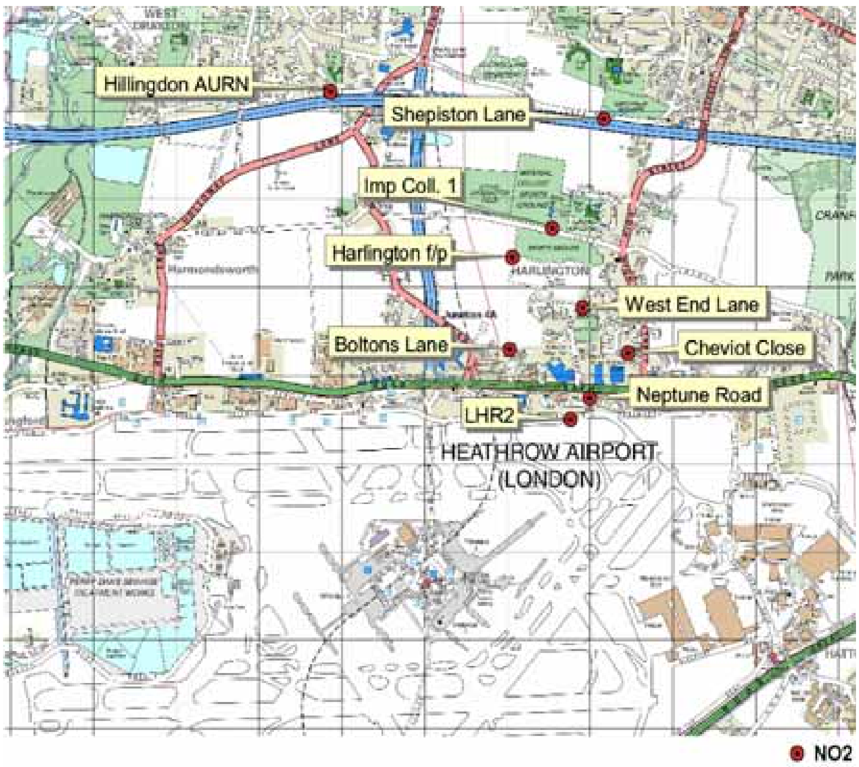
Report

A Continued Investigation of Air Pollution in The Vicinity of Heathrow Airport (2/11/2004 to 1/11/2005)

Report to British Airways plc



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Executive Summary

British Airways has previously undertaken dispersion modelling of aircraft emissions at Heathrow Airport. In order to compare modelling results with measurements, Netcen (a division of AEA Technology Environment) was commissioned to undertake an extended study of air pollution concentrations across the airport, over a 12-month period, from October 2002 to October 2003.

As a result of this survey, a further 12 months of nitrogen dioxide (NO_2) monitoring was undertaken, at seven of the previously selected landside locations, between October 2003 and October 2004. These locations were in the commercial/residential areas to the north of the airport. A co-location site for bias-adjustment purposes was retained from the earlier survey and located at the London Heathrow 2 (LHR2) airside continuous monitoring trailer.

A further twelve months of indicative nitrogen dioxide monitoring was undertaken at these eight locations, from 2 November 2004 to 1 November 2005. For this period, a second co-location site was included. This was located at the Hillingdon **A**utomatic **U**rban and **R**ural **N**etwork (AURN) continuous air quality monitoring station. This site was included to provide more information on the diffusion tube bias and to aid in verification of the bias factors derived from the long running co-location site at LHR2.

The level of the LHR2-derived bias adjustment factors obtained from both the 2004-05 contract period and 2005 annual mean period were very similar to those from previous monitoring periods.

Using these LHR2 bias adjustment factors, the resulting 12-month mean and 2005 annual mean NO_2 concentrations at all the original eight locations, remain closely aligned with those from both the previous sampling periods.

By applying the LHR2 2005 annual mean bias adjustment factor, the 2005 annual mean NO_2 concentrations, are likely to remain below the 40 $\mu g.m^{-3}$ Air Quality Objective (AQO) level at five of the nine sampled locations (after taking in to account the 95% Confidence Interval uncertainty of up to $\pm$ 4 $\mu g\ m^{-3}$, associated with the precision of the triplicate tubes).

The Shepiston site at 54 $\mu g.m^{-3}$; Neptune Road and LHR2 sites at 55 $\mu g.m^{-3}$ continue to have adjusted annual mean levels of NO_2 above 40 $\mu g.m^{-3}$. The Harlington site footpath was close to the AQO at 39 $\pm$ 3 $\mu g\ m^{-3}$. The expected uncertainty, associated with all quoted bias adjusted concentrations, should be in the range $\pm$ 25%. From the precision demonstrated in the results the uncertainty was well within this requirement.

The LHR2 bias adjustment factors remain lower than might be expected from similar sites, at approximately 0.61. However, the bias adjusted NO_2 concentrations, particularly from the Heathrow tube sites located away from major roads, were generally in good agreement with the NAEI predicted 2005 NO_2 background concentrations for these locations. The reason for the relatively low LHR2 factor was unclear but may be associated with wind-effects at this exposed location and/or pollution spikes from vehicles in the immediate area, affecting the uptake of NO_2 within the diffusion tubes.

The level of the 12-month mean and 2005 annual mean bias adjustment factors, obtained from the additional co-location site at Hillingdon, differ from those gained from LHR2. However, the location of the diffusion tubes at Hillingdon was in the best practical position but not the ideal. Hence, the primary bias adjusted results are given from LHR2 and Appendix C presents the bias adjusted results from Hillingdon.

When the calculated Hillingdon bias adjustment factor was used, the 2005 annual mean NO_2 concentration for each location was above the 40 $\mu g.m^{-3}$ Air Quality Objective/Limit Value level. (Even after taking in to account the 95% Confidence Interval uncertainty of up to $\pm$ 8 $\mu g\ m^{-3}$, associated with precision of the triplicate tubes).

Monitoring at the same locations is continuing for a further 14-months, to the end of 2006. However, in order to assist in the interpretation of the ‘2006’ results, it is recommended that additional gauze-capped tubes are exposed at the LHR2 site. This should clarify any over-read due to possible wind-effects at this location.

