Air Pollution at Stansted Airport: Annual Report for 2010

Report for Stansted Airport Ltd

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Executive summary

This report presents a summary and analysis of the results of an air quality monitoring programme, carried out around Stansted airport, during 2010. The monitoring was carried out by AEA (part of the AEA Group) on behalf of Stansted Airport Ltd.

The aim of the programme is to monitor air pollution at the airport, to provide a reliable assessment in relation to applicable air quality limit values and objectives, and to determine trends in air pollution concentrations over time.

Automatic monitoring of oxides of nitrogen (nitric oxide and nitrogen dioxide) and PM_{10} particulate matter were carried out at the Stansted 3 site (High House, to the south of the airport). Monitoring of oxides of nitrogen was also undertaken at Stansted 4 (north of the runway). Automatic monitoring was supplemented by indicative monitoring of NO_2 and a suite of hydrocarbons (benzene, toluene, ethylbenzene and xylenes) using diffusion tubes. These were deployed at five sites to the north, south, east and west of the airport, and at Stansted 3.

The EC Directive data capture target of at least 90% was achieved for NO_2 at both sites: for PM_{10} at Stansted 3 it was missed by a very small margin (less than 1%).

The UK Air Quality Strategy (AQS) objectives for daily mean and annual mean PM_{10} concentration were achieved at Stansted 3. The AQS Objectives for annual mean and hourly mean NO_2 concentration were achieved at Stansted 3 and Stansted 4. Neither site recorded any instances where the hourly mean NO_2 concentration exceeded 200 $\mu g\ m^{-3}$.

The NO_2 diffusion tube data indicated that all of the diffusion tube sites met the Air Quality Strategy objective of 40 $\mu g\ m^{-3}$ for annual mean NO_2 concentration. The annual mean benzene concentrations measured by diffusion tubes were all well within the Air Quality Strategy objective for this pollutant.

An investigation was undertaken into the source of pollutants by plotting hourly pollutant concentrations against the corresponding wind speed and wind direction. These indicated that NO_2 concentrations measured at Stansted 4 originated mainly from the airport (i.e. highest concentrations were measured when the monitoring station site was downwind of the airport). At Stansted 3 the sources of NO_2 appeared to be more mixed.

Some brief periods of very high PM_{10} concentration were recorded at Stansted 3. These were not associated with any specific wind direction, and there was no evidence that they were the result of emissions at the airport. They were associated with raised NO_2 concentrations, suggesting a combustion source. All occurred during daytime. It is possible that localised activity was responsible.

Average concentrations of NO_2 and PM_{10} at Stansted have decreased in recent years. NO_2 concentrations are generally comparable to those measured at urban background air pollution monitoring sites in the south east, and lower than those measured at London Heathrow, Birmingham and London Gatwick airports. Average concentrations of PM_{10}, however, were higher than urban background sites and comparable to concentrations recorded at Heathrow, Birmingham and London Gatwick.

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Appendices

1 Introduction

AEA (part of the AEA Group) is undertaking air pollution measurements at Stansted Airport on behalf of Stansted Airport Ltd. This report presents a summary and analysis of the data for 2010.

The aim of the programme is to monitor air pollution at the airport, to provide a reliable assessment in relation to current and proposed air quality standards and guidelines, and to determine any trends in air pollution concentrations over time. It should be noted that the pollutants measured in this study will have originated from a variety of sources, both local and long range i.e. not all of these sources will be directly connected with the airport.

This report presents and summarises the fully validated and quality controlled dataset for the period 1st January to 31st December 2010. The pollutants monitored were as follows:

- oxides of nitrogen (nitric oxide NO and nitrogen dioxide NO_2)
- particulate matter (PM_{10})
- selected volatile organic compounds (VOCs) – benzene, toluene, ethylbenzene and xylenes.

This monitoring was carried out using automatic monitoring techniques at two locations, supplemented by indicative monitoring of NO_2 and hydrocarbons using diffusion tubes at five locations. The locations used for automatic monitoring were the sites Stansted 3 (High House) and Stansted 4 (Runway).

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

- relevant UK air quality guidelines and standards, including the UK Government's Air Quality Strategy Objectives set out in the UK Air Quality Strategy and Addendum[1];
- corresponding results from a selection of national air pollution monitoring sites;
- statistics related to airport activity.

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

The Air Quality Strategy adopts standards published in the EC Directive on Ambient Air Quality and Cleaner Air for Europe[2] (2008/50/EC) and its predecessors, and/or previously recommended by the Expert Panel on Air Quality Standards (EPAQS)[3-7]. These standards have been adopted into UK law in the Air Quality Regulations 2000[8] and the Air Quality (Amendment) Regulations 2002[9]. The UK Air Quality Strategy Objectives are at least as stringent as the corresponding EC Limit Values. The currently applicable Air Quality Objectives are summarized in Appendix 1.

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 to the 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.

This report presents and analyses the data for 2010, the fifth full year of continuous monitoring. Data in this annual report have been fully subjected to the rigorous quality assurance and quality control procedures adopted by AEA, to ensure data of the highest quality, accuracy and traceability to UK national measurement standards.

In addition to this report, Stansted Airport has access to provisional data from both Stansted monitoring sites, and to National Monitoring Network sites operated by AEA on behalf of the Department for Environment, Food and Rural Affairs (Defra), via the National Air Quality Archive (www.airquality.co.uk).

2 Pollutants Monitored and Monitoring Locations

2.1 Pollutants Monitored

The monitoring programme concentrates on the pollutants which may be of concern in and around airports. These were identified by considering those pollutants listed in the UK Air Quality Strategy, which have significant health effects reported by EPAQS; and those pollutants, which have significant emissions sources at Stansted Airport. The pollutants monitored are described below.

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 . Major outdoor sources of NO_x in urban areas are fuel combustion in motor vehicles, power generation, heating plant and industrial processes. Based on 2006 National Atmospheric Emission Inventory (NAEI) data, in the UK, civil aircraft are estimated to contribute only approximately 0.55% of total UK emissions[10] of NO_x. However, such emission inventories only consider emissions up to a height of 1000m. There will be emissions from aircraft above this height, but under most weather conditions they are unlikely to affect ground level concentrations. At airports (and in their immediate surroundings) the contribution from aircraft and other airport-related sources is likely to be much more significant.

(i) NO

NO is described as a primary pollutant, being directly emitted from a range of mobile and stationary sources. 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

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.

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[10].

2.1.3 Hydrocarbons

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

A wide range of hydrocarbons is emitted from both fuel storage and handling, and from fuel combustion in vehicles. It is not easy to measure all of these hydrocarbon species (particularly the most volatile) without expensive continuous monitoring systems. However, there are four moderately volatile species, all of which may be associated with fuels and vehicle emissions, which are easy to monitor using passive samplers. These are benzene, toluene, ethyl benzene and xylene. They are not the largest constituents of petrol emissions, but due to their moderate volatility they can be monitored using simple diffusive samplers. Diffusion tubes are available for monitoring this group of organic compounds, and are known as “BTEX” tubes.

(i) Benzene

Of the organic compounds measured in this study, benzene is the one of most concern, as it is a known human carcinogen; long-term exposure can cause leukaemia. Benzene is well known as one of the harmful compounds found in cigarette smoke, but it is also found in petrol and other liquid fuels, in small concentrations. In urban areas, the major source of benzene in ambient air is vehicle emissions.

(ii) Toluene

Toluene is also found in petrol in small concentrations. Its primary use is as a solvent in paints and inks; it is also a constituent of tobacco smoke. It has been found to adversely affect human health. Typical ambient concentrations range from trace to 3.8 µg m^{-3} in rural areas, up to 204 µg m^{-3} in urban areas, and higher near industrial sources. There are no recommended limits for ambient toluene concentrations, although there are occupational limits for workplace exposure.

(iii) Ethyl benzene

Again, there are no limits for ambient concentration of ethyl benzene, and although there are occupational limits relating to workplace exposure, they are several orders of magnitude higher than typical outdoor ambient concentrations.

(iv) Xylene

Xylene exists in ortho (o), para (p) and meta (m) isomers. There are no limits for ambient concentration of xylenes, although (as in the case of toluene and ethyl benzene) there are occupational limits relating to workplace exposure. Xylene, like toluene, can cause odour nuisance near processes (such as vehicle paint spraying), which emit it.

2.2 Air Quality Limit Values and Objectives

This report compares the results of the monitoring survey with air quality Limit Values and Objectives applicable in the UK. These are summarized in Appendix 1 and below.

2.2.1 European Community

Throughout Europe, ambient air quality is regulated by the EC Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC)[2]. This Directive sets Limit Values, which are mandatory, and other requirements for the protection of human health and ecosystems. NO_2, PM_{10} and benzene are covered by this Directive.

The Air Quality Directive contains Limit Values for NO_2 as follows:

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

The Limit Values for PM_{10} are as follows:

- 50 µg m^{-3} as a 24 hour mean, not to be exceeded more than 35 times per calendar year. To have been achieved by 1st January 2010.
- 40 µg m^{-3} as an annual mean, for protection of human health. To have been achieved by 1st January 2010.

The Air Quality Directive also sets a limit of 5 µg m^{-3} for annual mean benzene, to be achieved by 2010.

2.2.2 UK Air Quality Strategy

The UK Air Quality Strategy (AQS) contains standards and objectives for a range of pollutants including NO_2 , PM_{10} and benzene[1]. These are also summarised in Appendix 1. These are very similar to the EC Directive limits above: the only difference in most cases being the more stringent deadline by which they had to be achieved: 31st December 2005.

The UK Air Quality Strategy[1] sets the following objectives for benzene:

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

2.3 Location of the Monitoring Sites

Two automatic monitoring sites, referred to as Stansted 3 and Stansted 4, were operational during 2010. 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)[11]), *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 and BTEX hydrocarbons 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 2.1Table 2.1 describes the montoring locations and the map in Figure 2.1 shows 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, PM_{10} Diffusion tube monitoring of NO_2 and BTEX hydrocarbons, 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 and BTEX hydrocarbons, monthly	TL 555 248
Stansted East	Enterprise House offices	Diffusion tube monitoring of NO_2 and BTEX hydrocarbons, monthly	TL 555 234
Stansted South	Balancing Pond south of site	Diffusion tube monitoring of NO_2 and BTEX hydrocarbons, monthly	TL 522 215
Stansted West	Radar tower, Burton End	Diffusion tube monitoring of NO_2 and BTEX hydrocarbons, monthly	TL 536 235

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.

The second 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 also shown on the map in Figure 2.1, and a photo is provided in Figure 2.3.

