Air Quality Monitoring at Stansted Airport: Annual Report for 2012

Report for Stansted Airport Ltd

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Executive summary

This report presents the results of an air quality monitoring programme carried out around Stansted Airport during 2012. The monitoring was carried out by Ricardo-AEA 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 co-located with the automatic monitor at Stansted 3.

The EU Air Quality Directive sets a data capture target of 90 %. This was achieved for NOx, NO_2 and PM_{10} at Stansted 3 and Stansted 4.

The UK Air Quality Strategy (AQS) objectives for annual mean and hourly mean NO_2 concentration were achieved at Stansted 3 and Stansted 4. No instances were recorded when the hourly mean NO_2 concentration exceeded 200 µg m^{-3} at either Stansted 3 or Stansted 4.

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. These were 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, particularly during March, August and October 2012. 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 27th 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.

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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 site. Prior to 2006, three months monitoring per year were required: 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 2012, the seventh 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 Ricardo-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 2012.

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 summarised in Appendix 1.

2 Monitoring details

2.1 Pollutants monitored

Aircraft jet engines produce similar emissions to those produced by other combustion processes. These include carbon monoxide (CO), nitrogen oxides (NOx), 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 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 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 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 - primarily nitric oxide (NO) and nitrogen dioxide (NO_2) - collectively termed NOx.

(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 NOx 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 NOx 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 1,000 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 is larger due to the inherent volume of traffic[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 year 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 10 µm. 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 main sources of airborne particulate matter in the UK are combustion (industrial, commercial and residential fuel use). This is followed by road vehicle emissions. Based on 2010 NAEI data, 0.1% of UK total PM_{10} emissions are believed to originate from civil aircraft taking off and landing[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 Locations of monitoring sites

Automatic monitoring was carried out at two sites in 2012. 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], *(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").*

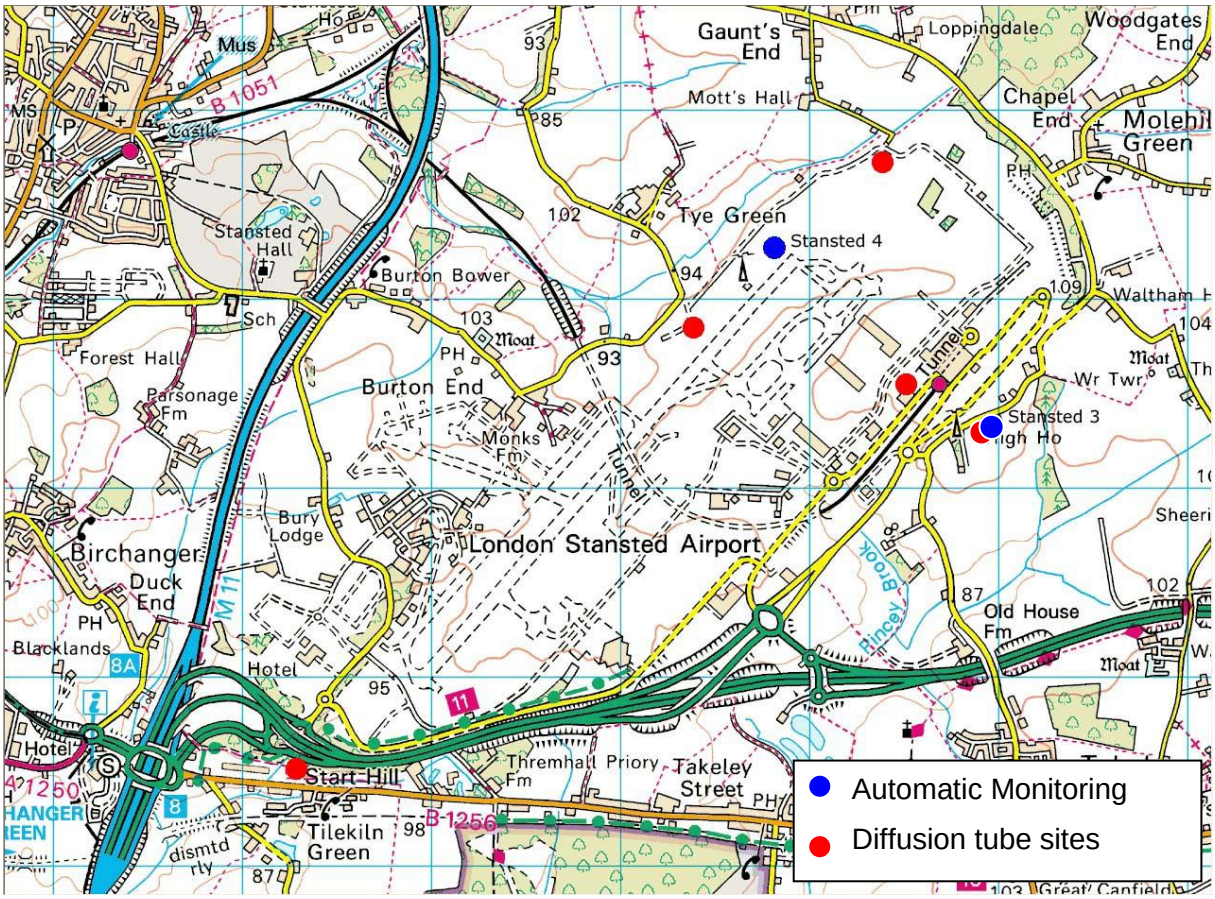
These two automatic sites were supplemented by five sites at which diffusion tubes were used to monitor NO_2 on a monthly basis. These were located at the Stansted 3 automatic site, and four sites to the north, east, south and west of the airport.

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 NOx and PM_{10}. Diffusion tube monitoring of NO_2 monthly (co-located).	TL 558 233
Stansted 4	Grass area near runway	Automatic monitoring of NOx.	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 photo 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 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 Ricardo-AEA. Data are downloaded hourly. The data are converted to concentration units at Ricardo-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[6].

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 Model[7] (VCM), 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/ . 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 PM_{10}. 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, where the VCM has been used to correct PM_{10} data, this is clearly indicated. However, in some cases, when 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 2012 (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 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. 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 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 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 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 NOx 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 typically equate to 0.4 µg m^{-3} for NO_2. Diffusion tube results that are less than 10 times 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 2012

Site	NOx	NO_2	PM_{10}
Stansted 3	94.4 %	94.4 %	98.1 %
Stansted 4	93.1 %	93.1 %	N/A

The 90 % data capture target was therefore achieved for NOx, NO_2 and PM_{10} at both Stansted 3 and Stansted 4. Table 3-3 shows the significant gaps in data capture that occurred during the year.

Table 3-3: Significant data gaps 2012

Site	Poll-utant	Start date	End date	No. of days	Reason	Comments
Stansted 3	NO_2, PM_{10}	03/01/2012	05/01/2012	2	Service	Routine six-month service
Stansted 3	NO_2	25/05/2012	06/06/2012	12	Power cut	Suspect power cut
Stansted 3	NO_2	03/07/2012	04/07/2012	1	Service	
Stansted 3	PM_{10}	11/09/2012	11/09/2012	0.3	Noisy	Inconsistent (“noisy”) data
Stansted 3	NO_2	26/09/2012	30/09/2012	4	Analyser	Resolved remotely
Stansted 3	NO_2	31/10/2012	31/10/2012	0.5	No readings	Site communications, the modem and the telemetry not working
Stansted 3	NO_2	10/12/2012	10/12/2012	0.3	No readings	Site communications, the modem and the telemetry not working
Stansted 3	PM_{10}	10/12/2012	11/12/2012	1	Analyser	Flow fault
Stansted 4	NO_2	04/01/2012	05/01/2012	1	Service	Service
Stansted 4	NO_2	28/04/2012	18/05/2012	21	Analyser	Power supply and ozone generator faults
Stansted 4	NO_2	03/07/2012	04/07/2012	1	Service	Routine service. Pre-service gas tests / data recorded by Ricardo-AEA
Stansted 4	NO_2	26/09/2012	27/09/2012	2	Offline	Following calibration

The 2011 report recorded frequent interruptions to data recording because of trips in the power supply. At that time, work was being carried out to upgrade the power supply to the monitoring site. The number of power breaks was much reduced in 2012.

4 Results and discussion

4.1 Automatic monitoring data

The summary statistics for 2012 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 2012

Stansted 3	NO (µg m^{-3})	NO_2 (µg m^{-3})	NOx (µg m^{-3})	PM_{10} as measured (µg m^{-3})	PM_{10} VCM corrected (µg m^{-3})
Max. 15-minute mean	458	201	892	3,487	-
Maximum hourly mean	315	180	653	1,693	1,287
Max. running 8-hour mean	136	136	334	403	-
Maximum running 24-hour mean	97	100	224	149	-
Maximum daily mean	92	98	208	149	115
Average	8	26	38	20	19
Data capture	94.4 %	94.4 %	94.4 %	98.1 %	98.1 %
Stansted 4	**NO (µg m^{-3})**	**NO_2 (µg m^{-3})**	**NOx (µg m^{-3})**	**PM_{10} as measured (µg m^{-3})**	**PM_{10} VCM corrected (µg m^{-3})**
Max. 15-minute mean	219	107	413		
Maximum hourly mean	201	101	382		
Max. running 8-hour mean	140	85	284		
Maximum running 24-hour mean	95	67	211		
Maximum daily mean	94	66	211		
Average	5	19	26		
Data capture	93.1 %	93.1 %	93.1 %		

Measured concentrations of the oxides of nitrogen NO and NO_2 are reported in micrograms per cubic metre µg m^{-3}. PM_{10} is conventionally reported in units of µg m^{-3}, micrograms 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 2.4 for an explanation of this.

