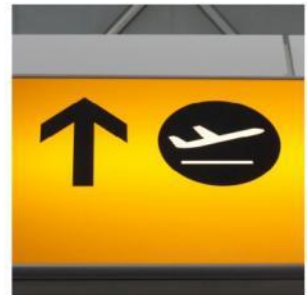


Air Quality Monitoring at Stansted Airport: Annual Report for 2013




Report for Stansted Airport Ltd

Ricardo-AEA/R/3408

Issue 1

Date 14/04/2014

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Ricardo-AEA reference: ED57706	
Ref: Ricardo-AEA/R/3408- Issue 1	

Executive summary

This report provides details of air quality monitoring conducted around Stansted Airport during 2013. The work, carried out by Ricardo-AEA on behalf of Stansted Airport Ltd, is a continuation of monitoring undertaken at Stansted Airport since 2004. The aims of the programme are to monitor air pollution around the airport, to assess compliance with relevant air quality objectives, and to investigate changes in air pollutant concentrations over time.

Automatic continuous monitoring was carried out at two locations, referred to as Stansted 3 and Stansted 4. Stansted 3 was located to the south-east of the airport at High House, and Stansted 4 was located to the north of the runway. Both sites monitored oxides of nitrogen (nitric oxide and nitrogen dioxide); PM₁₀ particulate matter was also monitored at Stansted 3 only. Measured PM₁₀ concentrations were adjusted using the King's College London Volatile Correction Model to correct for potential losses of volatile and semi-volatile components from the Tapered element oscillating microbalance (TEOM) particulate monitor.

In addition to automatic monitoring, indicative monitoring of nitrogen dioxide was carried out using diffusion tubes. These were co-located with the continuous monitor at Stansted 3 and also used at four other sites, to the north, south, east and west of the airport.

The applicable data capture target of 90% was achieved for PM₁₀ at Stansted 3 and for NO_x and NO₂ at Stansted 4. However, data capture was only 88% for NO_x and NO₂ at Stansted 3 and therefore just below the 90 % target.

The UK AQS hourly mean objective for NO₂ is 200 µg m⁻³, with no more than 18 exceedances allowed each year. (Where data capture is below 90%, the 99.8th percentile of hourly means must be within 200 µg m⁻³). Stansted 3 met this objective, with no hourly means recorded above the objective, Stansted 4 had 34 exceedances recorded and therefore did not meet the AQS objective. However, 32 of these occasions were during a two-day period when the site was affected by emissions from a nearby generator.

The annual mean AQS objective for NO₂ is 40 µg m⁻³. This was met at Stansted 3, Stansted 4, and at all four of the diffusion tube monitoring sites..

PM₁₀ may exceed the 24-hour mean limit of 50 µg m⁻³ up to 35 times per year to meet the AQS objective. The annual mean AQS for PM₁₀ is 40 µg m⁻³. These objectives were met at Stansted 3, with only two instances of concentrations exceeding the 24-hour mean value.

Wind speed and direction data provided by Stansted Airport Ltd were used to produce bivariate plots showing hourly mean pollutant concentrations against the corresponding weather conditions. These plots indicated that NO was predominantly arising close to the monitoring locations, suggesting the pollutant is largely associated with the airport. At both Stansted 3 and Stansted 4, NO₂ showed greater concentrations to the south east of the stations, especially at medium to high wind speeds. These signatures could be attributed to the A120 for Stansted 3 and the terminal building for Stansted 4. At Stansted 3, PM₁₀ also showed a source to the south east of the site, possibly arising from agricultural activities.

Several occurrences of high concentrations of NO_x and PM₁₀ occurred during 2013. At Stansted 4, particularly high concentrations of NO_x were recorded on 11th and 12th October. It is likely that these high levels arose because of a generator, operating near to the monitoring apparatus. PM₁₀ peaked at Stansted 4 on 10th April and 8th November. The second peak is known to have coincided with fertiliser movements from the adjacent barn. The high occurrence in April might also be related to agricultural activity, which is known to have affected measurements at this site in previous years.

Average NO₂ concentrations are broadly similar to those from comparable urban background monitoring sites and have remained lower than those for London Heathrow Airport. PM₁₀ levels at Stansted 3 have declined from a peak in 2006 and are also lower than those recorded at London Heathrow Airport.

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1 Introduction

1.1 Background

Stansted Airport is London's third busiest international airport, handling approximately 18 million passengers a year. The airport is situated approximately 40 miles north of London, in north east Hertfordshire. It is situated outside the general urbanised area of Greater London, and its surroundings are rural.

Stansted Airport Ltd is required, under the terms of its Section 106 Planning Agreement with the Local Authority (Uttlesford District Council), to carry out monitoring of oxides of nitrogen and particulate matter at an agreed location. Prior to 2006, monitoring was required for three months per year; from 2006 onwards, continuous monitoring throughout the year has been required.

Ricardo-AEA was contracted by Stansted Airport Ltd to carry out the required programme of air pollution measurements during 2013, the eighth full year of continuous monitoring.

Provisional data are reported to Stansted Airport Ltd quarterly throughout the year. This annual report presents and summarises the fully validated and quality controlled dataset for the entire calendar year (though please note the caveat in section 2.4 about VCM correction of the PM₁₀ data). Data in the annual report have been processed according to the rigorous quality assurance and quality control procedures used by Ricardo-AEA. These ensure the data are reliable, accurate and traceable to UK national measurement standards.

This report covers the period 1st January to 31st December 2013.

1.2 Aims and objectives

The aim of this monitoring programme is to monitor concentrations of two important air pollutants around the airport. The results of the monitoring are used to assess whether applicable air quality objectives have been met, and how pollutant concentrations in the area have changed over time.

The pollutants monitored were as follows:

- oxides of nitrogen (nitric oxide NO and nitrogen dioxide NO₂), using automatic techniques at two locations: Stansted 3 (High House) and Stansted 4 (Runway).
- particulate matter (PM₁₀) at Stansted 3.

The automatic monitoring was supplemented by indicative monitoring of NO₂ using diffusion tubes at five locations.

Monitoring data collected at Stansted are compared in this report with:

- relevant UK air quality limit values and objectives.
- corresponding results from a selection of national air pollution monitoring sites.
- statistics related to airport activity.

In addition, periods of relatively high pollutant concentrations are examined in more detail.

1.3 UK Air Quality Strategy

Within the European Union, controls on ambient air quality are covered by Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe¹, known as the Air Quality Directive. This consolidated three previously existing Directives, which set limit values for a range of air pollutants with known health impacts. The original Directives were transposed

into UK law through The Environment Act 1995 which 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 Environment Act 1995 also introduced the system of local air quality management (LAQM). This requires local authorities to review and assess air quality in their areas against the national air quality objectives. Where any objective is unlikely to be met by the relevant deadline, the local authority must designate an air quality management area (AQMA). Local authorities then have a duty to carry out further assessments within any AQMAs and draw up an action plan specifying the measures to be carried out, and the timescales, to achieve the air quality objectives. The legal framework given in the Environment Act has been adopted in the UK through the UK AQS. The most recent version of the AQS was published by Defra in 2007², and the currently applicable air quality objectives are summarised in Appendix 1 of this report.

2 Monitoring details

2.1 Pollutants monitored

Aircraft jet engines produce similar emissions to those created by other combustion processes. These include carbon monoxide (CO), nitrogen oxides (NO_x), oxides of sulphur (SO_x), particulate matter, hydrocarbons from partially combusted fuel, and other trace compounds. Water vapour and carbon dioxide (CO₂) are also emitted. Although CO₂ is implicated in climate change, it is not covered by air quality legislation, and is therefore outside the scope of this report.

Aircraft are not the only sources of air pollution associated with the airport: there are also emissions from the airside vehicles, from fuel use in the airport buildings, and from the large number of road vehicles travelling to and from the airport.

The pollutants of greatest concern around airports are oxides of nitrogen and particulate matter. Therefore, these pollutants are included in the current monitoring programme, and are described briefly below.

In previous years, hydrocarbons have also been monitored at Stansted. This was discontinued at the end of 2010, because the monitoring had established that ambient concentrations were low. In particular, ambient concentrations of benzene were well within the relevant AQS objective. Carbon monoxide was also measured until 2009, when measurements were discontinued because concentrations were well within the AQS objective.

It should be noted that the pollutants measured in this study will have originated from a variety of sources, both local and long range. Not all of these sources will be directly connected with the airport.

2.1.1 Oxides of nitrogen

Combustion processes emit a mixture of oxides of nitrogen – NO and NO₂ - collectively termed NO_x.

- i. NO is described as a primary pollutant (meaning it is directly emitted from source). NO is not known to have any harmful effects on human health at ambient concentrations. However, it undergoes oxidation in the atmosphere to form the secondary pollutant NO₂.
- ii. NO₂ has a primary (directly emitted) component and a secondary component, formed by oxidation of NO. NO₂ is a respiratory irritant and is toxic at high concentrations. It is also involved in the formation of photochemical smog and acid rain and may cause damage to crops and vegetation.

Of the NO_x emissions (including NO₂) considered to be airport-related, over 50 % arise from aircraft during take-off and landing, with around two-thirds of all emissions occurring at some distance from airport ground-level. The Air Quality Expert Group (AQEG)³ has stated that: *“Around a third of all NO_x emissions from the aircraft (including ground-level emissions from auxiliary power units, engine testing etc, as well as take-off and landing) occur below 100 m in height. The remaining two-thirds occur between 100 m and 1000 m and contribute little to ground-level concentrations. Receptor modelling studies ... show the impact of airport activities on ground-level NO₂ concentrations. Studies have shown that although emissions associated with road traffic are smaller than those associated with aircraft, their impact on population exposure at locations around the airport are larger”*. Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports

appear to have caused exceedances of air quality objectives for particulate matter measured as PM₁₀. Therefore, in the context of LAQM, the key pollutant of concern from airports is NO₂. Local authorities whose areas contain airports with over 10 million passengers per annum must take these into account in their annual review and assessment of air quality⁴.

2.1.2 PM₁₀ particulate matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The term PM₁₀ is used to describe particles with an effective size less than 10 µm. These 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.

The main sources of airborne particulate matter in the UK are combustion (industrial, commercial and residential fuel use). The next most significant source is road vehicle emissions. Based on 2011 National Atmospheric Emissions Inventory (NAEI) data, 0.07% of UK total PM₁₀ emissions were believed to originate from civil aircraft taking off and landing⁵.

Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports appear to have caused exceedances of air quality objectives for particulate matter measured as PM₁₀⁴.

2.2 Locations of monitoring sites

Automatic monitoring was carried out at two sites during 2013. These are referred to as Stansted 3 and Stansted 4 (the numbering of the sites continues the sequence used for previous short-term sites in earlier monitoring studies). The location descriptions of both sites fall into the category "other" as defined by the Defra Technical Guidance on air quality monitoring LAQM.TG(09)⁴, (ie "*any special source-oriented or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels*").

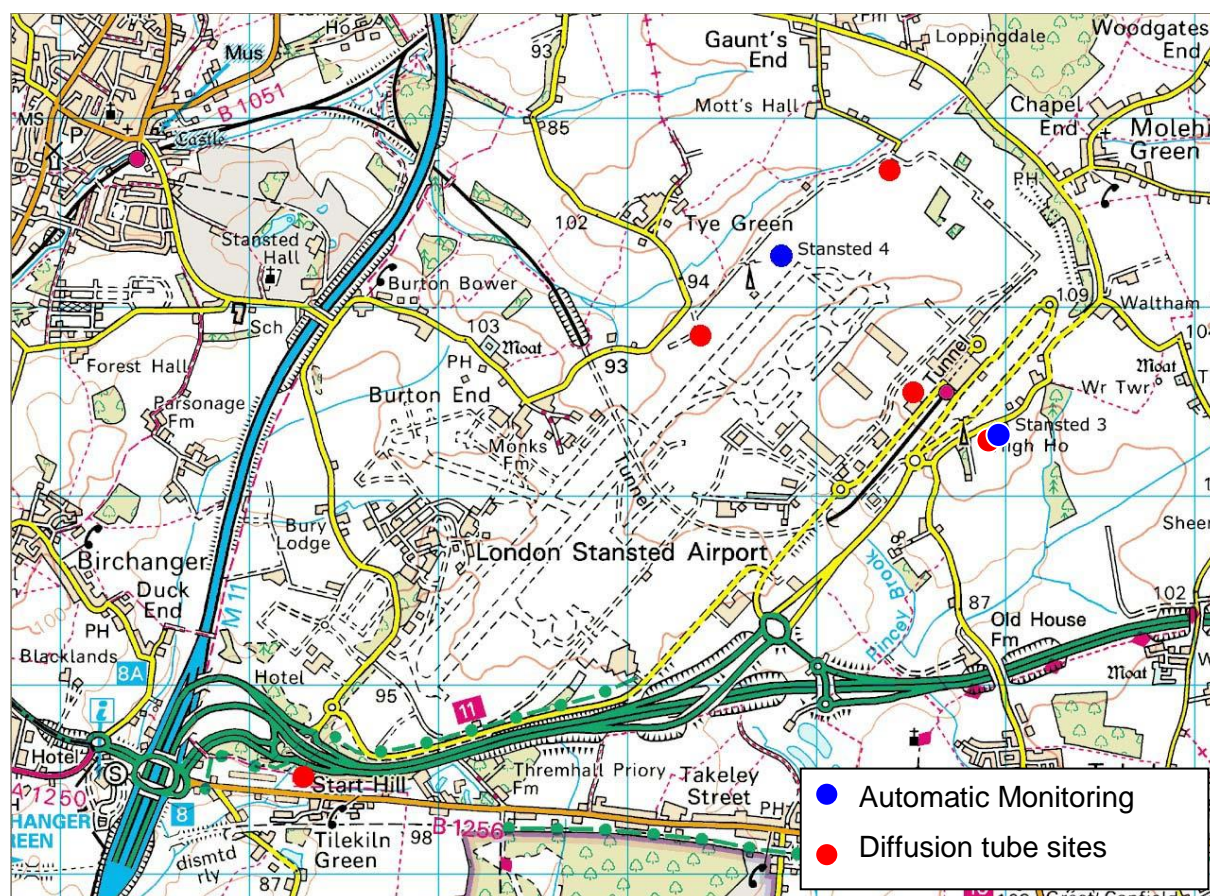
These two automatic sites were supplemented by five sites at which diffusion tubes were used to monitor NO₂ on a monthly basis. These were located at the Stansted 3 automatic site, and four sites to the north, east, south and west of the airport.