Figure 2.1 Location of Monitoring Sites

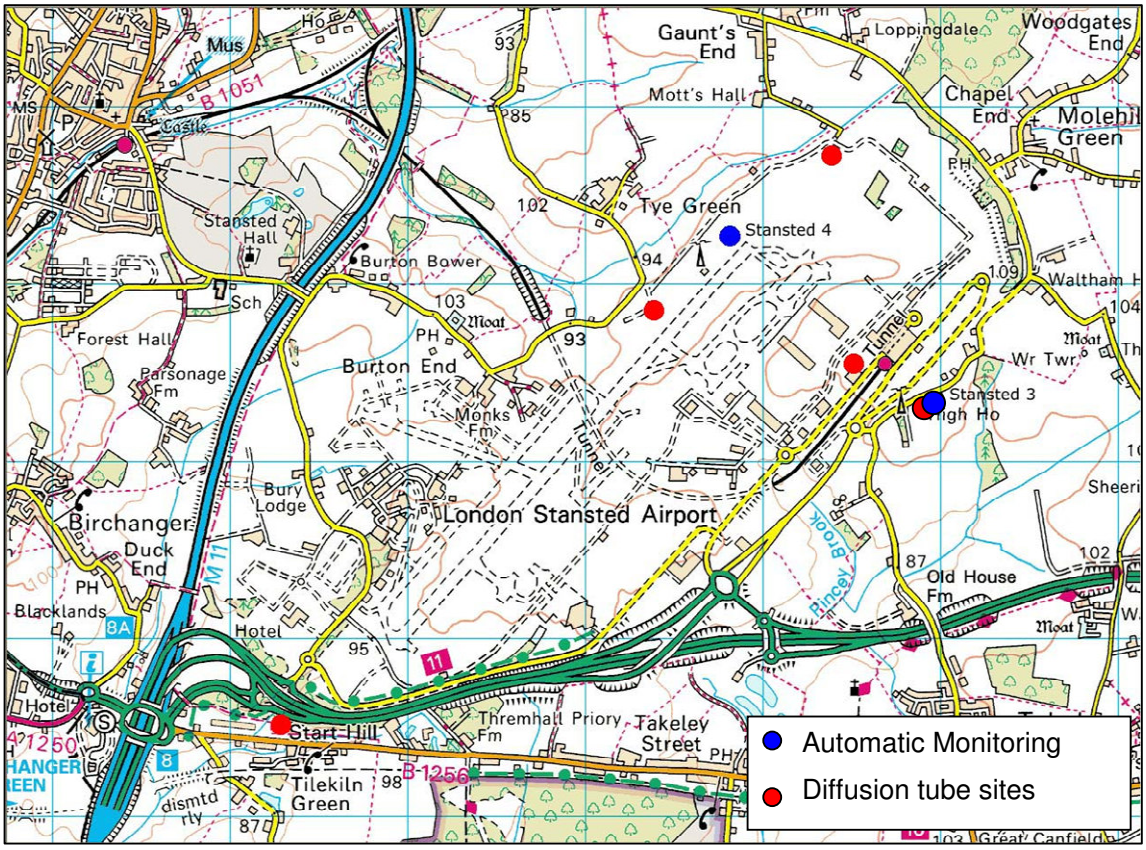


Figure 2.2 Stansted 3 Air Quality Monitoring Site at High House

Figure 2.3 Stansted 4 Air Quality Monitoring Site

Continuous automatic analysers for monitoring NOx and PM_{10} were selected, in order to provide real-time data. The analysers use the operating principles listed below: further information is provided in Appendix 2.

- PM_{10} tapered element oscillating microbalance (TEOM)
- NO, NO_2 chemiluminescence with ozone

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 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.

The TEOM monitoring method uses a 50°C heated sample inlet in order to prevent condensation on the filter. Studies have shown that this elevated temperature results in the loss of volatile and semi-volatile components of PM_{10}. Secondary particles such as ammonium nitrate, for example, are known to evaporate below 50°C. This can cause the TEOM to under-estimate the PM_{10} concentration.

In earlier years of this ongoing survey, the advice of Defra and the Devolved Administrations was that, where the particulate concentration was not close to the AQS Objective, it was acceptable to use TEOM data multiplied by a "correction factor" of 1.3, as an indicative measurement. This was the approach taken in reports for years up to and including 2008, as PM_{10} concentrations at Stansted 3 were well within the AQS Objective. However, the conclusion of equivalence trials published by Bureau Veritas in 2006[12] was that the TEOM did not meet the criteria for equivalence to the European gravimetric method, and equivalence could not be achieved by application of a simple correction factor.

King's College London (KCL) have since developed a Volatile Correction Model[13], 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 particulate analysers of the FDMS TEOM type, which measure the volatile component of the PM_{10}. This volatile component (which typically does not vary much over a large region), can be used to correct the TEOM measurement. KCL state on the VCM website home page that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

Correction using the VCM model is now the preferred method of correctingTEOM data to datasets to air quality limit values and objectives, and this approach has been used 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 relationship between pollutant concentrations and wind direction, the VCM has not been applied and this too is clearly indicated.

2.4 Diffusive Samplers

Diffusion tubes were used for monitoring of NO_2 and BTEX. 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.

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

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.

The diffusion tube methodologies provide data that are accurate to ± 25% for NO_2 and ±20% for BTEX. The limits of detection vary from month to month, but are typically 0.4 µg m^{-3} for NO_2 and 0.2 µg m^{-3} for BTEX. It should be noted that tube results that are less than 10 x the limit of detection will have a higher level of uncertainty associated with them.

NO_2 and BTEX diffusion tube monitoring was carried out throughout the year. 2010 was the third full year of BTEX diffusion tube monitoring at Stansted.

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 our 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	*

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

The Local Air Quality Management Technical Guidance LAQM.TG(09)[11] 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. These co-located measurements have been used to calculate a bias adjustment factor (the ratio of the annual mean automatic measurement to the annual mean diffusion tube measurement), which can then be used to adjust diffusion tube measurements for bias. Where the bias adjustment factor has been applied, this is indicated. The NO_2 diffusion tube results in this report are unadjusted except where clearly specified. A bias adjustment factor is only applied to the annual mean.

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)[11].

Table 3.2 Data Capture Statistics 2010

Site	NO_x	NO_2	PM_{10}
Stansted 3	91.6 %	91.6 %	89.8 %
Stansted 4	99.5 %	99.5 %	-

The 90% data capture target was therefore achieved for NO_2 at both automatic monitoring sites. Data capture for PM_{10} at Stansted 3 was marginally below the target.

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

Table 3.3 Significant Data Gaps 2010

Site	Pollutant	Start date	End date	No. of days	Reason	Comments
Stansted 3	NO_2	19-Feb-10	24-Feb-10	5.4	Power cut	Power failure.
Stansted 3	NO_2	23-Mar-10	07-Apr-10	15.2	Power cut	Power failure.
Stansted 3	NO_2	29-Apr-10	05-May-10	5.4	Power cut	Power failure.
Stansted 3	NO_2	12-Aug-10	13-Aug-10	1.2	Routine service	-
Stansted 3	NO_2	30-Dec-10	06-Jan-11	7	Routine service followed by replacement of TEOM flow sensor	-
Stansted 3	PM_{10}	19-Feb-10	24-Feb-10	5.7	Power cut followed by unstable data.	-
Stansted 3	PM_{10}	23-Mar-10	07-Apr-10	14.8	Power cut followed by unstable data.	-
Stansted 3	PM_{10}	29-Apr-10	05-May-10	5.5	Power cut followed by unstable data.	-
Stansted 3	PM_{10}	09-Dec-10	16-Dec-10	7	Instrument fault	Required engineer callout
Stansted 3	PM_{10}	30-Dec-10	31-Dec-10	1.4	Power cut	Power supply to the site was cut.
Stansted 4	NO_2	12-Aug-10	13-Aug-10	1.1	Routine service	-

The main cause of lost data during 2010 was interruptions to the power supply at Stansted 3. On three occasions the power cut resulted in a period of unstable operation and poor quality data which was considered unreliable and therefore rejected.

4 Results and Discussion

4.1 Presentation of the Results

The summary statistics for 2010 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}. Conversion factors to other common units for air pollution concentrations parts per million (ppm) and parts per billion (ppb) are given in Appendix 1.

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[13] where appropriate, or otherwise to "indicative gravimetric equivalent" by application of a correction factor. 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 2010

Stansted 3	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_X (µg m^{-3})	PM_{10}* (µg m^{-3})	PM_{10} VCM corrected (µg m^{-3})
Maximum 15-minute mean	348	189	720	2481	-
Maximum hourly mean	310	124	590	826	816
Maximum running 8-hour mean	223	103	429	194	189
Maximum running 24-hour mean	138	75	287	77	77
Maximum daily mean	110	70	233	75	75
Average	9	25	38	16	21
Data capture	91.6 %	91.6 %	91.6 %	89.8 %	89.8%
Stansted 4	**NO (µg m^{-3})**	**NO_2 (µg m^{-3})**	**NO_X (µg m^{-3})**	**PM_{10}* (µg m^{-3})**	**PM_{10} VCM corrected (µg m^{-3})**
Maximum 15-minute mean	310	113	581		
Maximum hourly mean	253	99	481		
Maximum running 8-hour mean	208	85	402		
Maximum running 24-hour mean	135	74	278		
Maximum daily mean	115	70	246		
Average	5	19	27		
Data capture	99.5 %	99.5 %	99.5 %		

*PM_{10} as measured.