Figure 4-1: Time series of hourly averaged concentrations at Stansted 3 - 2012

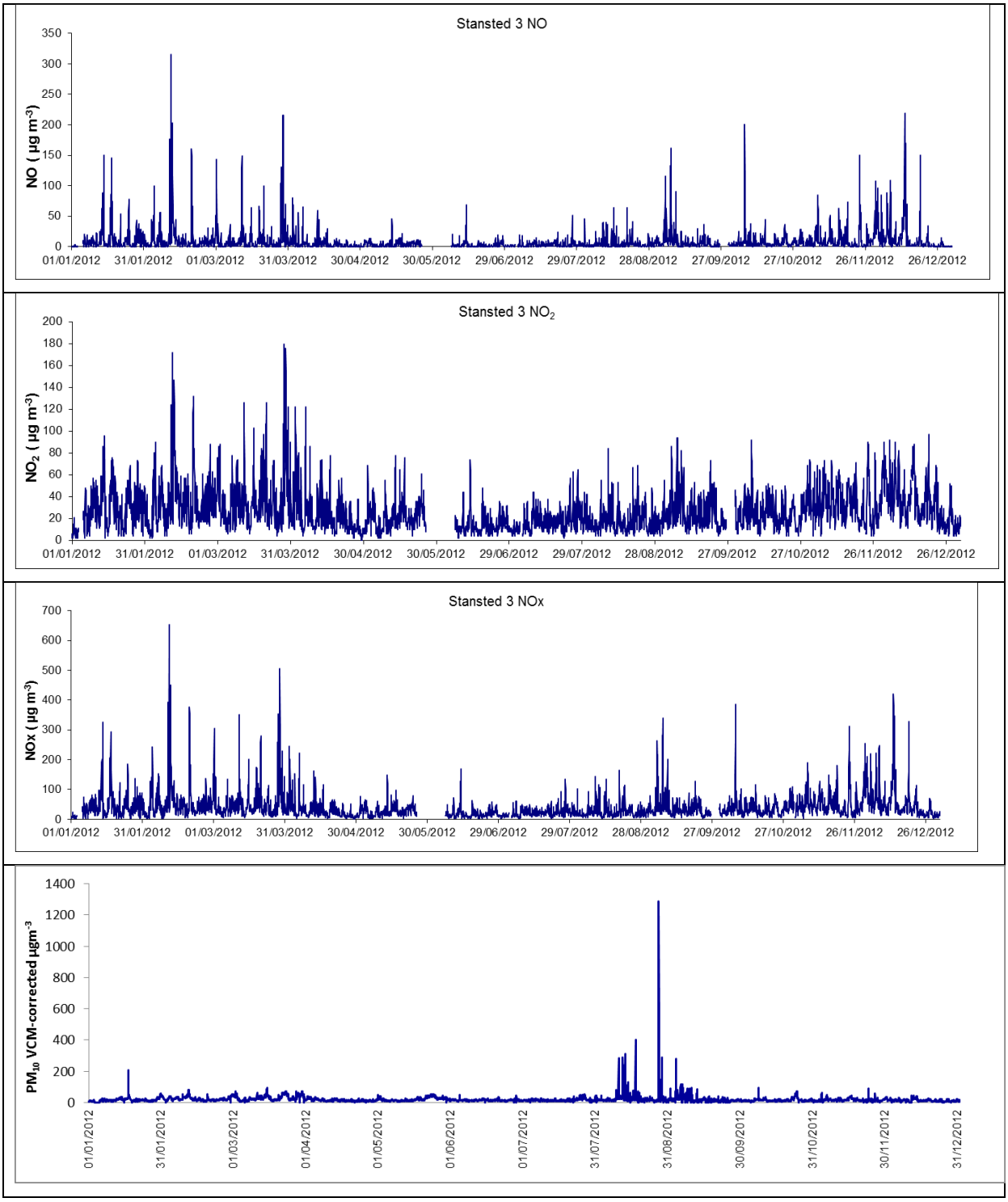
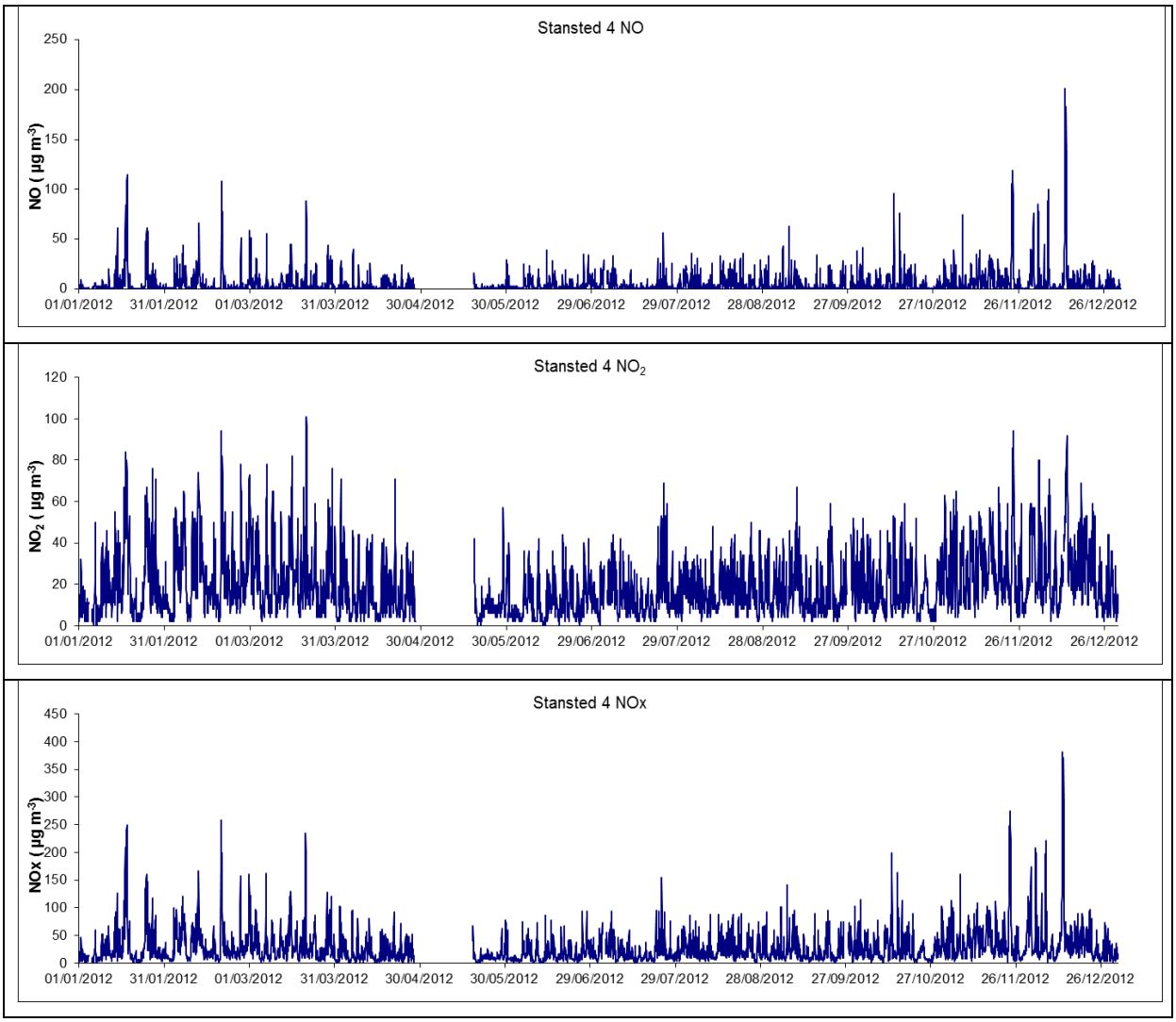


Figure 4-2: Time series of hourly averaged concentrations at Stansted 4 - 2012



4.2 Diffusion tube data

Table 4-2 shows the NO_2 diffusion tube results for 2012. Tubes are exposed in triplicate at all sites. The results shown are the means 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 in this report, in line with the reported uncertainty of the method.

Table 4-2: NO_2 diffusion tube results 2012, µg m^{-3}

Start date	Stansted North	Stansted East	Stansted South	Stansted West	Stansted 3
04/01/2012	25	40	39	24	31
01/02/2012	28	41	40	23	33
29/02/2012	24	33	33	22	28
28/03/2012	15	25	25	15	21
25/04/2012	12	22	25	13	19
30/05/2012	13	22	16	13	13
27/06/2012	No data	No data	No data	No data	No data
01/08/2012	23	29	20	19	20
29/08/2012	20	31	26	16	25
26/09/2012	22	27	25	19	21
31/10/2012	29	35	30	24	26
28/11/2012	22	28	25	21	26
Mean	21	30	28	19	24
Bias adjusted mean	24	34	31	22	27

The diffusion tubes used in July 2012 were found to be faulty so there are no data for this month. Otherwise, full data capture was achieved.