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Appendices

1 Introduction

British Airways (BA) has undertaken dispersion modelling of aircraft emissions at Heathrow Airport. In order to compare modelling results with measurements, Netcen (a division of AEA Technology Environment) was previously commissioned, to undertake a 12-month study[1] of air pollution concentrations, along a transect-line crossing the airport. This line extended into the residential areas to the north of the airport. The study measured indicative concentrations, from passive diffusion tubes, of both nitrogen dioxide and hydrocarbons during the period October 2002 to October 2003. Netcen was subsequently re-commissioned (again, in collaboration with BA staff) to undertake continued surveys of nitrogen dioxide, at eight of the previously selected sites, between October 2003 to October 2004[2] and November 2004 to early November 2005.

Whereas sampling continued uninterrupted across the end of the 2003 contract-period into 2004, it was agreed that, for the 2004-05 contract, the tube exposure periods would be harmonised with those of the U.K. Nitrogen Dioxide Diffusion Tube Survey. Passive nitrogen dioxide (NO_2) diffusion tubes (Appendix A) have been used, supplied by the same laboratory as those used in the previous surveys. BA staff continued to visit the sites on a monthly basis to exchange the exposed tubes, returning them to Netcen for analysis by Harwell Scientifics Ltd. The results are summarised in Chapter 3 with full results in Appendix B. Examples of diffusion tubes are shown in Figure 1.

Nitrogen dioxide, is covered by the first European Union Air Quality Daughter Directive (1999/30/EC) and by the Air Quality Strategy[3] Objectives, set by the UK Government. This Air Quality Strategy defines levels for air pollutants that must be met in the UK by specific dates. These are formally incorporated into English law by a number of UK Statutory Instruments detailed in Appendix E.

The analysis was carried out by Harwell Scientifics Ltd, who have been awarded UKAS accreditation (Testing Laboratory No 0322) for this service.

Figure 1: Diffusion Tubes for (left to right) SO_2, BTX and NO_2

2 Survey Methodology

The 2003 to 2004 Heathrow NO_2 diffusion tube survey concluded that the NO_2 tubes exposed at LHR2 continuous monitoring site (operated by Netcen on behalf of BA) may be influenced by near-by vehicle emissions. This may have resulted in an unrepresentative bias adjustment factor. As a result, further triplicate tubes were exposed at the Hillingdon AURN station, a second locally sited continuous monitoring site.

For the continued '2004 to 2005' survey results from the LHR2 co-location site continued to be used as the primary means of bias correcting both the 12-month and annual statistics from the Heathrow tube-monitoring sites. No further changes were made to the tube-only sampling locations, which remain the same as those used during the previous twelve months.

The NO_2 measurements from the Hillingdon AURN site were taken from the Defra UK National Air Quality Information Archive (http://www.airquality.co.uk/archive/index.php) and are presented in Appendix C.

All sampling locations are in the commercial/residential areas to the North of the airport. The LHR2 'continuous' air quality monitoring trailer was located approximately 10 metres airside of the northern perimeter fence, in the vicinity of the Heathrow Visitor Centre. The Hillingdon AURN station was located in a residential area to the north west of the diffusion tube monitoring area. It was positioned a relatively short distance to the north of the M4 motorway and the results were assessed to determine whether the bias adjustment, applied to previous mean NO_2 concentrations, could be refined using this additional data.

Triplicate diffusion tubes for nitrogen dioxide (NO_2) have continued to be exposed at monthly intervals. However, in order to realign the Heathrow exposure periods with those of the National NO_2 Diffusion tube Survey, the start of the new monitoring period was deferred until 2 November 2004. A further twelve months of NO_2 tube monitoring was undertaken until 1 November 2005.

This monitoring period provided a twelve-month mean, for the duration of the agreed monitoring campaign. However, monitoring had continued at these sites and data to the end of 2005 has been included in this report, so that full 2005 annual statistics were available for comparison with the required UK Objectives and Limit Values.

2.1 DIFFUSION TUBE MEASUREMENTS

Diffusion tubes are passive sampling devices, which require no mains or battery power and are ideal for this type of survey, where an indication of nitrogen dioxide concentrations is required at a number of locations in the same area. Further details of diffusion tube samplers for NO_2 are provided in Appendix A. For this continued survey, triplicate NO_2 tubes were, again, deployed at each site, in order to maximise the reliability and accuracy of the data. In line with Defra guidance[4] on the use of diffusion tubes, tubes have also been co-located with continuous automatic NO_2 analysers, as described previously.

Two sets of annual statistics have been calculated to cover the period from 2 November 2004 to 1 November 2005 (12-month mean) and to cover the 2005 annual mean period.

The bias adjustment factors have been calculated primarily from the LHR2 data set. However, an upper and lower boundary of adjusted values is presented in Appendix C, assuming that the LHR2 could potentially provide an over-correcting bias adjustment. These factors have then been applied to the mean NO_2 concentrations, in line with the defra Technical Guidance on the use of diffusion tubes and the resulting data from longer survey-periods.

An average value between the two sets of bias adjusted data has also been provided in Appendix C, for information.

For the monthly submission of the provisional data to BA, all diffusion tube results continued to be re-scaled, using 'monthly' factors, derived from only the LHR2 co-location site. However, it should be noted that this is not the recommended approach for deriving the final concentrations, as detailed in the Defra Technical Guidance document.

Diffusion tube samplers are an indicative method of measurement. In terms of the EC Directive for NO_2 concentrations, indicative methods of measurement should be accurate to ±25%. The monitoring of NO_2 at the two automated sites was undertaken using a chemiluminescence analyser, which is defined as the European Union (EU) reference method of monitoring. Under the Directive, this reference method is required to have an accuracy of ±15%.

From the co-location data and assuming an ideal analyser the uncertainty associated with the bias corrected NO_2 concentration ranges from ±6% to ±8%.

Table 1 shows a summary of the exposure dates for the contract period and also the final two periods of 2005, relevant to the calculation of 2005 annual mean NO_2 concentrations.