Figure 4.1 Time Series of Hourly Averaged Concentrations at Stansted 3 – 2010

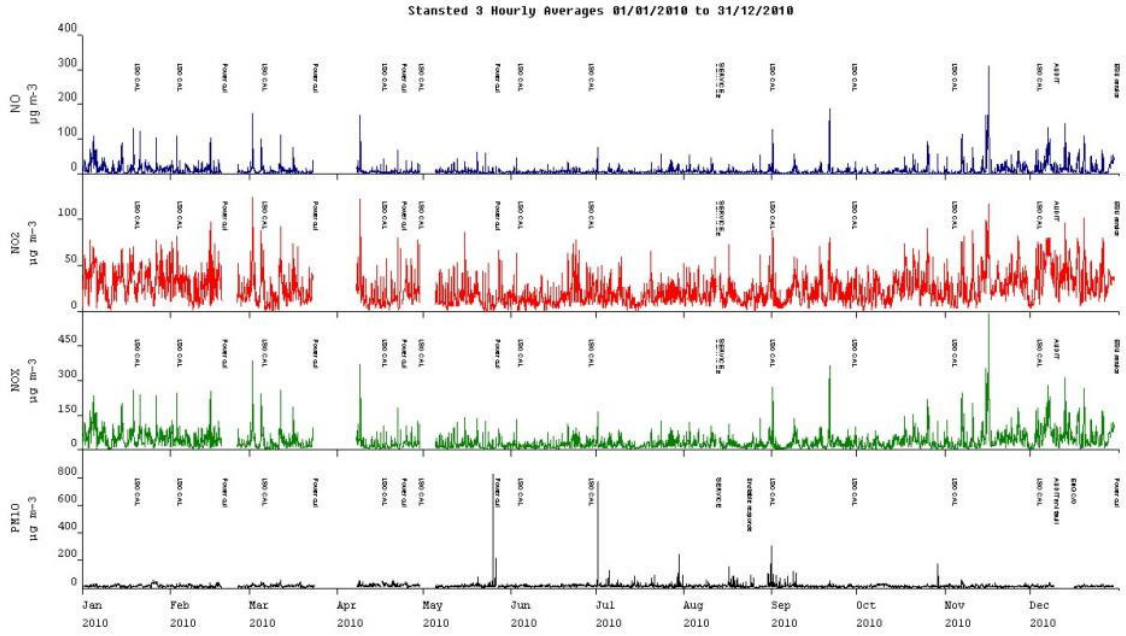


Figure 4.2 Time Series of Hourly Averaged Concentrations at Stansted 4 – 2010

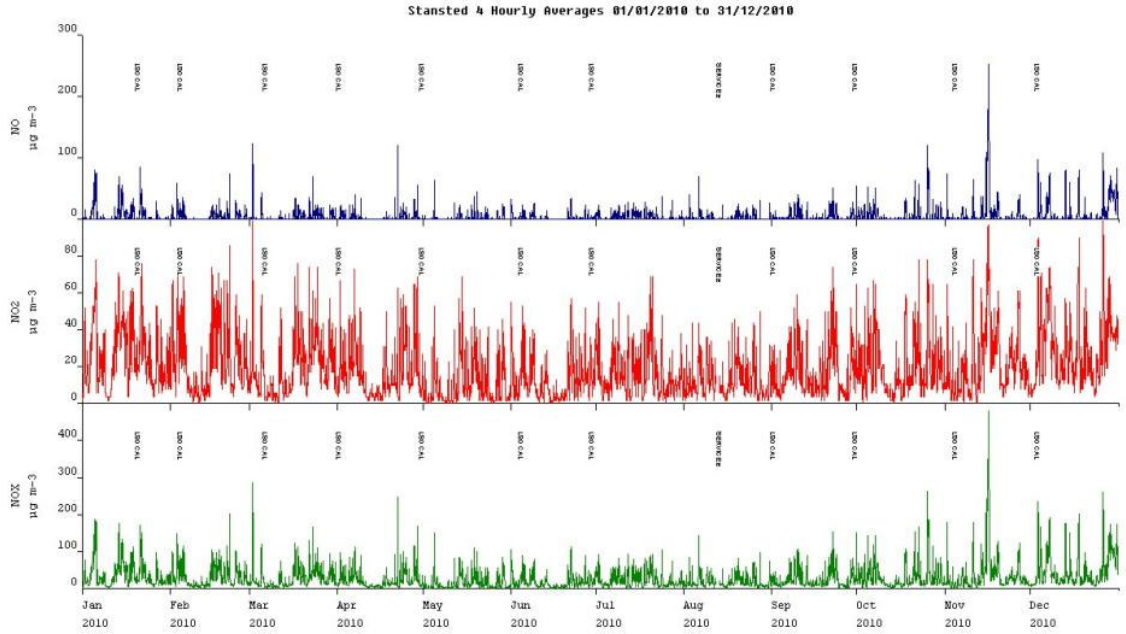


Table 4.2 shows the NO_2 diffusion tube results for 2010. Full data capture was achieved at all the diffusion tube sites. Tubes are exposed in triplicate at all sites. The results shown are the mean of these replicate measurements. The full dataset is shown in Appendix 4.

Table 4.2 NO_2 Diffusion Tube Results 2010, µg m^{-3}

Start date	Stansted North	Stansted East	Stansted South	Stansted West	Stansted 3	Stansted 3 (automatic)
19/01/2010	29	43	44	29	39	34
03/02/2010	21	34	36	23	30	30
05/03/2010	25	32	32	23	25	23
31/03/2010	18	29	28	19	24	22
29/04/2010	12	25	25	15	20	17
03/06/2010	11	24	25	14	19	16
28/06/2010	19	27	23	17	20	17
27/07/2010	18	28	26	13	23	19
31/08/2010	22	35	29	21	25	21
29/09/2010	26	33	30	19	24	25
03/11/2010	24	36	34	26	32	31
02/12/2010	25	35	33	25	29	39
Mean	**21**	**32**	**30**	**20**	**26**	**25**
Bias adjusted mean	20	31	29	19	25	**-**

Annual mean NO_2 concentrations measured with diffusion tubes ranged from 20 µg m^{-3} to 32 µg m^{-3} at the five sites. The annual mean concentration measured at Stansted 3 using diffusion tubes was 26 µg m^{-3}. This was very slightly higher than the value of 25 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 (more commonly) 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 annual mean concentration measured at Stansted 3 using diffusion tubes was 26 µg m^{-3}, and the annual mean obtained using the chemiluminescence analyser was 25 µg m^{-3}. This gives a "bias adjustment factor" of 0.96. (This is the same as the bias adjustment factor calculated for both 2008 and 2009). Table 4.2 includes annual means at the other sites, corrected by application of this bias adjustment factor.

It should be noted that

(i) only the annual mean concentration should be adjusted in this way, as 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.

Mean concentrations of BTEX hydrocarbons, as measured using diffusion tubes during 2010, are shown in Table 4.3. The full dataset is provided in Appendix 5.

Table 4.3 Annual Mean Concentrations of Hydrocarbon Species at Stansted, 2010

Site	Benzene µg m^{-3}	Toluene µg m^{-3}	Ethyl Benzene µg m^{-3}	m+p- Xylene µg m^{-3}	o- Xylene µg m^{-3}
Stansted North	0.88	1.35	0.67	0.60	0.47
Stansted East	1.13	1.98	0.71	1.08	0.60
Stansted South	1.23	1.44	0.44	0.56	0.40
Stansted West	0.93	1.60	0.46	0.67	0.39
Stansted 3	1.04	1.92	0.53	0.73	0.49

4.2 Comparison With Air Quality Standards and Guidelines

Full details of the air quality standards and objectives used for analysis of Stansted Airport monitoring data are provided in Appendix 1.

Neither of the automatic monitoring sites, Stansted 3 and Stansted 4, recorded any hourly mean NO_2 concentrations greater than the hourly mean Limit Value and AQS Objective of 200 µg m^{-3}. Therefore both sites met the Limit Value and Objective for this pollutant.

The annual mean NO_2 concentrations measured at Stansted 3 and Stansted 4 during 2010 were 19 µg m^{-3} and 25 µg m^{-3} respectively. Both automatic sites were therefore well within the annual mean Limit Value and 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 and EC Limit Value 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 three: this is well within the maximum permitted number of exceedences (35), so this site met the AQS Objective and Limit Value for 24-hour mean PM_{10}.

The 2010 annual mean PM_{10} concentration (based on VCM-corrected data) was 21 µg m^{-3}: this was well within the Limit Value and AQS Objective for this parameter.

The annual mean benzene concentrations measured at all five BTEX diffusion tube sites ranged from 0.88 µg m^{-3} to 1.23 µg m^{-3}. All were well within the EC Limit Value and AQS Objective for England and Wales, which is 5 µg m^{-3}.

4.3 Temporal Variation in Pollutant Concentrations

4.3.1 Seasonal Variation

Figure 4.3 and Figure 4.4 show the variation of monthly averaged pollutant concentrations during 2010 at Stansted 3 and Stansted 4 respectively. Because there is a slight possibility of very local emissions influencing the measurements at Stansted, the PM_{10} data shown here have not been corrected using the VCM. Instead they are expressed as "indicative gravimetric equivalent", i.e. TEOM measured value x 1.3. Only months with at least 75% data capture are shown.

As with previous years both sites 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.

By contrast, PM_{10} concentrations at Stansted 3 showed a less clear seasonal pattern, with highest monthly mean concentration occurring in July. This is similar to previous years' observations: the PM_{10} concentrations at this site have not exhibited a consistent seasonal pattern, and in recent years the highest concentrations have often occurred in the summer months. It is likely that secondary material makes up a substantial component of the particulate matter at this site: for secondary pollutants, high concentrations can also often occur during summer months when chemical reactions in the atmosphere are promoted by high temperatures and strong sunlight. This observation is consistent with other particulate matter measurements made in the south of England.

Figure 4.3 Seasonal variation of pollutant concentrations at Stansted 3, 2010

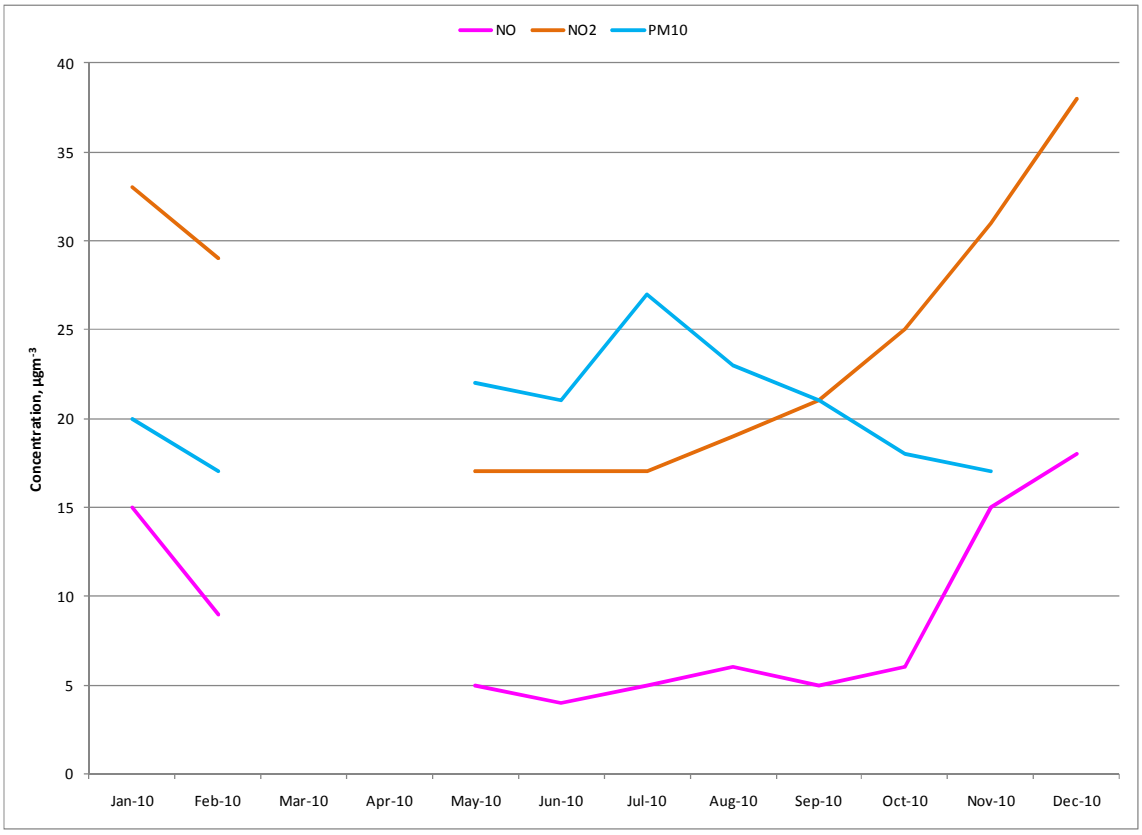
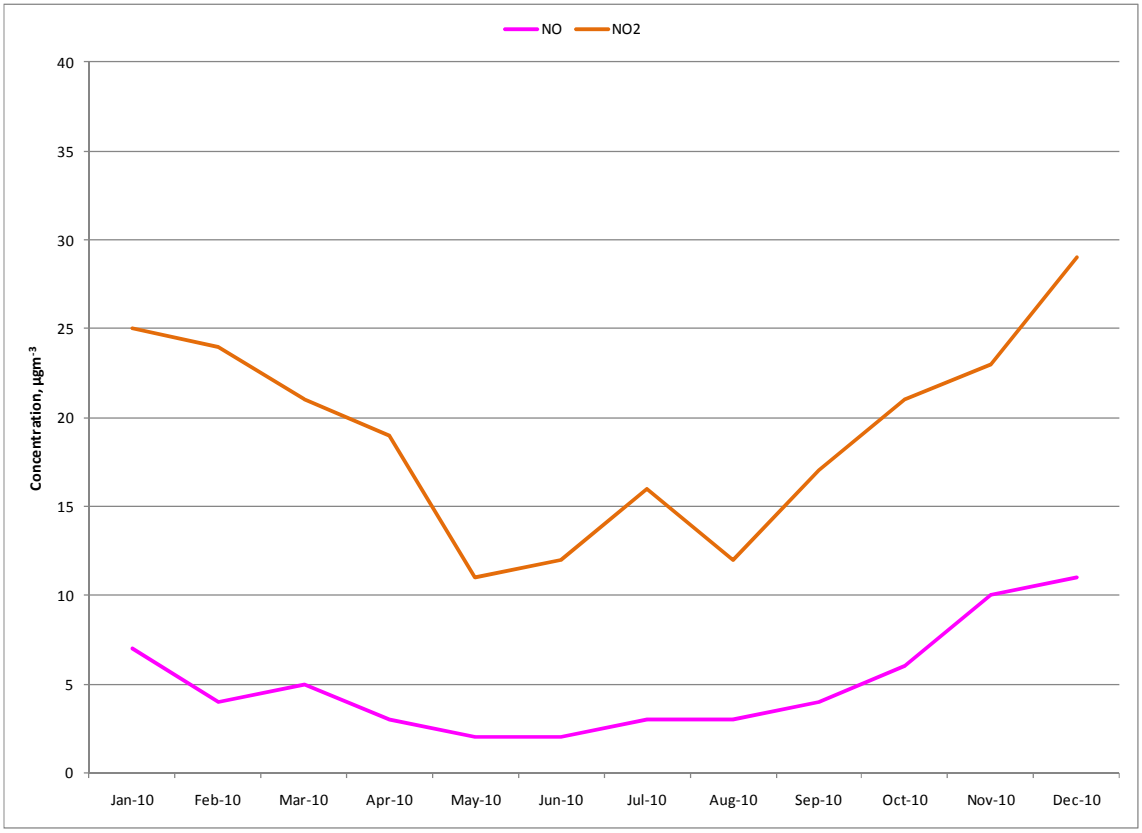