Table 2-1 describes the monitoring locations. Figure 2-1 shows a map of the locations of all monitoring sites used in this study. Automatic monitoring sites are shown by blue dots, diffusive samplers by red dots.

Table 2-1: Locations of air quality monitoring sites at Stansted

Site name	Description	Parameters monitored	Grid reference
Stansted 3	East of High House	Automatic monitoring of NO _x and PM ₁₀ . Diffusion tube monitoring of NO ₂ monthly (co-located).	TL 558 233
Stansted 4	Grass area near runway	Automatic monitoring of NO _x .	TL 548 243
Stansted North	North lights, north end of runway	Diffusion tube monitoring of NO ₂ monthly.	TL 555 248
Stansted East	Enterprise House offices	Diffusion tube monitoring of NO ₂ monthly.	TL 555 234
Stansted South	Balancing pond south of site	Diffusion tube monitoring of NO ₂ monthly.	TL 522 215
Stansted West	Radar tower, Burton End	Diffusion tube monitoring of NO ₂ monthly.	TL 536 235

Figure 2-1: Locations of monitoring sites © Crown Copyright Ordnance Survey. Reproduced from Landranger 1:50000 map series, Licence number 100040905.



The location of the automatic monitoring site at High House (Stansted 3) was agreed with Stansted Airport, Uttlesford District Council and Ricardo-AEA. It is located just outside the eastern perimeter of the airport. It is considered to be close enough to the airport to detect effects relating to airport emissions. It is also close to vulnerable receptors, being located in a

nursery school car park. The A120 main road runs approximately 1.5 km to the south of the site. The monitoring apparatus is housed in a purpose-built enclosure. Figure 2-2 shows a photograph of the Stansted 3 site.

Figure 2-2: Stansted 3 automatic monitoring site



Stansted 4 is located at the north-eastern end of the main runway, within the airport perimeter. It is intended to monitor any effects on air quality related to airport emissions. The location of Stansted 4 is included in Figure 2-1, and a photograph is provided in Figure 2-3.

Figure 2-3: Stansted 4 automatic monitoring site

2.3 Monitoring methods

The following techniques were used for the automatic monitoring of NO_x (ie NO and NO₂) and PM₁₀.

- PM₁₀ Tapered element oscillating microbalance (TEOM)
- NO, NO₂ Chemiluminescence.

Further information on these techniques is provided in Appendix 2 of this report. These analysers provide a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15-minute mean values by internal data loggers. The analysers are connected to a modem and interrogated through a GPRS internet device to download the data to Ricardo-AEA. Data are downloaded hourly. The data are converted to concentration units at Ricardo-AEA then averaged to hourly mean concentrations.

2.4 King's College London Volatile Correction Model

The TEOM particulate monitor uses a 50 °C heated sample inlet to prevent condensation on the filter. Although necessary, this elevated temperature can result in the loss of volatile and semi-volatile components of PM₁₀ such as ammonium nitrate⁶.

It is not possible to address this problem by applying a simple correction factor. However, King's College London (KCL) has developed a Volatile Correction Model⁷ (VCM), which allows TEOM PM₁₀ data to be corrected for the volatile components lost as a result of the TEOM's heated inlet. It uses data from nearby TEOM-FDMS (Filter Dynamics Measurement System) particulate analysers in the national air quality monitoring network, which measure the volatile and non-volatile components of PM₁₀. The volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. KCL

states that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

Correction using the VCM is now the preferred approach when comparing TEOM data with air quality limit values and objectives. In this report, it is clearly indicated when the VCM has been used to correct PM₁₀ data. In some cases, when investigating diurnal patterns and long-term trends (which started prior to the development of the VCM), the VCM has not been applied and this too is clearly indicated.

The methodology for the VCM correction of PM₁₀ data is presented in Appendix 2 of this report. **The TEOM-FDMS data from the national monitoring network for the final three months of 2013 (October to December) were still provisional at the time of writing. Therefore, the VCM-corrected dataset could change slightly if the VCM-correction is repeated at a later date.**

2.5 Diffusive samplers

Diffusion tubes were used for additional indicative monitoring of NO₂. These are "passive" samplers which work by absorbing the pollutants direct from the surrounding air and need no power supply.

Diffusion tubes for NO₂ 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 to be monitored, in this case NO₂. The tube is mounted vertically with the open end at the bottom. Ambient NO₂ 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.

Diffusion tubes were prepared by a commercial laboratory (Gradko International Ltd). The tubes were supplied in a sealed condition prior to exposure. They were exposed at the sites for a set period of time. After exposure, the tubes were again sealed and returned to the laboratory for analysis. The exposure periods used were approximately equivalent to calendar months.

3 Quality assurance and data capture

3.1 Quality assurance and quality control

In line with current operational procedures within the Defra Automatic Urban and Rural Network (AURN)⁸, full intercalibration audits of the Stansted air quality monitoring sites took place at six-monthly intervals. Full details of these UKAS-accredited calibrations, together with data validation and ratification procedures, are given in Appendix 3 of this report. In addition to instrument and calibration standard checking, the air intake sampling systems were cleaned and all other aspects of site infrastructure were 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 Stansted are summarised in Table 3-1.

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

Pollutant	Precision	Accuracy
NO	± 2.5	± 15 %
NO ₂	± 6.9	± 15 %
PM ₁₀	± 4	Estimated* accuracy of a TEOM ± 30 % or better. With VCM correction, estimated as ± 25 %.

* Accuracy of particle measurements with a TEOM instrument cannot be assessed reliably.

When using diffusion tubes for indicative NO₂ monitoring, the LAQM Technical Guidance LAQM.TG(09)⁴ states that correction should be made for any systematic bias (ie over-read or under-read compared to the automatic chemiluminescent technique, which is the reference method for NO₂). Throughout this study, diffusion tubes have been exposed alongside the automatic NO_x analyser at Stansted 3. These co-located measurements were used for bias adjustment of the annual mean diffusion tube data from the other sites.

The diffusion tube methodologies used for this monitoring programme provide data that are accurate to ± 25 % for NO₂. The limits of detection vary from month to month, but typically equate to 0.4 µg m⁻³ for NO₂. Diffusion tube results that are below 10 times the limit of detection have a higher level of uncertainty associated with them. All were above this threshold.

3.2 Data capture

Data capture statistics for the two monitoring sites are given in Table 3-2. A data capture target of 90 % is recommended in the European Commission Air Quality Directive¹ and Defra Technical Guidance LAQM.TG(09)⁴.

Table 3-2: Data capture statistics 2013

Site	NO _x	NO ₂	PM ₁₀
Stansted 3	88.1 %	88.1 %	97.6 %
Stansted 4	98.7 %	98.7 %	N/A

The 90 % data capture target was therefore achieved for PM₁₀ at Stansted 3 and for NO_x and NO₂ at Stansted 4. However, data capture was below the 90 % target for NO_x and NO₂ at Stansted 3. Table 3-3 shows the significant gaps in data capture that occurred during the year.

Table 3-3: Significant data gaps 2013

Site	Pollutant	Start date	End date	No. of days	Reason	Comments
Stansted 3	NO ₂	10/01/2013	11/01/2013	1.2	Service	Routine Service
Stansted 3	NO ₂	26/03/2013	28/03/2013	1.9	No data collected	Communications problem.
Stansted 3	NO ₂	16/04/2013	19/04/2013	2.9	Power cut	Power was disconnected due to building work
Stansted 3	NO ₂	23/06/2013	28/06/2013	5.5	Pump fault	Engineer called out: replaced pump
Stansted 3	NO ₂	22/07/2013	23/07/2013	1.2	Service	Routine service
Stansted 3	NO ₂	30/10/2013	31/10/2013	1.1	Flat response	Resolved by local site operator
Stansted 3	NO ₂	22/11/2013	22/11/2013	0.3	Communication fault	
Stansted 3	NO ₂	04/12/2013	31/12/2013	28	Instrument fault	

4 Results and discussion

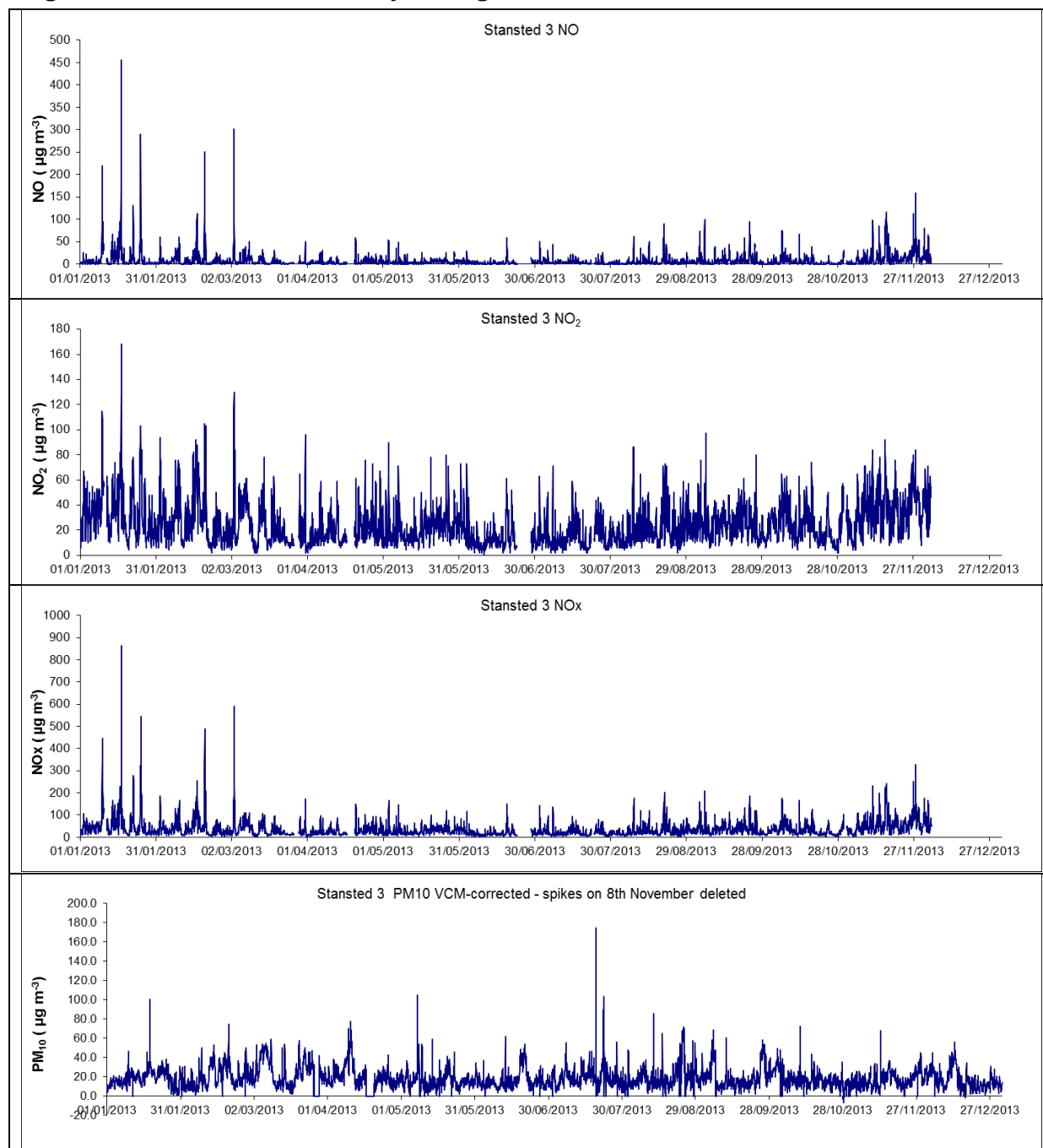
4.1 Automatic monitoring data

The summary statistics for 2013 are given in Table 4-1, and the time series of data for the full year, as measured by the automatic monitoring sites, are shown in Figure 4-1 and Figure 4-2.