Table 1: Summary of Diffusion Tube Exposure Periods

Overall Period	Diffusion Tube Exposure Dates
25	2 Nov. to 30 Nov. 2004
26	30 Nov. to 4 Jan. 2005
27	4 Jan. to 1 Feb. 2005
28	1 Feb. to 1 Mar. 2005
29	1 Mar. to 31 Mar. 2005
30	31 Mar. to 3 May 2005
31	3 May to 31 May 2005
32	31 May to 28 Jun. 2005
33	28 Jun. to 2 Aug 2005
34	2 Aug. to 30 Aug. 2005
35	30 Aug. to 4 Oct. 2005
36	4 Oct. to 1 Nov. 2005
37	1 Nov. to 29 Nov. 2005
38	29 Nov. to 3rJan. 2006

2.2 MONITORING LOCATIONS

For the 2004 to 2005 survey, the eight previously selected monitoring locations have been retained. The only addition has been the Hillingdon AURN station, included as a second co-location site. The tube-only sites are all located in the residential areas to the North east of the airport and are listed in Table 2. This also shows details of the LHR2 and Hillingdon AURN sites. Table 2 and Figure 2 summarise the continuing diffusion tube exposure locations.

The tubes were supported in aluminium blocks, fixed at a height of approximately 2 metres, where possible and using street-furniture or other available supports. Due to access and safety reasons, the Hillingdon tubes were not ideally positioned, being close to the wall of the monitoring hut.

Table 2: Monitoring Locations

Site	Easting	Northing	Comment
Shepiston Lane	508582	178453	Close to M4 motorway
Imperial College 1	508270	177831	Opposite sports ground
Harlington foot path	508030	177670	On f/p in centre of field
West End Lane	508455	177383	
Boltons Lane	508014	177147	
Cheviot Close	508728	177124	
Neptune Road	508496	176869	North of Northern perimeter
LHR2 *	508382	176749	Close to perimeter fence
Hillingdon AURN	506933	178607	Residential but close to M4.

* Denotes airside continuous monitoring trailer with co-located NO_2 tubes. The co-ordinates are indicative and reported to an accuracy of ±10 metres based on the operating instructions of the GPS system used at each of the sites.

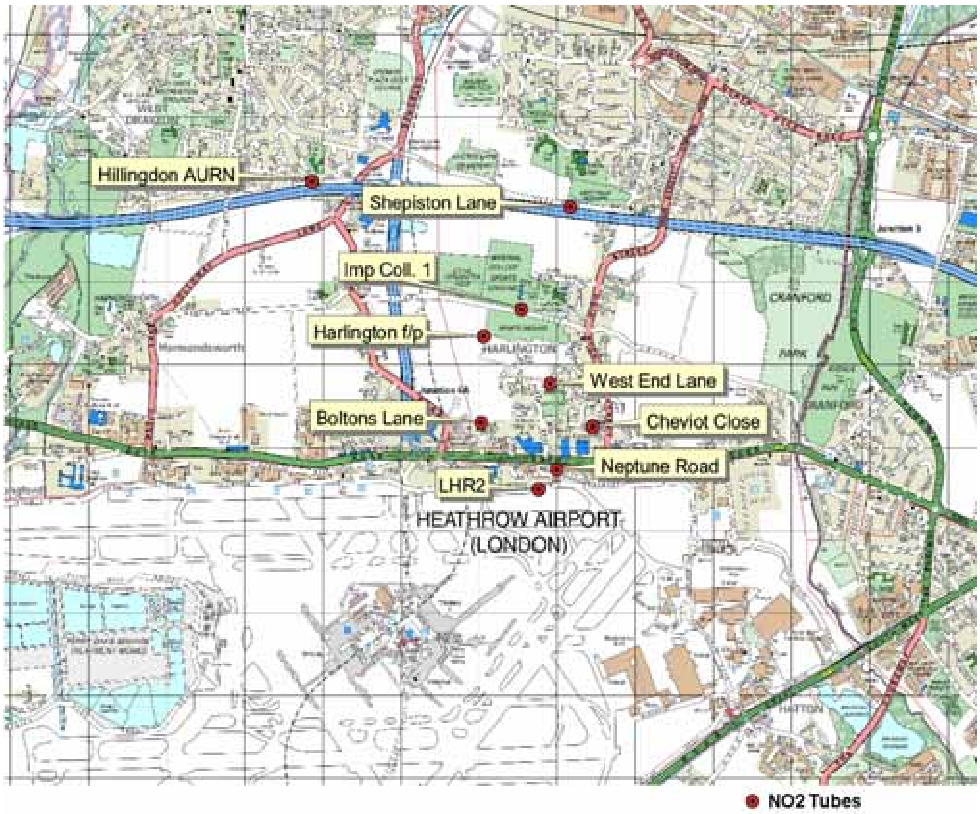

Figure 2: Geographic Representation of the NO_2 Diffusion Tube Monitoring sites Used in the 2004/05 Survey

3 Results

Throughout the 2004 to 2005 survey period, results from the non-exposed ‘blank’ tubes were consistently low for legitimate tubes (i.e. where no obvious defect was apparent e.g. split cap) typically being close to the limit of detection. Therefore, no blank-adjustment, to the analytical results, was required.

There were no instances of split end caps, evident on exposed tubes, throughout the period November 2004 to November 2005, when returned to AEAT prior to analysis.

3.1 DIFFUSION TUBES - BIAS ADJUSTMENT

The bias correction factors have been calculated following the Technical Guidance LAQM.TG (03) by which the average of the chemiluminescence results are compared to the average of the diffusion tube results from the co-location sites.

In order to maintain continuity with previous Heathrow diffusion tube monitoring results, the LHR2 continuous monitoring site was retained as the primary co-location site for the 2004-05 contract-period. Triplicate NO_2 tubes were exposed here in order to calculate the bias adjustment factors. These have been applied to the 12-month mean and 2005 annual mean concentrations, quoted within this report.

Previous tube monitoring at LHR2, had indicated higher than expected period mean tube concentrations, compared to the mean chemiluminescence concentrations from equivalent periods. This may indicate the influence of an, as yet, unconfirmed factor, possibly the exposed nature of the tube-sampling site, being subjected to interference from wind. The proximity of both the northern perimeter road and runway may also be relevant. Consequently, the bias adjustment factors obtained from LHR2 from previous monitoring periods (i.e. chemiluminescence mean concentration divided by the diffusion tube mean concentration) have been lower than might have been anticipated, at approximately 0.6. Applying this to the mean diffusion tube concentration from each of the other sites may result in an over-correction.

In order to assess any possible over-correction, a second co-location site, was included for the 2004-05 contract-period. As indicated previously, this was at the Hillingdon AURN site, located a short distance away. The results from this additional site are presented in Appendix C. The NO_2 data capture from the LHR2 automatic station was:

- 12 month contract period = 98.3%.
- 2005 monitoring period = 97.4%.