Figure 4.4 Seasonal variation of pollutant concentrations at Stansted 4, 2010



4.3.2 Diurnal Variation

Figure 4.5 and Figure 4.6 show diurnal variation in pollutant concentrations, as measured at Stansted 3 and Stansted 4 respectively.

Both sites show clear peaks for NO and NO_2 in the morning, corresponding to rush hour traffic at around 6am and 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 as high as the morning peak. For NO, the afternoon peak is very much smaller. 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. Rather than there being a morning peak, then a decrease during the middle of the day, then an afternoon peak, at Stansted there is a steady increase through the day, with highest concentrations in late afternoon. 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 4.5 Diurnal variation of pollutant concentrations at Stansted 3, 2010

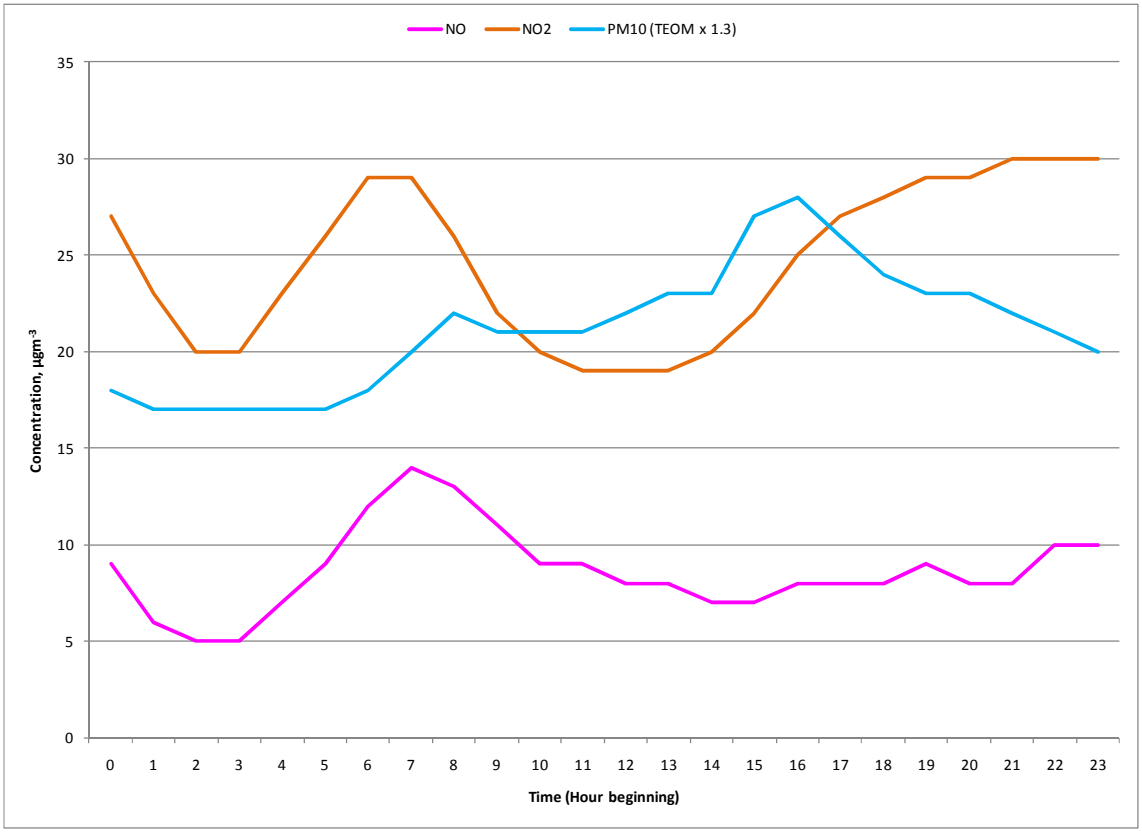
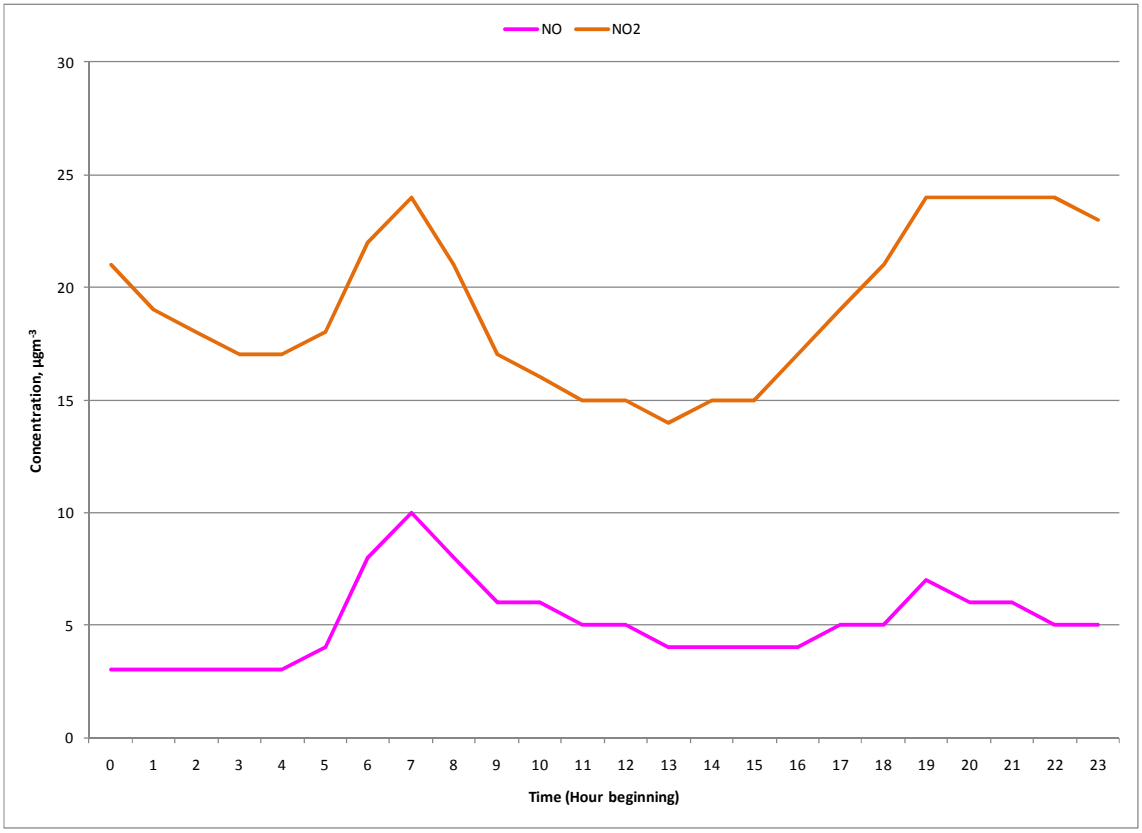


Figure 4.6 Diurnal variation of pollutant concentrations at Stansted 4, 2010



4.4 Source Apportionment

In order to investigate the possible sources of air pollution that are being monitored at Stansted airport, meteorological data was used to add a directional component to the air pollutant concentrations. No data were available from the airport itself, but wind speed and wind direction data from the St Albans Fleetville monitoring station were obtained from the Herts and Beds Monitoring Network website[14].

Although this is not ideal due to the site being approximately 40 km from Stansted, the Fleetville site is not restricted by any nearby buildings, therefore the wind direction and wind speed data will be broadly representative of the area. This site was also used for the 2009 Annual Report.

Figure 4.7 shows the wind speed and direction data from the St Albans site. The length of the "spokes" against the grey concentric circles indicate the percentage of time during the year that the wind was measured from each direction. For example, the prevailaing wind direction was 240º, and the wind was from this direction approximately 18% 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 1.6 ms^{-1}, and the 75th percentile wind speed was 2.3 ms^{-1}. Wind speeds rarely exceeded 6 ms^{-1}, and for the majority of the time were less than 4 ms^{-1}.

Figure 4.7 Wind rose showing the wind speed and direction in 2010 from St Albans, Fleetville monitoring site.