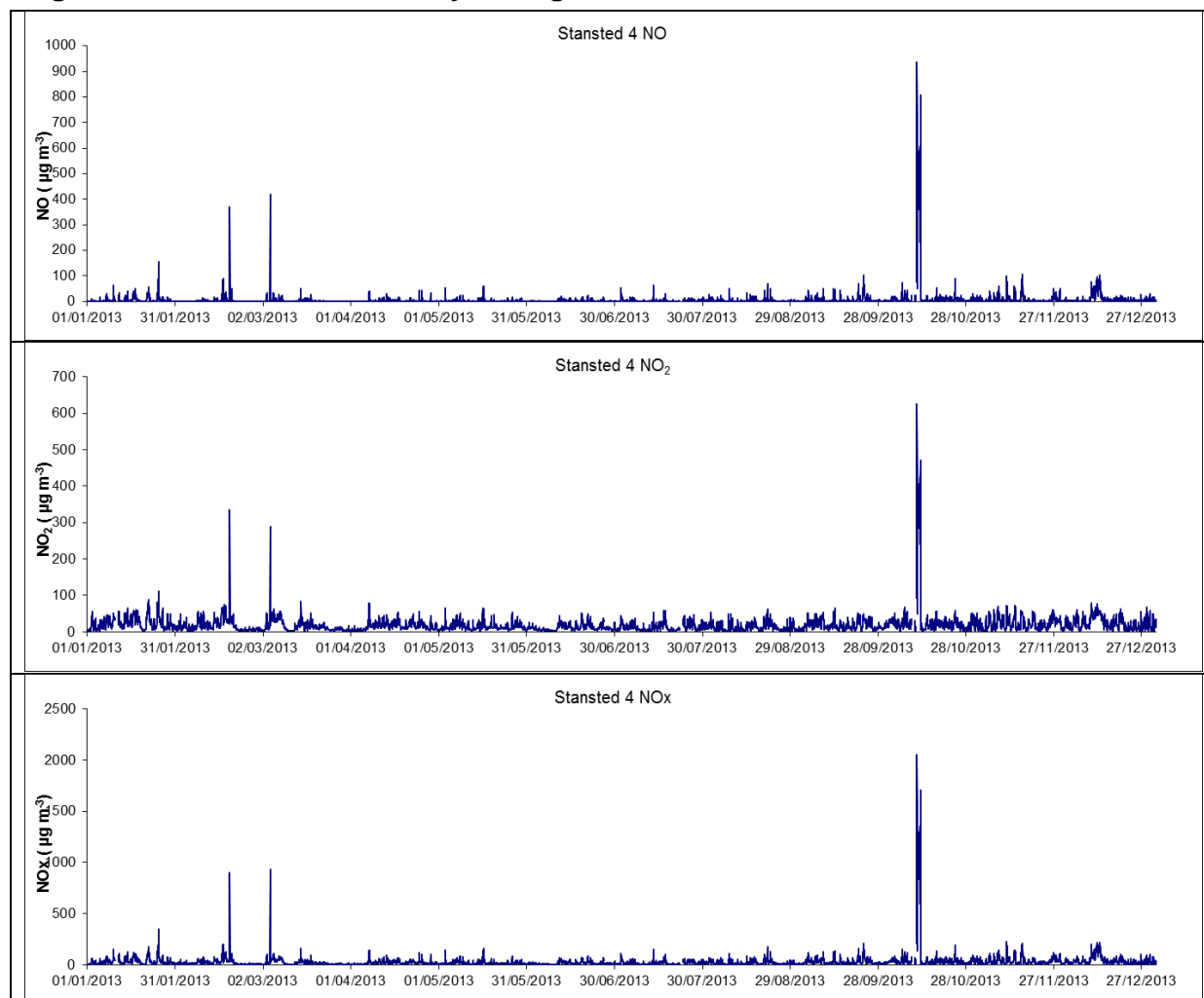
Table 4-1: Air pollution statistics for Stansted 3 and Stansted 4, from 1st January to 31st December 2013

Stansted 3	NO ($\mu\text{g m}^{-3}$)	NO ₂ ($\mu\text{g m}^{-3}$)	NOx ($\mu\text{g m}^{-3}$)	PM ₁₀ as measured ($\mu\text{g m}^{-3}$)	PM ₁₀ VCM corrected ($\mu\text{g m}^{-3}$)
Maximum 15-minute mean	590	183	1,083	6,570	-
Maximum hourly mean	455	168	863	1,927	1,924
Maximum running 8-hour mean	159	101	328	326	-
Maximum running 24-hour mean	96	70	217	120	-
Maximum daily mean	67	61	162	115	118
Average	7	24	35	15	19
Data capture	88.1 %	88.1 %	88.1 %	97.6 %	97.6 %
Stansted 4	NO ($\mu\text{g m}^{-3}$)	NO ₂ ($\mu\text{g m}^{-3}$)	NOx ($\mu\text{g m}^{-3}$)		
Maximum 15-minute mean	1,104	674	2,279		
Maximum hourly mean	936	625	2,055		
Maximum running 8-hour mean	584	414	1,306		
Maximum running 24-hour mean	488	353	1,094		
Maximum daily mean	458	336	1,036		
Average	6	19	29		
Data capture	98.7 %	98.7 %	98.7 %		

In this report PM₁₀ measured using the TEOM instrument were converted to gravimetric equivalent using the King's College London Volatile Correction Model⁷ where appropriate. See section 2.4 for an explanation of this.

Figure 4-1: Time series of hourly averaged concentrations at Stansted 3 - 2013

At Stansted 3, some unusually high hourly average PM₁₀ concentrations were recorded on 8th November 2013, reaching 1,924 $\mu\text{g m}^{-3}$ (after VCM-correction). The monitoring site is close to an adjacent farm and it was confirmed that this high concentration coincided with movement of fertilisers on the farm. In Figure 4-1 this peak has been removed in order that the rest of the data can be seen clearly.

Figure 4-2: Time series of hourly averaged concentrations at Stansted 4 - 2013

At Stansted 4, there are clearly visible peaks in oxides of nitrogen, on 11th and 12th October 2013. These were caused by emissions from a backup generator which was brought into operation very close to the monitoring site. During this period, hourly mean NO₂ concentrations reached a maximum of 625 $\mu\text{g m}^{-3}$.

4.2 Diffusion tube data

Table 4-2 shows the NO₂ diffusion tube results for 2013. Tubes were exposed in triplicate at all sites. The results shown are the means of those replicate measurements. The full dataset is shown in Appendix 4. The analyst provided diffusion tube data to two decimal places. These have been rounded to one decimal place in the table below, but are quoted as integer values in this report, in accordance with the reported uncertainty of the method.

Table 4-2: NO₂ diffusion tube results 2013, µg m⁻³

Start date	Stansted North	Stansted East	Stansted South	Stansted West	Stansted 3
04/01/2013	29.2	39.8	36.4	27.1	32.5
30/01/2013	15.9	28.4	30.7	17.4	25.0
27/02/2013	17.6	29.5	32.8	21.2	24.0
27/03/2013	15.1	21.9	26.0	14.2	17.9
24/04/2013	13.0	22.0	23.4	12.9	20.9
29/05/2013	12.4	19.5	22.7	11.9	17.8
26/06/2013	12.2	21.5	22.5	12.6	18.4
31/07/2013	15.7	25.4	23.7	14.2	22.7
28/08/2013	20.4	33.0	27.0	17.3	28.8
25/09/2013	23.5	33.0	24.9	20.5	24.6
30/10/2013	27.3	35.6	30.5	24.2	33.1
27/11/2013	27.1	31.1	28.2	21.6	27.5
Mean	19.1	28.4	27.4	17.9	24.4
Bias adjusted	18.7	27.8	26.9	17.6	23.9

Six results were rejected as they were suspected to be spurious. Details of these are shown in Table 4-3. In most cases, these were “outliers”; results much lower or higher than those of the other two co-exposed tubes.

Table 4-3: Details of NO₂ diffusion tube results rejected

Site	Month	Tube number	NO ₂ concentration (µg m ⁻³)	Reason for rejection
Stansted 3	May 2013	Tube 2	6.5	Low outlier in triplet.
Stansted North	May 2013	Tube 2 and Tube 3	7.0 and 5.2	Unusually low results for the site: thought most likely to be faulty tubes
Stansted North	August 2013	Tube 1	8.4	Low outlier in triplet.
Stansted West	May 2013	Tube 3	5.6	Low outlier in triplet.
Stansted West	August 2013	Tube 1	22.8	High outlier in triplet.

Across the five sites, annual mean NO₂ concentrations measured with diffusion tubes ranged from 18 µg m⁻³ to 28 µg m⁻³. At Stansted 3, where diffusion tube results could be compared directly with data from automatic monitoring, the (rounded) annual mean concentration was 24 µg m⁻³. This was equal to the annual mean of 24 µg m⁻³ obtained using the reference technique (the chemiluminescence analyser).

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 NO₂ 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, but with the one outlier for Stansted 3 (in Table 4-3) removed. On this basis, the bias adjustment factor was calculated to be 0.98.

The annual mean values from the other four diffusion tube sites were all corrected using the same bias adjustment factor.

Please note:

- i. 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.
- ii. Even after application of a bias adjustment factor, diffusion tube measurements remain indicative only.

4.3 Comparison with air quality objectives

Details of the UK air quality standards and objectives specified by Defra are provided in Appendix 1.

The AQS objective for hourly mean NO₂ concentration is 200 µg m⁻³ which may be exceeded up to 18 times per calendar year. Where data capture is less than 90%, compliance is assessed by comparing the 99.8th percentile of hourly means with the objective. This was the case at Stansted 3 which fell just short of the data capture target. However, since there were no recorded hourly mean NO₂ concentrations in excess of the hourly mean AQS objective of 200 µg m⁻³, the site therefore met the AQS objective for this pollutant.

Stansted 4 had 34 recorded exceedances, therefore going over the 18 times a year allowed. This site therefore did not meet the AQS objective for NO₂. This is not typical for this site. However, 32 of these 34 exceedances were during the two-day period when a generator was in operation nearby, and its emissions directly affected the monitoring site. This period was not representative of typical conditions at the site.

The annual mean NO₂ concentrations measured at Stansted 3 and Stansted 4 during 2013 were 24 µg m⁻³ and 19 µg m⁻³ respectively. Both automatic sites were therefore within the annual mean AQS objective for NO₂ of 40 µg m⁻³ for protection of human health and the objective of 30 µg m⁻³ for protection of vegetation and ecosystems.

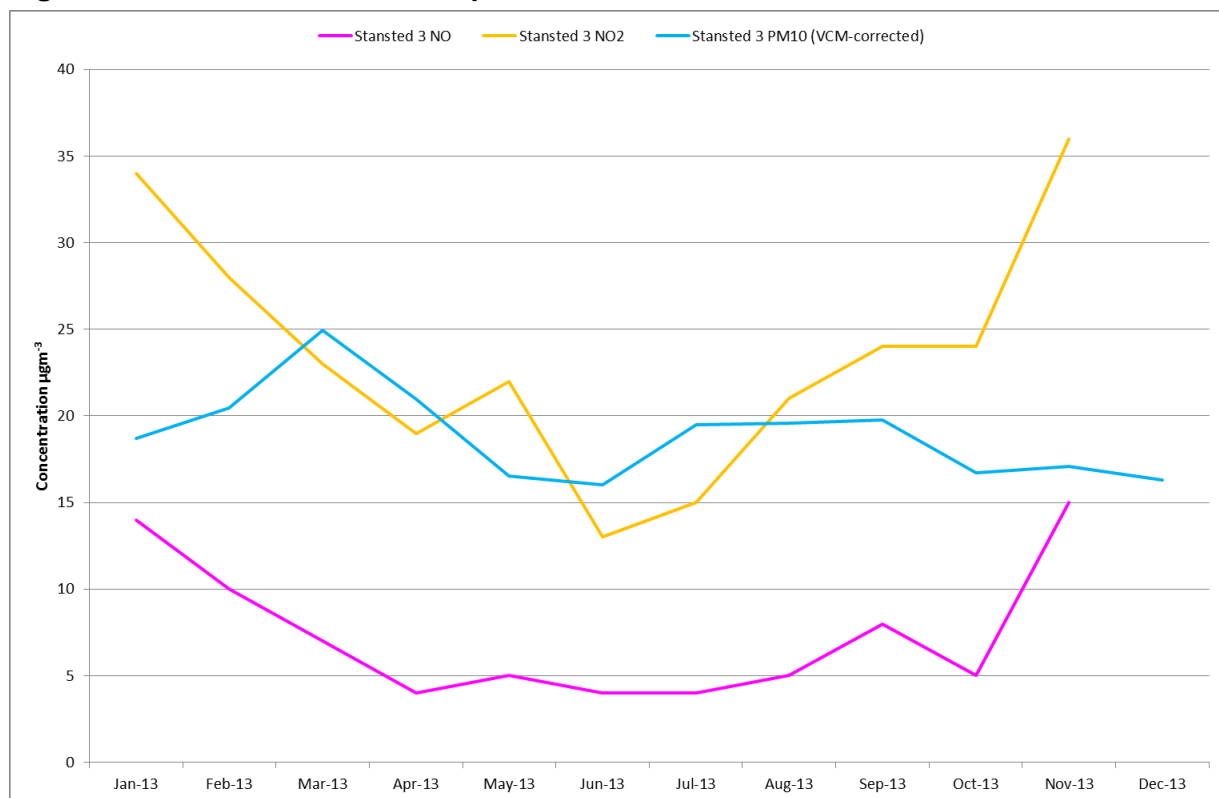
The bias-adjusted annual mean NO₂ concentrations measured at the five diffusion tube sites were all well within the AQS objective of 40 µg m⁻³.