As with the 2003 to 2004 annual report, the final dataset for this report has been compiled using the Netcen NO_2 diffusion tube precision accuracy bias spreadsheet[5]. This is available on the Defra Air Quality website[5], as a standardised means of calculating the final data sets from NO_2 diffusion tube surveys in the U.K. The spreadsheet calculates annual or 12-month bias adjustment factors from the co-location-site data.

The spreadsheet did not screen diffusion tube data for outliers but was set to exclude data from the bias calculation if the coefficient of variance of the triplicate set was 20% or greater (this is an option within the spreadsheet). It will also exclude any data from a period where the comparative reference sampler data capture was below 75%. This condition was not applicable for the dataset under review.

This approach was similar to that used in the 2004 Report but differs slightly from that used in the previous 2003 report, where outlier-identification was achieved via the application of the Dixons Q test when the C.o.V. was above 10%. The current method accepts all triplicate data with a C.o.V below 20% irrespective of the fact that the data may fail the Q-test.

An introduction to the new spreadsheet is given in Appendix D. Table 3 shows the LHR2 diffusion tube and continuous analyser data used for the 2004-05 bias adjustment calculations.

Table 3: NO_2 Data from the Co-Location Site at LHR2

Overall Period	Tube 1 ($\mu g.m^{-3}$)	Tube 2 ($\mu g.m^{-3}$)	Tube 3 ($\mu g.m^{-3}$)	Mean (S) ($\mu g.m^{-3}$)	CoV (%)	Precision Check	Analyser ($\mu g.m^{-3}$)	Data Capture (%)	Data Ratification Status
25	93	106	103	101 (6.8)	6.8	Good	58	99.3	R
26	122	88	117	109 (18)	17	Good	63	98.7	R
27	109	102	150	120 (26)	22†	Poor	54	99.7	R
28	90	92	89	90 (1.4)	1.5	Good	57	99.1	R
29	105	91	108	101 (9.2)	9.1	Good	62	91.4	R
30	70	90	85	82 (10)	13	Good	53	98.0	R
31	66	75	59	67 (7.8)	12	Good	47	96.4	R
32	78	87	86	83 (5.1)	6.2	Good	51	99.6	R
33	80	84	68	77 (8.5)	11	Good	48	99.5	R
34	76	69	70	72 (3.8)	5.2	Good	46	99.6	R
35	84	112	95	97 (14)	15	Good	54	99.5	R
36	104	109	85	99 (13)	13	Good	51	98.5	R
37	112	111	115	113 (2.4)	2.1	Good	62	89.4	R
38	85	102	92	93 (9.0)	9.7	Good	58	98.3	R

S – Standard Deviation. R – Fully ratified automatic data. † The monthly tube results not used in the calculation of the 12-month bias correction factor

The bias adjustment factor obtained from the LHR2 co-location study, for the monitoring period of November 2004 to November 2005 was 0.614 (compares to 0.602 for the 2003-04 period). The equivalent bias adjustment factor for the 2005 annual mean period was 0.615.

3.2 DIFFUSION TUBE RESULTS – DATA HANDLING

In order to maximise the benefits of all the available data, the compilation of this report was deferred until all the diffusion tube measurement results were available for 2005 and the LHR2 data had been ratified for this period. This has enabled the calculation of 2005 bias adjusted annual mean concentrations, which will also enable the comparison of the data with the Objectives and Limit Values for NO_2 and results from other long-term NO_2 diffusion tube surveys, which are typically reported as annual mean concentrations, and other continuous monitoring sites.

All individual monthly NO_2 diffusion tube results are given in Appendix B. The mean, standard deviation and coefficient of variation (CoV) for each monthly set have been calculated. The final data was calculated using the Defra Technical Guidance procedures.
The bias-adjusted 12-month mean NO_2 concentrations from the diffusion tubes, exposed at each location, are shown in Table 4, which also shows the 95% confidence interval associated with each concentration.

As a result, it was inappropriate, to apply a mean of either just the '12-month' or '2005' factors, in order to recalculate a final data set. Hence, bias adjusted concentrations are presented using results from each period of sampling.

3.3 NO_2 DIFFUSION TUBE RESULTS (2/11/2004 TO 1/11/2005)

Table 4 and Figure 3 present NO_2 results for the monitoring period 2 November 2004 to 1 November 2005. The table contains the actual means and the bias adjusted mean NO_2 concentrations.

Where the individual monthly triplicate diffusion tube data for a site had a coefficient of variance greater than 20% the monthly mean was excluded from the monitoring period/annual mean calculations. Table 5 gives the number of months excluded from the calculation due to this for each site.

Table 4: 12-Month Mean NO_2 Concentrations (November 2004 – November 2005)

Site	NAEI† Predicted 2005 NO_2 Background ($\mu g.m^{-3}$)	Unadjusted Mean NO_2 ($\mu g.m^{-3}$)	LHR2 adjusted mean NO_2 ($\mu g.m^{-3}$)
Shepiston Lane	32	88	54 ± 3
Imperial College 1	35	58	36 ± 2
Harlington Footpath	35	65	40 ± 3
West End Lane	35	61	37 ± 2
Boltons Lane	35	53	32 ± 2
Cheviot Close	35	58	36 ± 2
Neptune Road	39	89	55 ± 3
LHR2	39	89	55 ± 4
Hillingdon AURN	30	56	34 ± 2
Bias factor applied	-	-	0.614

† predicted background levels from the National Atmospheric Emissions Inventory (NAEI) for 2005.

The LHR2, Neptune Road and Shepiston Lane sites are close by some of the major roads in the UK. The annual NO_2 levels at these sites (adjusted to LHR2) at 54-55 $\mu g.m^{-3}$ are higher than the levels at the other sites, which are set back further from the major carriageways. The NO_2 levels at the other sites range from 32 $\mu g.m^{-3}$ to 40 $\mu g.m^{-3}$ using the LHR2 co-location bias.

There was no evidence of any defined concentration gradient along the transept of sites. However, the sites set back from the major roads have lower levels than the three sites close by main roads.

The predicted background levels from the NAEI are calculated from measured ambient data and knowledge of major sources. These concentrations from the NAEI maps were produced to indicate what the background level of NO_2 was in 2005 at sites with no other local influence, essentially the baseline for the area. It was interesting to note that there was actually a good comparison between some of the sites corrected for the LHR2 bias and the predicted background, apart from the three sites with the highest levels (and closest to the major thoroughfares).

