Air Quality Monitoring at Stansted Airport: Annual Report for 2011

Report for Stansted Airport Ltd

AEA/ENV/R/3266
Issue 1
Date 16/04/2012

Customer:

Stansted Airport Ltd

Customer reference:

Confidentiality, copyright & reproduction:

AEA reference:

Ref: AEA/ENV/R/3266- Issue 1

Contact:

Nick Rand
AEA Technology plc
Gemini Building, Harwell, Didcot, OX11 0QR
t: 0870 190 6140
e: nick.rand@aeat.co.uk
AEA is a business name of AEA Technology plc
AEA is certificated to ISO9001 and ISO14001

Author:

Alison Loader

Approved By:

Brian Stacey

Date:

16 April 2012

Signed:

Executive summary

This report presents the results of an air quality monitoring programme carried out around Stansted airport, during 2011. The monitoring was carried out by AEA (part of the AEA Group) on behalf of Stansted Airport Ltd.

The aim of this ongoing monitoring programme is to monitor air pollution around the airport, to compare the results with applicable air quality objectives, and to investigate how air pollutant concentrations are changing over time.

Automatic monitoring was carried out at two sites, referred to as Stansted 3 and Stansted 4. Stansted 3 was located at High House, to the south of the airport. Oxides of nitrogen (nitric oxide and nitrogen dioxide) and PM_{10} particulate matter were monitored. Stansted 4 was located within the airport boundary, to the north of the runway. Oxides of nitrogen were monitored at this site.

The automatic monitoring was supplemented by indicative monitoring of nitrogen dioxide (NO_2) using diffusion tubes. These were deployed at five sites to the north, south, east and west of the airport, and at Stansted 3.

The EU Air Quality Directive sets a data capture target of 90%. This was achieved for NO_2 at Stansted 4. However, at Stansted 3 repeated interruptions to the power supply, and problems with the air conditioning system, reduced data capture to 78% for NO_2 and 81% for PM_{10}.

The UK Air Quality Strategy (AQS) objectives for annual mean and hourly mean NO_2 concentration were achieved at Stansted 3 and Stansted 4. Stansted 3 recorded no instances where the hourly mean NO_2 concentration exceeded 200 µg m^{-3}: Stansted 4 recorded one such instance, due to use of an emergency generator in early May.

The NO_2 diffusion tube data indicated that all the diffusion tube sites met the Air Quality Strategy objective of 40 µg m^{-3} for annual mean NO_2 concentration.

The AQS objectives for daily mean and annual mean PM_{10} concentration were achieved at Stansted 3.

Wind speed and wind direction data were provided by Stansted Airport Ltd. This was used to investigate the sources of the pollutants, by plotting hourly mean pollutant concentrations against the corresponding wind speed and wind direction. These bivariate plots indicated that NO_2 concentrations measured at Stansted 4 originated mainly from the airport.

At Stansted 3 the sources of NO_2 appeared to be more mixed, with contributions from the immediate vicinity (evident at low wind speeds), and evidence of a source to the south east, which contributed to NO_2 concentrations at higher wind speeds. There also appeared to be a source of PM_{10} in the same direction, which contributed at higher wind speeds. It has not been possible to identify this source.

Some periods of relatively high PM_{10} concentration occurred at Stansted 3, mostly in the period February to April 2011. Similar patterns in PM_{10} concentration were observed at other monitoring sites in the south east of England, indicating that these were regional pollution episodes and not linked to local activity. By contrast, there was one brief period of elevated PM_{10} concentration on the afternoon of 22nd August, which was not reflected in the results from other sites. In this case, it is possible that the source was local.

Average concentrations of NO_2 and PM_{10} at Stansted have generally decreased slightly since monitoring began in 2004. NO_2 concentrations are generally comparable to those measured at urban background air pollution monitoring sites in the south east, but lower than at the LHR2 monitoring site at London Heathrow airport.

Table of contents

Appendices

1 Introduction

1.1 Background

Stansted Airport is London's third 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 site. Prior to 2006, three months monitoring per year were required: from 2006 onwards, continuous monitoring throughout the year has been required.

AEA (part of the AEA Group) were contracted by Stansted Airport Ltd to carry out the required programme of air pollution measurements during 2011, the sixth full year of continuous monitoring.

Provisional data are reported to Stansted Airport Ltd on a quarterly basis throughout the year. The annual report presents and summarises the fully validated and quality controlled dataset for the full calendar year. Data in the annual report have been processed according to the rigorous quality assurance and quality control procedures used by AEA. This ensures the data are reliable, accurate and traceable to UK national measurement standards.

This report covers the period 1st January to 31st December 2011.

1.2 Aims and Objectives

The aim 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 NO_2), using automatic techniques at two locations, Stansted 3 (High House) and Stansted 4 (Runway).
- particulate matter (PM_{10}) at Stansted 3.

The automatic monitoring was supplemented by indicative monitoring of NO_2 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, ambient air quality is covered by Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[1], 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 via The Environment Act 1995 which placed a requirement on the Secretary of State for the

Environment to produce a national air quality strategy 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 timescale, to achieve the air quality objectives. The legal framework given in the Environment Act has been adopted in the UK via the UK Air Quality Strategy (AQS). The most recent version of the AQS was published by Defra in 2007[2], and the currently applicable Air Quality objectives are summarized in Appendix 1.

2 Monitoring Details

2.1 Pollutants Monitored

Aircraft jet engines produce similar emissions to 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 (CO_2) are also emitted: although CO_2 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 will also be 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 most 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 it was also 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 - primarily nitric oxide (NO) and nitrogen dioxide (NO_2) - collectively termed NO_x.

(i) NO is described as a primary pollutant (meaning it is directly emitted from source). Though NO is not known to have any harmful effects on human health at ambient concentrations, it undergoes oxidation in the atmosphere to form the secondary pollutant NO_2.

(ii) NO_2 has a primary (directly emitted) component and a secondary component, formed by oxidation of NO. NO_2 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 (of which NO_2 is a component) designated as airport-related, 72% occur from the aircraft during take-off and landing, although much of this will be at some distance from airport ground-level. 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 100m and 1000 m and contribute little to ground-level concentrations. Receptor modelling studies show that there is an impact from airport activities on ground-level NO_2 concentrations. However, studies have shown that although emissions associated with vehicles are smaller than those associated with aircraft, their impact on population exposure at locations around airports are larger due to the inherent volume[3]. NO_2 is the key pollutant of concern, with respect to airports. 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 quality[4].

2.1.2 PM_{10} Particulate Matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The term PM_{10} is used to describe particles with an effective size less than 10µm. These are of most 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 principal source of airborne PM_{10} in European cities is road traffic emissions, particularly from diesel vehicles. Based on 2006 data, less than 0.1% of UK total PM_{10} emissions are believed to originate from aircraft[5].

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 PM_{10}.

2.2 Location of Monitoring Sites

Automatic monitoring was carried out at two sites in 2011. 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 description of both sites fall into the category "other" as defined by the Defra Technical Guidance on air quality monitoring LAQM.TG(09)[4], *i.e. "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 NO_2 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 site.

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 Air Quality Monitoring at Stansted: Locations of Monitoring Sites

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

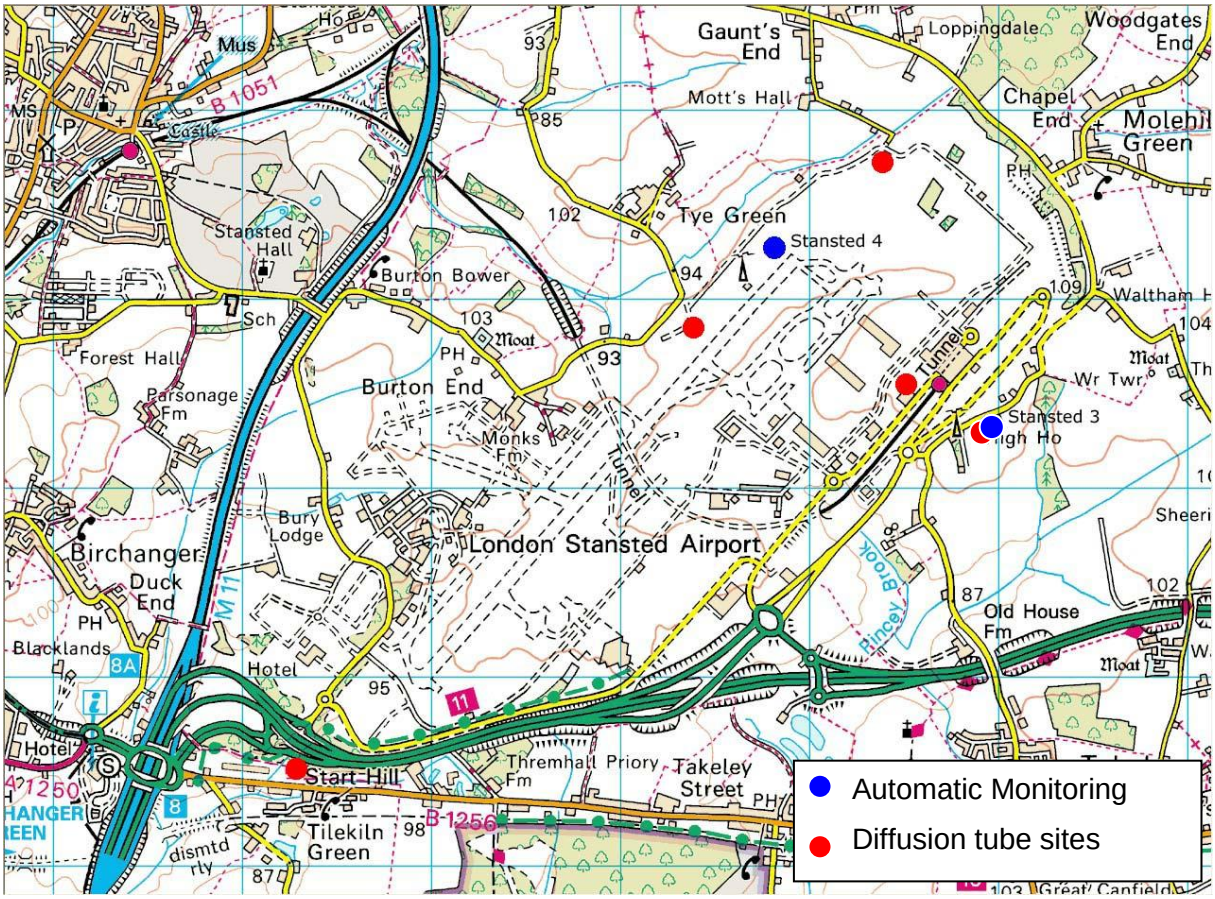

Figure 2-1 Locations of Monitoring Sites *© Crown Copyright Ordnance Survey. Reproduced from Landranger 1:50000 map series, Licence number 100040905.*

The location of the automatic monitoring site at High House (Stansted 3) was agreed with Stansted Airport, Uttlesford District Council and 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 1.5km 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.

