you have any enquiries about this spreadsheet please contact the LAQM Helpdesk at: LAQMHelpdesk@uk.bureauveritas.com

Appendix 4 - BTEX diffusion tubes: Monthly dataset and annual means 1997 - 2013

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

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o- xylene
2-Jan-13	<0.4	1.0	<0.2	0.9	0.3
31-Jan-13	0.4	1.4	<0.2	0.8	0.3
28-Feb-13	0.5	1.7	<0.2	0.7	<0.2
26-Mar-13	1.6	3.0	0.4	1.0	0.4
24-Apr-13	0.6	2.5	0.4	1.2	0.5
30-May-13	0.6	2.6	2.3	3.3	1.4
26-Jun-13	0.6	2.8	1.0	2.4	0.9
30-Jul-13	0.7	2.9	0.9	2.5	1.1
29-Aug-13	0.5	2.5	0.8	2.8	0.9
25-Sep-13	0.5	2.3	0.3	1.7	0.6
30-Oct-13	0.7	2.5	0.6	2.2	0.8
27-Nov-13	1.1	3.9	2.4	4.0	1.6
Average	**0.7**	**2.4**	**0.8**	**2.0**	**0.7**

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

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o- xylene
2-Jan-13	<0.4	0.6	<0.2	0.7	<0.2
31-Jan-13	1.1	2.8	0.5	1.4	0.6
28-Feb-13	<0.4	0.7	<0.2	0.5	<0.2
26-Mar-13	1.7	3.2	0.4	1.0	0.4
24-Apr-13	0.9	4.0	0.9	3.5	1.6
30-May-13	0.8	3.1	0.7	2.3	0.9
26-Jun-13	0.7	3.6	0.9	2.9	1.2
30-Jul-13	1.0	4.6	1.5	3.1	1.5
29-Aug-13	0.7	3.2	0.7	2.5	1.0
25-Sep-13	0.4	2.4	0.3	1.7	0.7
30-Oct-13	0.8	3.2	0.6	2.8	1.0
27-Nov-13	1.0	3.7	1.1	3.8	1.4
Average	**0.8**	**2.9**	**0.7**	**2.2**	**0.9**

Table A4-3: Monthly mean hydrocarbon concentrations, µg m^{-3} – Airport Fence

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o- xylene
2-Jan-13	<0.4	<0.2	<0.2	<0.2	<0.2
31-Jan-13	1.3	1.8	0.3	0.6	0.1
28-Feb-13	<0.4	0.3	<0.2	<0.2	<0.2
26-Mar-13	0.9	1.0	<0.2	<0.2	<0.2

24-Apr-13	0.4	1.1	<0.2	0.2	<0.2
30-May-13	0.9	1.8	0.5	1.1	0.5
26-Jun-13	0.5	1.4	<0.2	0.5	<0.2
30-Jul-13	0.5	1.4	0.5	0.9	0.4
29-Aug-13	<0.2	0.8	<0.2	0.5	<0.2
25-Sep-13	<0.2	0.4	<0.2	<0.2	<0.2
30-Oct-13	0.4	1.4	<0.2	0.6	<0.2
27-Nov-13	<0.2	0.3	<0.2	<0.2	<0.2
Average	**0.4**	**1.0**	**0.2**	**0.4**	**0.2**

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

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o-xylene
2-Jan-13	0.7	1.3	0.6	1.8	0.6
31-Jan-13	0.8	1.6	1.0	2.9	0.9
28-Feb-13	<0.4	0.6	0.4	1.4	0.4
26-Mar-13	0.3	0.7	0.4	1.5	0.5
24-Apr-13	0.5	2.5	1.5	3.8	1.3
30-May-13	0.5	6.3	5.9	11.8	4.6
26-Jun-13	0.6	5.9	5.8	13.0	5.0
30-Jul-13	0.4	3.0	2.8	9.7	3.5
29-Aug-13	<0.2	1.8	0.9	3.5	1.1
25-Sep-13	<0.2	2.1	1.3	5.1	1.5
30-Oct-13	0.4	3.6	1.5	5.6	1.7
27-Nov-13	0.6	2.3	0.7	2.1	0.7
Average	**0.4**	**2.6**	**1.9**	**5.2**	**1.8**