Table 5: Triplicate Tube Mean Concentrations Excluded For C.o.V. >20%.

Site	Excluded Monthly-Means Nov 04 to Dec 05	Site	Excluded Monthly-Means Nov 04 to Dec 05
Shepiston Lane	1	Cheviot Close	0
Imperial College 1	2	Neptune Road	1
Harlington Footpath	1	LHR2	1
West End Lane	1†	Hillingdon AURN	0
Boltons Lane	0		

†The West End Lane lost a further period of measurement due to theft of the diffusion tubes.

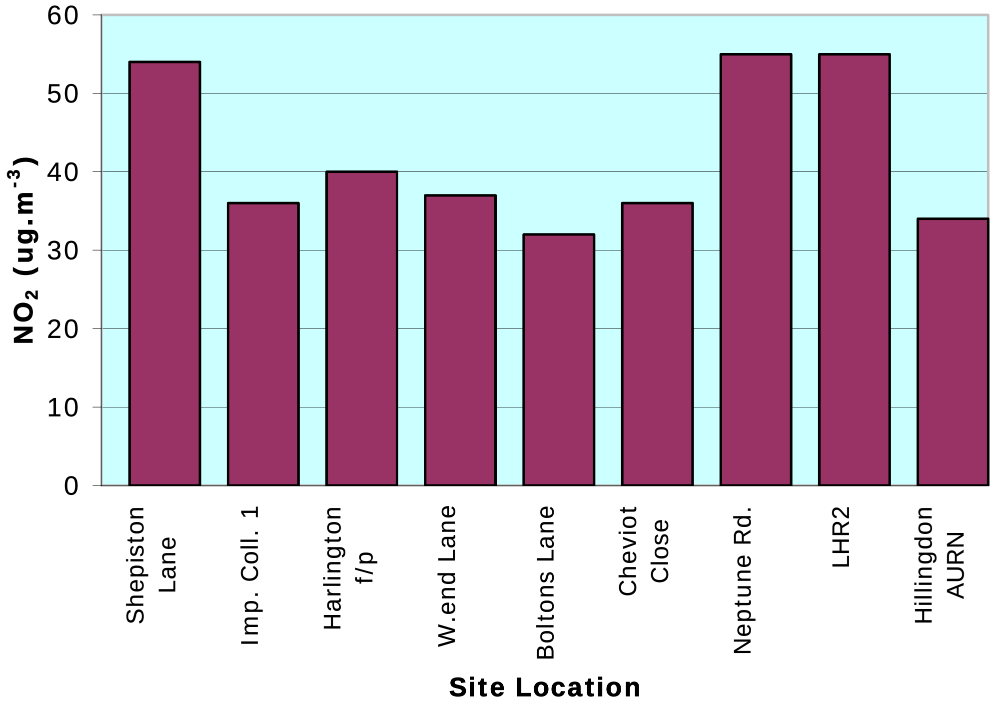

Figure 3: Bias-Adjusted Mean NO_2 Concentrations Using The LHR2 2004-05 Adjustment Factors

3.4 COMPARISON OF THE LHR2-DERIVED DATA FROM THE PREVIOUS THREE CONTRACT PERIODS

Nitrogen dioxide diffusion tube sampling has been undertaken at the current eight Heathrow locations for some years. This enables the bias adjusted results (via the historic LHR2 co-location data) from the last three contract periods to be reviewed.

Table 6 and Figure 4 show the comparison between the LHR2 bias-adjusted concentrations, from the last three contract-periods.

Table 6: LHR2 Bias Adjustment, 12-Month Mean NO_2 Concentrations

Site	Bias adjusted 12-month mean from the 2004 to 2005 survey ($\mu g.m^{-3}$)	Bias adjusted 12-month mean from the 2003 to 2004 survey ($\mu g.m^{-3}$)	Bias adjusted 12-month mean from the 2002 to 2003 survey ($\mu g.m^{-3}$)
Shepiston Lane	54	54	56
Imperial College 1	36	37	36
Harlington Footpath	40	40	39
West End Lane	37	38	40
Boltons Lane	32	34	35
Cheviot Close	36	35	36
Neptune Road	55	57	59
LHR2	55	57	57

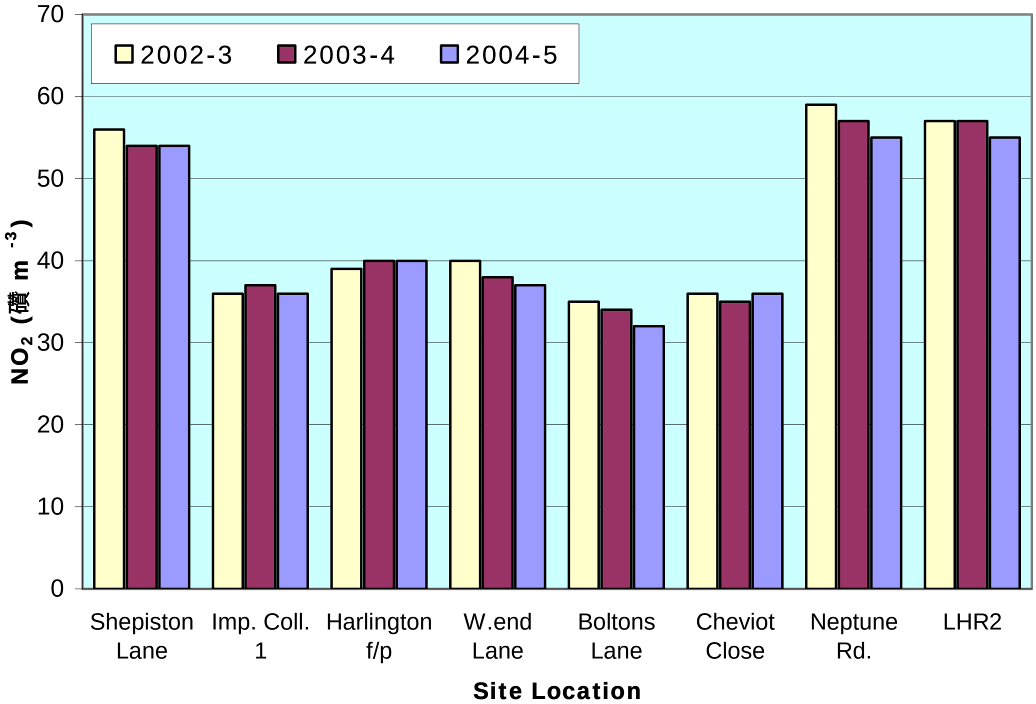

Figure 4: Plot of LHR2 Bias-Adjusted Mean NO_2 Concentrations

Figure 4 demonstrates that the bias adjusted concentrations from the 2004-05 period, are consistent with those from the previous two 12-month monitoring periods.