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 photo is provided in Figure 2-3.

Figure 2-2 Stansted 3 Automatic Monitoring Site

Figure 2-3 Stansted 4 Automatic Monitoring Site

2.3 Monitoring Methods

The following techniques were used for the automatic monitoring of NOx and PM_{10}

- PM_{10} Tapered element oscillating microbalance (TEOM)
- NO, NO_2 Chemiluminescence

Further information on these techniques is provided in Appendix 2. 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 average values by internal data loggers. The analysers are connected to a modem and interrogated via a GPRS internet device to download the data to AEA. Data are downloaded hourly. The data are converted to concentration units at AEA and 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 PM_{10}, such as ammonium nitrate.

It is not possible to address this problem by applying a simple correction factor. However, King's College London (KCL) have developed a Volatile Correction Model[7], which allows TEOM PM_{10} data to be corrected for the volatile components lost as a result of the TEOM's heated inlet. The model is available at http://www.volatile-correction-model.info/Default.aspx. It uses data from nearby TEOM-FDMS particulate analysers in the national air quality monitoring network, which measure the volatile and non-volatile components of the PM_{10}. The volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. KCL state that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

Correction using the VCM model is now the preferred approach when comparing TEOM data with air quality limit values and objectives. In this report, where the VCM has been used to correct PM_{10} data in this report, this is clearly indicated. However, in some cases, where investigating diurnal patterns and long-term trends (going back to the years before the VCM existed), the VCM has not been applied and this too is clearly indicated.

The methodology for the VCM correction of PM_{10} data is presented in Appendix 2. **The TEOM-FDMS data from the national monitoring network for the final three months of 2011 (October-December) are still provisional at the time of writing. Therefore, the VCM-corrected dataset could also change slightly.**

2.5 Diffusive Samplers

Diffusion tubes were used for additional monitoring of NO_2. These are "passive" samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply.

Diffusion tubes for NO_2 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 NO_2. 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.

Diffusion tubes were prepared by a commercial laboratory (Gradko International Ltd). 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 the laboratory for analysis. The exposure periods used approximated 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 Monitoring Network, 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. In addition to instrument and calibration standard checking, the air intake sampling system was 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 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.*

The Local Air Quality Management Technical Guidance LAQM.TG(09)[4] 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). Throughout this study, diffusion tubes have been exposed alongside the automatic NO_x analyser at Stansted 3. It was intended that these co-located measurements should be used for bias adjustment of the annual mean diffusion tube data from the other sites.

The diffusion tube methodologies provide data that are accurate to ± 25% for NO_2. The limits of detection vary from month to month, but are typically 0.4 µg m^{-3} for NO_2. Diffusion tube results that are less than 10 x the limit of detection will have a higher level of uncertainty associated with them: however, all results in this survey were well above this threshold.

3.2 Data Capture

Overall data capture statistics for the two monitoring sites are given in Table 3.2. A data capture target of 90% is recommended in the Defra Technical Guidance LAQM.TG(09)[4].

Table 3.2 Data Capture Statistics 2011

Site	NO_x	NO_2	PM_{10}
Stansted 3	77.6	77.6	80.8
Stansted 4	99.2	99.2	-

The 90% data capture target was therefore achieved for NO_2 at Stansted 4. Data capture for NOx and PM_{10} at Stansted 3 was substantially below the target.

Table 3.3 shows the significant gaps in data capture that occurred during the year:

Table 3.3 Significant Data Gaps 2011

Site	Pollutant	Start date	End date	No. of days	Reason	Comments
Stansted 3	NOx, PM_{10}	30-Dec-10	06-Jan-11	7	Power cut	Power supply tripped.
Stansted 3	NOx, PM_{10}	31-Mar-11	01-Apr-11	1	Power cut	Power supply tripped.
Stansted 3	NOx	03-Apr-11	07-Apr-11	4.1	Air Conditioning or Temp fault	
Stansted 3	NOx	19-Apr-11	20-Apr-11	0.8	Power cut	Power supply tripped.
Stansted 3	NOx	21-Apr-11	28-Apr-11	6.9	Power cut	Power supply tripped.
Stansted 3	NOx	05-May-11	19-May-11	13.9	Power cut	Power supply tripped.
Stansted 3	NOx	19-Jul-11	25-Jul-11	6.1	ESU service	Power supply tripped.
Stansted 3	NOx	25-Jul-11	26-Jul-11	0.5	Power cut	Power supply tripped.
Stansted 3	NOx	28-Jul-11	01-Aug-11	4.1	Power cut	Power supply tripped.
Stansted 3	NOx	03-Aug-11	08-Sep-11	36	Power cut	Power supply tripped.
Stansted 3	NOx	19-Dec-11	20-Dec-11	0.6	Power cut	Power supply tripped.
Stansted 3	PM_{10}	30-Dec-10	04-Jan-11	5	Power cut	Power supply tripped.
Stansted 3	PM_{10}	31-Mar-11	01-Apr-11	1	Power cut	Power supply tripped.
Stansted 3	PM_{10}	03-Apr-11	09-Apr-11	6	Air Conditioning or Temp fault	
Stansted 3	PM_{10}	19-Apr-11	20-Apr-11	0.8	Power cut	Power supply tripped.
Stansted 3	PM_{10}	21-Apr-11	18-May-11	27.3	Power cut	Power supply tripped.
Stansted 3	PM_{10}	16-Jul-11	16-Jul-11	0.3	Unstable response	Power supply tripped.
Stansted 3	PM_{10}	20-Jul-11	18-Aug-11	28.6	Power cut	Power supply tripped.
Stansted 3	PM_{10}	19-Dec-11	20-Dec-11	0.6	Power cut	Power supply tripped.

The main cause of lost data during 2011 was interruptions to the power supply at Stansted 3. The power supply to the site repeatedly tripped out. In some cases the duration of the interruption was longer for one pollutant than the others, because it took longer for normal operation of the instrument to be restored.

Power interruptions were the main source of data loss reported in 2010: however, these became considerably more frequent in 2011. It is understood that work is under way, to upgrade the power supply to the monitoring site.

4 Results and Discussion

4.1 Automatic Monitoring Data

The summary statistics for 2011 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 4.2 gives a summary of the NO_2 diffusion tube data.

Measured concentrations of the oxides of nitrogen NO and NO_2 are reported in microgrammes per cubic metre µg m^{-3}. PM_{10} is conventionally reported in units of µg m^{-3}, microgrammes per cubic metre. In this report PM_{10} measured using the TEOM instrument are converted to gravimetric equivalent using the King's College London Volatile Correction Model[7] where appropriate. See section 2.3 for an explanation of this.

Table 4.1 Air Pollution Statistics for Stansted 3 and Stansted 4, from 1st January to 31st December 2011

Stansted 3	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_X (µg m^{-3})	PM_{10} as measured (µg m^{-3})	PM_{10} VCM corrected (µg m^{-3})
Maximum 15-minute mean	284	111	510	716	-
Maximum hourly mean	170	97	334	235	242
Maximum running 8-hour mean	77	72	169	116	-
Maximum running 24-hour mean	42	55	112	56	-
Maximum daily mean	40	55	111	56	57
Average	5	22	30	15	21
Data capture	77.6 %	77.6 %	77.6 %	80.8 %	80.8%
Stansted 4	**NO (µg m^{-3})**	**NO_2 (µg m^{-3})**	**NO_X (µg m^{-3})**	**PM_{10} as measured (µg m^{-3})**	**PM_{10} VCM corrected (µg m^{-3})**
Maximum 15-minute mean	579	409	1203		
Maximum hourly mean	430	279	936		
Maximum running 8-hour mean	72	73	159		
Maximum running 24-hour mean	39	53	105		
Maximum daily mean	38	49	103		
Average	5	19	27		
Data capture	99.2 %	99.2 %	99.2 %		