PM₁₀ was measured at Stansted 3 only. After correction of the data using the King's College VCM, the number of days when the 24-hour mean was in excess of 50 µg m⁻³ was two. This is well within the maximum permitted number of exceedances (35), so this site met the AQS objective for 24-hour mean PM₁₀.

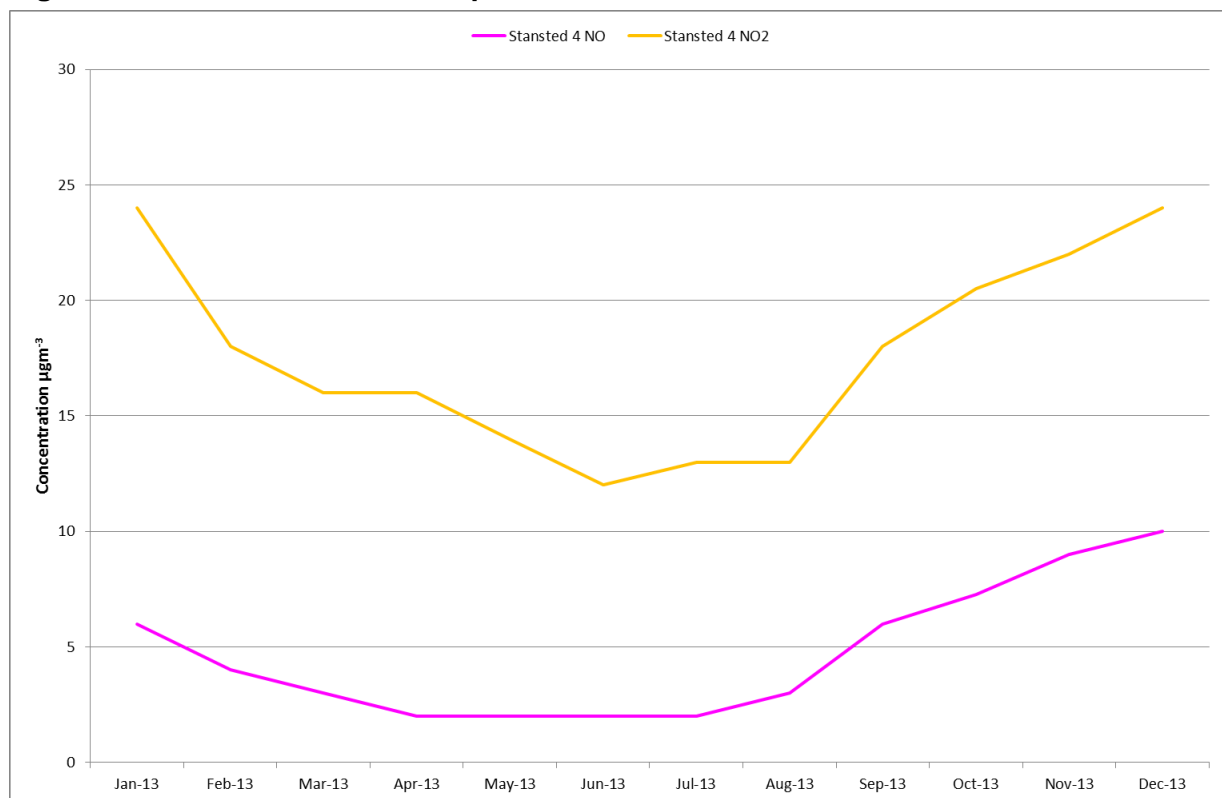
4.4 Temporal variation in pollutant concentrations

4.4.1 Seasonal variation

Figure 4-3 and Figure 4-4 show the variation of monthly averaged NO and NO₂ concentrations during 2013 at Stansted 3 and Stansted 4.

Figure 4-3: Seasonal variation of pollutant concentrations at Stansted 3, 2013

As highlighted in section 4.1, there was an unusual peak in PM₁₀ values on 8th November 2013, which was associated with fertiliser movements at the farm adjacent to the monitoring site. This high value distorts the seasonal pattern and has therefore been excluded from the graph shown in Figure 4-3. In previous years, peaks have occurred during August to September, probably arising from farm activities associated with harvesting. That pattern did not occur in 2013, although a moderate peak occurred during March. NO and NO₂ both showed increases in winter, a pattern that would be expected during periods of cold weather and relatively low wind speeds.

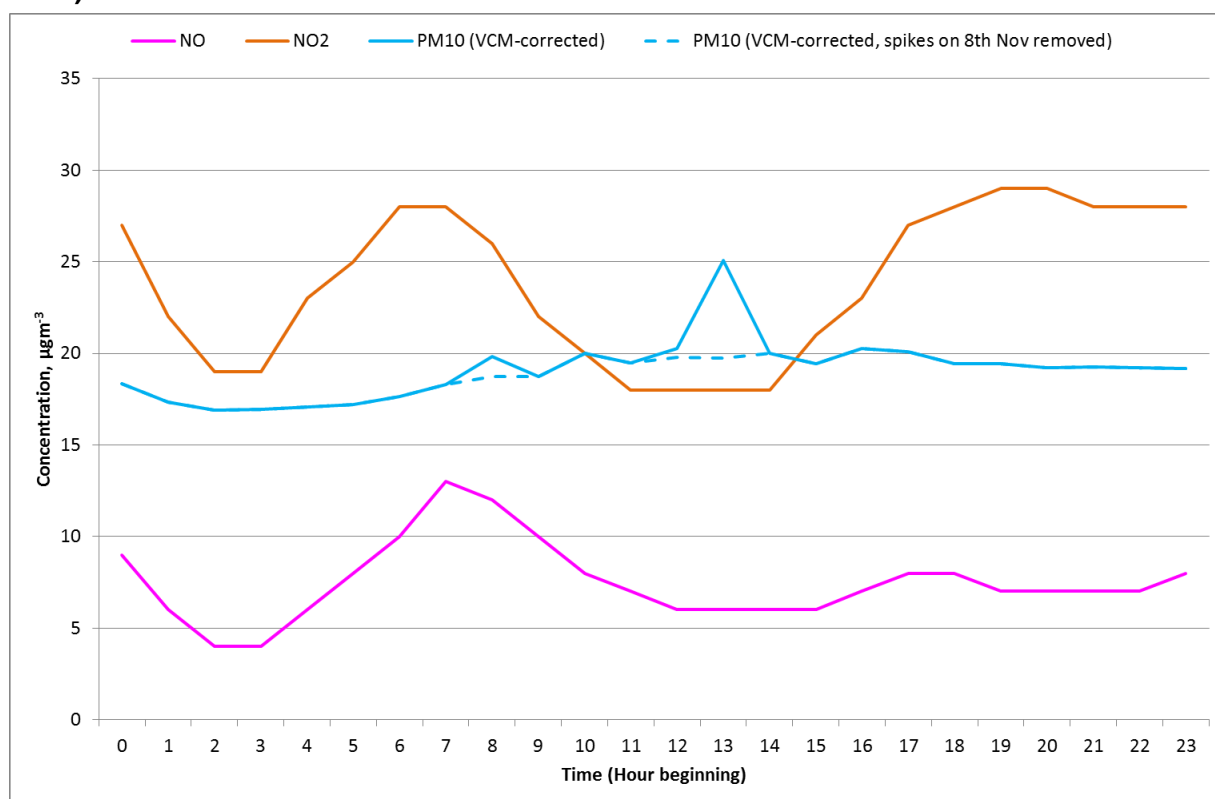
Figure 4-4: Seasonal variation of pollutant concentrations at Stansted 4, 2013

Stansted 4 recorded unusually high concentrations of NO_x on 11th to 12th October 2013 due to a nearby generator (as shown in Figure 4-2) and these spikes have been removed from the graph above to avoid distortion of the seasonal pattern. Apart from those peaks, the highest concentrations of NO and NO₂ occurred during the winter months. This pattern was also observed in previous years and is typical of urban monitoring sites. 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.

4.4.2 Diurnal variation

Figure 4-5 and Figure 4-6 show diurnal variation in pollutant concentrations, as measured at Stansted 3 and Stansted 4. The PM₁₀ data shown here are VCM-corrected.

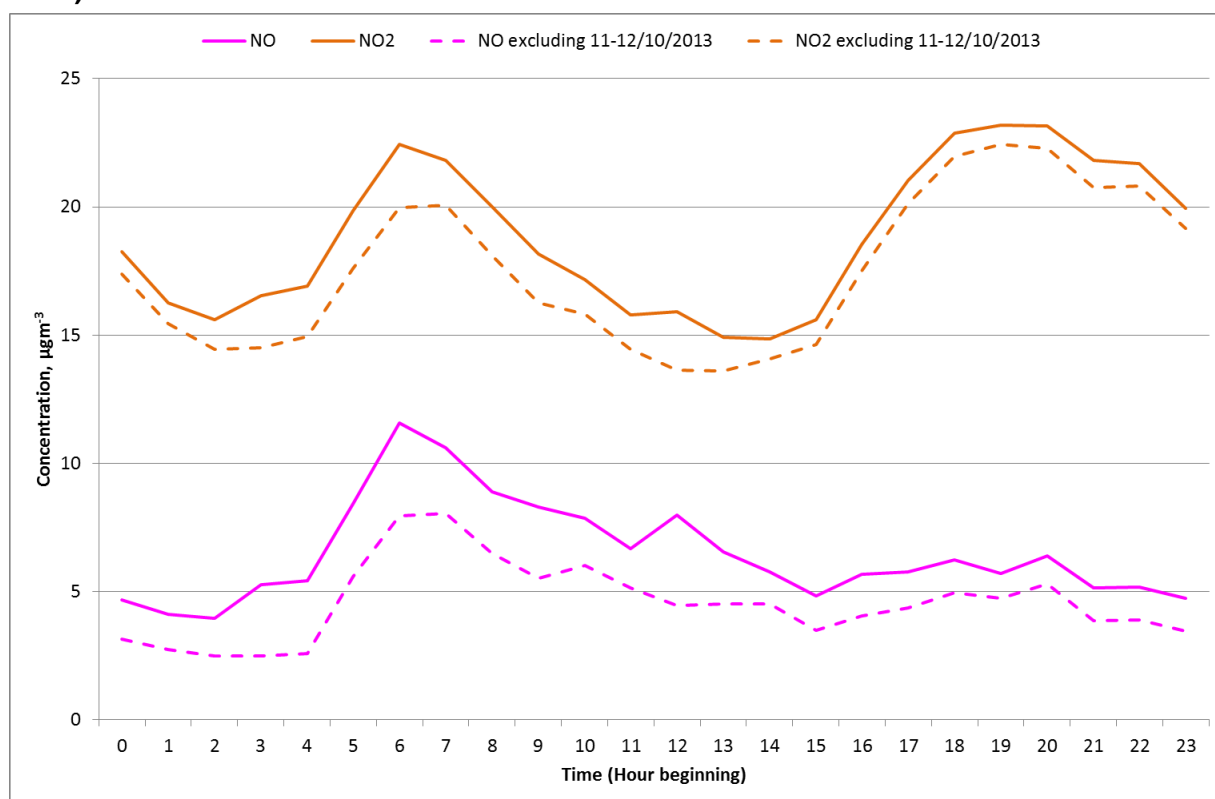
Figure 4-5: Diurnal variation of pollutant concentrations at Stansted 3, 2013 (times in GMT)



PM₁₀ was only measured at Stansted 3. The “spikes” in PM₁₀ concentration on 8th November 2013, thought to have arisen from fertiliser movements on the adjacent farm, occurred at 08:00, 12:00 and 13:00. These “spikes”, especially the latter, were large enough to affect the diurnal pattern. Therefore Figure 4-5 shows the diurnal patterns with (solid line) and without (dotted line) those readings. The effect of removing them can therefore be seen very clearly, particularly between 12:00 and 13:00.

Ignoring the spikes in measurements on 8th November, there was a steady increase in average PM₁₀ concentrations throughout the day. This is similar to the pattern observed in 2012. Emissions of sulphur dioxide and NO_x can react with other chemicals in the atmosphere to form secondary sulphate and nitrate particles, resulting in elevated levels of PM₁₀.