Many of the sampling locations continue to show a slight reduction in NO_2 concentration, for the 2004-05 results. However, the apparent reduction was small, compared to the general uncertainty associated with the monitoring technique. Therefore, in order to assess possible trends, monitoring over a longer period would be required.

3.5 COMPARISON OF 2005 ANNUAL MEAN NO_2 LEVELS

There was no substantial difference between the November to November levels (Table 4) and the 2005 annual means in Table 7. The bias adjustments were calculated from concurrent data at the two co-location sites and hence there was a margin of difference between the 2004-05 factors used in Table 4 and the 2005 factors used in Table 7. The data in Table 7 is shown graphically in Figure 5.

Table 7: Bias-Corrected Mean NO_2 Concentrations (4 January 2005 to 3 January 2006)

Site	NAEI† Predicted 2005 NO_2 Background ($\mu g.m^{-3}$)	Unadjusted Mean NO_2 ($\mu g.m^{-3}$)	LHR2 adjusted mean NO_2 ($\mu g.m^{-3}$)
Shepiston Lane	32	88	54 ± 4
Imperial College 1	35	59	36 ± 2
Harlington Footpath	35	64	39 ± 3
West End Lane	35	60	37 ± 2
Boltons Lane	35	53	33 ± 2
Cheviot Close	35	58	36 ± 2
Neptune Road	39	92	57 ± 4
LHR2	39	89	54 ± 4
Hillingdon AURN	30	56	34 ± 2
Bias factor applied	-	-	0.615

† Predicted background levels from the National Atmospheric Emissions Inventory (NAEI) for 2005.

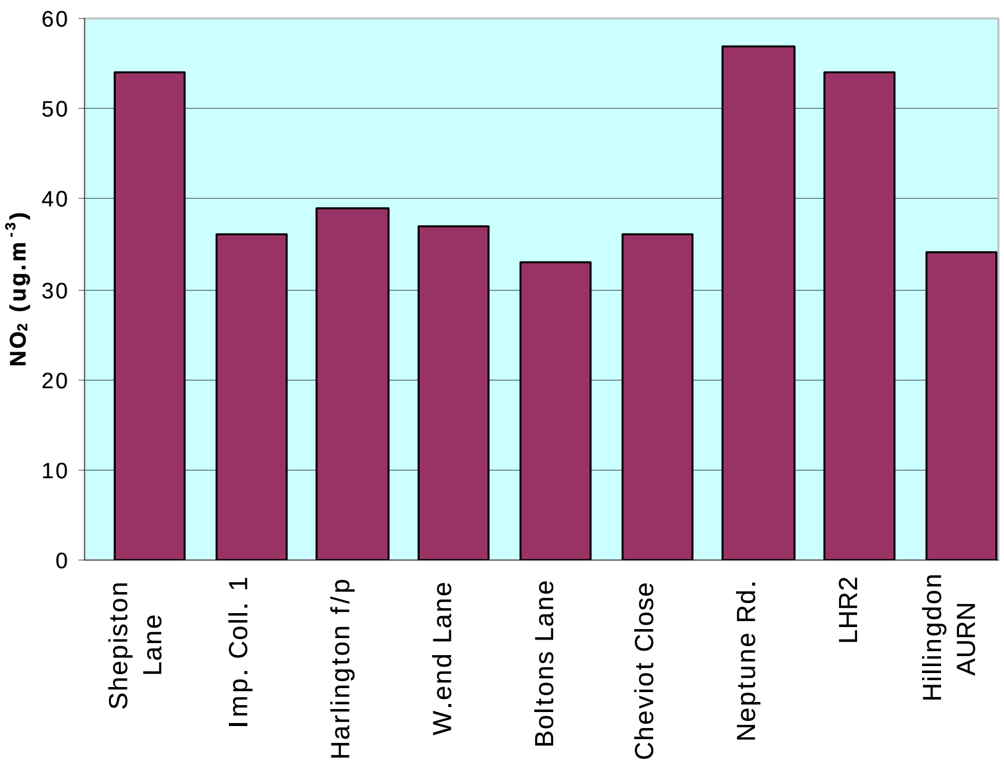

Figure 5: Bias Adjusted Annual Mean NO_2 Concentrations for 2005 Calculated Using LHR2 Bias Factor

The availability of the November and December 2005 tube results enabled the calculation of full 2005 annual mean NO_2 concentrations from both LHR2 automatic data and the diffusion tube locations in the survey. These concentrations can be readily compared with annual mean NO_2 levels from other sources.

The London Hillingdon continuous monitoring site was located in a suburban area, which borders the M4 Motorway, to the north of the airport. It shows a 2005 chemiluminescence annual mean NO_2 concentration of 45 $\mu g.m^{-3}$, approximately half way between the lower and upper groupings of tube-exposure locations, used in this Heathrow study, which display values in the mid 30's and mid 50's $\mu g.m^{-3}$, respectively.

The London' Marylebone Road continuous monitoring station, located on the kerbside of the busy 6-lane urban highway opposite Madame Tussauds, recorded an annual mean NO_2 concentration of 112 $\mu g.m^{-3}$, twice that of the highest mean levels from Heathrow.

The London' North Kensington continuous monitoring station was classified as an urban background site. The 2005 annual mean NO_2 concentration, from the site NO_2 monitor, was 40 $\mu g.m^{-3}$. This was slightly lower than the equivalent Hillingdon annual mean, which was 45 $\mu g.m^{-3}$ and very similar to the London Harlington annual mean of 38 $\mu g.m^{-3}$.

Table 8 shows the 2005 annual mean chemiluminescence NO_2 concentrations from the automatic Heathrow sites and a selection of AURN air quality monitoring stations.