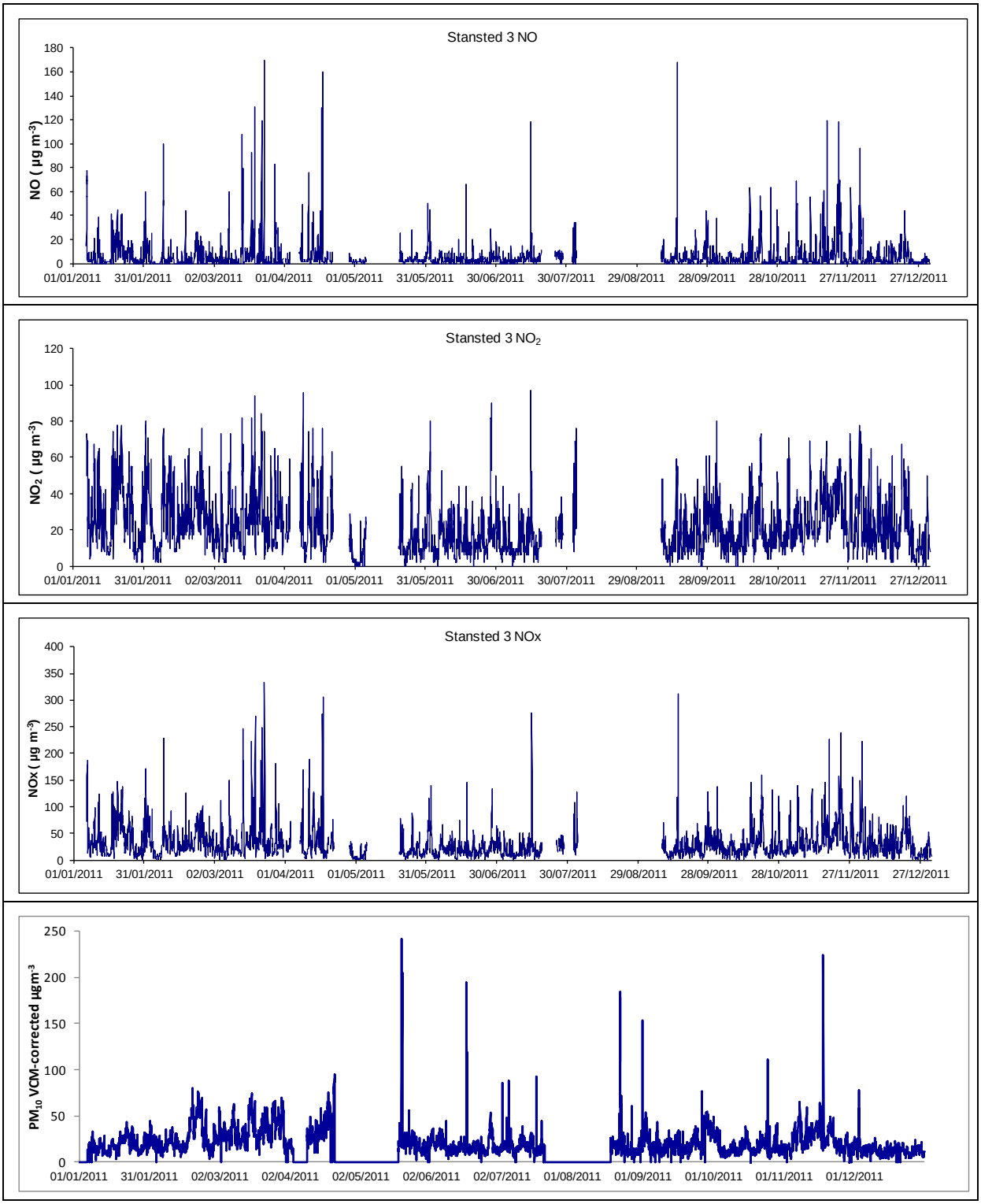

Figure 4-1 Time Series of Hourly Averaged Concentrations at Stansted 3 – 2011

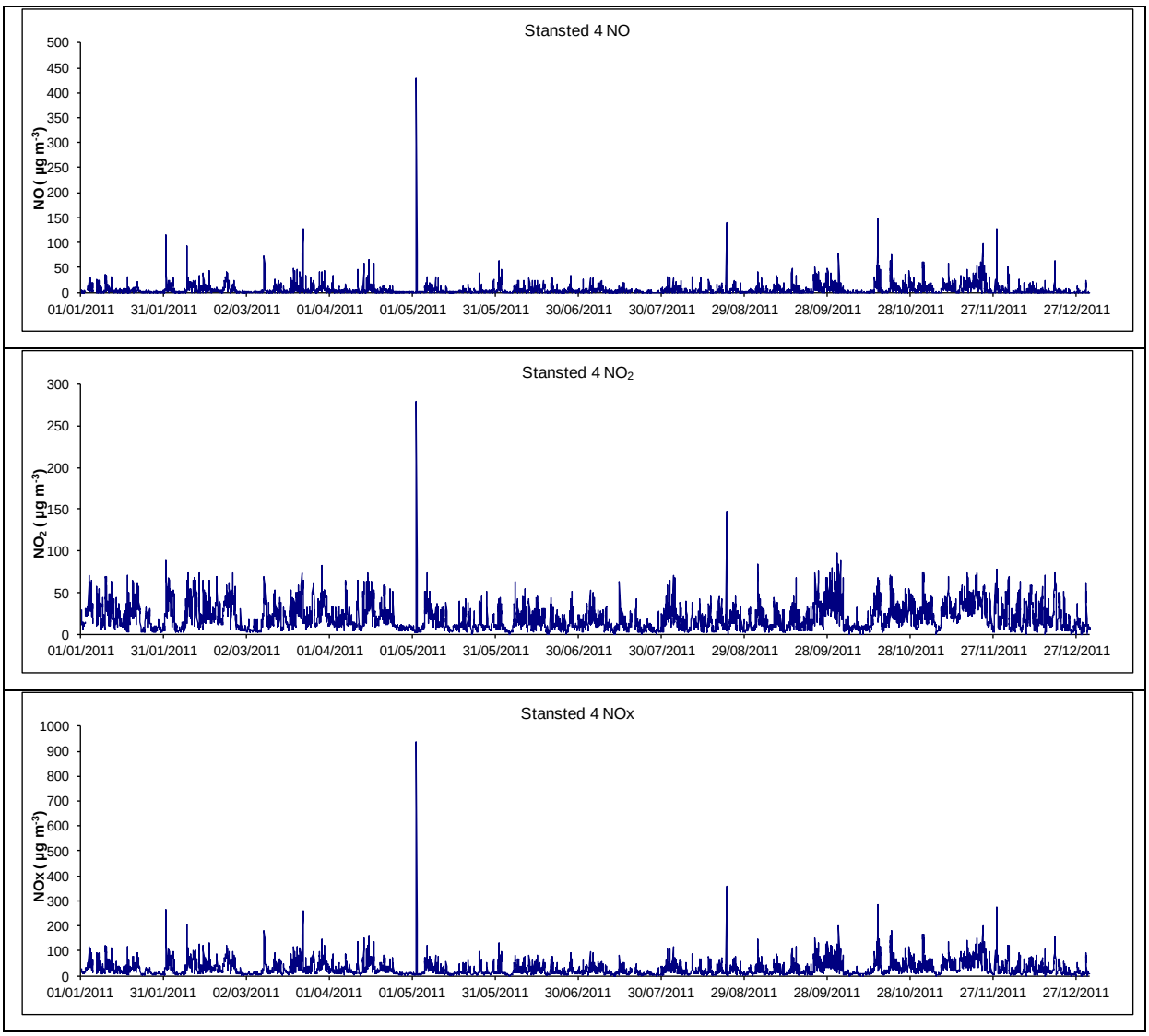

Figure 4-2 Time Series of Hourly Averaged Concentrations at Stansted 4 – 2011

4.2 Diffusion Tube Data

Table 4.2 shows the NO_2 diffusion tube results for 2011. Tubes are exposed in triplicate at all sites. The results shown are the mean of these replicate measurements. The full dataset is shown in Appendix 4. The analyst provides diffusion tube data to two decimal places: these have been rounded to integer values.

Table 4.2 NO_2 Diffusion Tube Results 2011, µg m^{-3}

Start date	Stansted North	Stansted East	Stansted South	Stansted West	Stansted 3
05/01/2011	28	33	34	24	29
03/02/2011	27	32	26	23	25
03/03/2011	25	32	32	24	26
31/03/2011	23	38	31	23	27
28/04/2011	14	24	21	15	17
01/06/2011	22	34	25	19	22
29/06/2011	16	22	22	15	21
03/08/2011	21	27	24	15	21
31/08/2011	28	34	23	21	22
28/09/2011	28	36	27	27	26
02/11/2011	32	36	32	36	31
30/11/2011	27	38	32	22	27
Mean	**24**	**32**	**27**	**22**	**25**
Bias adjusted mean	**22**	**30**	**25**	**20**	**23**

Figures in brackets for Stansted 3 automatic indicate poor data capture (< 75%).

One of the three tubes exposed in June at Stansted West went missing from the site. Otherwise, full data capture was achieved.

Annual mean NO_2 concentrations measured with diffusion tubes ranged from 22 µg m^{-3} to 32 µg m^{-3} at the five sites. The annual mean concentration measured at Stansted 3 using diffusion tubes was 25 µg m^{-3} (rounded to the nearest integer). This was slightly higher than the annual mean of 22 µg m^{-3} obtained using the reference technique (the chemiluminescence analyser), although data capture for the latter was poor.

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", based on co-located diffusion tube and automatic analyser measurements, to annual mean NO_2 concentrations measured by diffusion tubes. 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 non-co-located sites.

Based upon *only the seven months for which the automatic analyser obtained > 75% data capture*, the annual mean obtained using diffusion tubes was 24 µg m^{-3}, and the annual mean obtained using the chemiluminescence analyser was 22 µg m^{-3}. This gives a "bias adjustment factor" of 0.92.

As this bias adjustment factor is based upon only seven months of the year, it should be treated with caution. When the "national" bias adjustment factors for 2011 become available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html, the relevant national bias adjustment factor should be used in preference to the factor calculated from the Stansted 3 data. These are due to be published at the end of March 2012.

Table 4.2 includes annual mean values from the other four diffusion tube sites, corrected using the Stansted bias adjustment factor of 0.92.

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

Full details of the air quality standards and objectives are provided in Appendix 1.

Stansted 4 recorded one hourly mean NO_2 concentration greater than the hourly mean AQS objective of 200 µg m^{-3}. Stansted 3 recorded none. Therefore both sites met the Air Quality Strategy (AQS) objective for this pollutant.

The annual mean NO_2 concentrations measured at Stansted 3 and Stansted 4 during 2011 were 22 µg m^{-3} and 19 µg m^{-3} respectively. Both automatic sites were therefore well within the annual mean AQS objective for NO_2.

The annual mean NO_2 concentrations measured at the five diffusion tube sites were also all well within the AQS objective of 40 µg m^{-3}.

PM_{10} was measured at Stansted 3 only. After correction of the data using the King's College Volatile Correction Model, the number of 24-hour means in excess of 50 µg m^{-3} was seven: this is well within the maximum permitted number of exceedences (35), so this site met the AQS objective for 24-hour mean PM_{10}.

The 2011 annual mean PM_{10} concentration (based on VCM-corrected data) was 21 µg m^{-3}: this was well within the AQS objective for this parameter.

4.4 Temporal Variation in Pollutant Concentrations

4.4.1 Seasonal Variation

Figure 4-3 shows the variation of monthly averaged NO and NO_2 concentrations during 2011 at Stansted 4. Monthly means have not been plotted for Stansted 3 this year, because of the poor data capture due to the repeated power interruptions.

As in previous years, Stansted 4 recorded highest concentrations of NO and NO_2 during the winter months. This pattern is typical of urban monitoring sites; 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.