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

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o-xylene
2-Jan-13	<0.4	<0.2	<0.2	<0.2	<0.2
31-Jan-13	0.9	3.4	0.5	1.3	0.5
28-Feb-13	2.7	7.8	1.2	4.2	1.5
26-Mar-13	1.6	8.0	1.5	4.4	1.8
24-Apr-13	1.4	9.2	1.4	5.2	1.9
30-May-13	1.1	1.5	0.1	0.7	0.1
26-Jun-13	1.3	6.9	1.0	3.3	1.2
30-Jul-13	2.2	13.5	2.3	8.1	3.1
29-Aug-13	1.3	9.1	1.2	5.2	1.8
25-Sep-13	1.1	7.2	1.0	4.1	1.5
30-Oct-13	1.1	6.2	0.9	3.9	1.3
27-Nov-13	1.3	7.6	1.1	4.0	1.5
Average	**1.4**	**6.7**	**1.0**	**3.7**	**1.4**

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

Start date	Benzene	Toluene	Ethyl benzene	m,p - xylene	o-xylene
2-Jan-13	0.38	3.43	3.82	3.02	1.53
31-Jan-13	<0.32	0.71	<0.26	<0.26	<0.26
28-Feb-13	0.38	0.28	<0.26	<0.26	<0.26
26-Mar-13	0.24	0.12	0.17	0.18	0.04
24-Apr-13	0.18	0.10	0.12	0.12	0.04
30-May-13	0.26	0.09	0.11	0.09	0.06
26-Jun-13	<0.30	<0.08	<0.14	<0.10	<0.04
30-Jul-13	no data	no data	no data	no data	no data
29-Aug-13	<0.38	<0.24	<0.26	<0.12	<0.06
25-Sep-13	<0.46	<0.46	<0.52	<0.56	<0.24
30-Oct-13	0.21	0.09	0.13	0.08	0.03
27-Nov-13	0.10	0.06	0.12	0.12	0.03
Average	**0.2**	**0.5**	**0.5**	**0.4**	**0.2**

Table A4-8: Comparison of hydrocarbon concentrations, Jersey, 1997 - 2013

	Benzene, µg m^{-3}	Toluene, µg m^{-3}	Ethylbenzene µg m^{-3}	m+p xylene, µg m^{-3}	o-xylene, µg m^{-3}
Le Bas Centre					
1997	9.1	17.2	5.3	9.7	4.4
1998	7.5	16.1	3.1	8.4	4.0
1999	3.6	11.1	2.2	5.7	2.7
2000	2.9	12.6	3.1	8.4	3.1
2001	2.6	13.4	2.7	7.5	3.1
2002	2.0	8.0	1.8	5.7	2.2
2003	1.3	8.0	1.8	4.9	1.8
2004	1.3	6.6	3.3	3.9	1.4
2005	1.3	5.3	1.1	3.4	1.2
2006	1.5	4.4	0.8	2.8	1.0
2007	1.5	6.5	1.3	3.2	1.3
2008	1.4	5.6	1.4	3.7	1.4
2009	1.4	5.4	1.4	3.9	1.5
2010	1.0	3.6	0.9	2.5	1.2
2011	1.0	5.1	1.2	2.6	0.9
2012	0.6	3.0	0.8	1.9	0.7
2013	0.7	2.4	0.8	2.0	0.7
Halkett Place					
2012	0.8	3.1	0.8	2.0	0.8
2013	0.8	2.9	0.7	2.2	0.9
Airport Fence					
2012	0.2	0.6	0.4	0.4	0.2
2013	0.4	1.0	0.2	0.4	0.2
Hansford Lane					
2004	1.0	16.1	7.3	8.5	2.0
2005	1.0	3.7	2.1	7.1	2.2
2006	1.2	4.8	1.3	5.1	1.6
2007	1.1	6.7	2.2	6.4	2.2
2008	1.0	4.0	2.2	7.6	2.2
2009	1.1	4.9	2.0	8.5	2.4
2010	0.8	2.6	2.0	7.1	2.5
2011	0.6	1.9	2.0	6.5	2.0
2012	0.3	1.1	0.7	2.3	0.8
2013	0.4	2.6	1.9	5.2	1.8
Faux Bie					
2009	1.3	5.5	1.1	3.4	1.3
2010	1.8	6.7	1.4	4.0	1.6
2011	1.3	6.2	1.0	3.6	1.3
2012	0.8	4.5	0.7	2.3	0.8
2013	1.4	6.7	1.0	3.7	1.4

RICARDO-AEA

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 01235 753000
Website: www.ricardo-aea.com