Annual mean NO_2 concentrations measured with diffusion tubes ranged from 19 µg m^{-3} to 30 µg m^{-3} at the five sites. The annual mean concentration measured at Stansted 3 using diffusion tubes was 24 µg m^{-3} (rounded to the nearest integer). This was slightly lower than the annual mean of 26 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”, 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.

The bias adjustment factor was calculated using ten of the twelve months’ data: the months excluded were June (when there was less than 70% data capture for the automatic method) and July (when there were no diffusion tube results). On this basis, the bias adjustment factor was calculated as 1.13. Unusually for this site, the 2012 diffusion tubes at Stansted 3 under-read by 13 % relative to the chemiluminescence analyser, leading to a “bias adjustment factor” of greater than 1.

Table 4-2 includes annual mean values from the other four diffusion tube sites, 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.
iii. Because only 10 of the 12 months of the year could be used to calculate the bias adjustment factor, the bias adjusted diffusion tube annual mean shown in Table 4-2 for Stansted 3 is slightly different from the annual mean measured using the automatic method.

4.3 Comparison with air quality objectives

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

Neither Stansted 3 nor Stansted 4 recorded any hourly mean NO_2 concentrations greater than the hourly mean AQS objective of 200 µg m^{-3}. 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 2012 were 26 µg m^{-3} and 19 µg m^{-3} respectively. Both automatic sites were therefore within the annual mean AQS objectives for NO_2 of 40 µg m^{-3} for protection of human health and 30 µg m^{-3} for protection of vegetation and ecosystems.

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 VCM, the number of 24-hour means in excess of 50 µg m^{-3} was 8. This is well within the maximum permitted number of exceedances (35), so this site met the AQS objective for 24-hour mean PM_{10}.

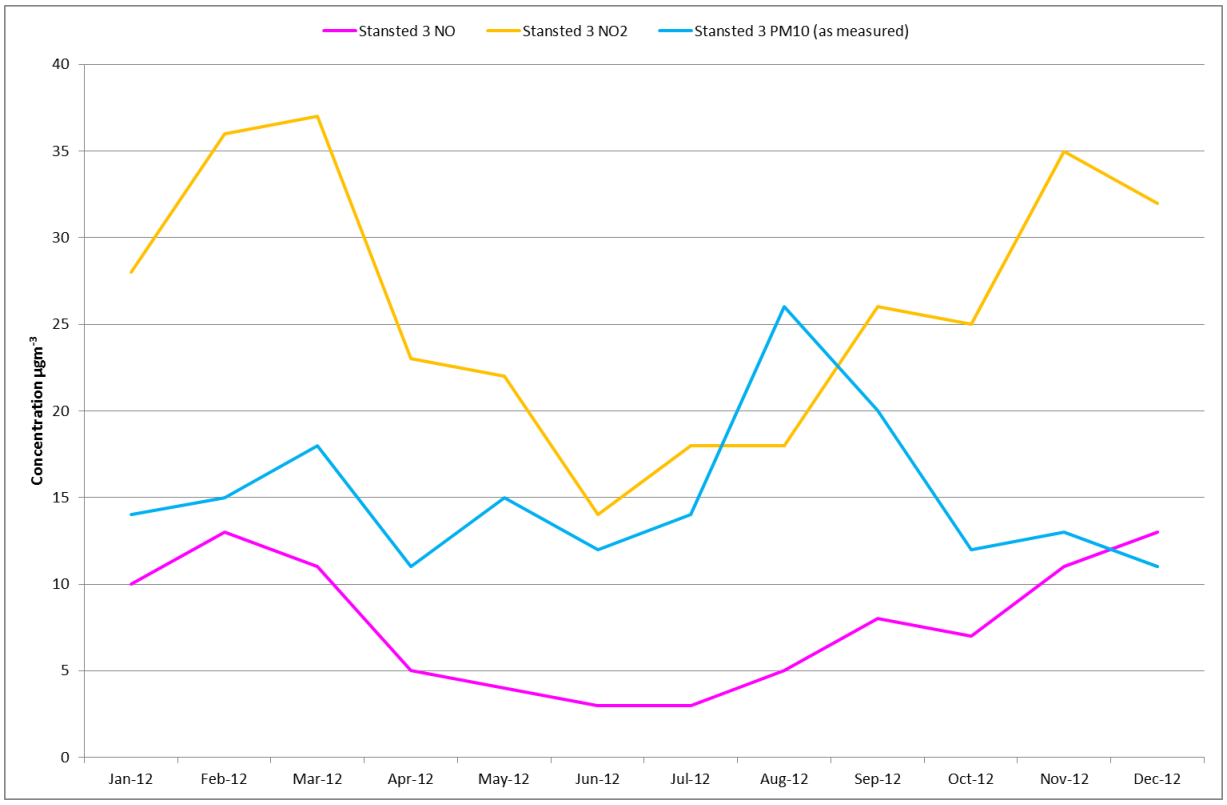
The 2012 annual mean PM_{10} concentration (based on VCM-corrected data) was 19 µg m^{-3}. This was well within the AQS objective for this parameter.

4.4 Temporal variation in pollutant concentrations

4.4.1 Seasonal variation

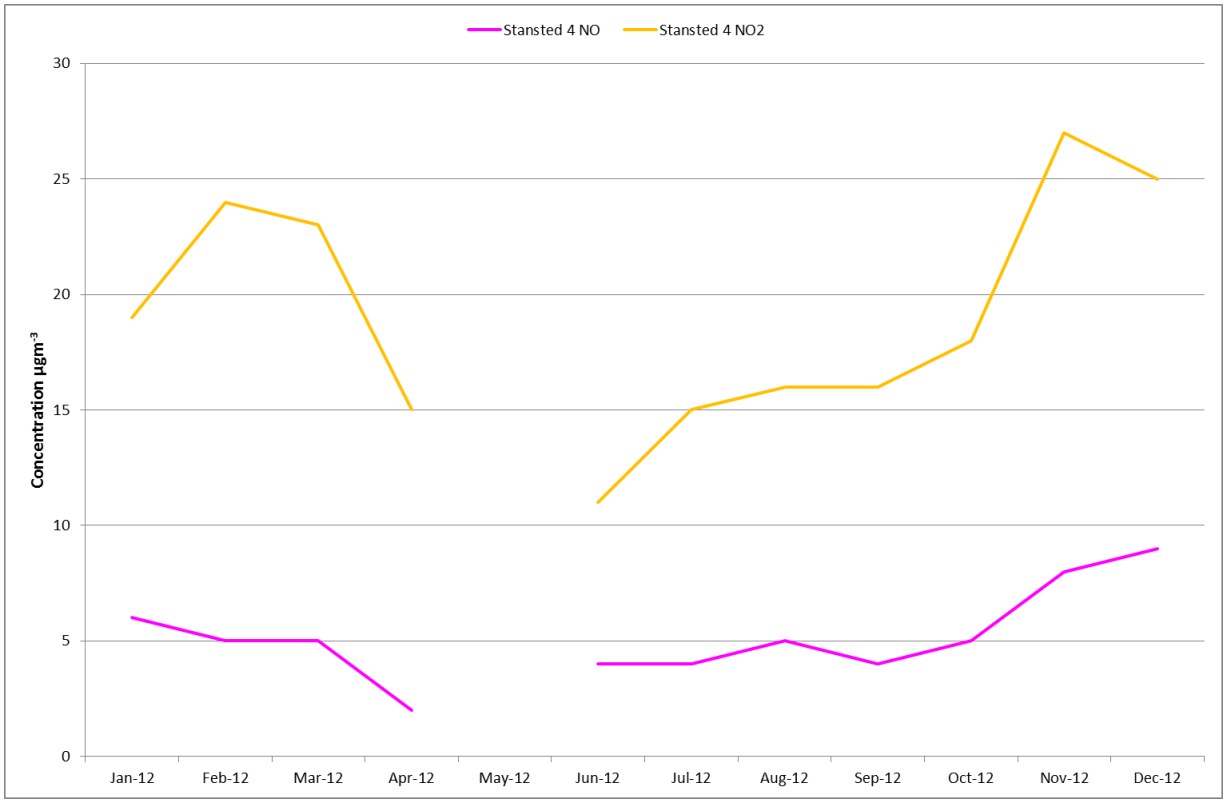
Figure 4-3 and Figure 4-4 show the variation of monthly averaged NO and NO_2 concentrations during 2012 at Stansted 3 and Stansted 4.

Figure 4-3: Seasonal variation of pollutant concentrations at Stansted 3, 2012



There is a notable peak in PM_{10} values during August to September. Similar peaks have occurred in the summers of previous years. There is farmland adjacent to the site, including farm buildings that are understood to include a grain store. Farm activities may therefore be responsible for the observed high PM_{10} values, which coincide with harvesting.