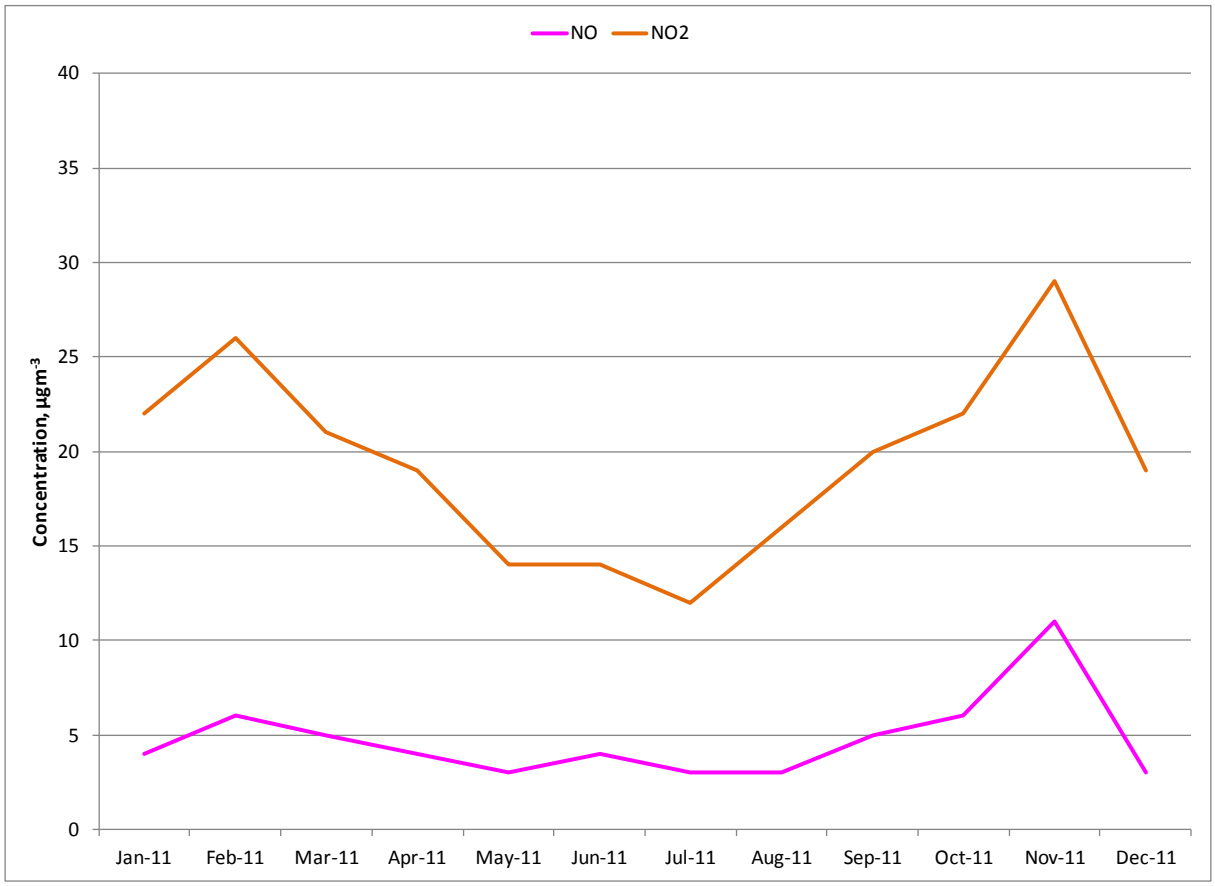

Figure 4-3 Seasonal variation of pollutant concentrations at Stansted 4, 2011

4.4.2 Diurnal Variation

Figure 4-4 and Figure 4-5 show diurnal variation in pollutant concentrations, as measured at Stansted 3 and Stansted 4 respectively. The PM_{10} data shown here are **TEOM data as measured, rather than VCM-corrected.**

Both sites show clear peaks for NO and NO_2 in the morning, corresponding to rush hour traffic at around 7am. Concentrations decrease during the middle of the day, with a much broader evening rush-hour peak building up from early afternoon. For NO_2, which has a secondary component, the afternoon peak is at least as high as the morning peak. For NO, the afternoon peak is very much smaller (or non-existent in the case of Stansted 3). This is because in the afternoon, concentrations of oxidising agents, particularly ozone, in the atmosphere tend to increase, leading to enhanced oxidation of NO to NO_2. This is a typical pattern for oxides of nitrogen in urban areas.

For PM_{10} at Stansted 3, the diurnal pattern is less pronounced. There is barely any dip between the morning and afternoon peaks (this is similar to the pattern observed last year, which appeared as a steady increase through the day, rather than two peaks). For PM_{10}, emissions of sulphur dioxide and NO_x can react with other chemicals in the atmosphere to form secondary sulphate and nitrate particles, which can result in elevated levels of PM_{10}. It is noticeable that the afternoon PM_{10} peak is earlier than the NO_2 peak. It is possible that diurnal PM_{10} profile may be affected by the pattern of use of light and heavy-duty vehicles throughout the day.

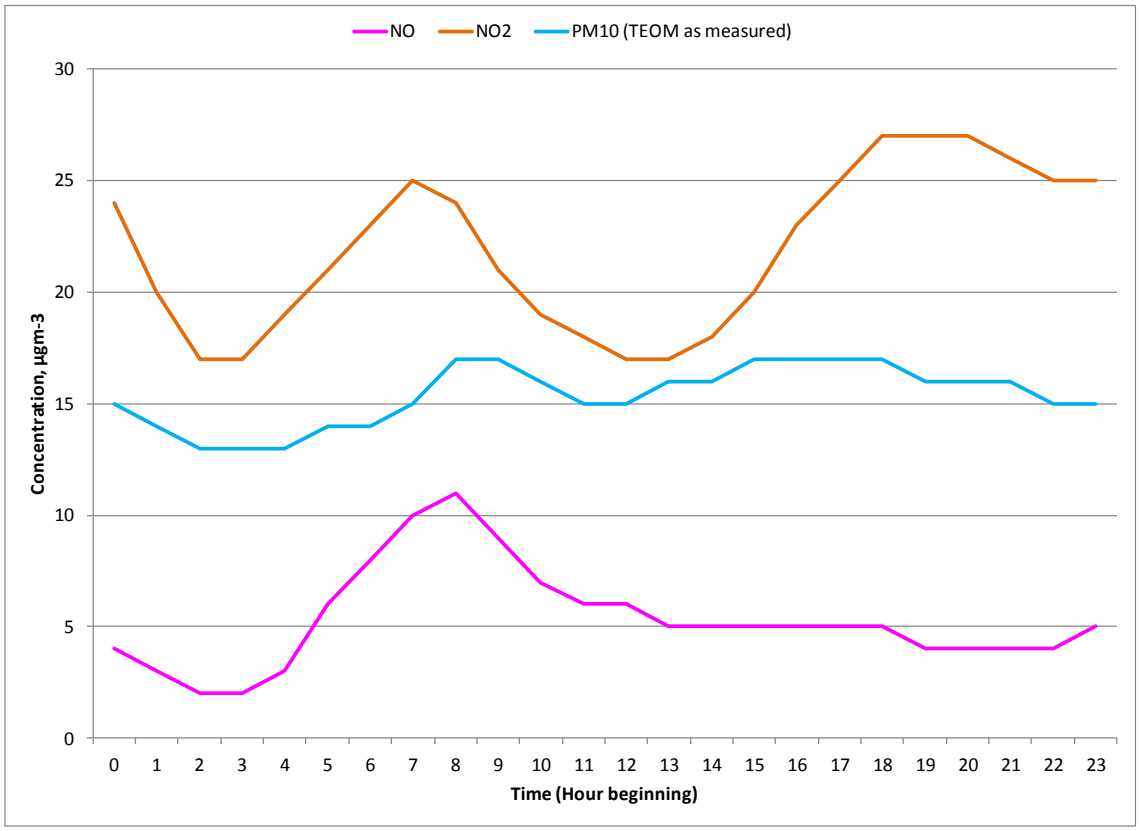

Figure 4-4 Diurnal variation of pollutant concentrations at Stansted 3, 2011

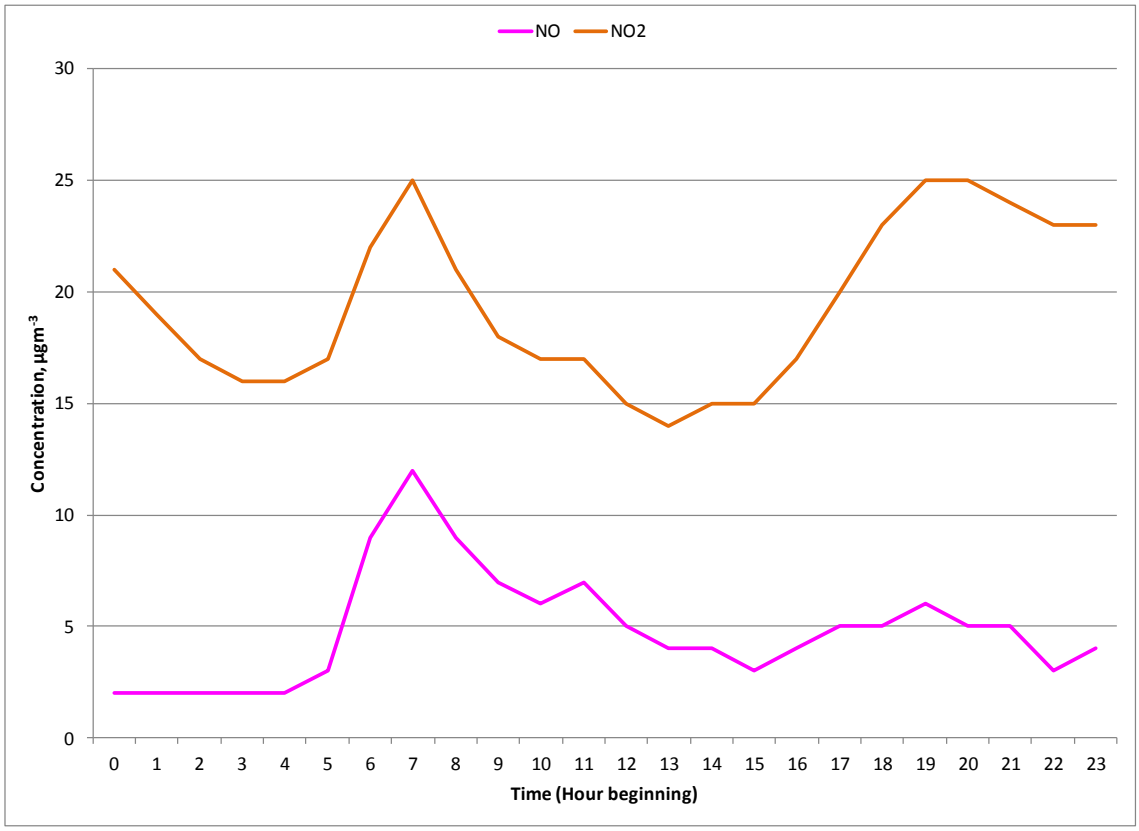

Figure 4-5 Diurnal variation of pollutant concentrations at Stansted 4, 2011

4.5 Source Investigation

In order to investigate the possible sources of air pollution that are being 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 wind speed and direction data were combined from the airfield anemometer, and two noise monitoring stations outside the airport perimeter, approximately 3.2 km from the end of each runway. *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 4-6 shows the wind speed and direction data, as supplied by Stansted Airport. The length 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 240º, and the wind was from this direction approximately 20% of the year. Each "spoke" is divided into coloured sections: these are wind speed intervals of 2 ms^{-1} as shown by the scale bar in the plot. The mean wind speed was 3.1 ms^{-1}, and the 75th percentile wind speed was 4.1 ms^{-1}. The maximum measured wind speed was 11.5 ms^{-1}.