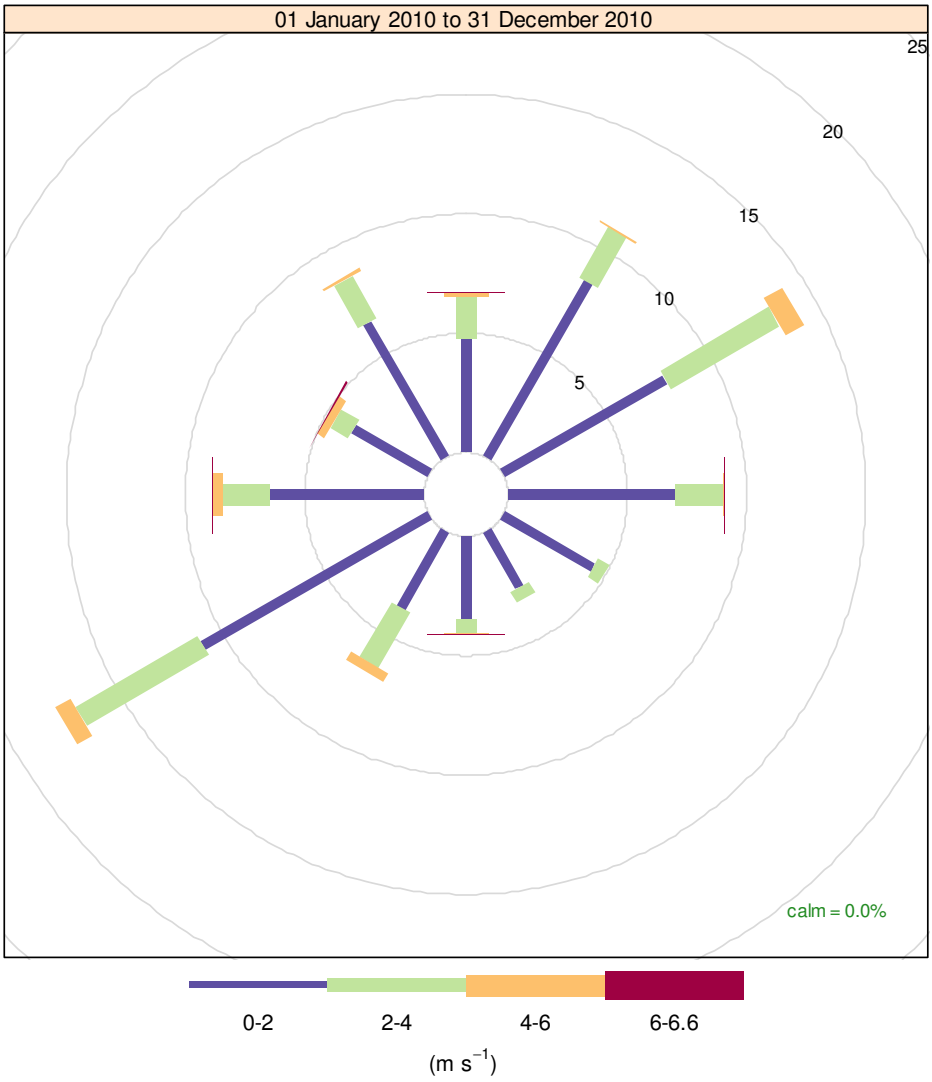


Figure 4.8 and Figure 4.9 show bivariate plots of hourly mean NO and NO2 concentrations against the corresponding wind speed and wind direction. These plots should be interpreted as follows:

- 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 grey 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 4.8 Pollution Rose for NO at Stansted 3

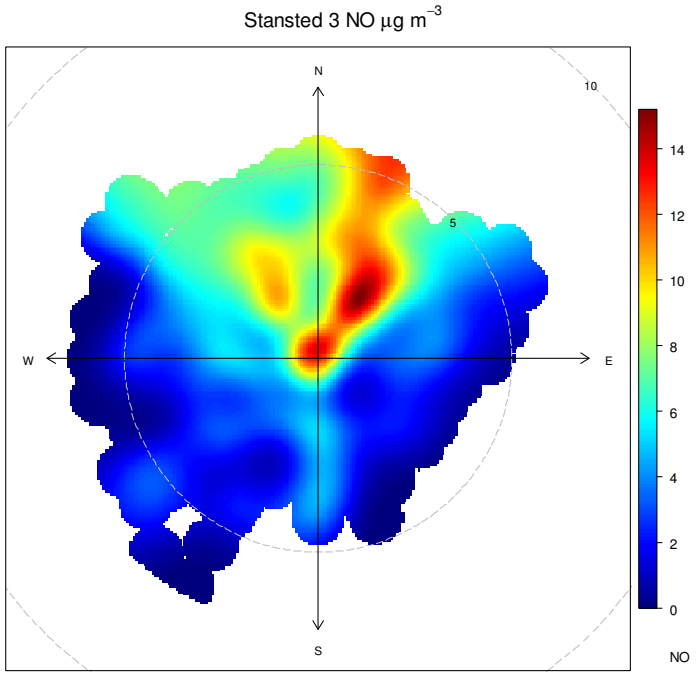
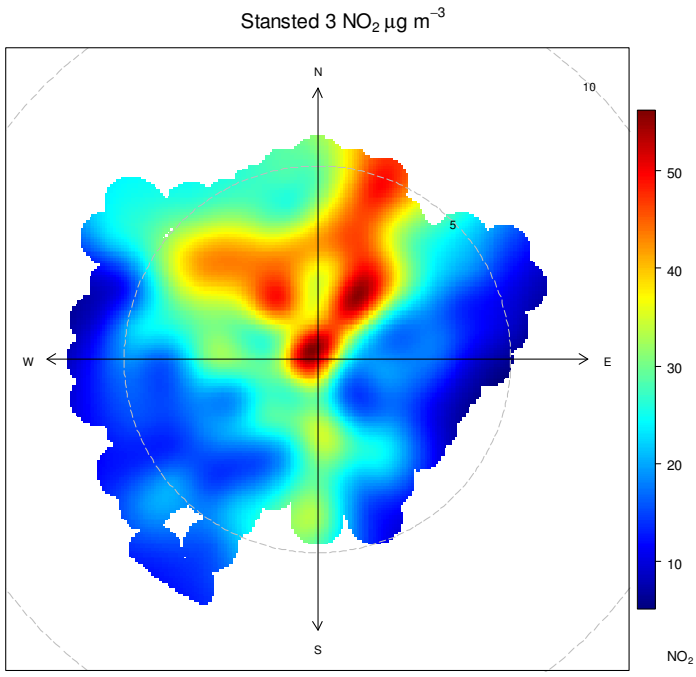


Figure 4.9 Pollution Rose for NO_2 at Stansted 3

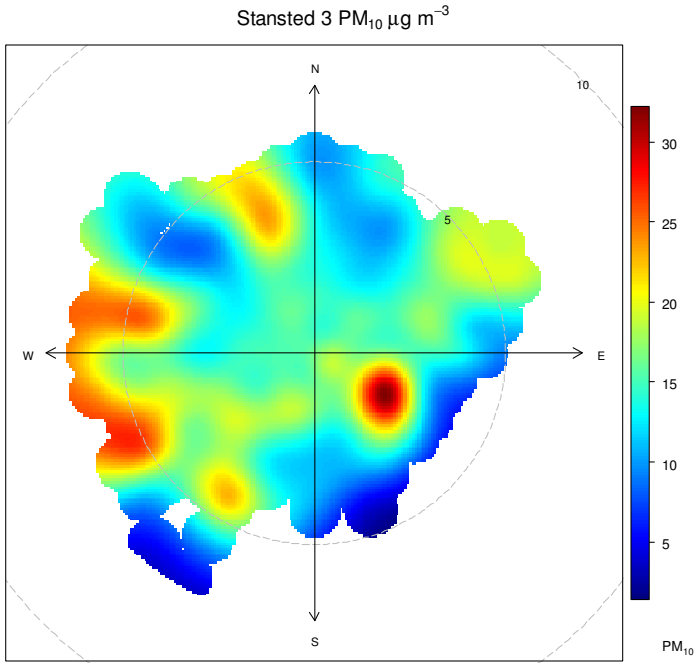


Overall, highest concentrations of NO and NO_2 were recorded at Stansted 3 when the wind direction was in a quandrant between north (360°) and north-east (045°). The red spot at the very centre of the NO and NO_2 plots which occur at near-zero wind speeds suggests a significant emissions source just to the north of the monitoring site. This may reflect the site's location in the High House car park. The highest NO concentrations appear to be associated with wind speeds of around 1-2 ms^{-1} and wind directions of approximately 030°. This is also mirrored by high NO_2 concentrations. The direction of this source is consistent with the location of the main terminal buildings, the terminal car park and associated road

infrastructure. There is also a source to the south which is most clearly visible in the NO_2 plot. This is possibly a weak signature from A120 which lies to the south of the airport.

Figure 4.10 shows a similar bivariate plot for PM_{10} at Stansted 3. This shows a very different pattern from the plots for oxides of nitrogen above.

Figure 4.10 Pollution Rose for PM_{10} at Stansted 3



Highest concentrations are associated with wind speeds of around 2 ms^{-1} and a wind direction of approximately 120°. The signature suggests a point source to the south east of the monitoring site. The nature of this source is unknown. Higher concentrations are also seen at wind speeds over 5 ms^{-1} from a westerly direction. This suggests a general contribution from operations within the airport although these concentrations are well below the annual mean UK air quality objective.

Figure 4.11 Pollution Rose for NO at Stansted 4

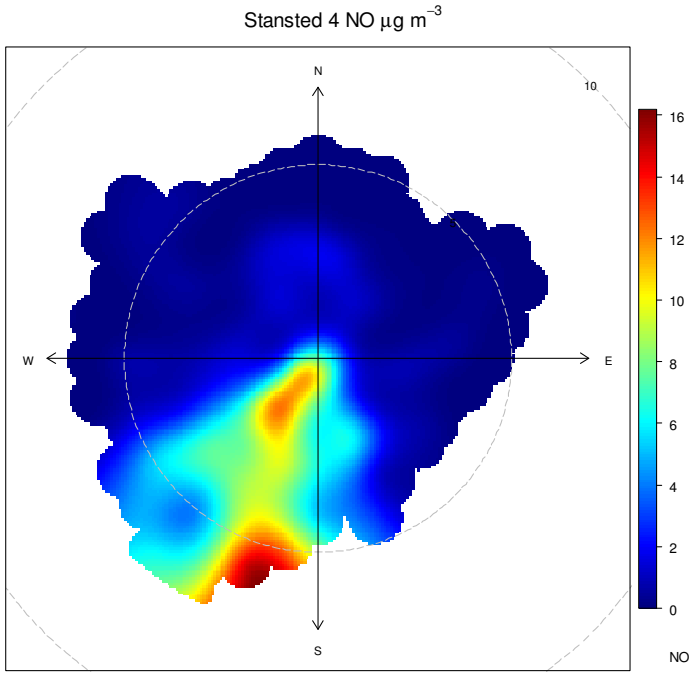


Figure 4.12 Pollution Rose for NO_2 at Stansted 4

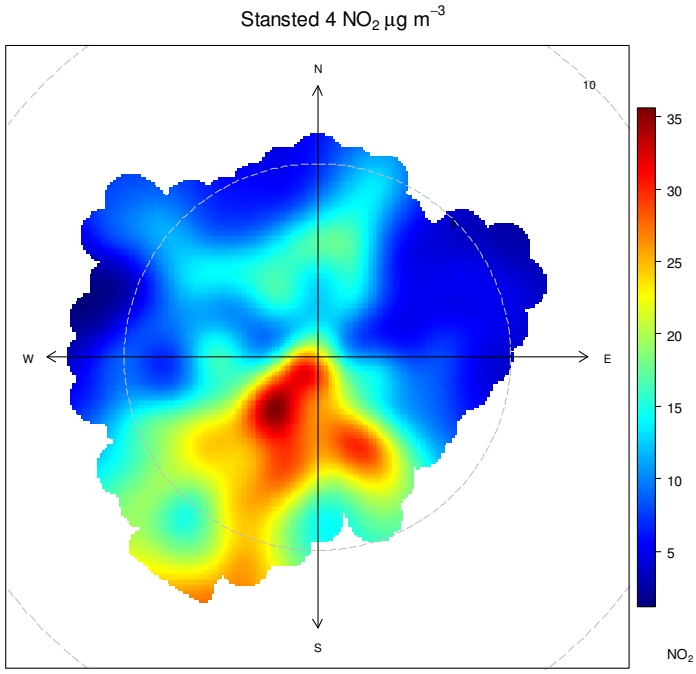


Figure 4.11 shows the "pollution rose" for NO at Stansted 4. At low wind speeds, there is evidence of a source on a bearing of approximately 225° (south west). This may be aircraft traffic on the runway. At higher wind speeds, there are NO contributions associated with a slightly different wind direction, more to the south. This is consistent with the location of the main airport terminal, with its associated traffic. It is possible that at low wind speeds, the NO

emitted from these more distant sources is oxidised to NO_2 before it reaches the monitoring site, whereas at higher wind speeds it reaches the site before oxidation has occurred.