Figure 4-6: Diurnal variation of pollutant concentrations at Stansted 4, 2013 (times in GMT)



Elevated levels of NO and NO₂ were recorded at Stansted 4 between 02:00 on 11th October 2013 and 13:00 on 12th October 2013 (see Figure 4-2). As discussed, these heightened concentrations occurred as a result of a generator operating close to the monitoring station. Diurnal patterns are shown including (solid lines) those unusually high levels and excluding them (dotted lines). For both pollutants, the lines are approximately parallel, indicating that the concentrations were different but the patterns across 24 hours were not severely affected. This is because the generator was in continuous use over more than 24 hours and therefore impacted on data across all times.

Both sites showed pronounced peaks for NO and NO₂ during the mornings, corresponding to rush hour traffic at around 07:00. Concentrations decreased during the middle of the day, with a much broader evening rush-hour peak in NO₂ building up from early afternoon. At Stansted 3 the afternoon peak in NO₂ was higher than the morning peak and then stayed high for much of the night. NO showed a much smaller peak in the afternoons. This is to be expected as concentrations of oxidising agents in the atmosphere (eg ozone) tend to increase in the afternoon, leading to enhanced oxidation of NO to NO₂. This is a typical pattern for oxides of nitrogen in urban areas.

4.5 Source investigation

In order to investigate the possible sources of air pollution that were monitored at Stansted airport, meteorological data (kindly supplied by Stansted Airport Ltd) were used to add a directional component to the air pollutant concentrations. The meteorological data used here are as received from Stansted Airport Ltd. The QA/QC procedures for checking of these data are not known.

Figure 4-7 shows the wind speed and direction data, as supplied by Stansted Airport Ltd. The lengths of the “spokes” against the concentric circles indicate the percentage of time during the year that the wind was measured from each direction. The prevailing wind direction was 195 ° to 255 °, and the wind was from these directions approximately 32 % of

the year. Each “spoke” is divided into coloured sections representing wind speed intervals of 2 m s^{-1} as shown by the scale bar in the plot. The mean wind speed was 2.5 m s^{-1} , and the 75th percentile wind speed was 3.4 m s^{-1} . The maximum measured wind speed was 13.0 m s^{-1} . Some of the highest wind speeds occurred during October and December 2013.

Figure 4-7: Wind rose showing the wind speeds and directions in 2013

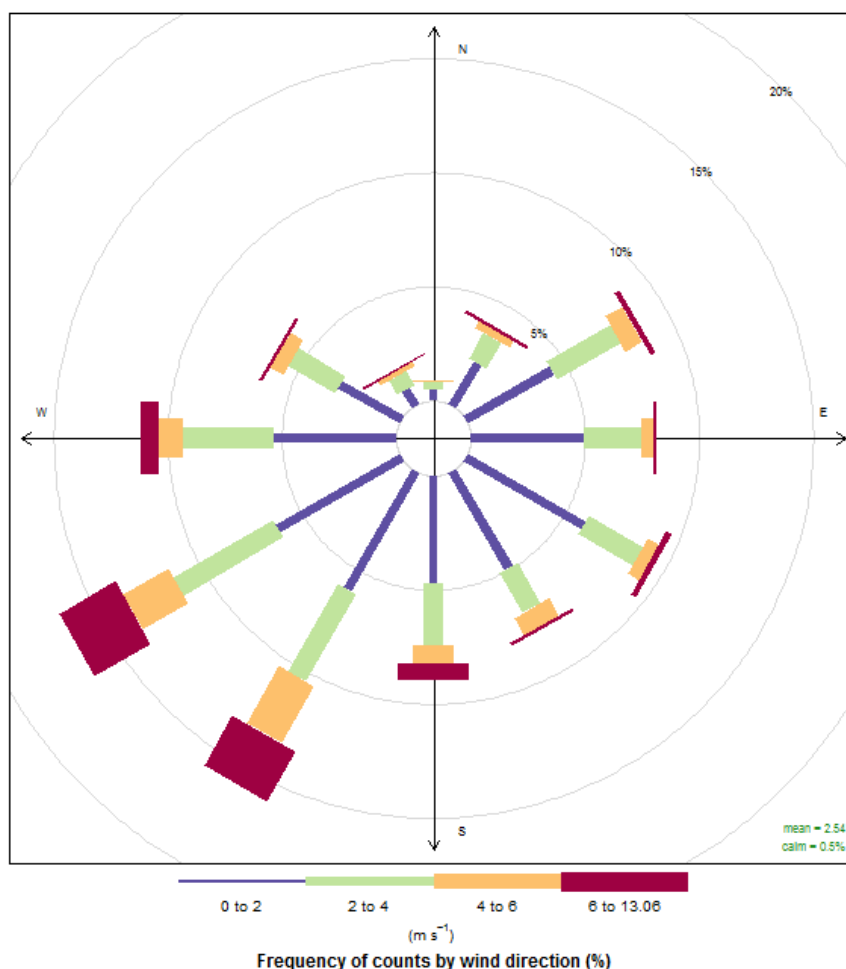
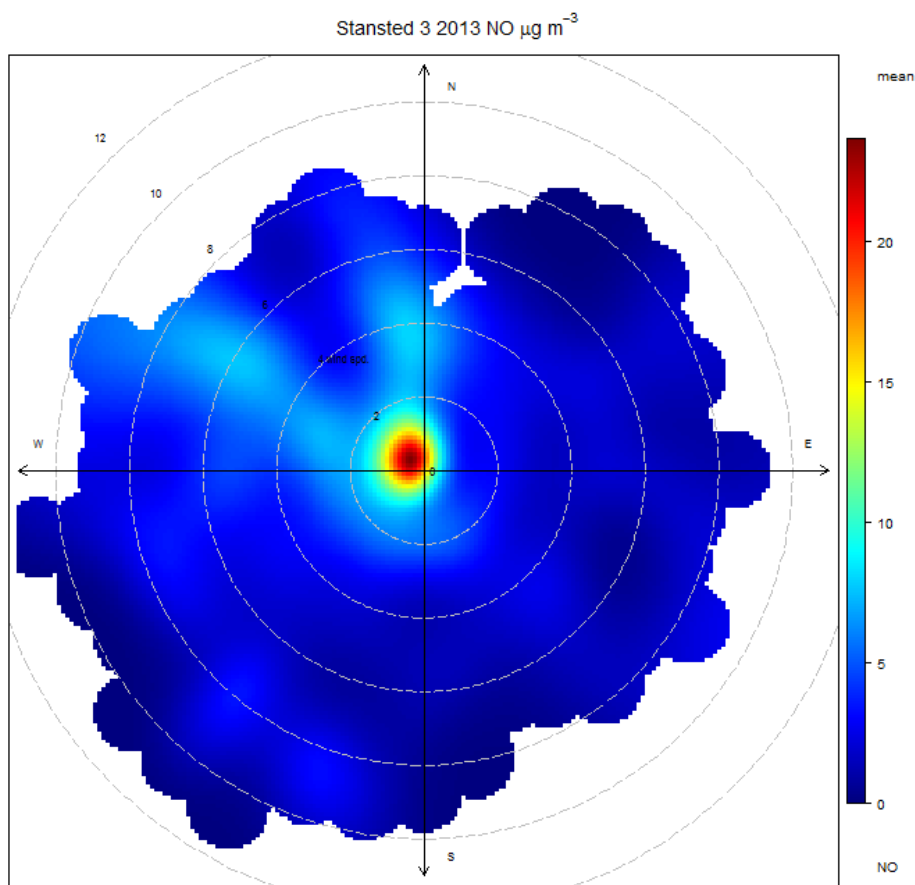


Figure 4-8 shows a bivariate plot of hourly mean NO concentrations against the corresponding wind speed and wind direction. This, and subsequent plots in this section, should be interpreted as follows.

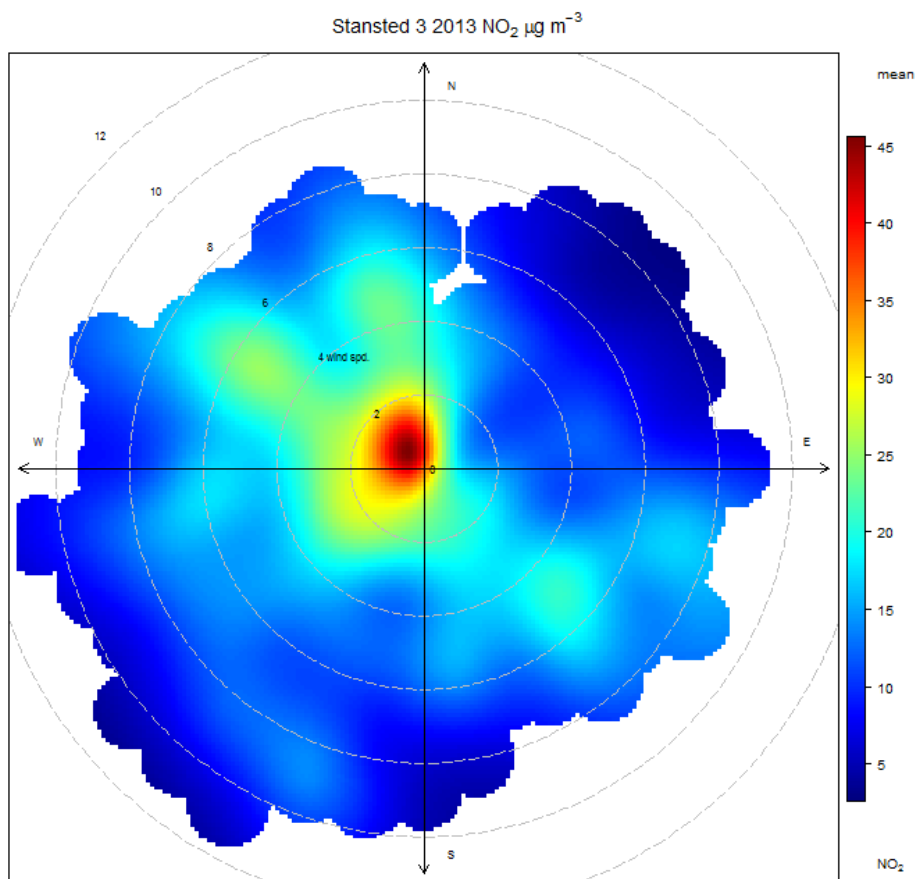
- The wind direction is indicated as in the wind rose above (north, south, east and west are indicated).
- The wind speed is indicated by the distance from the centre of the plot: the concentric circles indicate wind speeds in intervals of 2 m s^{-1} .
- The pollutant concentration is indicated by the colour (as shown in the scale bars).

These plots therefore show how pollutant concentration varies with wind direction and wind speed. They do not depict distance from the monitoring location. They are best interpreted with reference to the map in Figure 2-1.

Figure 4-8: Pollution rose for NO at Stansted 3 in 2013

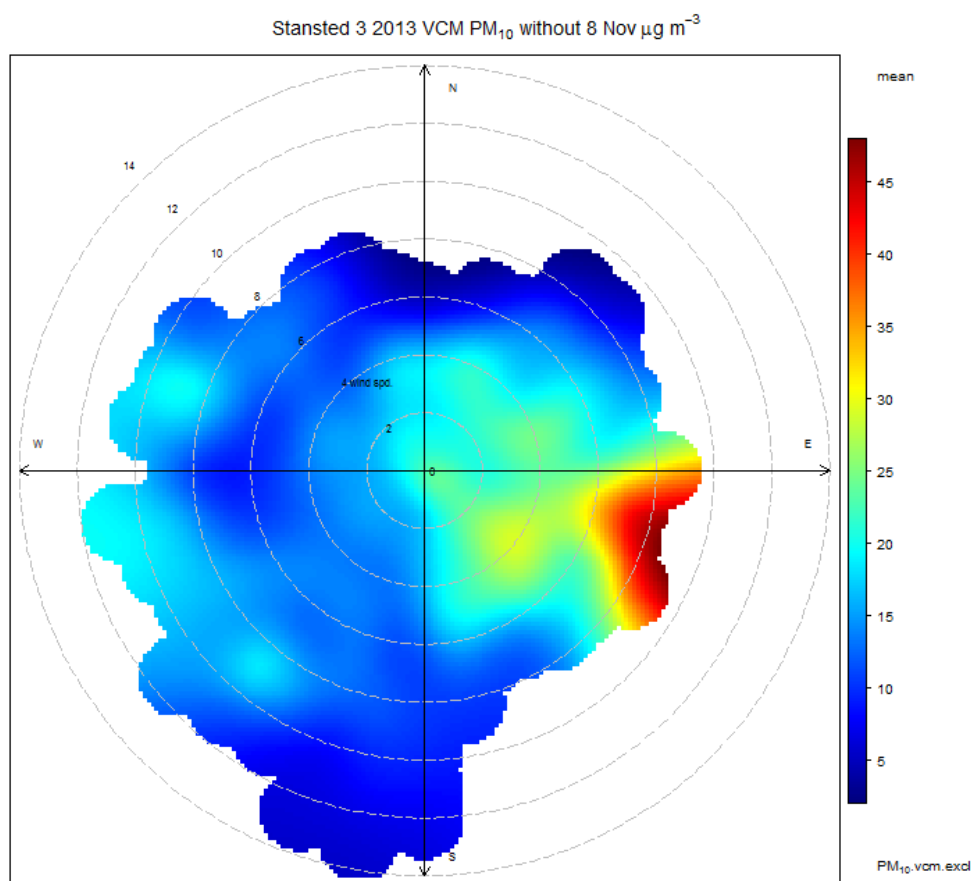
The highest concentrations of NO were recorded at Stansted 3 when the wind speed was low, suggesting that the main sources are close to the monitoring site. However, minor sources can also be detected to the north west of the monitoring location at higher wind speeds, indicated by the paler blue traces between 270 ° and 360 °.