Figure 4-4: Seasonal variation of pollutant concentrations at Stansted 4, 2012



Stansted 4 recorded highest concentrations of NO and NO_2 during the winter months. This pattern also occurred 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 respectively. The PM_{10} data shown here are **TEOM data as measured, rather than VCM-corrected.**

Figure 4-5: Diurnal variation of pollutant concentrations at Stansted 3, 2012 (times in GMT)

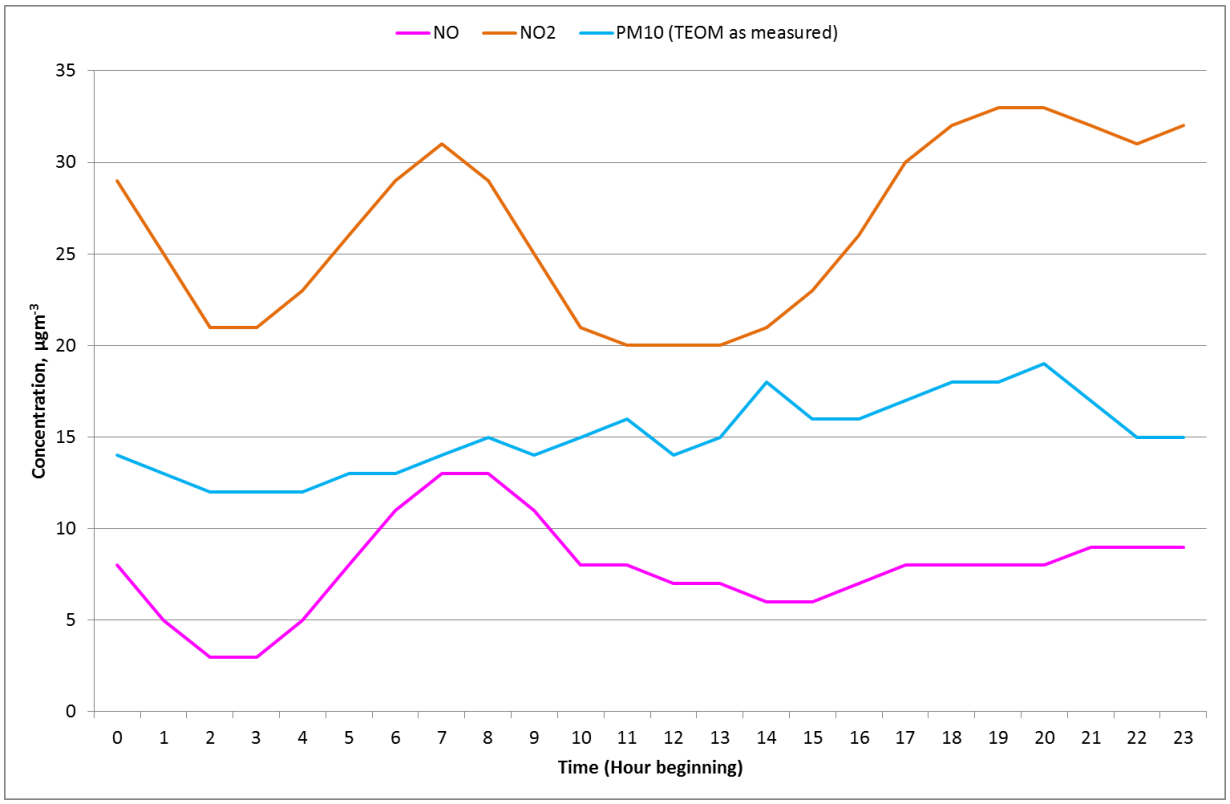
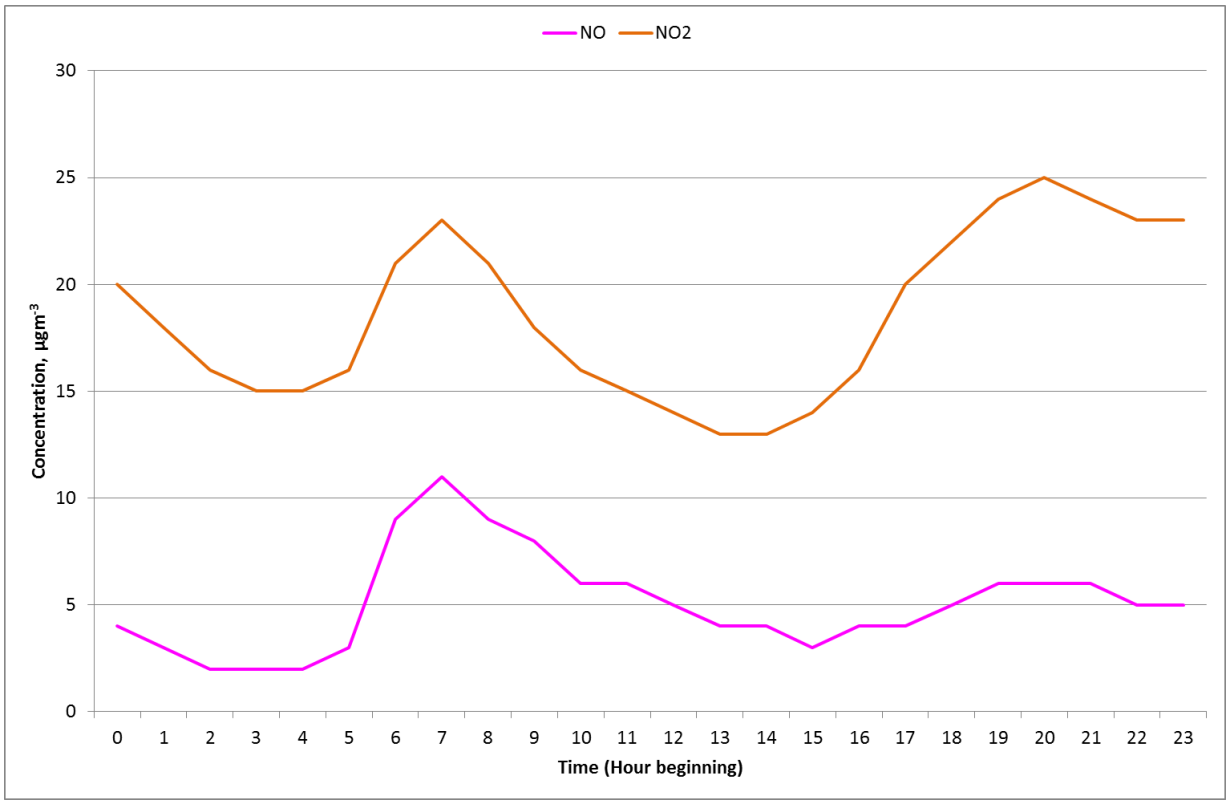


Figure 4-6: Diurnal variation of pollutant concentrations at Stansted 4, 2012 (times in GMT)



Both sites show pronounced peaks for NO and NO_2 during the morning, corresponding to rush hour traffic at around 07:00. 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 higher than the morning peak and it stays high for much of the night. For NO, the afternoon peak is very much smaller, particularly at Stansted 3. This is because concentrations of oxidising agents in the atmosphere (e.g. ozone) tend to increase in the afternoon, leading to enhanced oxidation of NO to NO_2. This is a typical pattern for oxides of nitrogen in urban areas.

Stansted 3 is located in a nursery car park so there is a lot of vehicle activity between 14:00 and 15:00. This is reflected in the NO_2 concentrations, which start to rise at about this time.

For PM_{10} at Stansted 3, the diurnal pattern is less pronounced. Instead of two peaks, there appears to be a steady increase in concentration through the day (this is similar to the pattern observed in 2010). 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 PM_{10}. It is noticeable that there is a small afternoon PM_{10} peak occurring earlier than the NO_2 peak. It is possible that this diurnal PM_{10} profile may be related by the pattern of use of light and heavy-duty vehicles throughout the day.

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. 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. 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 210 ° to 240 °, and the wind was from these directions approximately 38 % 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 2.6 ms^{-1}, and the 75th percentile wind speed was 3.4 ms^{-1}. The maximum measured wind speed was 13.5 ms^{-1}.