The NO_2 pollution rose (Figure 4.12) shows these sources also, with NO_2 concentrations generally highest when the site is downwind of the airport. The 2009 report also highlighted a significant point source to the north east of Stansted 4, which was identified as the location of an emergency generator. However, this source is not evident in the 2010 data suggesting that the generator was not in use during 2010.

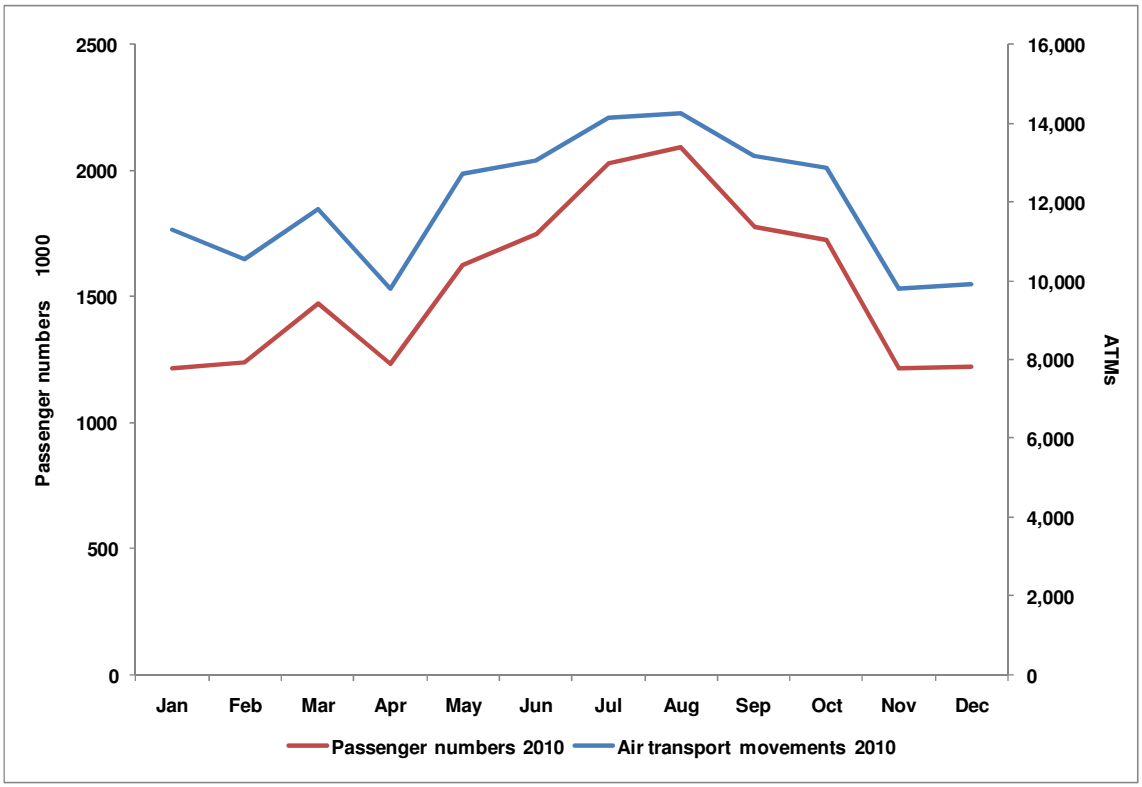
4.4.1 Relationship with Airport Activity

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 4.13 shows monthly statistics for the number of passengers and air traffic movements (ATM's) during 2010. The distinct seasonal pattern indicating high 'activity' in the summer months (July and August) and lower in the winter is clearly seen. Figure 4.3 and Figure 4.4 above show the corresponding monthly air pollutant concentrations. As discussed in section 4.3, these also show a seasonal distribution for oxides of nitrogen, but in this case, concentrations are higher in the winter months rather than the summer. This is a typical seasonal pattern.

Although the emissions from the airport and its surrounding roads are a significant contributor to the ambient pollutant concentrations, as is illustrated in the pollution "rose" plots above, this simplistic analysis of air and passenger movements indicates that seasonal variation in pollutant concentrations (i.e. the periods of high and low concentration) at Stansted is influenced greatly by general meteorological factors.

Figure 4.13 Monthly variation of Stansted airport activity 2010



4.5 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, and remained within the Defra "Low" air quality band throughout most of the year.

4.5.1 Nitrogen Dioxide

In 2010, neither Stansted 3 or Stansted 4 recorded any exceedences of the NO_2 1-hour mean AQS Objective. Concentrations of this pollutant remained in the Defra "Low" air pollution band throughout the year. This is in contrast to 2009, when a number of exceedences of the above Objective occurred at Stansted 4. These appeared to be associated with the diesel-powered emergency generator located nearby, and were highly localised to Stansted 4 and coincided with wind directions from the north to west quadrant.

4.5.2 Particulates

Stansted 3 recorded a number of "spikes" in PM_{10} concentration, with the hourly mean reaching the Defra "High" band on 18 occasions. Some spikes were observed in 2009, but in 2010 there were more and they were higher.

The most significant are detailed below:

1. Over the period 12:00 – 15:00 on 25th May and 11:00 – 16:00 on 26th May, numerous elevated 1-hour mean PM_{10} concentrations occurred. Several were over 200 µg m^{-3}, with a maximum 1-hour mean of 817 µg m^{-3} (VCM-corrected) at 14:00. Wind speeds in the general area (as measured at St Albans Fleetville) were relatively high (2.3 ms^{-1}) at the time. The wind direction ranged between 111° and 117°, so the site was not downwind of the airport at the time. There was a corresponding small peak in NO and NO_2, indicating that combustion sources were involved.
2. 1st July 2010, between 10:00 and 16:00: PM_{10} concentrations were again elevated, with a maximum 1-hour mean of 743 µg m^{-3} (VCM-corrected) at 15:00. Wind speeds were again relatively high (between 2.5 ms^{-1} and 3.3 ms^{-1}) and the wind direction ranged between 235° and 247° over this period. So the site was again not downwind of the main airport terminal at the time (although it was downwind of the roads approaching it). There was a corresponding small peak in NO and NO_2, indicating that combustion sources were involved - although the NOx peak did not coincide exactly with the PM_{10} peak.
3. 5th July 2010, 10:00 – 14:00, when the hourly mean reached 126 µg m^{-3} (VCM-corrected). Wind speeds were lower (1.1-1.6 ms^{-1}) and wind directions were around 342°.
4. 29th July 2010 at 21:00 and 30th July 2010, 07:00. Wind speeds on this occasion were relatively low, at between 0.6 – 1.6 ms^{-1}, and the wind direction ranged from 342° to 014° , i.e. approximately from the north. Again, there was a slight corresponding increase in NO_2, indicating the involvement of combustion sources.
5. 30th Aug (16:00 – 18:00) when the wind was from approximately the north east (052°-058°) and 31st Aug, 14:00 – 19:00, when the wind was easterly to south easterly(101° – 141°).The hourly mean reached 309 µg m^{-3} (VCM-corrected).

The periods of high particulate concentration therefore did not appear to be associated with any specific wind direction or wind speed. It is possible that they may be associated with local activity.

4.6 Comparison with Other UK Sites

Figure 4.14 and Figure 4.15 provide a comparison between annual mean pollutant levels at the Stansted sites, and corresponding measurements made at several AURN monitoring stations in the region. 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.
- Birmingham Airport – an airside apron location at Birmingham International Airport, approximately halfway down the runway and 900 metres north east of the terminal complex
- LHR2 – a long-term airside monitoring station at Heathrow. 180 metres north of runway 27R and north east of the Central Terminal Area.
- London Harlington – a background monitoring station approximately 1km north east of the Heathrow perimeter.
- Gatwick LGW3 – a long-term monitoring station at Gatwick, directly under the runway approach, 250 metres from the threshold of runway 26L and 25 metres from the A23.

Annual mean concentrations of NO_2 at Stansted 4 have been consistently comparable with the urban background concentrations measured at Southend-on-Sea and Northampton. Annual mean NO_2 at Stansted 4 has been consistently lower than at the other airside airport sites used here for comparison (Birmingham Airport, LHR2 and Gatwick LGW3). Annual mean NO_2 concentrations at Stansted 3 have been falling since 2004: although still higher than at Stansted 4 and Northampton, they are similar to those measured at Southend-on-Sea and Birmingham Airport.

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. The Cambridge Roadside site also shows a large increase this year: the reason is not known.

In the case of PM_{10}, the data discussed below are “as measured”, i.e. where the instrument is a TEOM (as in the case of all sites shown except Southend and Thurrock). Concentrations of PM_{10} at Stansted 3 have historically been higher than local urban background sites, both in London and regionally. Concentrations of PM_{10} at Stansted 3 are comparable to those measured at the other airport monitoring sites, Heathrow, Gatwick and Birmingham. Stansted 3’s annual mean PM_{10} concentrations follow those at Birmingham Airport particularly closely.

The apparent increases in PM_{10} at Southend and Thurrock may be due to the change of monitoring method at these sites, in 2008 and 2009 respectively.

Concentrations of PM_{10} at Stansted 3 have decreased by 5 µg m^{-3} over the past six years.

Figure 4.14 Annual mean trend NO_2 concentrations at Stansted 3, Stansted 4 and other regional monitoring sites.