Figure 4-9 shows a bivariate plot of hourly mean NO₂ concentrations against the corresponding wind speed and wind direction during 2013.

Figure 4-9: Pollution rose for NO₂ at Stansted 3 in 2013

As in previous years, the main source of NO₂ appeared to be close to the monitoring site, with the highest concentrations occurring at low wind speeds. At higher wind speeds, two sources emerged to the north west of the monitoring location and another in the south east, these occurring at low to moderate wind speeds (around 6-8 m s⁻¹). These might be the result of activities around the airport terminal buildings and emissions from roads such as the A120 which lies to the south of the airport.

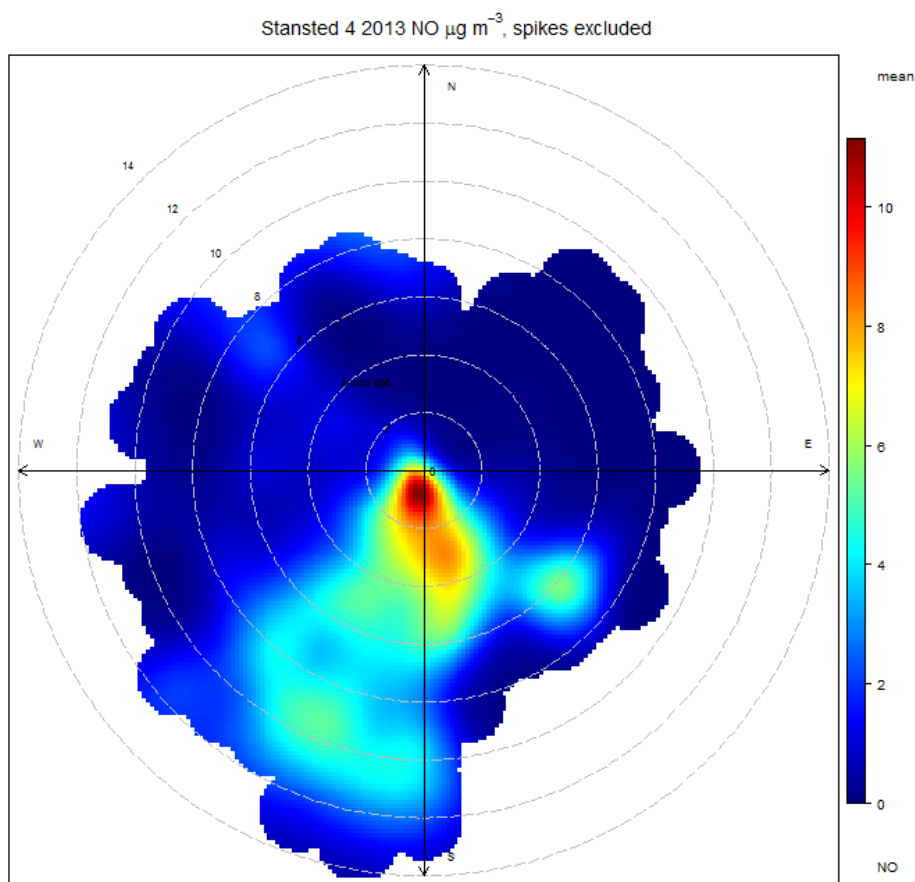
Figure 4-10 shows a similar bivariate plot for PM₁₀ at Stansted 3.

Figure 4-10: Pollution rose for VCM-corrected PM₁₀ at Stansted 3 in 2013

Hourly means for 08:00, 12:00 and 13:00 on 8th November have been excluded from this plot because of particularly high peaks in PM₁₀ measurements at those times.

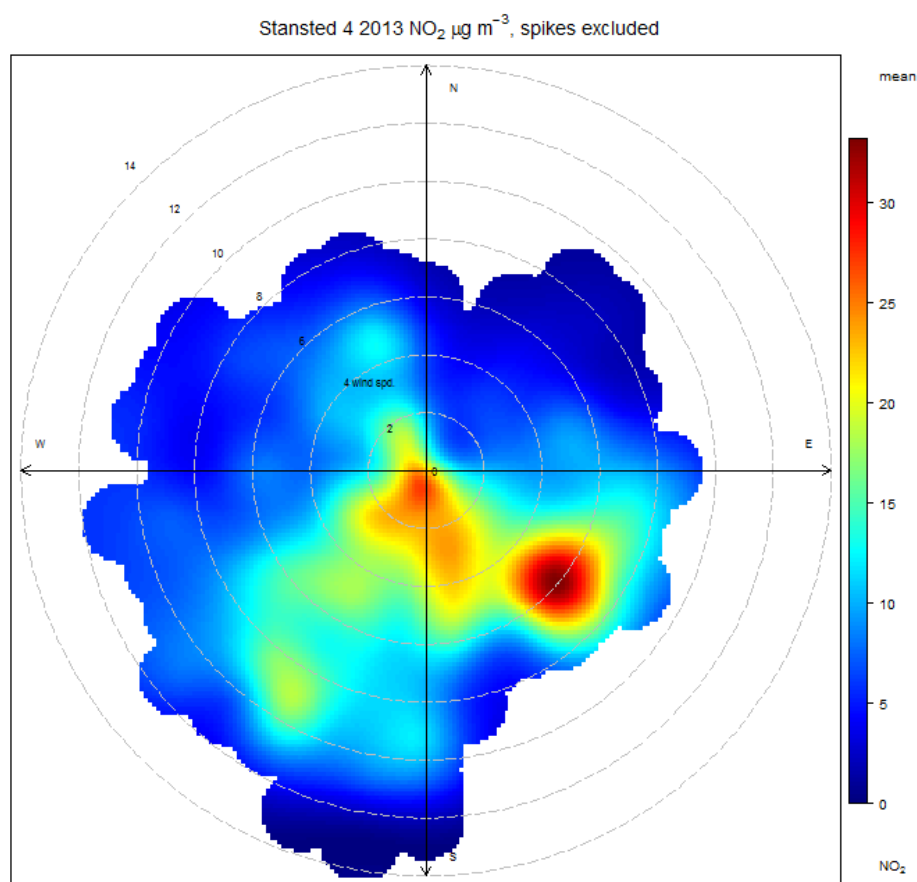
For PM₁₀, the highest concentrations were associated with faster wind speeds and wind directions between 90 ° and 135 °. The signature was similar to that seen in previous years and suggests a source to the east of the monitoring site. Although the source has not been identified, it is most likely related to agricultural activity.

Figure 4-11 shows the pollution rose for NO and Figure 4-12 shows the pollution rose for NO₂ at Stansted 4. Several unusually high peaks in concentrations have been removed from these plots. These include high concentrations measured between 02:00 on 11th October 2013 and 13:00 on 12th October 2013, as well as additional spikes on 18th February 2013 and 4th March 2013. The high values recorded on 11th to 12th October are known to have arisen because of a generator operating nearby. It is assumed that the peaks on 18th February and 4th March also occurred because of localised activities.

Figure 4-11: Pollution rose for NO at Stansted 4 in 2013

The highest concentrations of NO occurred at low wind speeds, indicating that the main sources were close to the monitoring site. There were also contributions from the south, correlating with the direction of the runway and the main airport terminal with its associated traffic.

The NO₂ pollution rose for Stansted 4 (Figure 4-12) also showed evidence of sources close to the monitoring site. However, a stronger signature also appeared from the south east at higher wind speeds matching the direction of the main airport terminal.

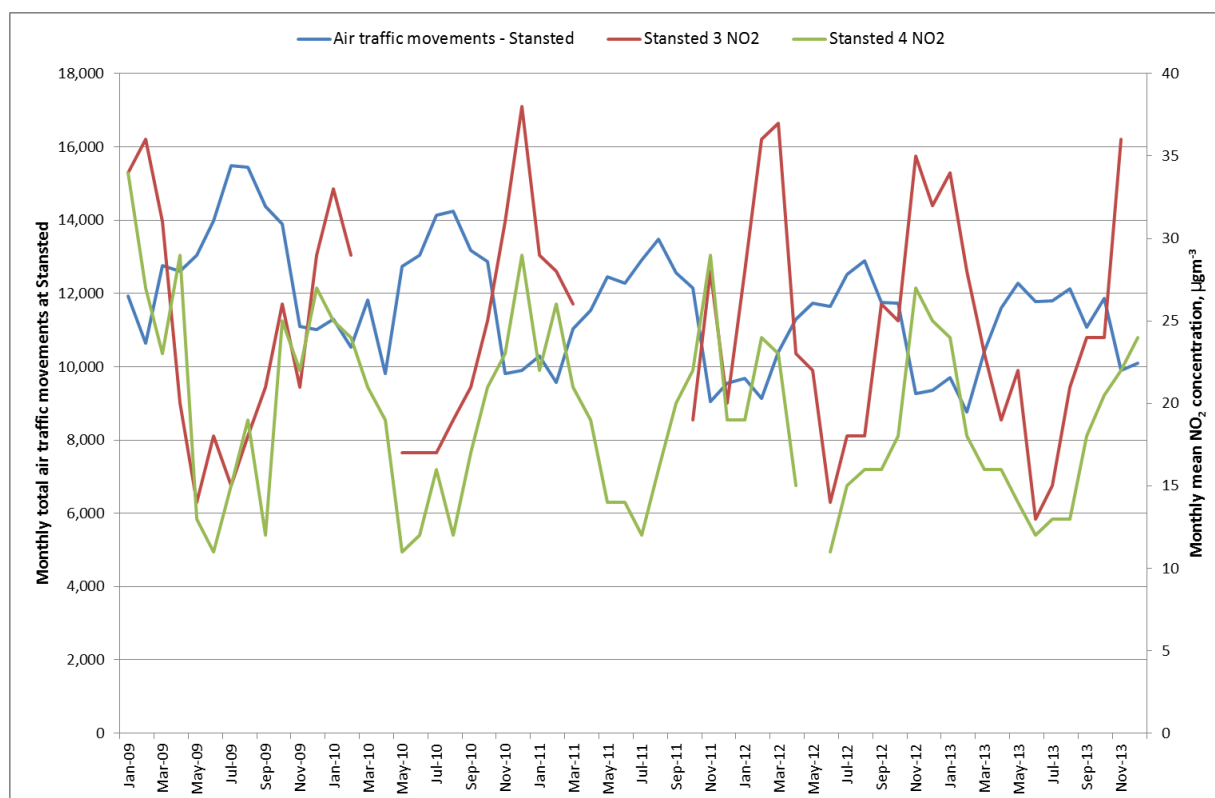
Figure 4-12: Pollution rose for NO₂ at Stansted 4 in 2013

4.6 Relationship with airport activity

The data presented in the sections above suggest that the airport is a major source of oxides of nitrogen and, to a lesser degree, of PM₁₀. In this section, the potential for correlation between airport activity and pollutant concentrations is investigated by comparing pollutant concentrations with aircraft movements at Stansted.

Figure 4-13 shows monthly statistics for the number of air traffic movements (ATMs) during the years 2005 to 2013. Also shown (plotted against the secondary y-axis) are monthly mean NO₂ concentrations at Stansted 3 and Stansted 4.

Figure 4-13: Monthly variation of Stansted airport activity and NO₂ concentration 2005-2013



The distinct seasonal pattern indicating high air traffic ‘activity’ in the summer months (July and August) and lower in the winter was clearly seen. Monthly mean NO₂ concentrations showed the opposite seasonal pattern, being higher in the winter months rather than the summer. This is a typical seasonal pattern for an urban area.

The emissions from the airport and its surrounding roads are a significant contributor to the ambient pollutant concentrations, as illustrated in the pollution rose plots in section 4.5. However, this simple analysis of air traffic movements indicates that seasonal variation in pollutant concentrations (ie the periods of high and low concentration) at Stansted are influenced to a greater extent by general meteorological factors than by air traffic movement.

4.7 Periods of elevated pollutant concentration

This section reviews the most significant periods of high air pollution concentrations for the whole year. It is important to stress that, despite there being some periods when pollutant concentrations exceeded the applicable air quality objectives, these were attributable to specific external sources.

4.7.1 Oxides of nitrogen

At Stansted 3, the highest hourly mean concentration of NO₂ was 168 µg m⁻³. There were no periods when hourly mean NO₂ concentrations exceeded 200 µg m⁻³, which is the AQS objective for hourly mean NO₂. The lower threshold of the Defra “Moderate” air quality band is 201 µg m⁻³ for hourly means. Therefore NO₂ levels at Stansted 3 stayed within the Defra “Low” band for the whole year and there were no periods of high NO₂ at Stansted 3.