Figure 4-7: Wind rose showing the wind speeds and directions in 2012

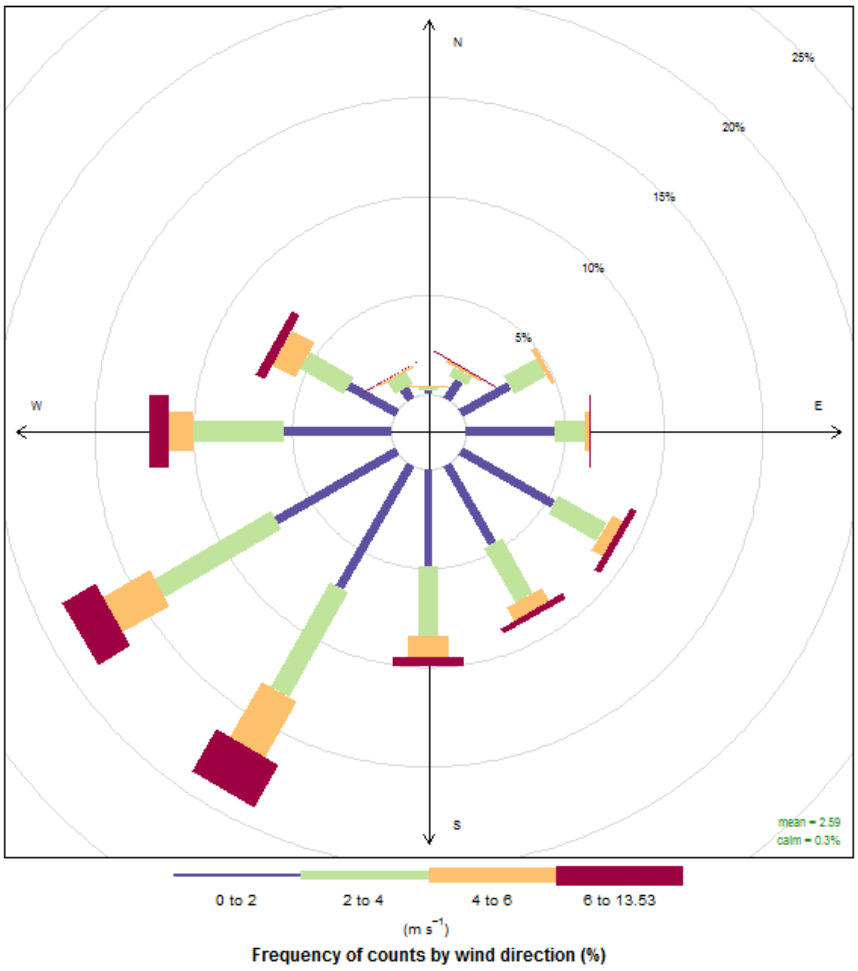
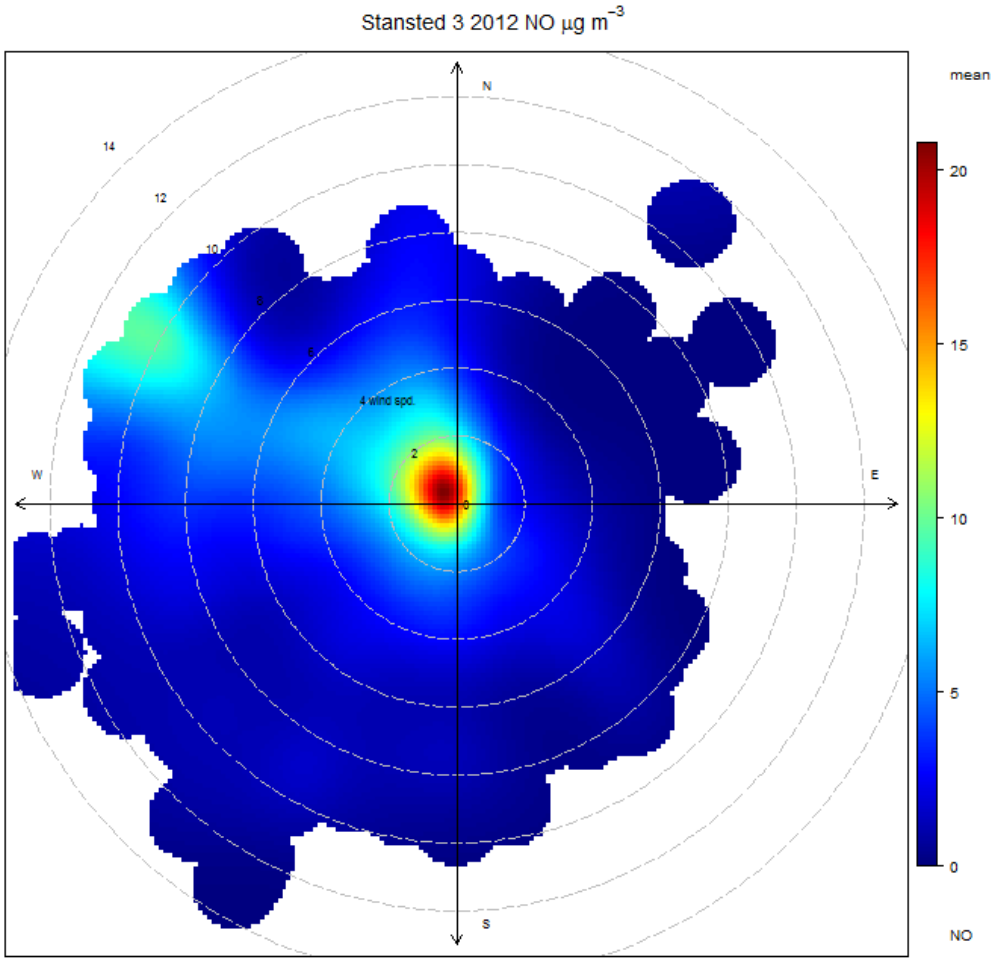


Figure 4-8 shows a bivariate plot of hourly mean NO concentrations against the corresponding wind speed and wind direction. This, and subsequent plots in this section, should be interpreted as follows.

- 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 5 ms^{-1}.
- 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.

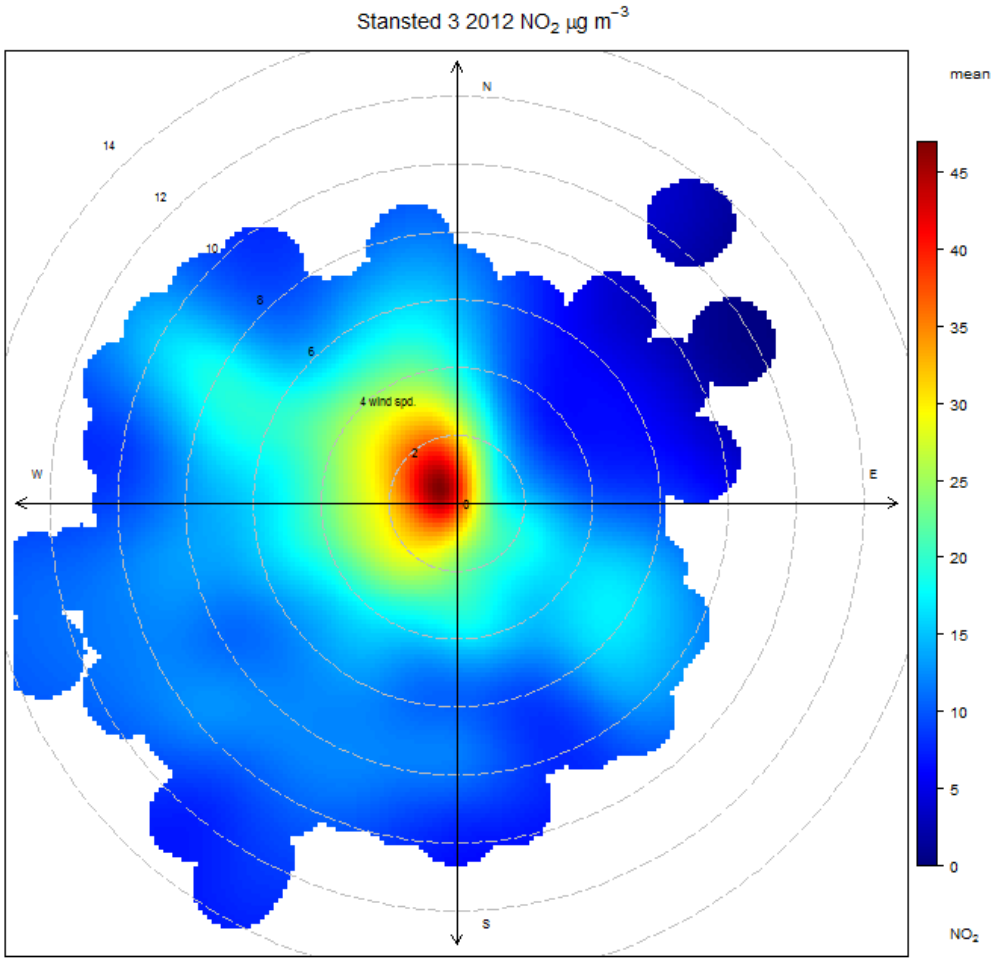
Figure 4-8: Pollution rose for NO at Stansted 3



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.

Figure 4-9 shows a bivariate plot of hourly mean NO_2 concentrations against the corresponding wind speed and wind direction.

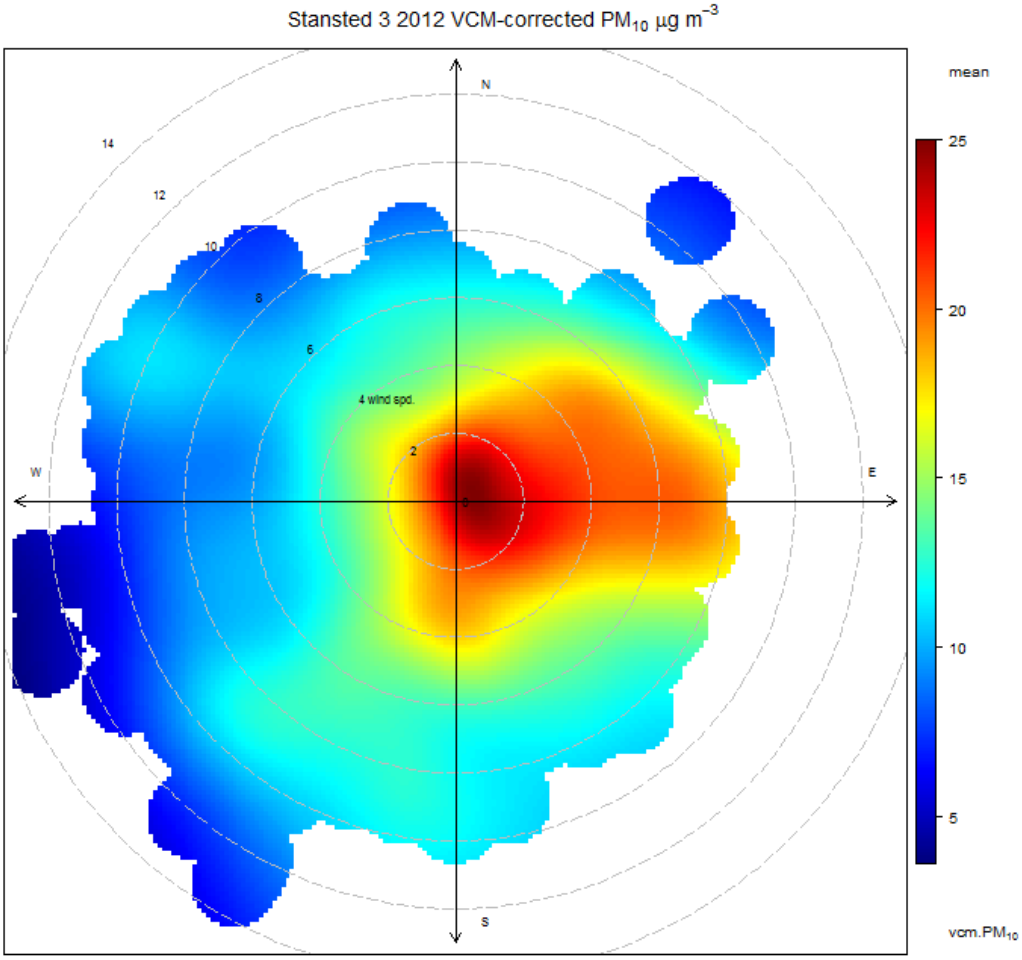
Figure 4-9: Pollution rose for NO_2 at Stansted 3