Table 8: Annual Mean NO_2 Concentrations (2005) at Selected AURN Sites

Monitoring site	Location	2005 annual mean NO_2 concentrations ($\mu g.m^{-3}$)
Heathrow LHR2	10m airside of the Northern Perimeter Road at Heathrow Airport	54 (98% data capture)
Harlington AURN	Just south of the Imperial College sports training ground	38 (99% data capture)
London Hillingdon	A suburban site approximately 30m from the M4 in Hillingdon	45 (94% data capture)
London N. Kensington	An urban background location	40 (96% data capture)
London Marylebone Rd	Kerbside of Marylebone Road – a 6-lane urban highway	112 (98% data capture)

The NO_2 concentration for each site in Table 8 was calculated from Chemiluminescent NO_2 data, from the period 4 January 2005 to 3 January 2006 (equivalent to the Heathrow diffusion tube exposure period, covering 2005).

The data was fully ratified up to 1 October 2005 for all except LHR2, which was ratified up to end of 31 December 2005.

3.6 LIKELIHOOD OF AIR QUALITY OBJECTIVE AND LIMIT VALUE EXCEEDENCES

Appendix E shows a summary of the Air Quality Objectives and Limit Values associated with NO_2 monitoring. The relevant Objective is the 40 $\mu g.m^{-3}$ level for nitrogen dioxide, equivalent to 21 ppb and measured as an annual mean (calendar year) concentration. This objective was to be achieved by 31 December 2005. Further, the Air Quality Limit Value Regulations 2003 set a limit value for NO_2 of 40 $\mu g.m^{-3}$ to be achieved by

1 January 2010. For 2005, the limit value contains a 10 µg.m^{-3} margin of tolerance. There is a subtle difference between the Objective and the Limit Value, which may be significant for installations under IPPC.

From the diffusion tube monitoring undertaken over the last few years, the likelihood of the bias adjusted NO_2 concentrations, at the majority of sampled locations, exceeding the 40µg m^{-3} Objective level, appeared low. Using the LHR2 bias adjustment factors, the only two tube-only locations, which appeared to consistently indicate likely exceedances, were and remain, Neptune Road and Shepiston Lane. However, with the possibility that the LHR2 bias adjustment may be over-correcting the tube results, these findings may require revision.

The bias adjusted concentrations resulting from the Hillingdon co-location site, were higher than those from the historical LHR2 site. However, there is generally good agreement between these LHR2-derived concentrations and the National Atmospheric Emissions Inventory (NAEI) predicted 2005 NO_2 background concentrations for the Heathrow tube-monitoring locations.

Hence, without further evidence to support the use of one or other co-location factor, or an explanation as to the substantial difference, it was also difficult to substantiate the use of a mean factor derived from the combination of data from the two co-location sites. However, an average NO_2 level was calculated and included in the tables presented in Appendix C, which reviews the Hillingdon co-location data.

The diffusion tube method was indicative and may be used to provide an indication of relative levels over a wider area and as such, the larger overall uncertainty over the measurement should be taken into consideration. The assessment of the precision of the triplicate tubes at the co-location sites showed an uncertainty of ±6% assuming that the reference analyser was ideal. Since there will be an uncertainty with the measurement by the reference analyser, the overall measurement uncertainty will be between ± 15% (given for the reference system) and the ±25% target uncertainty for the manual method.

3.7 METEOROLOGICAL ANALYSIS OF 2004-05 DATA

Wind and pollution rose analysis plots are traditionally used in order to make an assessment of likely pollution sources. However, due to the extended exposure-periods of approximately one month, detailed meteorological examination was not possible and mean wind direction analysis therefore gives an overview of the situation, over a 12-month period. The meteorological and NO_2 data used in this section has been obtained from the LHR2 continuous monitoring trailer.

The following figures are aligned such that the top of each ‘rose’ is north. Each is divided into segments of 22.5 degrees each.

The inner and outer rings, on the NO_2 plots, indicate concentrations of 40 and 90 µg.m^{-3}, respectively. On the wind speed plots, the same rings indicate 3 m/s and 6 m/s, respectively.

Figures 6 and 8 show wind rose analysis plots of mean NO_2 concentration against mean wind direction. They confirm that over the two overlapping 12-month periods of diffusion tube monitoring; the highest mean NO_2 concentrations occurred when the wind direction was from the north east and to a lesser extent the south west.

Figures 7 and 9 show wind rose analysis plots of mean wind speed against mean wind direction, for the two over lapping periods. These confirm that the highest wind speeds occur from the south west.
There continues to be a fairly even spread of mean concentrations from directions other than from those described above. In general, the slightly lower mean concentrations observed at the Heathrow monitoring locations, during the 2003-04 period, may be attributable to the prevailing meteorology. It was accepted that the extended period of hot, sunny weather during the summer of 2003, produced elevated concentrations of pollution[6]. This elevation was reflected in the annual mean concentrations for that year.

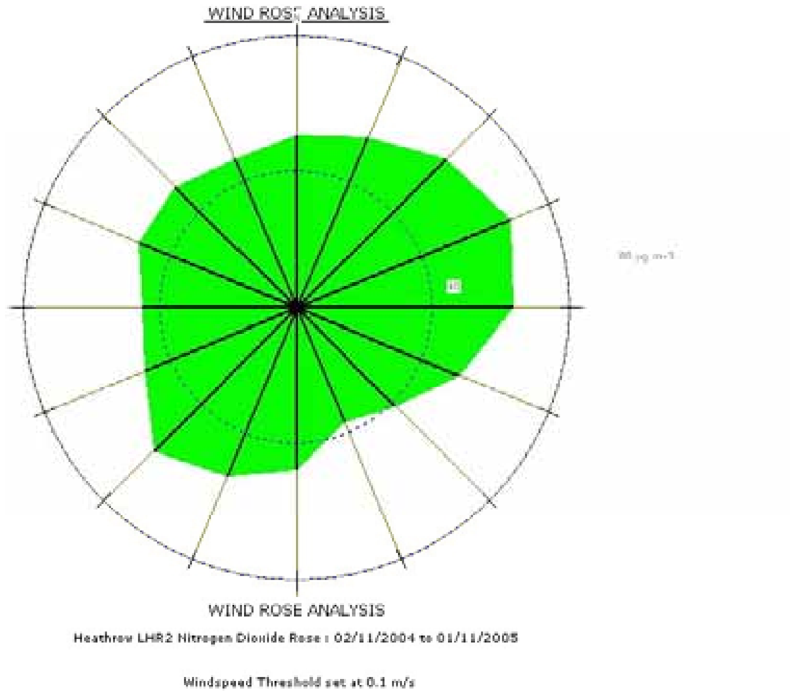

Figure 6: LHR2 NO_2 vs Wind Direction Analysis for the Period 02/11/04 To 01/11/05 (Produced from data standardised to 20^o C and 1013 mb)