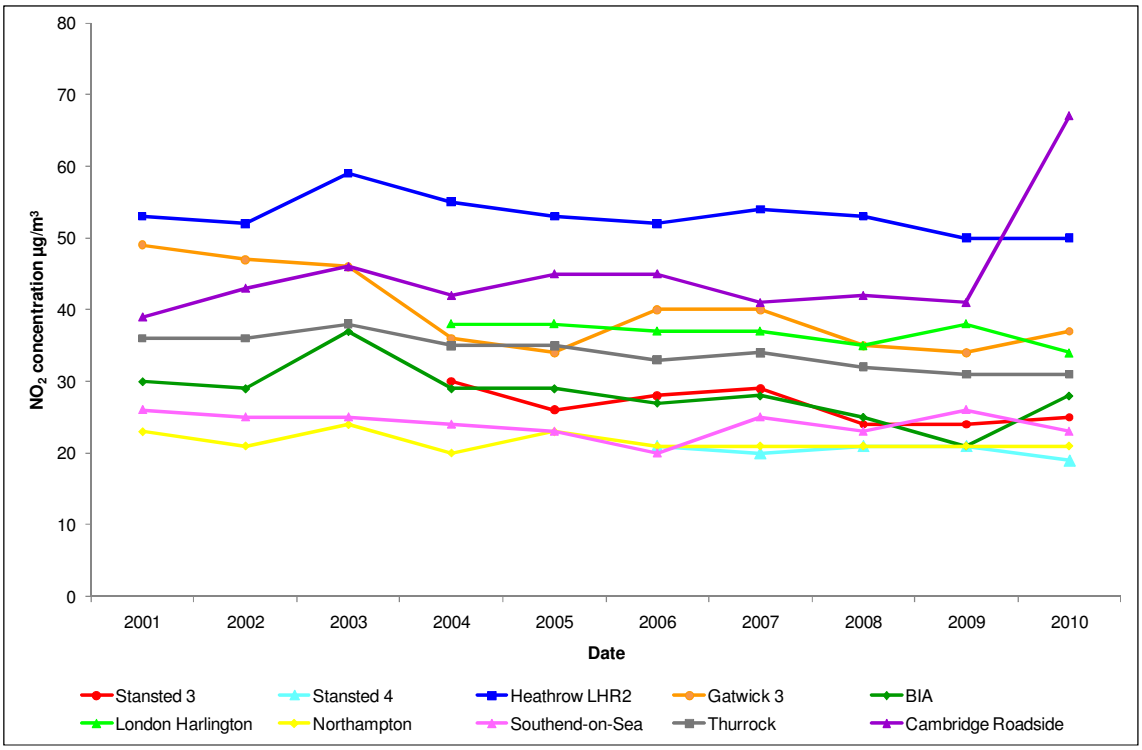
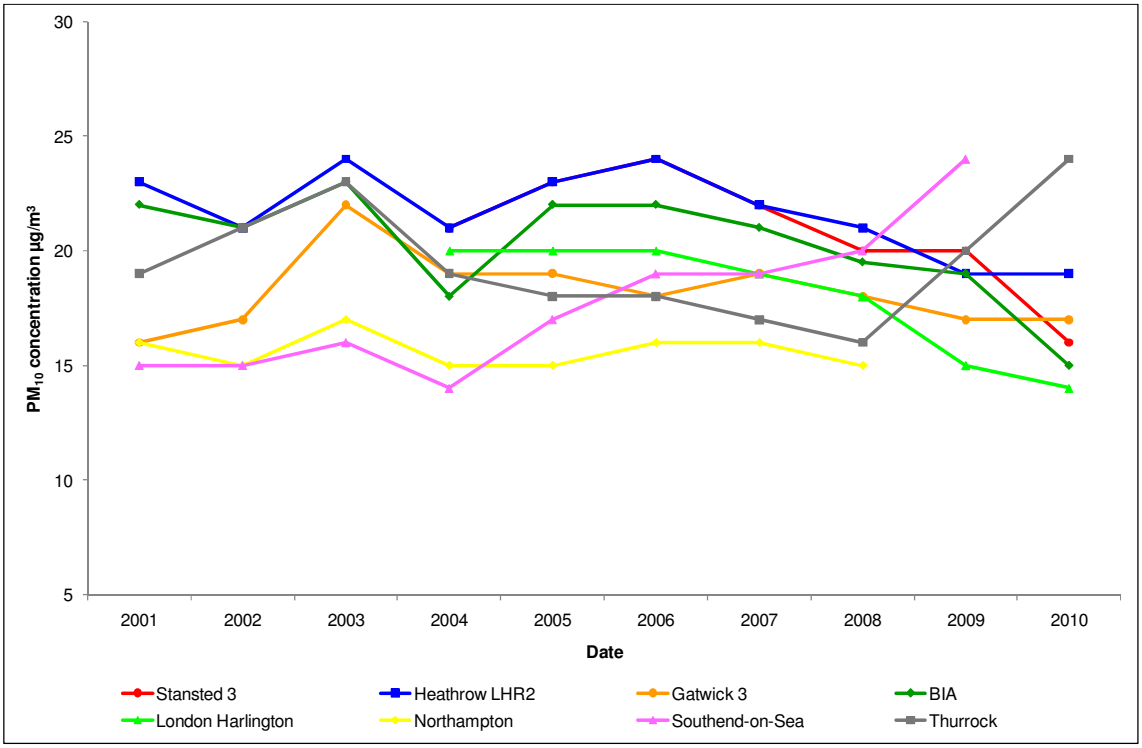


Figure 4.15 Annual mean PM_{10} concentrations at Stansted 3 and other regional monitoring sites.



(note: measurement method changed from TEOM to FDMS during 2008 at Southend and during 2009 at Thurrock. This may account for the apparent increase at these sites).

5 Conclusions

This report describes results from the ongoing air pollution monitoring programme undertaken at Stansted Airport during calendar year 2010. This was the fifth year in which ongoing continuous monitoring has been undertaken. Oxides of nitrogen were measured using automatic techniques at two sites, together with PM_{10} at one of these. This was supplemented by diffusion tube measurements of nitrogen dioxide and a range of hydrocarbon species at one of the automatic sites and at four other sites around the airport.

The following conclusions have been drawn from the 2010 dataset:

1. The data capture target of least 90% was achieved for oxides of nitrogen at both sites. Data capture for PM_{10} at Stansted 3 missed this target, but by a very small margin of < 1%.

2. Both automatic monitoring sites (Stansted 3 and 4) met the AQS Objectives for hourly mean NO_2 and also for annual mean NO_2.

4. All five NO_2 diffusion tube sites met the AQS Objective for this pollutant.

5. PM_{10} was measured at Stansted 3: this site met the AQS Objectives for daily mean and annual mean average PM_{10} concentration.

6. NO and NO_2 concentrations were higher during the winter months: this is a fairly typical pattern for urban sites. There were no clear patterns in seasonal PM_{10} concentrations.

7. "BTEX" diffusion tubes were deployed at four sites on a monthly basis, measuring benzene, toluene, ethylbenzene and xylenes. Annual mean benzene concentrations at all five sites ranged from 0.88 µg m^{-3} to 1.23 µg m^{-3}, and were well within the AQS Objective for the running annual mean for benzene. The AQS Objective for this pollutant was therefore achieved by the required date of 2010.

8. 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.

9. An investigation into the source of pollutants found that NO and NO_2 concentrations measured at Stansted 3 probably originated from several sources, including very local ones such as the nursery car park. NO and NO_2 concentrations at Stansted 4 were more clearly associated with the direction of the airport's main terminal. The highest PM_{10} concentrations did not appear to be associated with the airport: it was not possible to clearly identify the source of these emissions.

10. Annual mean concentrations of NO_2 at Stansted 4 have been consistently comparable with the urban background concentrations measured at Southend-on-Sea and Northampton. Concentrations at Stansted 3 have historically been slightly higher than these urban background concentrations but these have been reducing and since 2008 annual mean concentrations have been more in line with the urban background concentrations.

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

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Appendices

Appendix 1: Air Quality Standards and Objectives

Appendix 2: Monitoring Apparatus and Techniques

Appendix 3: Quality Assurance and Quality Control

Appendix 4: NO_2 Diffusion Tubes – Full Dataset

Appendix 5: BTEX Diffusion Tubes – Full Dataset

Appendix 1 - Air Quality Standards and Objectives

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		□Running annual mean□	
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 at present.*

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 at present*
$^{+}$ AOT 40 is the sum of the differences between hourly concentrations greater than 80 $\mu g\ m^{-3}$ (=40ppb) and 80 $\mu g\ m^{-3}$, over a given period using only the 1-hour averages measured between 0800 and 2000.

Conversion factors from volumetric to mass concentration measurement for gaseous pollutants are provided below:

- NO 1 ppb = 1.25 $\mu g\ m^{-3}$
- NO_2 1 ppb = 1.91 $\mu g\ m^{-3}$
- O_3 1 ppb = 2.00 $\mu g\ m^{-3}$
- C_6H_6 (benzene) 1 ppb = 3.25 $\mu g\ m^{-3}$
- C_7H_8 (toluene) 1 ppb = 3.83 $\mu g\ m^{-3}$
- C_8H_{10} (xylene) 1 ppb = 4.41 $\mu g\ m^{-3}$
- PM_{10} indicative gravimetric equivalent = PM_{10} as measured by TEOM x1.3 (at 20°C and 1atmosphere (101.3 kPa) pressure). However, where possible, the King's College London Volatile Correction Model is used instead.

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

$NO_x\ \mu g\ m^{-3}$=(NO ppb+NO_2 ppb)*1.91.

This conforms with the requirements of the Ambient Air Quality Directive[2] and is also the convention generally adopted in air quality modelling.

Table A1.3 Defra Air Pollution Bands and Index Values

Air Quality Bands and Index Values for NO_2		
Band	**Index**	**Nitrogen Dioxide µg m^{-3}**
Low	1	0-95
	2	96-190
	3	191-286
Moderate	4	287-381
	5	382-477
	6	478-572
High	7	573-635
	8	363-700
	9	701-763
Very High	10	764 or more

Air Quality Bands and Index Values for PM_{10} (Gravimetric equivalent)		
Band	**Index**	**PM_{10} µg m^{-3} (Gravimetric equivalent)**
Low	1	0-21
	2	22-42
	3	43-64
Moderate	4	65-74
	5	75-86
	6	87-96
High	7	97-107
	8	108-118
	9	119-129
Very High	10	130 or more

Air Quality Bands and Index Values for PM_{10} (Reference equivalent)		
Band	**Index**	**PM_{10} µg m^{-3} (Reference equivalent)**
Low	1	0-19
	2	20-40
	3	41-62
Moderate	4	63-72
	5	73-84
	6	85-94
High	7	95-105
	8	106-116
	9	117-127
Very High	10	128 or more

Appendix 2 - Monitoring Apparatus and Techniques

Monitoring Equipment

Continuous automatic analysers for monitoring NO, NO_2 and PM_{10} were selected, in order to provide real-time data. The analysers use the operating principles listed below: these represent the current state-of-the-art techniques for ambient monitoring of these species.

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

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.

Each gas analyser is 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 TEOM monitoring method uses a 50^{o}C heated sample inlet in order to prevent moisture from contaminating the filter. Many studies have shown that this elevated temperature results in the loss of volatile and semi-volatile components of PM_{10}. Secondary particles such as ammonium nitrate for example, are known to evaporate below 50^{o}C. Until recently, Government advice was that TEOM results could be converted to indicative gravimetric equivalent measurements by applying a factor of 1.3.

However, the conclusion of equivalence trials published in 2006 was that the TEOM did not meet the equivalence criteria, even with correction factors applied. (See “UK Particulate Monitoring Equipment Study” report by Bureau Veritas, at http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf.