In 2011, there appeared to be contributions of NO_2 from a source to the south east at high wind speeds (around 8 ms^{-1}). This was believed to be a possible a signature from A120 which lies to the south of the airport. That pattern is repeated in the plot for 2012, although less clearly.

Figure 4-10 shows a similar bivariate plot for PM_{10} at Stansted 3.

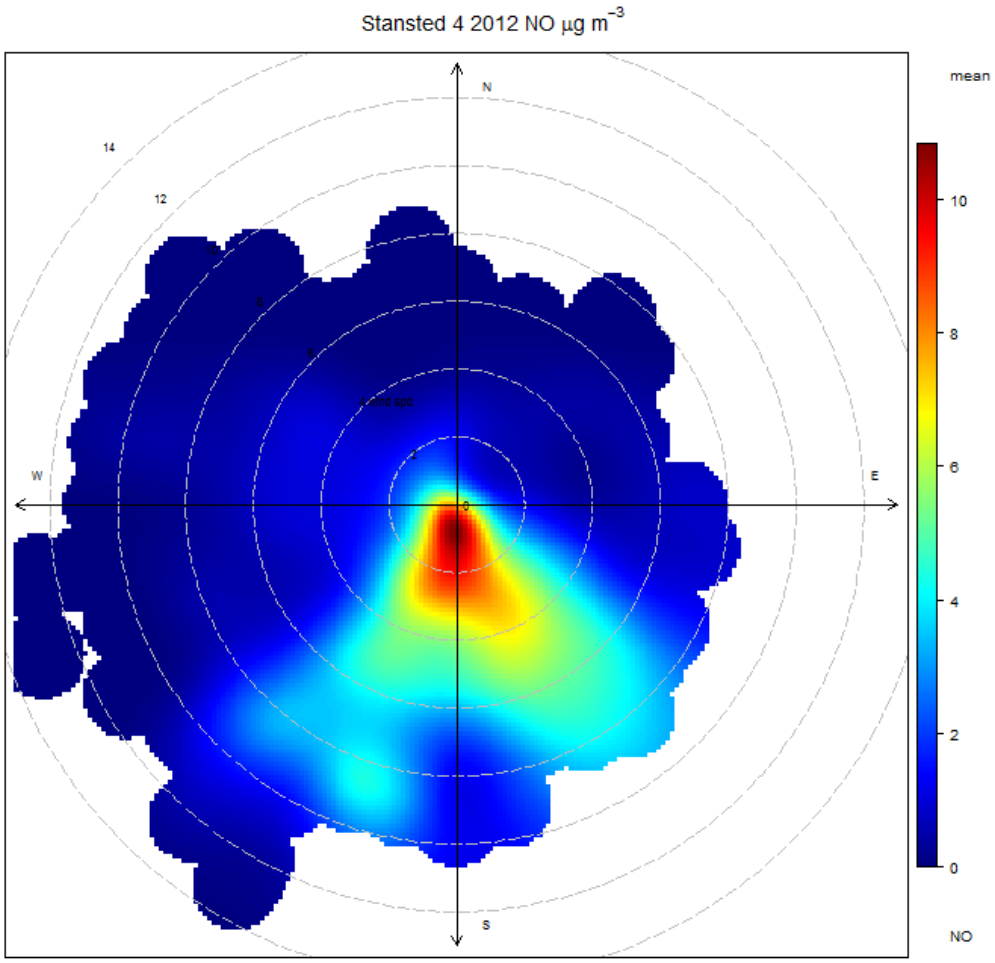
Figure 4-10: Pollution rose for VCM-corrected PM_{10} at Stansted 3



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 90 °. The signature suggests a source to the east of the monitoring site. The nature of this source is unknown, but could be related to agricultural activity.

Figure 4-11 shows the "pollution rose" for NO at Stansted 4.

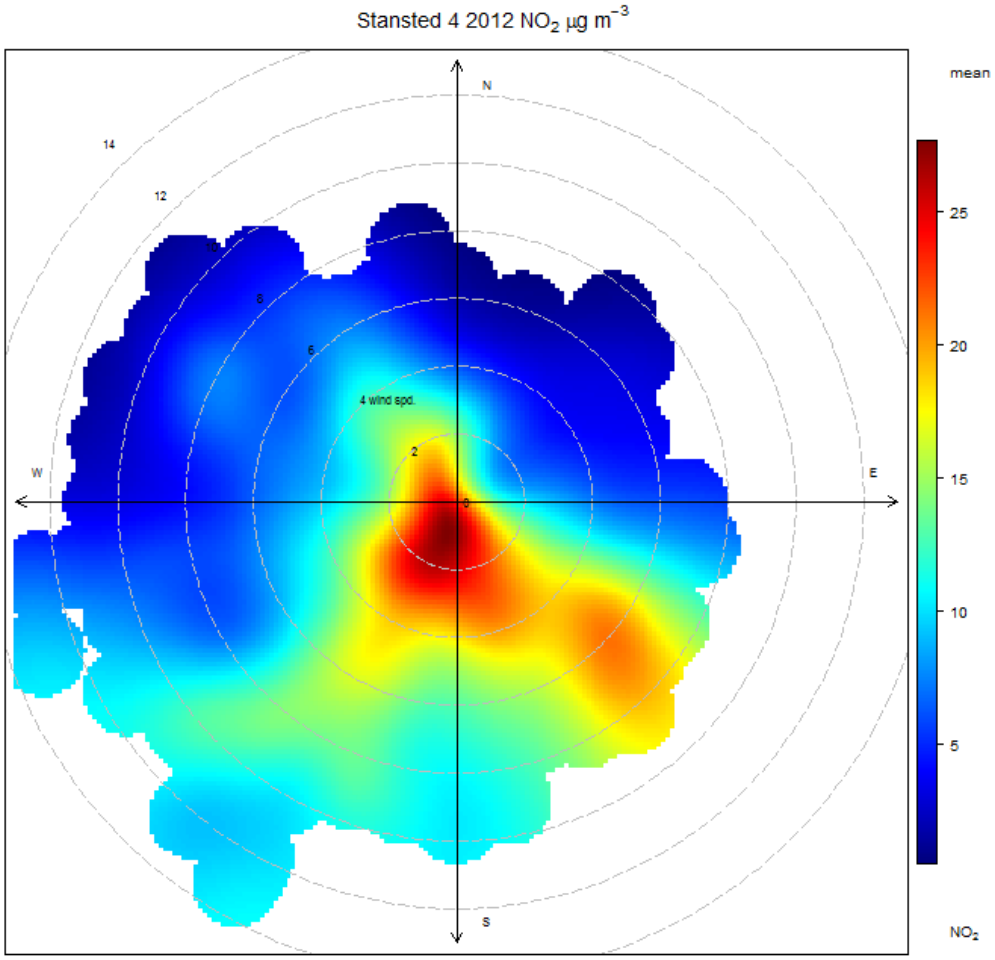
Figure 4-11: Pollution rose for NO at Stansted 4



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 4-12) 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 4-12: Pollution rose for NO_2 at Stansted 4