At Stansted 4, there were 34 hours (on 4 days) when hourly mean NO₂ concentrations exceeded 200 µg m⁻³. These peaks can be seen clearly in Figure 4-2. Most of these occasions (32 of the 34) were on 11th and 12th October 2013 and arose because of a backup

generator which was brought into operation very close to the monitoring site. During this period, hourly mean NO₂ concentrations reached 625 µg m⁻³. This concentration is in the Defra “Very High” band. The other two occasions were at 14:00 on 18th February 2013 (334 µg m⁻³) and 10:00 on 4th March 2013 (290 µg m⁻³). Both of these occurrences were within the “Moderate” band and appeared to be short-term spikes, probably resulting from localised activities in the vicinity.

4.7.2 PM₁₀

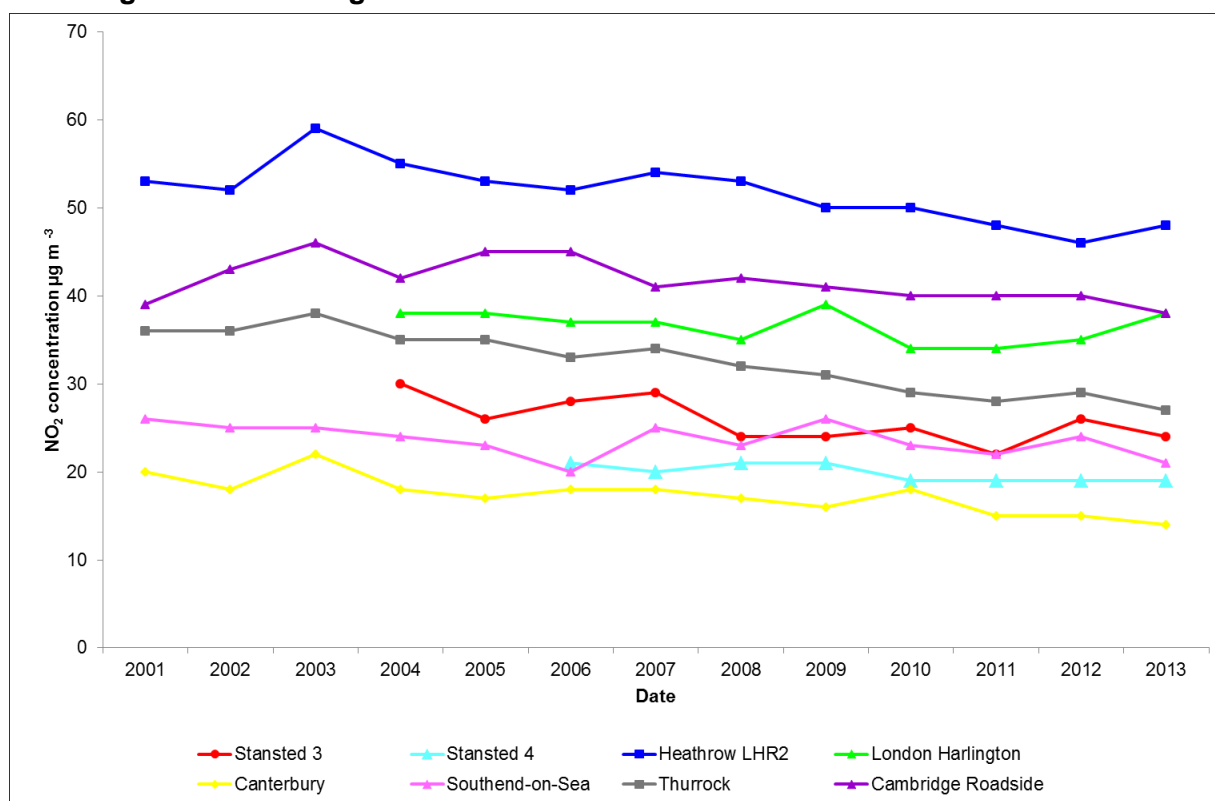
At Stansted 3, there were two days when daily mean PM₁₀ (after VCM correction) exceeded the AQS objective of 50 µg m⁻³. The first of these was on 10th April 2013 when a VCM-corrected daily mean of 58 µg m⁻³ occurred. This is within the “Moderate” band. The second peak was on 8th November 2013. The monitoring site is close to an adjacent barn and it was confirmed that this high concentration coincided with movement of fertilisers from the barn. The resulting increase in PM₁₀ concentration took the VCM-corrected daily mean to 118 µg m⁻³ which is in the Defra “Very High” band.

4.8 Comparison with other UK sites

Figure 4-14 provides a comparison between annual mean pollutant NO₂ levels at the Stansted sites and corresponding measurements made at six other monitoring stations. Five of these are other AURN monitoring sites in the south and east of England and the sixth is in the vicinity of a major airport. These sites are listed below.

- Canterbury – an urban background site approximately 1.5 kilometres from the centre of Canterbury.
- Thurrock – an urban background site in the town of Thurrock, Essex, approximately 35 metres from the kerb of a busy road.
- Cambridge Roadside – roadside site in the city of Cambridge, where vehicle emissions are the major pollution source.
- Southend-on-Sea – an urban background site situated in an urban public park in a residential area.
- London Harlington – a background monitoring station approximately 1 km north east of the perimeter of Heathrow airport.
- LHR2 – a long-term airside monitoring station at Heathrow, 180 metres north of runway 27R and north east of the central terminal area. This site is not part of the AURN, but data are made available to the public through the Heathrow Airwatch website⁹.

Figure 4-14: Annual mean trend NO₂ concentrations at Stansted 3, Stansted 4 and other regional monitoring sites

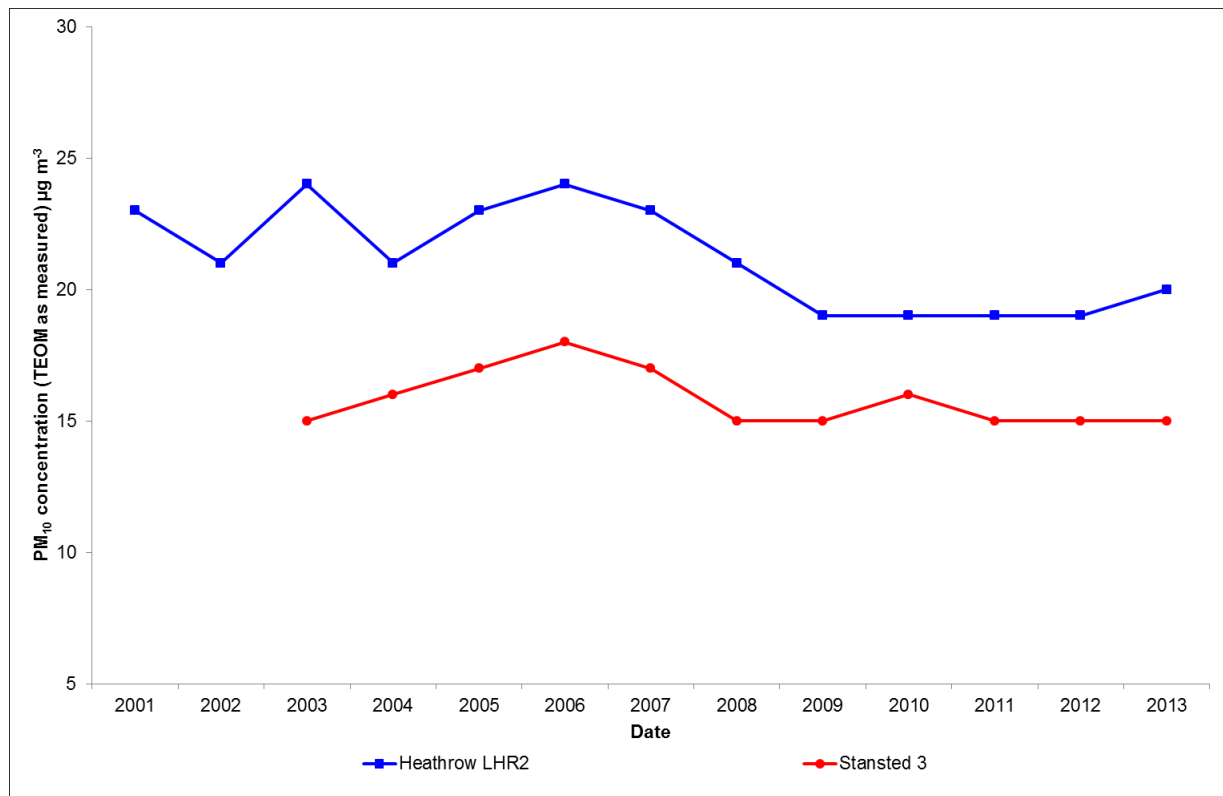


In recent years, annual mean concentrations of NO₂ at the Stansted sites have resembled urban background concentrations measured at similar sites. For example, the concentrations seen at Stansted 3 and Stansted 4 are comparable with those at Southend-on-Sea and Thurrock, although they are slightly higher than those reported from Canterbury.

Both Stansted sites have consistently reported lower concentrations than those recorded at London Harlington, Heathrow LHR2, Thurrock, and Cambridge Roadside. Annual mean NO₂ concentrations at Stansted 3 have exhibited a slight general decrease since 2004, reducing the gap between this site and Stansted 4, which has stayed largely constant.

Cambridge Roadside, located at the kerb of a busy road in the nearby city of Cambridge, is included as an example of a site showing constant high annual mean NO₂ concentrations. The site (like many other urban roadside sites in the UK) has consistently recorded annual mean NO₂ concentrations in excess of 38 µg m⁻³, substantially higher than those observed at either of the Stansted sites.

Figure 4-15 shows annual mean PM₁₀ concentrations at Stansted 3 and the London Heathrow site LHR2. These are “as measured” data without VCM correction.

Figure 4-15: Annual mean PM₁₀ concentrations at Stansted 3 and Heathrow LHR2

Concentrations of PM₁₀ at Stansted 3 were lower than those measured at LHR2. Since 2004, the two lines have shown very similar patterns from one year to the next.

5 Conclusions

The following conclusions have been drawn from the results of air quality monitoring at Stansted Airport during 2013.

1. The data capture target of least 90 % was achieved for PM₁₀ at Stansted 3 and oxides of nitrogen at Stansted 4. Data capture was below 90 % for oxides of nitrogen at Stansted 3.
2. Stansted 3 met the AQS objectives for 1-hour mean NO₂ concentrations. (Although data capture was less than 90 %, there were no hourly mean concentrations above the objective).
3. Stansted 4 did not meet the AQS objective for hourly mean NO₂: this is not usual for the site, but in 2013 occurred because of a short period (11th – 12th October) when the site was affected by emissions from a generator. If this period is disregarded, the site met the objective.
4. All five NO₂ diffusion tube sites met the AQS annual mean objective for this pollutant.
5. Stansted 3 met the AQS objectives for daily mean and annual mean PM₁₀ concentration.
6. At Stansted 4, as mentioned above, unusually high concentrations of NO_x were recorded over 2 days in October 2013. The high emissions were attributed to a generator operating close to the monitoring site.
7. At Stansted 3, very high levels of PM₁₀ occurred on 8th November 2013. These coincided with fertiliser movements on the adjacent farm.
8. NO and NO₂ concentrations were higher during the winter months at both Stansted 3 and Stansted 4. This is a typical pattern for urban sites. PM₁₀ levels showed a peak in March.
9. Concentrations of NO and NO₂ followed a characteristic diurnal pattern, with peaks coinciding with the morning and evening rush hour periods. PM₁₀ concentrations showed no marked diurnal variation.
10. Bivariate plots of pollutant concentrations against meteorological data indicated that sources of NO were located close to the monitoring sites and were probably associated with the airport. Although NO₂ also arose from the airport, there was also a minor source to the south east of Stansted 3, suggesting a contribution from the A120. The pattern observed for PM₁₀ at Stansted 3 suggested that particulates were associated with a source to the east of the site, possibly associated with agricultural activity.
11. Annual mean concentrations of NO₂ at Stansted 3 and Stansted 4 were similar to those measured at similar urban background sites such as Canterbury, Southend-on-Sea and Thurrock. PM₁₀ concentrations (as measured) at Stansted 3 were lower than those for London Heathrow Airport.

6 Acknowledgements

Ricardo-AEA would like to thank Stansted Airport Ltd, particularly Duncan Smith, for assistance with this monitoring study.