To solve this problem, King’s College London (KCL) have developed a Volatile Correction Model, 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 particulate analysers of the FDMS TEOM type, which measure the volatile component of the PM_{10}. This volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. **KCL state on the VCM website home page that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.** This is the preferred method of dealing with TEOM data when comparing them to air quality limit values and objectives, and has been used for this purpose in the present report.

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

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. 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)	$\pm 2.5\ \mu g\ m^{-3}$	±15%
Nitrogen Dioxide (NO_2)	$\pm 6.9\ \mu g\ m^{-3}$	±15%
Particles (PM_{10})	$\pm 4\ \mu g\ m^{-3}$ *	

* accuracy of particle measurements cannot currently be assessed.

Appendix 4 - NO_2 Diffusion Tubes – Full Dataset

Results are quoted here to two decimal place 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
19/01/2010	27.63	29.05	29.08	28.6	
03/02/2010	20.05	21.06	22.43	21.2	
05/03/2010	24.32	27.94	22.20	24.8	
31/03/2010	17.14	18.07	17.50	17.6	
29/04/2010	11.92	12.92	11.92	12.3	
03/06/2010	11.83	11.12	10.80	11.3	
28/06/2010	20.68	19.33	17.99	19.3	
27/07/2010	17.10	17.61	17.90	17.5	
31/08/2010	21.37	21.61	22.12	21.7	
29/09/2010	25.95	26.60	25.54	26.0	
03/11/2010	24.99	23.25	25.26	24.5	
02/12/2010	24.79	*25.06*	24.74	24.9	
				20.8	

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
19/01/2010	43.9	46.0	38.9	42.9	
03/02/2010	32.8	31.8	36.0	33.5	
05/03/2010	28.9	35.0	30.6	31.5	
31/03/2010	30.9	27.3	28.0	28.7	
29/04/2010	26.7	24.5	24.3	25.2	
03/06/2010	23.8	24.4	25.3	24.5	
28/06/2010	25.6	25.3	31.0	27.3	
27/07/2010	26.1	25.4	31.5	27.7	
31/08/2010	34.7	36.0	34.4	35.0	
29/09/2010	35.4	32.7	31.7	33.3	
03/11/2010	35.7	39.2	34.2	36.3	
02/12/2010	35.6	37.4	33.5	35.5	
Mean				31.8	

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
19/01/2010	43.65	44.14	44.75	44.2	
03/02/2010	34.82	34.51	37.68	35.7	
05/03/2010	33.78	32.39	30.91	32.4	
31/03/2010	28.55	26.06	28.82	27.8	
29/04/2010	25.42	26.42	23.90	25.2	
03/06/2010	25.18	23.96	24.67	24.6	
28/06/2010	20.36	22.48	24.73	22.5	
27/07/2010	26.11	25.78	25.34	25.7	
31/08/2010	29.02	29.22	28.70	29.0	
29/09/2010	28.78	30.61	29.65	29.7	
03/11/2010	32.58	34.75	33.61	33.6	
02/12/2010	31.23	32.83	34.60	32.9	
Mean				30.3	

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
19/01/2010	29.70	29.70	28.89	29.4	
03/02/2010	25.42	22.40	22.32	23.4	
05/03/2010	22.14	23.22	23.70	23.0	
31/03/2010	18.62	19.29	17.63	18.5	
29/04/2010	14.59	15.48	15.15	15.1	
03/06/2010	14.49	12.61	Void	13.6	Tube 3 "void" as it contained no grids.
28/06/2010	17.30	17.42	14.93	16.5	
27/07/2010	11.91	14.71	13.82	13.5	
31/08/2010	20.50	21.53	20.66	20.9	
29/09/2010	16.40	20.97	19.62	19.0	
03/11/2010	25.74	24.20	27.40	25.8	
02/12/2010	23.96	23.86	25.97	24.6	
Mean				20.3	

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
19/01/2010	35.62	39.79	41.24	38.9	
03/02/2010	28.13	31.61	29.85	29.9	
05/03/2010	24.74	24.94	25.95	25.2	
31/03/2010	24.67	24.51	22.62	23.9	
29/04/2010	19.77	Void	19.66	19.7	Tube 2 "void" as it contained no grids.
03/06/2010	19.47	18.55	19.15	19.1	
28/06/2010	18.62	20.54	21.13	20.1	
27/07/2010	22.75	23.44	23.19	23.1	
31/08/2010	25.66	25.46	24.67	25.3	
29/09/2010	22.72	22.31	25.93	23.7	
03/11/2010	30.84	32.78	32.26	32.0	
02/12/2010	29.10	29.46	29.04	29.2	
Mean				25.8	

Appendix 5 – BTEX Diffusion Tubes – Full Dataset

Table A5.1 Monthly Hydrocarbon concentrations at Stansted North – 23 Approach (μg m^{-3})

Period Sampled		Pollutant/ Concentration μg m^{-3}				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
19/01/2010	03/02/2010	1.45	1.02	0.36	0.49	0.22
03/02/2010	05/03/2010	1.20	0.87	0.27	0.41	0.73
05/03/2010	31/03/2010	1.02	1.16	0.32	0.48	0.30
31/03/2010	29/04/2010	1.51	0.28	0.55	0.16	0.07
29/04/2010	03/06/2010	0.68	1.11	2.39	0.20	1.38
03/06/2010	28/06/2010	0.39	0.88	0.45	0.42	0.21
28/06/2010	27/07/2010	0.36	1.11	0.49	0.62	0.25
27/07/2010	31/08/2010	0.30	0.67	0.24	0.40	0.10
31/08/2010	29/09/2010	0.46	0.56	0.54	0.51	0.32
29/09/2010	03/11/2010	0.52	0.94	0.28	0.61	0.23
03/11/2010	02/12/2010	0.20	0.43	0.14	<L.O.D.	<L.O.D.
02/12/2010	05/01/2011	2.45	7.15	1.96	2.34	1.36
Average		**0.88**	**1.35**	**0.67**	**0.60**	**0.47**

<L.O.D. – below the Limit of Detection

Table A5.2 Monthly Hydrocarbon concentrations at Stansted East – Enterprise House (μg m^{-3})

Period Sampled		Pollutant/ Concentration μg m^{-3}				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
19/01/2010	03/02/2010	2.30	1.51	0.62	0.74	0.68
03/02/2010	05/03/2010	1.38	1.55	0.40	0.74	0.34
05/03/2010	31/03/2010	1.31	1.31	0.41	0.78	0.41
31/03/2010	29/04/2010	1.27	0.32	0.05	0.24	0.21
29/04/2010	03/06/2010	0.58	0.91	0.64	0.32	0.44
03/06/2010	28/06/2010	0.45	0.99	0.30	0.65	0.20
28/06/2010	27/07/2010	0.52	1.23	0.34	0.83	0.35
27/07/2010	31/08/2010	0.38	1.60	0.31	0.72	0.26
31/08/2010	29/09/2010	0.75	2.43	0.53	0.87	0.50
29/09/2010	03/11/2010	0.61	1.67	0.40	0.98	0.31
03/11/2010	02/12/2010	1.27	2.24	0.62	1.18	0.61
02/12/2010	05/01/2011	2.76	8.03	3.91	4.84	2.89
Average		**1.13**	**1.98**	**0.71**	**1.08**	**0.60**

Table A5.3 Monthly Hydrocarbon concentrations at Stansted South – Pond B (μg m^{-3})

Period Sampled		Pollutant/ Concentration μg m^{-3}				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
19/01/2010	03/02/2010	1.86	1.36	0.49	0.70	0.57
03/02/2010	05/03/2010	1.34	0.97	0.32	0.53	0.22
05/03/2010	31/03/2010	0.94	0.75	0.27	0.48	0.26
31/03/2010	29/04/2010	0.96	0.22	0.08	0.16	0.25
29/04/2010	03/06/2010	0.50	0.58	0.43	0.24	0.20
03/06/2010	28/06/2010	0.41	0.98	0.49	0.41	0.15
28/06/2010	27/07/2010	0.34	0.80	0.31	0.59	0.14
27/07/2010	31/08/2010	0.24	0.55	0.17	0.35	<L.O.D.
31/08/2010	29/09/2010	4.43	0.66	0.49	0.33	0.53
29/09/2010	03/11/2010	0.36	0.90	0.29	0.55	0.21
03/11/2010	02/12/2010	0.26	0.36	0.11	0.14	<L.O.D.
02/12/2010	05/01/2011	3.08	9.17	1.77	2.20	1.46
Average		**1.23**	**1.44**	**0.44**	**0.56**	**0.40**

<L.O.D. – below the Limit of Detection

Table A5.4 Monthly Hydrocarbon concentrations at Stansted West – Ground Radar (μg m^{-3})

Period Sampled		Pollutant/ Concentration μg m^{-3}				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
19/01/2010	03/02/2010	2.26	1.73	0.66	0.77	0.41
03/02/2010	05/03/2010	1.04	1.10	0.26	0.54	0.34
05/03/2010	31/03/2010	0.85	0.90	0.31	0.55	0.30
31/03/2010	29/04/2010	1.32	0.36	0.08	0.16	0.23
29/04/2010	03/06/2010	0.52	0.76	0.26	0.30	0.43
03/06/2010	28/06/2010	0.41	0.93	0.37	0.65	0.21
28/06/2010	27/07/2010	0.45	1.14	0.44	0.65	0.27
27/07/2010	31/08/2010	0.35	0.84	0.36	0.55	0.25
31/08/2010	29/09/2010	0.52	0.78	0.36	0.45	0.34
29/09/2010	03/11/2010	0.54	1.24	0.37	0.71	0.26
03/11/2010	02/12/2010	0.15	0.82	0.25	0.41	0.14
02/12/2010	05/01/2011	2.76	8.58	1.79	2.34	1.50
Average		**0.93**	**1.60**	**0.46**	**0.67**	**0.39**

Table A5.5 Monthly Hydrocarbon concentrations at Stansted 3 – High House (μg m^{-3})

Period Sampled		Pollutant/ Concentration μg m^{-3}				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
19/01/2010	03/02/2010	1.93	2.87	1.01	1.35	0.93
03/02/2010	05/03/2010	1.23	1.76	0.67	0.84	0.49
05/03/2010	31/03/2010	1.01	0.90	0.28	0.48	0.27
31/03/2010	29/04/2010	1.15	0.22	0.07	0.20	0.30
29/04/2010	03/06/2010	0.83	1.04	0.37	0.32	0.39
03/06/2010	28/06/2010	0.40	1.17	0.56	0.52	0.22
28/06/2010	27/07/2010	0.46	1.40	0.51	0.73	0.28
27/07/2010	31/08/2010	0.42	1.26	0.46	0.72	0.27
31/08/2010	29/09/2010	0.72	0.95	0.55	0.54	0.43
29/09/2010	03/11/2010	0.81	1.66	0.53	0.85	0.31
03/11/2010	02/12/2010	0.46	0.57	0.23	0.24	<L.O.D.
02/12/2010	05/01/2011	3.06	9.23	1.09	1.90	1.51
Average		**1.04**	**1.92**	**0.53**	**0.73**	**0.49**

<L.O.D. – below the Limit of Detection

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