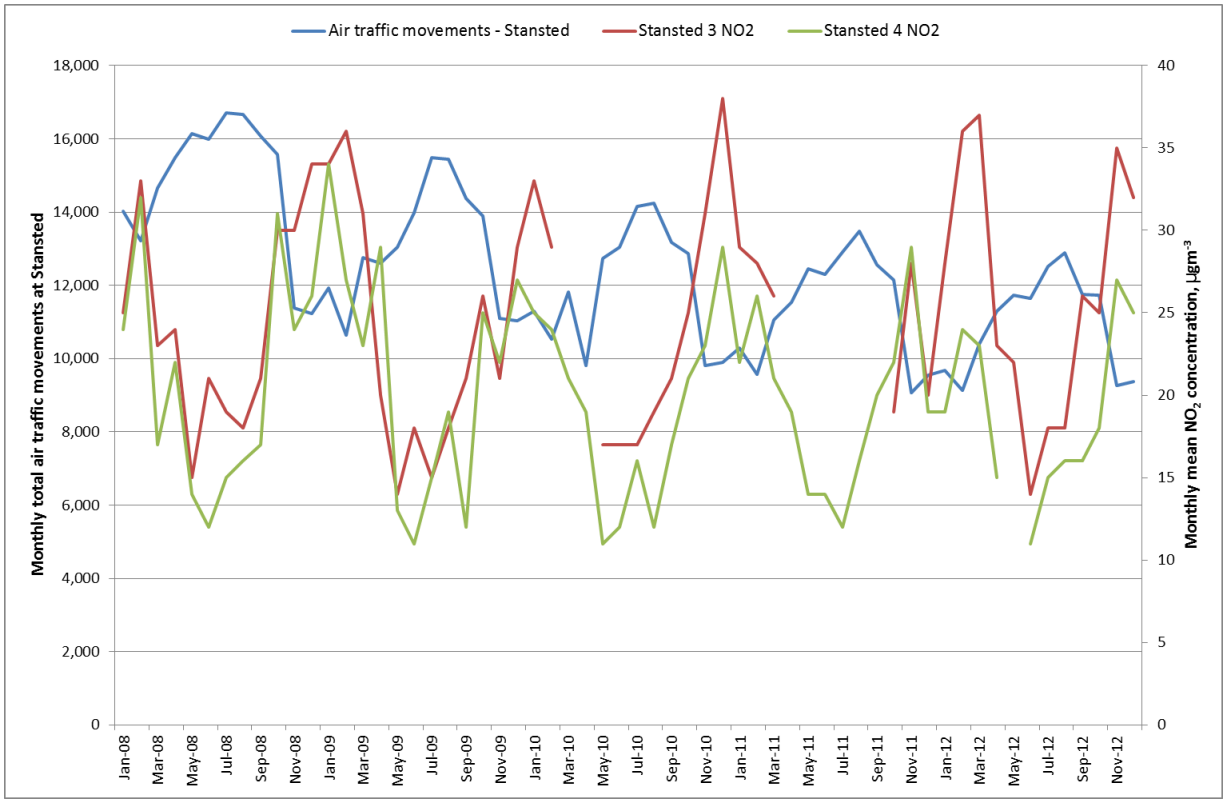


4.6 Relationship with airport activity

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

Figure 4-13 shows monthly statistics for the number of air traffic movements (ATMs) during the years 2005 to 2012. 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.

Figure 4-13: Monthly variation of Stansted airport activity and NO_2 concentration



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. However, 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 are influenced by general meteorological factors rather than 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 of high pollutant concentrations, both sites met the applicable air quality objectives.

4.7.1 Nitrogen dioxide

The highest hourly mean concentrations of NO_2 were 180 µg m^{-3} at Stansted 3 and 101 µg m^{-3} at Stansted 4. Therefore, all concentrations were within the Defra Low band (see Appendix 1) throughout 2012. No hourly means exceeded the AQS objective of 200 µg m^{-3}.

4.7.2 PM_{10}

The daily mean VCM-corrected PM_{10} concentration measured at Stansted 3 exceeded the AQS objective of 50 µg m^{-3} on 8 occasions in 2012. These exceedances occurred on the dates shown in Table 4-3.

Table 4-3: Dates on which daily mean PM_{10} concentrations exceeded 50 µg m^{-3} at Stansted 3

Date	Daily mean
15/03/2012	53.3
23/03/2012	60.2
30/03/2012	55.2
12/08/2012	69.4
13/08/2012	54.1
27/08/2012	115.2
06/09/2012	60.0
24/10/2012	50.8

On these dates, elevated concentrations of particulate matter were also measured at other sites in the area. For example, the Automatic Urban and Rural Network (AURN) sites at Thurrock, Norwich Lakenfields and Stanford-Le-Hope Roadside showed peaks on several of the dates in Table 4-3, with particularly marked high concentrations on 15th March, 23rd March and 24th October. It therefore appears that the elevated concentrations on most of these dates were due to regional particulate "episodes" and not specifically local sources.

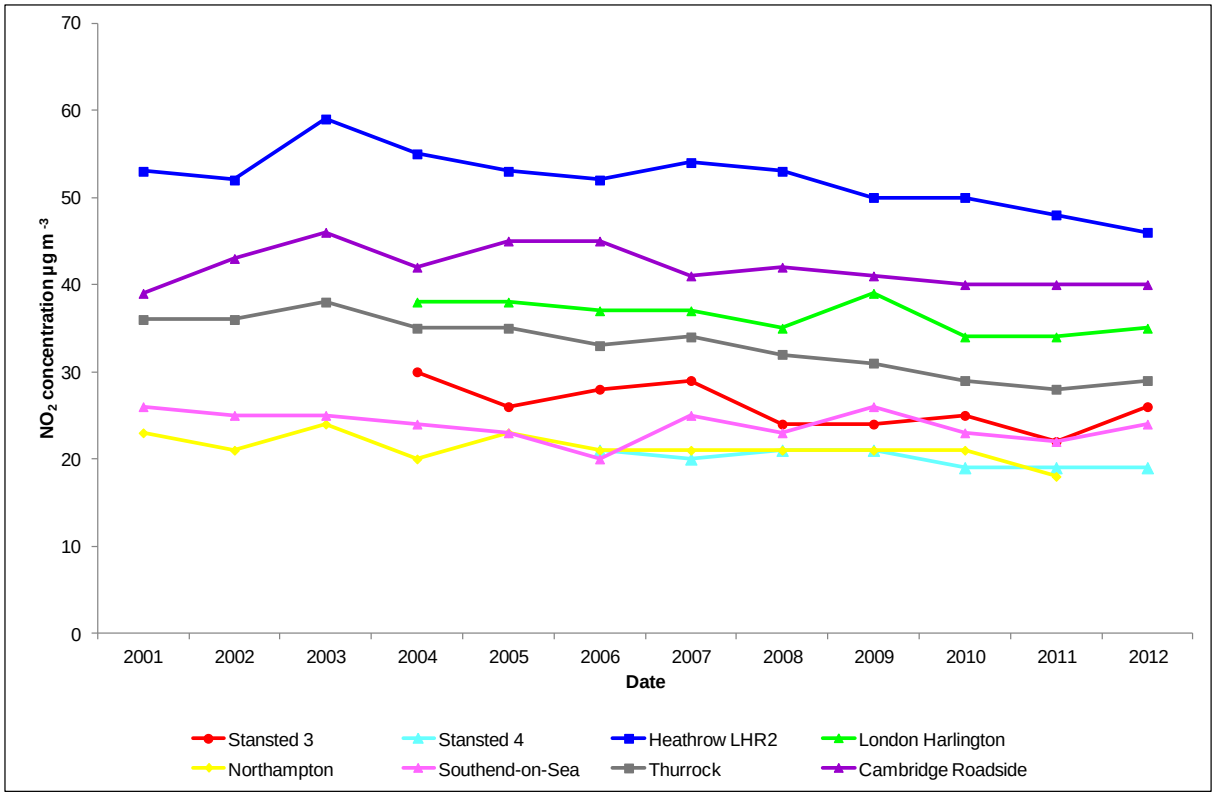
The only peaks in PM_{10} that are not clearly mirrored in data from local AURN sites occurred on 27th August, with high concentrations between 12:00 and 20:00, and second less pronounced, peak on 6th September. It is likely that these were related to local factors, possibly harvesting on the adjacent farm.

4.8 Comparison with other UK sites

Figure 4-14 provides a comparison between annual mean pollutant NO_2 levels at the Stansted sites, and corresponding measurements made at 5 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 45 metres from the nearest major road.
- 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 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 .

Figure 4-14: Annual mean trend NO_2 concentrations at Stansted 3, Stansted 4 and other regional monitoring sites