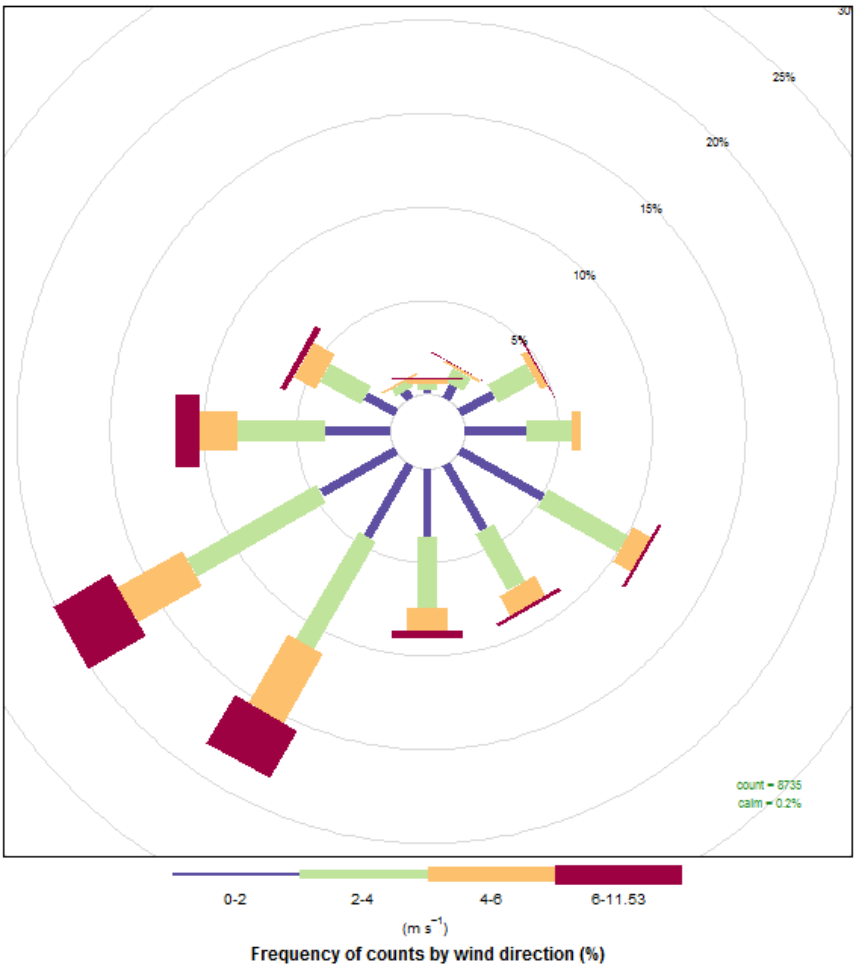

Figure 4-6 Wind rose showing the wind speed and direction in 2011 (data supplied by Stansted Airport Ltd).

Figure 4-7 and Figure 4-8 show bivariate plots of hourly mean NO and NO_2 concentrations against the corresponding wind speed and wind direction. These plots should be interpreted as follows:

- The wind direction is indicated as in the wind rose 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 5 ms^{-1} intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentration varies with wind direction and wind speed. They are best interpreted with reference to the map in Figure 2.1.

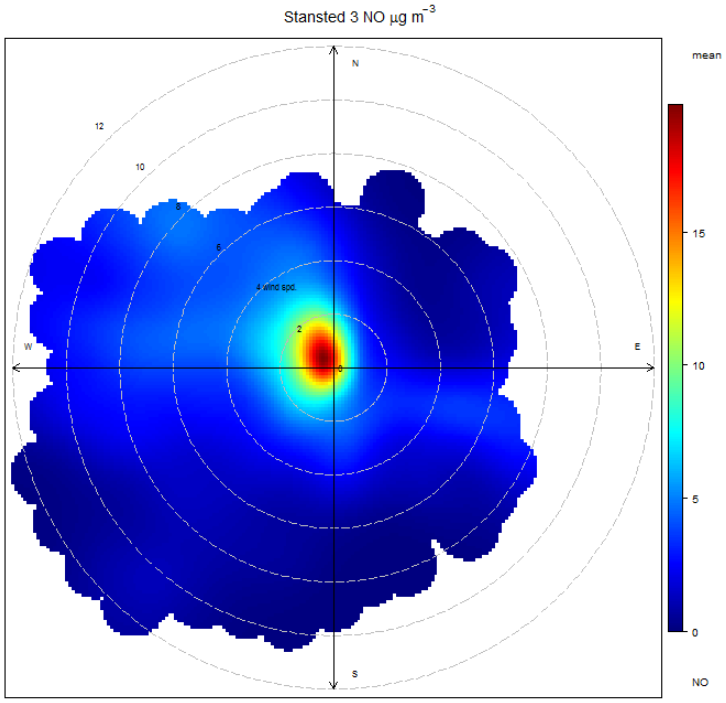

Figure 4-7 Pollution Rose for NO at Stansted 3

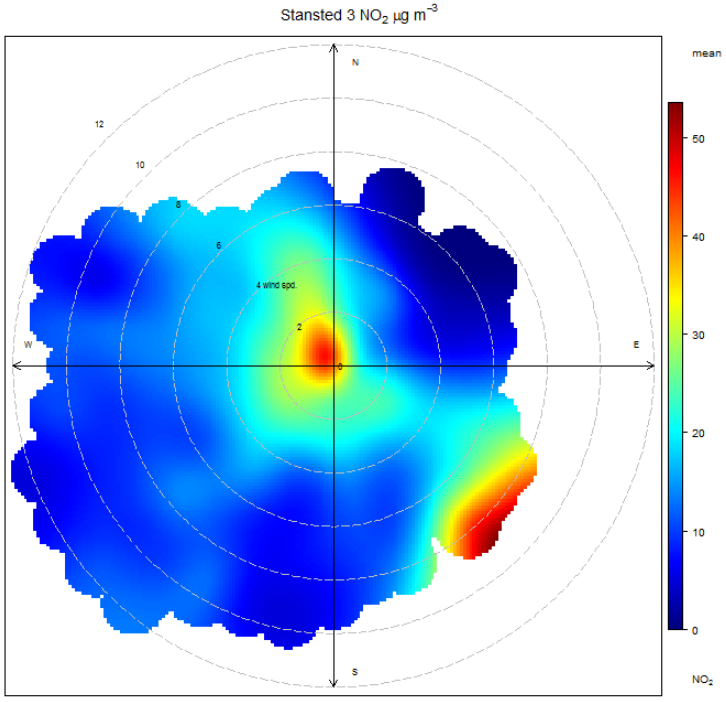

Figure 4-8 Pollution Rose for NO_2 at Stansted 3

Highest concentrations of NO were recorded at Stansted 3 when the wind speed was low, indicating that the main sources are close to the monitoring site. In the case of NO_2, there appear to be contributions from a source to the south east at high wind speeds (around 8 ms^{-1}). As highlighted last year, this is possibly a signature from A120 which lies to the south of the airport.

Figure 4-9 shows a similar bivariate plot for PM_{10} at Stansted 3. This shows a different pattern from the plots for oxides of nitrogen above. Highest concentrations are associated with higher wind speeds, and a wind direction of approximately 120°. The signature suggests a source to the south east of the monitoring site, as in the case of NO_2. The nature of this source (also observed last year) is unknown, but could be traffic on the A120, or possibly agricultural activity.

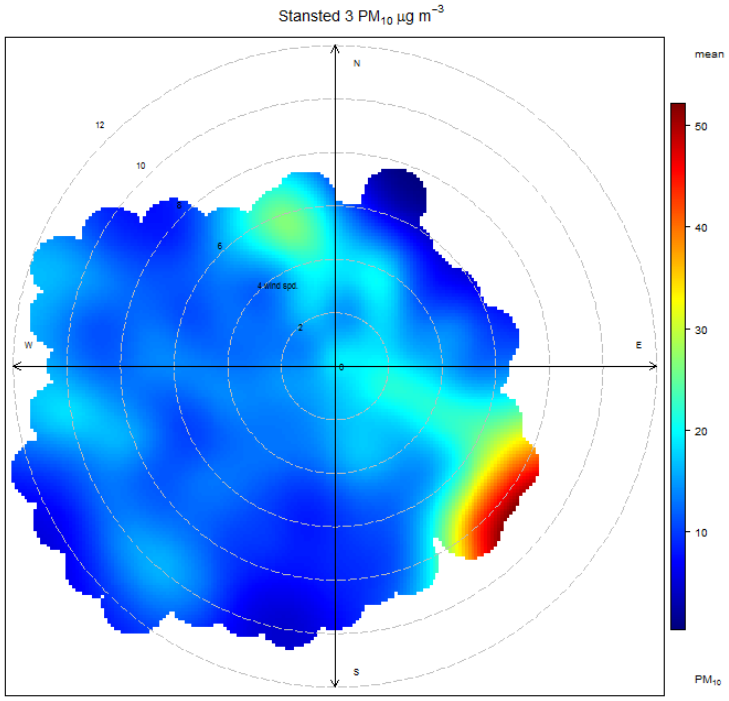

Figure 4-9 Pollution Rose for PM_{10} at Stansted 3

Figure 4-10 shows the "pollution rose" for NO at Stansted 4. Highest concentrations occurred at low wind speeds, indicating that the main sources of NO are nearby. The main contribution appears to be from between the south east and south west. This is the direction of the runway and the main airport terminal, with its associated traffic.

The NO_2 pollution rose (Figure 4-11) also shows evidence of sources close to the monitoring site: however, at higher wind speeds there is a stronger signature from the south east – the direction of the main airport terminal.