7 References

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Appendices

Appendix 1: Air quality objectives and index bands

Appendix 2: Monitoring apparatus and techniques

Appendix 3: Quality assurance and quality control

Appendix 4: NO₂ diffusion tubes – Full dataset

Appendix 1 – Air quality objectives and index bands

Table A1-1: UK air quality objectives for protection of human health, July 2007

Pollutant	Air quality objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 $\mu\text{g m}^{-3}$	Running annual mean	31/12/2003
England and Wales only	5.00 $\mu\text{g m}^{-3}$	Annual mean	31/12/2010
Scotland and Northern Ireland	3.25 $\mu\text{g m}^{-3}$	Running annual mean	31/12/2010
1,3-Butadiene	2.25 $\mu\text{g m}^{-3}$	Running annual mean	31/12/2003
Carbon monoxide England, Wales and Northern Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31/12/2003
Scotland	10.0 mg m^{-3}	Running 8-hour mean	31/12/2003
Lead	0.5 $\mu\text{g m}^{-3}$	Annual mean	31/12/2004
	0.25 $\mu\text{g m}^{-3}$	Annual mean	31/12/2008
Nitrogen dioxide	200 $\mu\text{g m}^{-3}$ not to be exceeded more than 18 times a year	1-hour mean	31/12/2005
	40 $\mu\text{g m}^{-3}$	Annual mean	31/12/2005
Particles (PM₁₀) (gravimetric) All authorities	50 $\mu\text{g m}^{-3}$, not to be exceeded more than 35 times a year	24-hour mean	31/12/2004
	40 $\mu\text{g m}^{-3}$	Annual mean	31/12/2004
Scotland	50 $\mu\text{g m}^{-3}$, not to be exceeded more than 7 times a year	24-hour mean	31/12/2010
	18 $\mu\text{g m}^{-3}$	Annual mean	31/12/2010
Particles (PM_{2.5}) (gravimetric)* All authorities	25 $\mu\text{g m}^{-3}$ (target)	Annual mean	2020
	15% cut in urban background exposure	Annual mean	2010-2020
Scotland only	12 $\mu\text{g m}^{-3}$ (limit)	Annual mean	2020
Sulphur dioxide	350 $\mu\text{g m}^{-3}$, not to be exceeded more than 24 times a year	1-hour mean	31/12/2004
	125 $\mu\text{g m}^{-3}$, not to be exceeded more than 3 times a year	24-hour mean	31/12/2004
	266 $\mu\text{g m}^{-3}$, not to be exceeded more than 35 times a year	15-minute mean	31/12/2005
PAH*	0.25 ng m^{-3}	Annual mean	31/12/2010
Ozone*	100 $\mu\text{g m}^{-3}$ not to be exceeded more than 10 times a year	8-hour mean	31/12/2005

* Not included in regulations.

Table A1-2: UK air quality objectives for protection of vegetation and ecosystems, July 2007

Pollutant	Air quality objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen oxides measured as NO ₂	30 µg m ⁻³	Annual mean	31st December 2000
Sulphur dioxide	20 µg m ⁻³	Annual mean	31st December 2000
	20 µg m ⁻³	Winter average (October to March)	31st December 2000
Ozone	18 µg m ⁻³	AOT40 ⁺ , calculated from 1-hour values May to July. Mean of 5 years, starting 2010	1st January 2010

+ AOT40 is the sum of the differences between hourly concentrations greater than 80 µg m⁻³ (= 40 ppb) and 80 µg m⁻³ over a given period using only 1-hour averages measured between 08:00 and 20:00.

Defra air pollution bands and index values

Table A1-3: Air pollution bandings and descriptions

Band	Index	Health descriptor
Low	1 to 3	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.
Moderate	4 to 6	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	7 to 9	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (eg reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Table A1-4: Air pollution bandings and descriptions

Band	Index	O ₃	NO ₂	SO ₂	PM _{2.5}	PM ₁₀
		Daily maximum 8-hour mean (µg m ⁻³)*	Hourly mean (µg m ⁻³)	15 minute mean (µg m ⁻³)	24 hour mean (µg m ⁻³)	24 hour mean (µg m ⁻³)
Low	1	0-33	0-67	0-88	0-11	0-16
	2	34-66	68-134	89-177	12-23	17-33
	3	67-100	135-200	178-266	24-35	34-50
Moderate	4	101-120	201-267	267-354	36-41	51-58
	5	121-140	268-334	355-443	42-47	59-66
	6	141-160	335-400	444-532	48-53	67-75
High	7	161-187	401-467	533-710	54-58	76-83
	8	188-213	468-534	711-887	59-64	84-91
	9	214-240	535-600	888-1,064	65-70	92-100
Very high	10	241 or more	601 or more	1,065 or more	71 or more	101 or more

Appendix 2 – Monitoring apparatus and techniques

Monitoring equipment

The following continuous monitoring methods were used at the Stansted air quality monitoring stations:

- NO, NO₂: chemiluminescence with ozone.
- PM₁₀: tapered element oscillating microbalance (TEOM).

These methods were selected in order to provide real-time data. The chemiluminescence analyser is the European reference method for ambient NO₂ monitoring.

Each 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 the on-site data logger. This logger is connected to a modem and interrogated twice daily, by telephone, to download the data to Ricardo-AEA. The data are then converted to concentration units and averaged to hourly mean concentrations.

The chemiluminescence analysers for NO_x are equipped with an automatic calibration system, which is triggered daily under the control of the data logger. Fully certificated calibration gas cylinders are also used at each site for manual calibration.

The PM₁₀ TEOM analyser cannot be calibrated in the same way as the gas analysers and these data are scaled using the results of 6-monthly checks. In these checks, the flow rate through the analyser is measured and the mass determination checked with pre-weighed filters.

The PM₁₀ monitoring data recorded by TEOM monitors were corrected with the King's College Volatile Correction Model (VCM)⁷. This online tool allows TEOM measurements to be corrected for the loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by this instrument. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

The VCM works by using the volatile particulate matter measurements provided by nearby FDMS (Filter Dynamic Measurement System) instruments (within 130 km) to assess the loss of PM₁₀ from the TEOM; this value is then added back onto the TEOM measurements.

Method

The following data are required as inputs to the VCM:

- Daily or hourly average temperatures
- Daily or hourly pressures
- Daily or hourly TEOM concentrations ($\mu\text{g m}^{-3}$)
- Daily or hourly FDMS purge measurements ($\mu\text{g m}^{-3}$)

The correction generated by the VCM is specific to that geographical location, so an exact location of the TEOM instrument is therefore required.

All of the air quality monitoring equipment at both sites is housed in purpose-built enclosures.

The native units of the analysers are volumetric (eg ppb). Conversion factors from volumetric to mass concentration measurement for gaseous pollutants are provided below:

- NO 1 ppb = 1.25 $\mu\text{g m}^{-3}$
- NO₂ 1 ppb = 1.91 $\mu\text{g m}^{-3}$

In this report, the mass concentration of NO_x has been calculated as follows:

$\text{NO}_x \mu\text{g m}^{-3} = (\text{NO ppb} + \text{NO}_2 \text{ ppb}) \times 1.91.$

This complies with the requirements of the Air Quality Directive¹ and is also the convention generally adopted in air quality modelling.

Appendix 3 – Quality assurance and quality control

Ricardo-AEA operates air quality monitoring stations within a tightly controlled and documented quality assurance and quality control (QA/QC) system. These procedures are documented in the AURN QA/QC manual⁸.

Elements covered within this system include: definition of monitoring objectives, equipment selection, site selection, protocols for instrument operation calibration, service and maintenance, integrity of calibration gas standards, data review, scrutiny and validation.

All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards at 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 regular six-monthly intercalibration and audit check undertaken at every monitoring site. This audit has two principal functions: firstly to check the instruments 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.

In line with current operational procedures within the Defra AURN, full intercalibration audits take place at the end of winter and summer. At these visits, the essential functional parameters of the monitors such as noise, linearity and, for the NO_x monitor, the efficiency of the NO₂ 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.

All air pollution measurements are reviewed daily by experienced staff at Ricardo-AEA. Data are compared with corresponding results from AURN monitoring stations and with expected air pollutant concentrations under the prevailing meteorological conditions. This review process rapidly highlights any unusual or unexpected measurements, which may require further investigation. When such data are identified, attempts are made to reconcile the data against known or possible local air pollution sources or local meteorology, and to confirm the correct operation of all monitors. In addition, the results of the daily automatic instrument calibrations (see Appendix 2) are examined to identify any possible instrument faults. Should any faults be identified or suspected, arrangements are made for Ricardo-AEA personnel or equipment service contractors to visit the site as soon as possible.

At the end of every quarter, the data for that period are reviewed to check for any spurious values and to apply the best daily zero and sensitivity factors, and to account for information which only became available after the initial daily processing. At this time, any data gaps are filled with data from the data logger back-up memory to produce as complete a data record as possible.

Finally, the data are re-examined on an annual basis, when information from the six-monthly intercalibration audits can be incorporated. After completion of this process, the data are fully validated and finalised, for compilation in the annual report.

Following these three-stage data checking and review procedures allows the overall accuracy and precision of the data to be calculated. The accuracy and precision figures for the pollutants monitored at Stansted are summarised in Table A3-1.

Table A3-1: Estimated accuracy and precision of the data presented

Pollutant	Precision	Accuracy
NO	± 2.5	± 15 %
NO ₂	± 6.9	± 15 %
PM ₁₀	± 4	Estimated* accuracy of a TEOM ± 30 % or better. With VCM correction, estimated as ± 25 %.

* Accuracy of particle measurements with a TEOM instrument cannot be reliably assessed.

Appendix 4 – NO₂ diffusion tubes – Full dataset

Results were reported to two decimal places by the analyst. However, given the uncertainty of diffusion tube measurements, in this report they have been rounded to one decimal place. In the main part of the report, diffusion tube results have been quoted to the nearest integer.

Table A4-1: Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted 3 (east of High House) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2013	34.6	33.1	29.8	32.5	
30/01/2013	26.2	25.3	23.4	25.0	
27/02/2013	21.9	26.0	23.9	24.0	
27/03/2013	18.6	16.3	18.8	17.9	
24/04/2013	20.4	Rejected	21.5	20.9	Low outlier of 6.5 µg m ⁻³ rejected
29/05/2013	17.1	17.7	18.6	17.8	
26/06/2013	18.3	18.7	18.3	18.4	
31/07/2013	23.0	22.3	22.7	22.7	
28/08/2013	28.1	28.1	30.2	28.8	
25/09/2013	24.3	23.6	26.0	24.6	
30/10/2013	35.0	35.8	28.5	33.1	
27/11/2013	27.9	26.1	28.6	27.5	

Table A4-2: Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted North (north lights, north end of runway) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2013	28.6	29.7	29.4	29.2	
30/01/2013	15.7	15.9	16.2	15.9	
27/02/2013	18.7	16.1	18.0	17.6	
27/03/2013	14.2	14.3	16.9	15.1	
24/04/2013	13.0	Rejected	Rejected	13.0	Low results of 7.0 µg m ⁻³ (Tube 2) and 5.2 µg m ⁻³ (Tube 3) rejected: these were unusually low for the site, and thought to be faulty tubes.
29/05/2013	12.7	13.1	11.4	12.4	
26/06/2013	11.2	12.6	12.8	12.2	
31/07/2013	Rejected	14.2	17.1	15.7	Low outlier of 8.4 µg m ⁻³ rejected
28/08/2013	21.0	18.8	21.4	20.4	
25/09/2013	25.2	21.9	23.3	23.5	
30/10/2013	26.5	29.0	26.4	27.3	
27/11/2013	31.9	25.5	23.8	27.1	

Table A4-3: Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted East (Enterprise House offices) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2013	40.4	40.0	38.9	39.8	
30/01/2013	26.0	30.4	28.8	28.4	
27/02/2013	28.9	28.0	31.5	29.5	
27/03/2013	24.7	21.2	19.7	21.9	
24/04/2013	23.0	21.1	21.8	22.0	
29/05/2013	19.6	18.4	20.4	19.5	
26/06/2013	21.9	21.1	21.5	21.5	
31/07/2013	26.9	24.2	25.1	25.4	
28/08/2013	32.2	30.2	36.6	33.0	
25/09/2013	31.3	33.3	34.3	33.0	
30/10/2013	38.4	34.8	33.6	35.6	
27/11/2013	33.0	33.0	27.4	31.1	

Table A4-4: Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted South (balancing pond south of site) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2013	35.5	37.4	36.3	36.4	
30/01/2013	30.3	29.5	32.3	30.7	
27/02/2013	33.7	29.3	35.5	32.8	
27/03/2013	25.1	26.8	26.1	26.0	
24/04/2013	24.3	23.6	22.5	23.4	
29/05/2013	22.9	22.9	22.4	22.7	
26/06/2013	22.4	22.6	22.5	22.5	
31/07/2013	24.0	23.7	23.3	23.7	
28/08/2013	27.5	28.4	25.2	27.0	
25/09/2013	25.5	25.6	23.7	24.9	
30/10/2013	28.9	29.4	33.1	30.5	
27/11/2013	30.5	26.8	27.2	28.2	

Table A4-5: Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted West (radar tower, Burton End) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2013	26.2	27.1	27.8	27.1	
30/01/2013	16.7	18.6	16.9	17.4	
27/02/2013	21.1	20.6	21.8	21.2	
27/03/2013	15.1	15.1	12.4	14.2	
24/04/2013	13.1	12.8	Rejected	12.9	Low outlier of 5.6 µg m ⁻³ rejected
29/05/2013	11.2	13.9	10.6	11.9	
26/06/2013	13.0	12.2	12.7	12.6	
31/07/2013	Rejected	13.8	14.6	14.2	High outlier of 22.8 µg m ⁻³ rejected
28/08/2013	17.5	17.4	16.9	17.3	
25/09/2013	20.3	21.0	20.3	20.5	
30/10/2013	23.9	25.3	23.2	24.2	
27/11/2013	22.3	21.8	20.8	21.6	



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