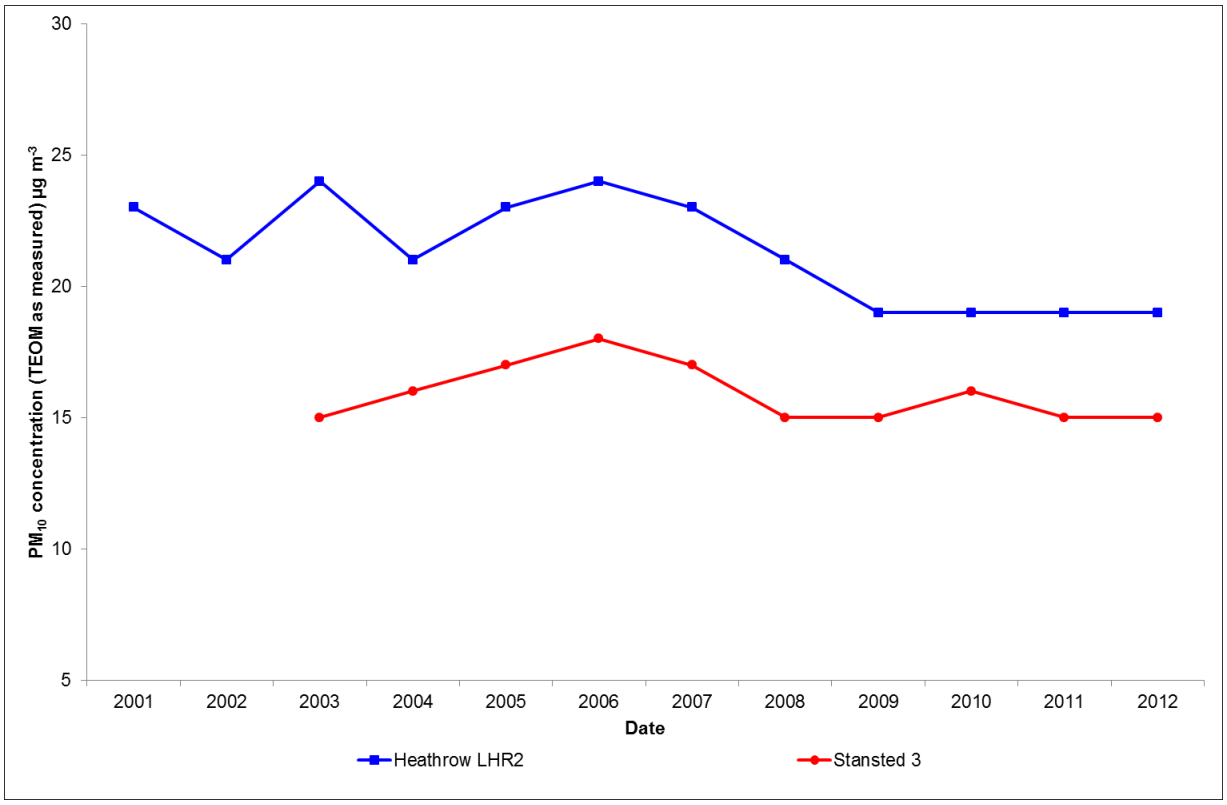


In recent years, annual mean concentrations of NO_2 at the Stansted sites have been similar to the urban background concentrations measured at Southend-on-Sea and Northampton. Both Stansted sites are currently reporting lower concentrations than London Harlington, Heathrow LHR2, Thurrock, and Cambridge 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. However, the annual mean for Stansted 3 has shown an increase during 2012.

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 consistently high annual mean NO_2 concentrations. The 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 4-15 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 2012 report. These are "as measured" data without VCM correction.

Figure 4-15: Annual mean PM_{10} concentrations at Stansted 3 and Heathrow LHR2



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

5 Conclusions

The following conclusions have been drawn from the results of air quality monitoring at Stansted Airport during 2012.

1. The data capture target of least 90 % was achieved for oxides of nitrogen and PM_{10} at Stansted 3 and Stansted 4.

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 3 and Stansted 4, NO and NO_2 concentrations were higher during the winter months. This is a fairly typical pattern for urban sites.

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. 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 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

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

7 References

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7. King's College London Volatile Correction Model available from http://www.volatile-correction-model.info/ . July 2008 (accessed 26th February 2013).

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 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
England and Wales only	5.00 $\mu g\ m^{-3}$	Annual mean	31.12.2010
Scotland and Northern Ireland	3.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
Carbon monoxide England, Wales & Northern Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31.12.2003
Scotland only	10.0 mg m^{-3}	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g\ m^{-3}$ 0.25 $\mu g\ m^{-3}$	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 $\mu g\ m^{-3}$ not to be exceeded more than 18 times a year 40 $\mu g\ m^{-3}$	1-hour mean Annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric) All authorities	50 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year 40 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2004 31.12.2004
Scotland only	50 $\mu g\ m^{-3}$, not to be exceeded more than 7 times a year 18 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2010 31.12.2010
Particles ($PM_{2.5}$) (gravimetric) * All authorities	25 µg m^{-3} (target) 15% cut in urban background exposure	Annual mean Annual mean	2020 2010 - 2020
Scotland only	12 µg m^{-3} (limit)	Annual mean	2010
Sulphur dioxide	350 $\mu g\ m^{-3}$, not to be exceeded more than 24 times a year 125 $\mu g\ m^{-3}$, not to be exceeded more than 3 times a year 266 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year	1-hour mean 24-hour mean 15-minute mean	31.12.2004 31.12.2004 31.12.2005
PAH *	0.25 ng m^{-3}	Annual mean	31.12.2010

Ozone *	100 $\mu g\ m^{-3}$ 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

** Not included in regulations.*

Pollutant	Air quality objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen dioxide *(for protection of vegetation and ecosystems) **	30 $\mu g\ m^{-3}$	Annual mean	31.12.2000
Sulphur dioxide *(for protection of vegetation and 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

[+] 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

The air pollution index and bandings were updated in January 2012. Tables A1.3 and A1.4 below show the new bandings, in use during 2012, the period covered by this report.

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 (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.

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	0–66	0-88	0-11	0-16
	2	34–65	67–133	89-176	12-23	17-33
	3	66–99	134–199	177-265	24-34	34-49
Mod-erate	4	100–120	200-267	266-354	35-41	50-58
	5	121–140	268-334	355-442	42-46	59-66
	6	141–159	335-399	443-531	47-52	67-74
High	7	160–187	400-467	532-708	53-58	75-83
	8	188–213	468-534	709-886	59-64	84-91
	9	214–239	535-599	887-1,063	65-69	92-99
Very High	10	240 or more	600 or more	1,064 or more	70 or more	100 or more

Note: there have since been some small changes to bring the Low-Moderate thresholds fully into line with the AQS Objectives. The above were the thresholds in use during 2012.

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 Ricardo-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.

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.

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 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 (eg 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 NOx has been calculated as follows:

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

This complies 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

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 Ricardo-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 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 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. Ricardo-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 NOx monitor, the efficiency of the NO_2 to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked.

All air pollution measurements are reviewed on a daily basis, at Ricardo-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 check 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 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, 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.

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 – NO_2 diffusion tubes – Full dataset

Results are reported to two decimal places by the analyst. However, given the uncertainty of diffusion tube measurements, they are here rounded to one decimal place and quoted 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 3 (east of High House) (µg m^{-3})

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2012	33.1	29.2	31.3	31.2	
01/02/2012	31.4	32.4	33.9	32.6	
29/02/2012	28.5	27.6	29.2	28.4	
28/03/2012	23.2	21.5	19.2	21.3	
25/04/2012	19.0	18.7	20.1	19.3	
30/05/2012	13.0	13.3	13.3	13.2	
27/06/2012	no data	no data	no data	no data	Faulty tubes
01/08/2012	19.3	19.5	20.5	19.8	
29/08/2012	24.0	26.1	23.8	24.6	
26/09/2012	19.5	20.6	23.2	21.1	
31/10/2012	28.1	28.8	22.4	26.4	
28/11/2012	23.0	28.4	25.4	25.6	

Table A4-2: Monthly mean NO_2 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
04/01/2012	23.5	28.3	24.7	25.5	
01/02/2012	25.4	30.0	27.1	27.5	
29/02/2012	24.7	23.9	24.8	24.5	
28/03/2012	13.2	16.9	15.1	15.0	
25/04/2012	12.3	12.9	11.4	12.2	
30/05/2012	13.4	12.8	12.4	12.9	
27/06/2012	no data	no data	no data	no data	Faulty tubes
01/08/2012	24.5	22.7	21.1	22.8	
29/08/2012	19.0	22.7	19.4	20.4	
26/09/2012	23.2	19.1	22.6	21.6	
31/10/2012	27.9	25.6	33.8	29.1	
28/11/2012	27.2	21.8	17.2	22.1	

Table A4-3: Monthly mean NO_2 concentrations as measured by diffusion tubes, Stansted East (Enterprise House offices) (µg m^{-3})

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
04/01/2012	40.5	41.3	37.9	39.9	
01/02/2012	38.7	42.4	42.0	41.0	
29/02/2012	32.4	32.0	35.6	33.3	
28/03/2012	24.5	23.2	25.9	24.6	
25/04/2012	20.8	21.2	23.2	21.7	
30/05/2012	22.4	22.4	20.0	21.6	
27/06/2012	no data	no data	no data	no data	Faulty tubes
01/08/2012	28.9	28.5	29.8	29.1	
29/08/2012	32.0	30.9	28.7	30.5	
26/09/2012	23.3	29.0	28.6	26.9	
31/10/2012	34.5	34.5	36.8	35.3	
28/11/2012	35.8	25.4	23.7	28.3	

Table A4-4: Monthly mean NO_2 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
04/01/2012	37.1	37.7	41.1	38.6	
01/02/2012	37.1	40.0	41.8	39.6	
29/02/2012	32.4	32.0	35.6	33.3	
28/03/2012	23.0	27.4	24.6	25.0	
25/04/2012	24.8	24.5	24.2	24.5	
30/05/2012	16.2	16.4	15.9	16.2	
27/06/2012	no data	no data	no data	no data	Faulty tubes
01/08/2012	18.6	19.4	20.5	19.5	
29/08/2012	26.3	27.1	25.8	26.4	
26/09/2012	25.6	24.3	24.6	24.8	
31/10/2012	29.0	31.2	30.9	30.4	
28/11/2012	27.7	26.5	21.4	25.2	

Table A4-5: Monthly mean NO_2 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
04/01/2012	25.0	22.8	24.6	24.2	
01/02/2012	22.4	23.5	23.6	23.2	
29/02/2012	21.5	24.2	21.1	22.2	
28/03/2012	14.6	15.2	16.6	15.5	
25/04/2012	12.8	13.4	11.9	12.7	
30/05/2012	13.7	13.2	12.4	13.1	
27/06/2012	no data	no data	no data	no data	Faulty tubes
01/08/2012	18.7	19.2	20.4	19.5	
29/08/2012	13.9	15.6	17.3	15.6	
26/09/2012	20.5	19.1	17.8	19.1	
31/10/2012	24.5	22.0	25.4	24.0	
28/11/2012	22.5	20.9	18.1	20.5	

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