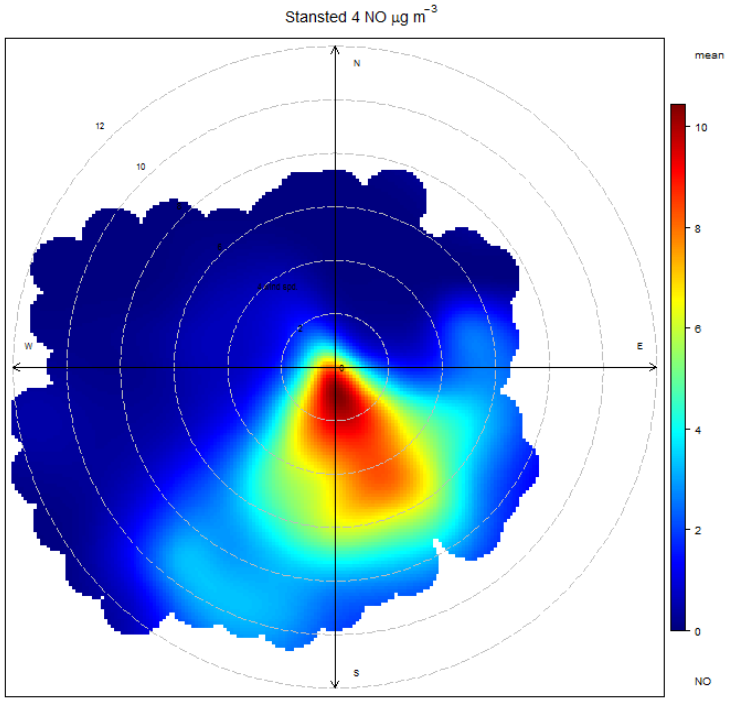

Figure 4-10 Pollution Rose for NO at Stansted 4

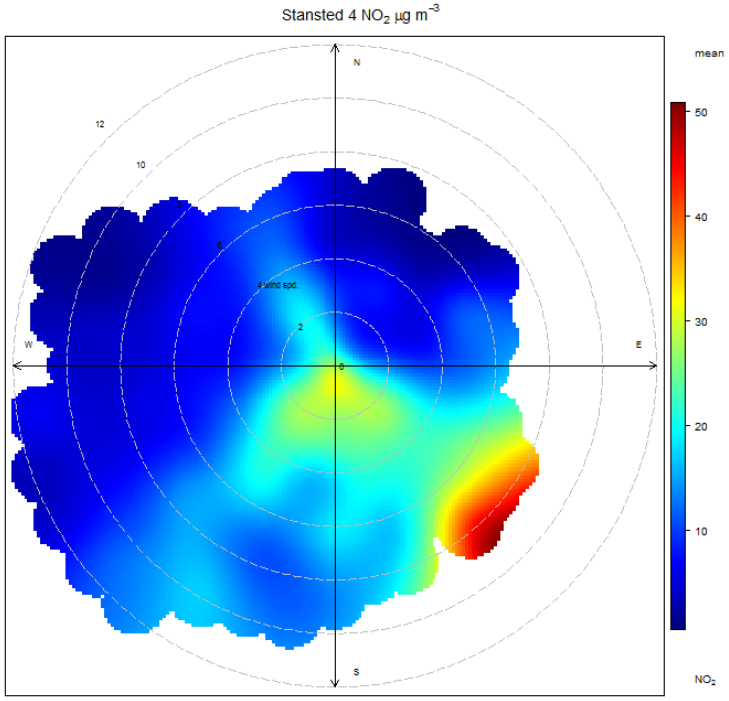

Figure 4-11 Pollution Rose for NO_2 at Stansted 4

4.6 Relationship with Airport Activity

The fact that the airport is a major source of oxides of nitrogen and, to a lesser a degree, a source of PM_{10}, might potentially lead to some correlation between airport activity and pollutant concentrations. This was investigated.

Figure 4-12 shows monthly statistics for the number of air traffic movements (ATM's) during the years 2005-2011. The distinct seasonal pattern indicating high 'activity' in the summer

months (July and August) and lower in the winter is clearly seen. Also shown (plotted against the secondary y-axis) are monthly mean NO_2 concentrations at Stansted 3 and Stansted 4. These show the opposite seasonal pattern, being higher in the winter months rather than the summer. This is a typical seasonal pattern for an urban area.

Although 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 above, this simplistic analysis of air traffic movements indicates that seasonal variation in pollutant concentrations (i.e. the periods of high and low concentration) at Stansted is influenced by general meteorological factors rather than air traffic movement.

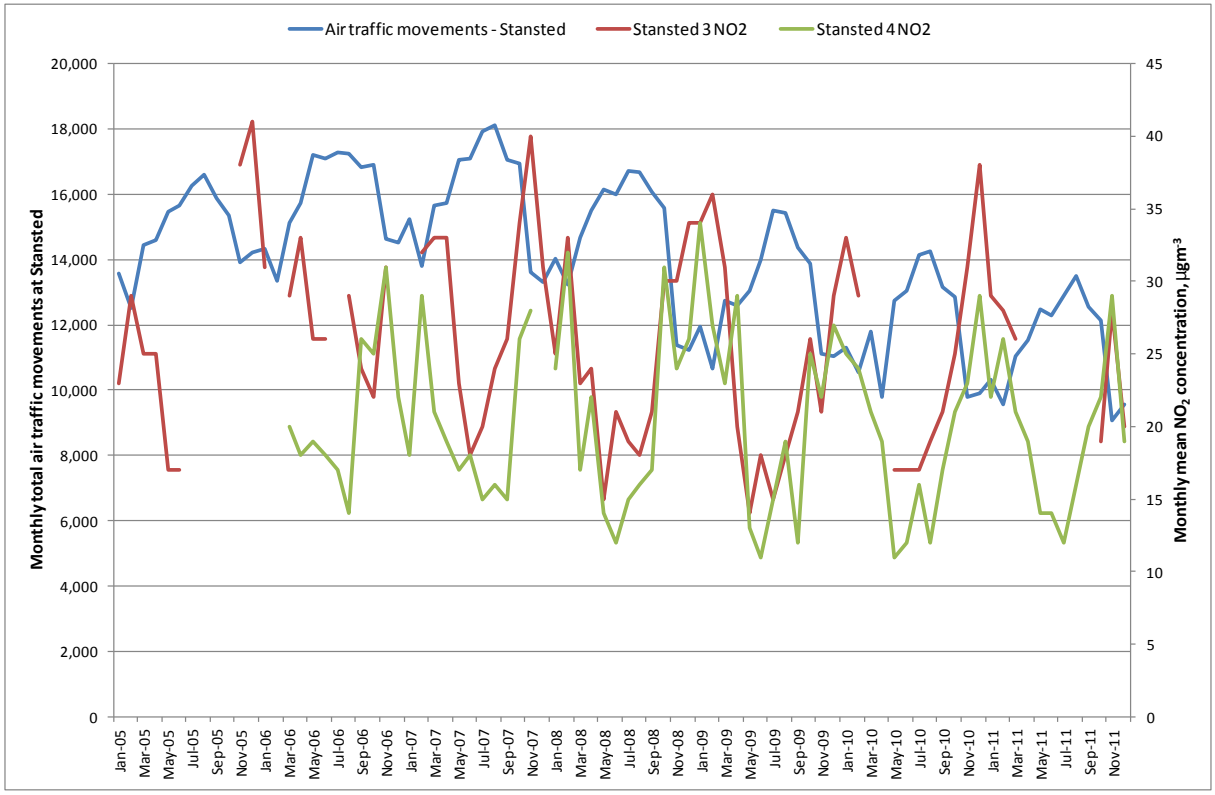

Figure 4-12 Monthly variation of Stansted airport activity and NO_2 concentration

4.7 Periods of Elevated Pollutant Concentration

In this section, the most significant periods of high air pollution concentrations for the whole year are briefly reviewed.

It is important to stress, however, that despite there being some periods of high pollutant concentration, both sites met the applicable Air Quality objectives.

4.7.1 Nitrogen Dioxide

Concentrations of NO_2 at Stansted 3 were within the Defra Low band (see Appendix 1) throughout 2011. No hourly means exceeded the AQS objective of 200 µg m^{-3}. At Stansted 4, a brief "spike" in NO_2 concentration occurred at 1000 on 2nd May 2011, with the hourly mean reaching 279 µg m^{-3}. This was traced to the use of an emergency generator. There were no other instances of high NO_2 concentration.

4.7.2 PM_{10}

The daily mean VCM-corrected PM_{10} concentration exceeded the AQS objective of 50 µg m^{-3} on 7 occasions in 2011. Most of these occurred during the period 18th Feb – 18th Apr, specifically around 18-20 Feb, 8th Mar and 16th Mar. On these days, elevated concentrations

of particulate matter were also measured at other sites in East Anglia, e.g. the AURN sites at Thurrock, Norwich Lakenfields and Stanford-Le-Hope Roadside. It therefore appears that the elevated concentrations on these days were due to regional particulate "episodes" and not specifically local sources.

A further peak in PM_{10} occurred on 22nd Aug, with high concentrations between 1300 and 2100. This was not seen in the data from other sites, so it is likely to have been due to local factors.

4.8 Comparison with Other UK Sites

Figure 4-13 provides a comparison between annual mean pollutant NO_2 levels at the Stansted sites, and corresponding measurements made at five AURN monitoring stations in the south and east of England, and one other site in the vicinity of a major airport. These sites are listed below:

- Northampton – an urban background site in the grounds of a college in Northampton, approximately 45m from the nearest major road.
- Thurrock – an urban background site in the town of Thurrock, Essex, approximately 35m 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 1km north east of the Heathrow perimeter.
- 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 via the Heathrow Airwatch website at http://www.heathrowairwatch.org.uk/ .

AURN data for 2011 will not be fully ratified until the end of Mar 2012. Therefore the annual means for AURN sites are still provisional at the time of writing (Feb 2012) and may change.

In recent years, annual mean concentrations of NO_2 at the Stansted sites have been similar to the urban background concentrations measured at Southend-on-Sea and Northampton. Both Stansted sites are currently reporting lower concentrations than London Harlington, Heathrow LHR2, Thurrock, and Cambridge Roadside. Annual mean NO_2 concentrations at Stansted 3 have showed a slight general decrease since 2004, reducing the "gap" between this site and Stansted 4.

Cambridge Roadside, located at the kerb of a busy road in the nearby city of Cambridge, is included for comparison. This site (like many other urban roadside sites in the UK) has consistently recorded annual mean NO_2 concentration in excess of 40 µg m^{-3}, and substantially higher concentrations than either of the Stansted sites.

Figure 4-14 shows annual mean PM_{10} concentrations at Stansted 3 and the London Heathrow site LHR2. (In previous years, other AURN sites were included in the comparison. However, some of these no longer measure PM_{10}, and in other cases the measurement technique has changed to FDMS. Therefore only LHR2 is used for comparison in the 2011 report). These are "as measured" data without VCM-correction.

Concentrations of PM_{10} at Stansted 3 are lower than those measured at LHR2, but (since 2004) show the same pattern of variation year-on-year.

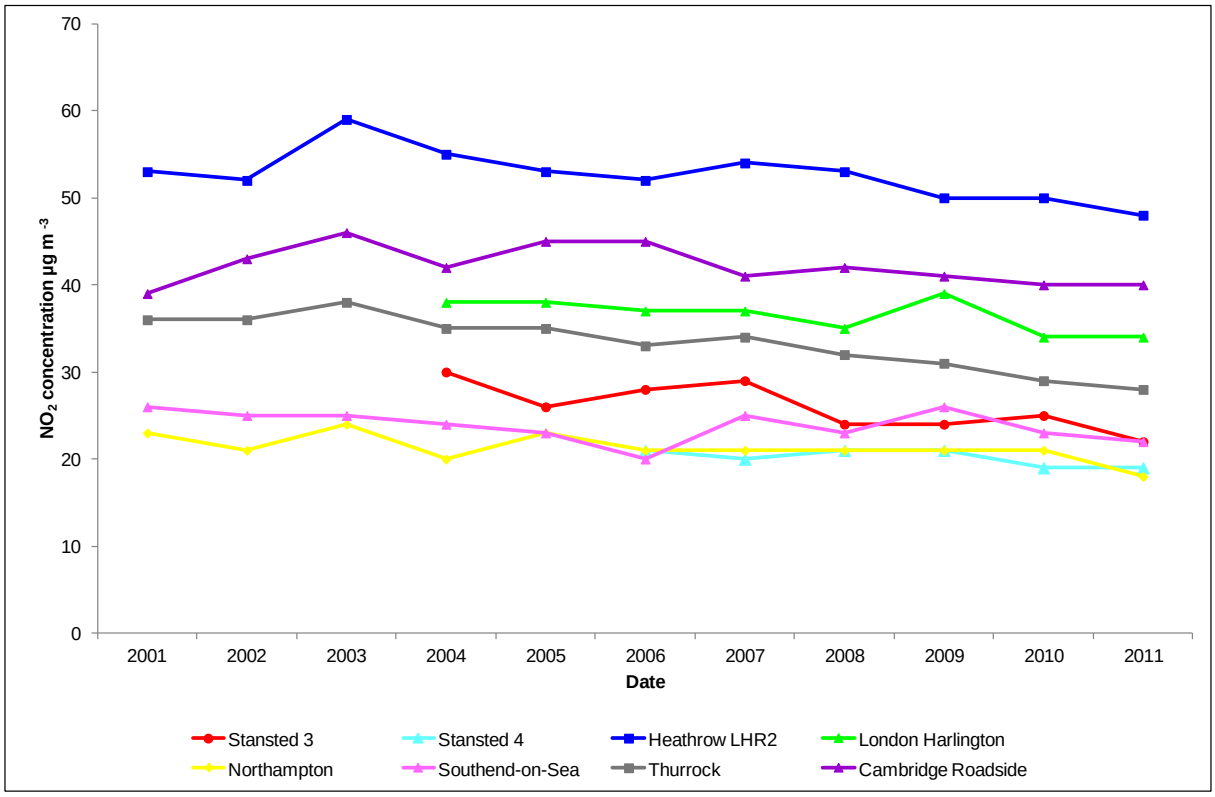

Figure 4-13 Annual mean trend NO_2 concentrations at Stansted 3, Stansted 4 and other regional monitoring sites.

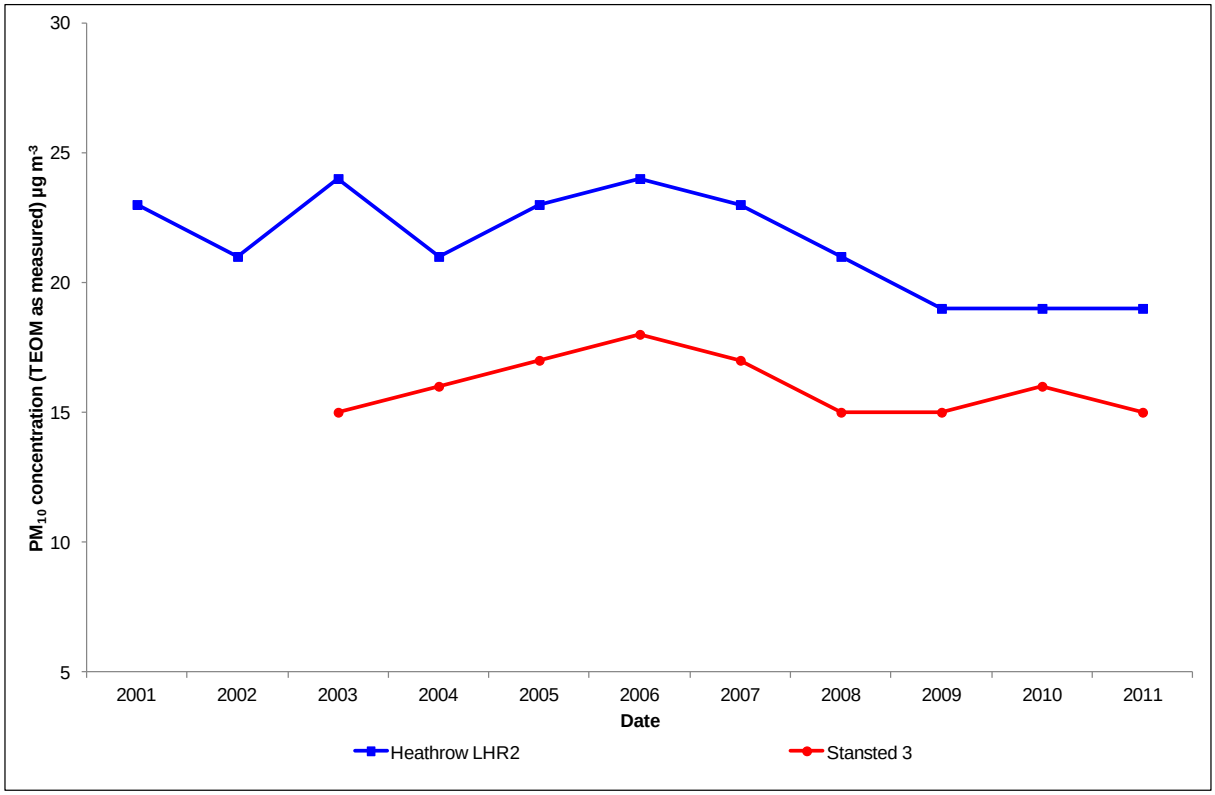

Figure 4-14 Annual mean PM_{10} concentrations at Stansted 3 and other regional monitoring sites.

5 Conclusions and Recommendations

The following conclusions have been drawn from the results of air quality monitoring at Stansted Airport during 2011:

1. The data capture target of least 90% was achieved for oxides of nitrogen at Stansted 4. However, data capture for both NOx and PM_{10} at Stansted 3 missed this target due to repeated power interruptions.

2. Both automatic monitoring sites (Stansted 3 and 4) met the AQS objectives for 1-hour mean and annual mean NO_2 concentration.

3. All five NO_2 diffusion tube sites met the AQS annual mean objective for this pollutant.

4. Stansted 3 met the AQS objectives for daily mean and annual mean PM_{10} concentration.

5. At Stansted 4, NO and NO_2 concentrations were higher during the winter months: this is a fairly typical pattern for urban sites. (Seasonal patterns at Stansted 3 were not investigated due to gaps in the dataset).

6. The diurnal variation of NO and NO_2 concentrations showed a pattern similar to that observed at other urban monitoring sites with the peak concentrations coinciding with the morning and evening rush hour period. By contrast, levels of PM_{10} showed a much less pronounced diurnal pattern.

7. An investigation into the source of pollutants at Stansted 3 (using meteorological data provided by Stansted Airport Ltd) found that highest concentrations of NO occurred at low wind speeds (indicating that the sources were close by). NO_2 concentrations measured at Stansted 3 appeared to originate from local sources: also, at higher wind speeds there was evidence of a contribution from a source to the south east. PM_{10} contributions were also influenced by a source to the south east at higher wind speeds. The highest PM_{10} concentrations at Stansted 3 therefore did not appear to be associated with the airport. It was not possible to clearly identify the source, but could have been nearby major roads or possibly agricultural activity.

8. NO and NO_2 concentrations at Stansted 4 were more clearly associated with the direction of the airport's main terminal.

9. Annual mean concentrations of NO_2 at Stansted 3 and Stansted 4 are comparable with concentrations measured at urban background sites such as Southend-on-Sea and Northampton. Annual mean PM_{10} concentrations (based on "as measured" TEOM data, i.e. before VCM correction) at Stansted 3 are lower than those at the LHR2 site, at London's Heathrow Airport.

6 Acknowledgements

AEA would like to thank Stansted Airport Ltd, and in particular Andy Jefferson and Duncan Smith, for assistance with this monitoring study.

7 References

1. Council Directive 2008/50/EC of the European Parliament and of the Council of 21st May 2008, on ambient air quality and cleaner air for Europe. Available from http://ec.europa.eu/environment/air/quality/legislation/directive.htm .

2. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 plus the Addendum to the Air Quality Strategy (2003), and update 2007.

3. Nitrogen dioxide in the United Kingdom. A report by the Air Quality Expert Group prepared for Department for Environment, Food and Rural Affairs in partnership, Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. Defra publications. (2004).

4. Part IV of the Environment Act 1995. Local Air Quality Management. Technical Guidance LAQM.TG(09) February 2009. Produced by Defra, available from www.defra.gov.uk/environment/airquality/index.htm

5. National Atmospheric Emissions Inventory – published on the UK National Atmospheric Emissions Inventory web site - http://www.naei.org.uk

6. Harrison D "UK Equivalence Programme for Monitoring of Particulate Matter". Report produced by Bureau Veritas, on behalf of Defra and the Devolved Administrations. Report reference number BV/AQ/AD202209/DH/2396, June 2006. Available from http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf

7. King's College London Volatile Correction Model available at http://www.volatile-correction-model.info/Default.aspx . July 2008 . (Accessed 27th Feb 2012).

Appendices

Appendix 1: Air Quality Objectives and Index Bands

Appendix 2: Monitoring Apparatus and Techniques

Appendix 3: Quality Assurance and Quality Control

Appendix 4: NO_2 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 μg m^{-3}	Running annual mean	31.12.2003
England and Wales only	5.00 μg m^{-3}	Annual mean	31.12.2010
Scotland and Northern Ireland	3.25 μg m^{-3}	Running annual mean	31.12.2010
1,3-Butadiene	2.25 μg m^{-3}	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31.12.2003
England, Wales & N. Ireland			
Scotland only	10.0 mg m^{-3}	Running 8-hour mean	31.12.2003
Lead	0.5 μg m^{-3}	Annual mean	31.12.2004
	0.25 μg m^{-3}	Annual mean	31.12.2008
Nitrogen dioxide	200 μg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 μg m^{-3}	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 μg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
All authorities	40 μg m^{-3}	Annual mean	31.12.2004
Scotland only	50 μg m^{-3}, not to be exceeded more than 7 times a year	24-hour mean	31.12.2010
	18 μg m^{-3}	Annual mean	31.12.2010
Particles ($PM_{2.5}$) (gravimetric) *	25 µg m^{-3} (target)	Annual mean	2020
All authorities	15% cut in urban background exposure	Annual mean	2010 - 2020
Scotland only	12 µg m^{-3} (limit)	Annual mean	2010
Sulphur dioxide	350 μg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 μg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 μg 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 μg m^{-3} not to be exceeded more than 10 times a year	Daily maximum of running 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 dioxide *(for protection of vegetation & ecosystems) **	30 $\mu g\ m^{-3}$	Annual mean	31.12.2000
Sulphur dioxide *(for protection of vegetation & ecosystems) **	20 $\mu g\ m^{-3}$ 20 $\mu g\ m^{-3}$	Annual mean Winter average (Oct-Mar)	31.12.2000 31.12.2000
Ozone *	18 mg m^{-3}	$AOT40^{+}$, calculated from 1h values May-July. Mean of 5 years, starting 2010	01.01.2010

** Not included in regulations.*
$^{+}$ AOT 40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.

Table A1.3 Defra Air Pollution Bands (in use during 2011) and Index Values

The air pollution index and bandings were updated in January 2012. The table below shows those in use during 2011, the period covered by this report.

Air pollution bandings and description.

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 (e.g. 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.

Boundaries between index points for each pollutant.

Band	Index	O_3	NO_2	SO_2	CO	PM_{10} (gravi-metric)	PM_{10} (Reference equiv.)
		8 hourly or hourly mean ($\mu g\ m^{-3}$)*	hourly mean ($\mu g\ m^{-3}$)	15 minute mean ($\mu g\ m^{-3}$)	8 hourly mean ($mg\ m^{-3}$)	24 hour mean ($\mu g\ m^{-3}$)	24 hour mean ($\mu g\ m^{-3}$)
Low	1	0-32	0-95	0-88	0-3.8	0-21	0-19
	2	33-66	96-190	89-176	3.9-7.6	22-42	20-40
	3	67-99	191-286	177-265	7.7-11.5	43-64	41-62
Mod-erate	4	100-126	287-381	266-354	11.6-13.4	65-74	63-72
	5	127-152	382-477	355-442	13.5-15.4	75-86	73-84
	6	153-179	478-572	443-531	15.5-17.3	87-96	85-94
High	7	180-239	573-635	532-708	17.4-19.2	97-107	95-105
	8	240-299	636-700	709-886	19.3-21.2	108-118	106-116
	9	300-359	701-763	887-1063	21.3-23.1	119-129	117-127
Very High	10	360 or more	764 or more	1064 or more	23.2 or more	130 or more	128 or more

* For ozone, the maximum of the 8 hourly and hourly mean is used to calculate the index value.

Appendix 2 - Monitoring Apparatus and Techniques

Monitoring Equipment

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

- NO, NO_2: chemiluminescence with ozone
- PM_{10}: tapered element oscillating microbalance

These methods were selected in order to provide real-time data. The chemiluminescence analyser is the European reference method for ambient NO_2 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 AEA. The data are then converted to concentration units and averaged to hourly mean concentrations.

The chemiluminescence analysers for NOx 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 PM_{10} 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 PM_{10} monitoring data recorded by TEOM monitors were corrected with the King's College Volatile Correction Model (VCM). 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.

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 (µg m^{-3})
- Daily or hourly FDMS (Filter Dynamic Measurement System) purge measurements (µg m^{-3})

The VCM works by using the volatile particulate matter measurements provided by nearby FDMS instruments (within 130 km) to assess the loss of PM_{10} from the TEOM; this value is then added back onto the TEOM measurements.

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

The VCM can be accessed through http://www.volatile-correction-model.info.

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

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

- NO 1 ppb = 1.25 μg m^{-3}
- NO_2 1 ppb = 1.91 μg m^{-3}

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

NO_x μg m^{-3}=(NO ppb+NO_2 ppb)*1.91.

This conforms with the requirements of the Ambient Air Quality Directive[1] and is also the convention generally adopted in air quality modelling.

Appendix 3 - Quality Assurance and Quality Control

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 AEA's AURN QA/QC manual, available at: http://uk-air.defra.gov.uk/reports/cat13/0910081142_AURN_QA_QC_Manual_Sep_09_FINAL.pdf

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 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 6-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. AEA's audit calibration procedures are UKAS accredited to ISO 17025.

In line with current operational procedures within the Defra Automatic Urban and Rural Network (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 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.

All air pollution measurements are reviewed on a daily basis, at AEA, by experienced staff. 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 to checking the data, 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 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, or occasionally the chart recorder record, to produce as complete as possible a data record.

Finally, the data are re-examined on an annual basis, when information from the 6-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 3-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 below.

Estimated Accuracy and Precision of the Data Presented

	Precision	Accuracy
Nitric Oxide (NO)	±2.5 μg m^{-3}	±15%
Nitrogen Dioxide (NO_2)	±6.9 μg m^{-3}	±15%
Particles (PM_{10})	±4 μg m^{-3} *	Estimated* accuracy of a TEOM ±30% or better : with VCM correction, estimated as ±25%.

* accuracy of particle measurements cannot currently be assessed.

Appendix 4 - NO_2 Diffusion Tubes – Full Dataset

Results are quoted here to two decimal places, as quoted by the analyst. However, given the uncertainty of diffusion tube measurements, they are rounded to the nearest integer in the main part of the report.

Table A4.1 Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted North (Runway lights, 23 Approach) ($\mu g\ m^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
05/01/2011	29.7	29.1	25.3	28.0	
03/02/2011	20.7	30.6	29.8	27.0	
03/03/2011	23.6	24.5	25.6	24.6	
31/03/2011	22.3	24.7	23.2	23.4	
28/04/2011	12.5	14.9	13.6	13.7	
01/06/2011	24.5	19.7	20.6	21.6	
29/06/2011	15.1	16.9	15.4	15.8	
03/08/2011	20.8	21.0	20.2	20.7	
31/08/2011	28.5	27.2	27.3	27.6	
28/09/2011	28.1	28.2	28.6	28.3	
02/11/2011	29.9	34.7	32.5	32.4	
30/11/2011	22.1	30.9	28.2	27.1	
Mean	23.2	25.2	24.2	24.2	

Table A4.2 Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted East (Enterprise House) ($\mu g\ m^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
05/01/2011	33.9	32.6	32.0	32.8	
03/02/2011	32.2	28.6	33.9	31.6	
03/03/2011	31.9	33.6	31.7	32.4	
31/03/2011	41.2	33.8	37.6	37.5	
28/04/2011	23.1	22.7	27.6	24.4	
01/06/2011	36.8	31.7	34.7	34.4	
29/06/2011	20.9	22.8	23.3	22.3	
03/08/2011	25.7	25.8	29.2	26.9	
31/08/2011	33.5	35.2	31.8	33.5	
28/09/2011	34.6	33.6	38.7	35.6	
02/11/2011	33.9	35.1	39.0	36.0	
30/11/2011	38.6	35.2	39.8	37.9	
Mean	32.2	30.9	33.3	32.1	

Table A4.3 Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted South (Balancing Pond "B") ($\mu g\ m^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
05/01/2011	33.1	37.4	32.5	34.3	
03/02/2011	26.9	26.0	23.5	25.5	
03/03/2011	32.2	33.2	29.6	31.7	
31/03/2011	30.3	30.0	31.8	30.7	
28/04/2011	20.8	21.3	20.9	21.0	
01/06/2011	24.1	24.4	25.6	24.7	
29/06/2011	22.7	22.2	21.6	22.1	
03/08/2011	24.7	24.2	24.0	24.3	
31/08/2011	20.4	25.7	22.6	22.9	
28/09/2011	27.3	26.7	27.5	27.1	
02/11/2011	29.9	34.6	30.3	31.6	
30/11/2011	30.9	31.7	32.4	31.7	
Mean	26.9	28.1	26.9	27.3	

Table A4.4 Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted West (Ground Radar Tower) ($\mu g\ m^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
05/01/2011	26.1	23.5	23.0	24.2	
03/02/2011	25.3	22.4	20.1	22.6	
03/03/2011	21.5	25.6	25.1	24.1	
31/03/2011	23.4	22.7	22.6	22.9	
28/04/2011	14.2	15.0	14.8	14.7	
01/06/2011	19.2	17.8	-	18.5	Missing tube.
29/06/2011	13.5	16.7	15.6	15.3	
03/08/2011	15.0	14.2	16.0	15.1	
31/08/2011	21.3	20.1	20.7	20.7	
28/09/2011	28.7	26.0	27.4	27.4	
02/11/2011	35.7	35.0	36.0	35.5	
30/11/2011	22.2	21.0	22.1	21.8	
Mean	22.2	21.7	22.1	21.9	

Table A4.5 Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted 3 (High House) ($\mu g\ m^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
05/01/2011	26.2	30.3	29.4	28.6	
03/02/2011	23.0	27.1	25.4	25.1	
03/03/2011	29.3	24.6	23.2	25.7	
31/03/2011	27.8	27.7	26.5	27.3	
28/04/2011	17.4	16.5	17.4	17.1	
01/06/2011	21.6	21.7	21.7	21.7	
29/06/2011	21.4	20.5	20.0	20.6	
03/08/2011	20.6	21.6	20.8	21.0	
31/08/2011	22.4	21.8	22.2	22.1	
28/09/2011	26.7	25.4	25.3	25.8	
02/11/2011	32.3	30.2	31.5	31.3	
30/11/2011	26.9	27.9	26.7	27.2	
Mean	24.6	24.6	24.2	24.5	

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 0870 190 1900
Fax: 0870 190 6318

www.aeat.co.uk