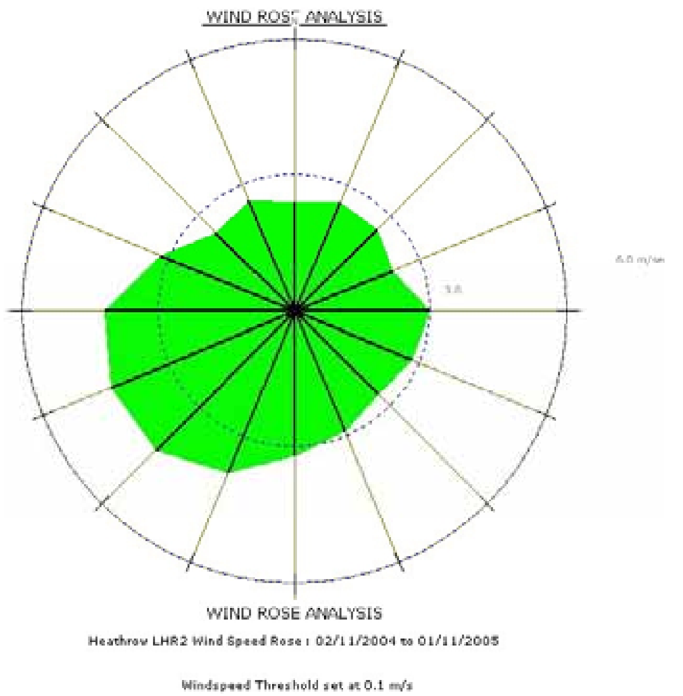

Figure 7: LHR2 Wind Speed vs Wind Direction Analysis for the Period 02/11/04 To 01/11/05 (Produced from data standardised to 20^{o} C and 1013 mb)

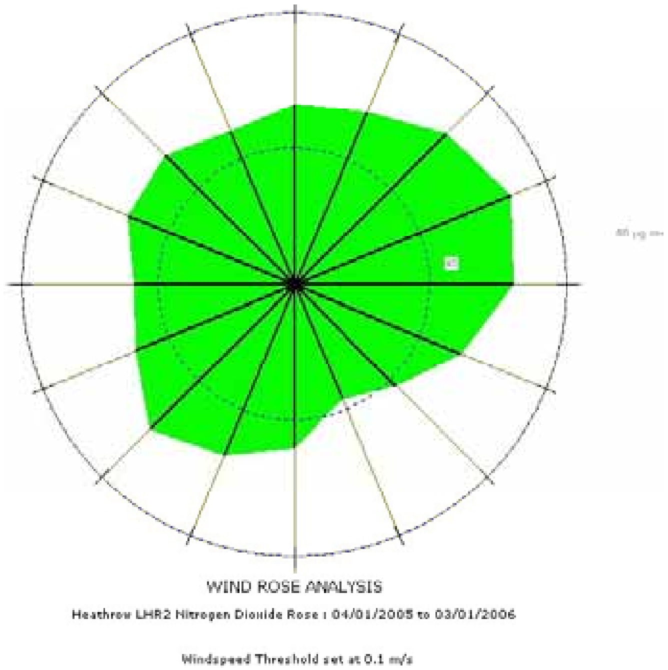

Figure 8: LHR2 NO_2 vs Wind Direction Analysis for the Period 04/01/05 To 03/01/06 (Produced from data standardised to 20^{o} C and 1013 mb)

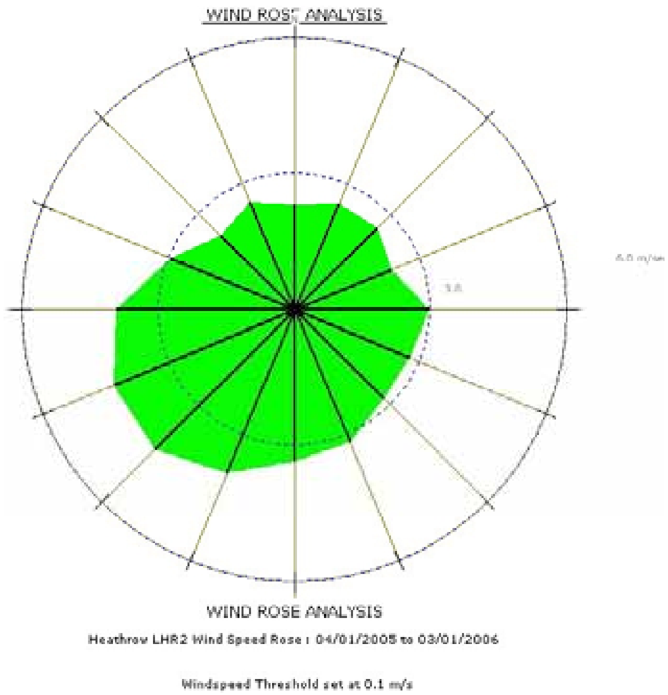

Figure 9: LHR2 Wind Speed vs Wind Direction Analysis for the Period 04/01/05 To 03/01/06 (Produced from data standardised to 20^{o} C and 1013 mb)

4 Conclusions

The main body of text within this report has been compiled using data from the historical LHR2 co-location site. The bias adjusted, mean NO_2 concentrations from the 2004-05 and 2005 annual mean periods indicate the following:

- Concentrations, at each Heathrow location, remain consistent with those from the 2002-03 and 2003-04 surveys. The concentration-profile across the eight sites continues to remain virtually unchanged.

- The LHR2-derived 2005 bias adjusted NO_2 concentrations appear relatively well aligned with NAEI predicted 2005 background concentrations. This is particularly evident at the tube locations away from the busier main roads.

- Using the LHR2 bias adjustment factors, the only locations that are likely to exceed the 40 $\mu g.m^{-3}$ NO_2 Objective are the Neptune Road and Shepiston Road sites.

- Due to access and operator safety implications, the siting of the Hillingdon tubes was not ideal, being close to the wall of the northern side of the hut.

- Applying the Hillingdon bias adjustment factors, result in a less severe correction which produced higher mean concentrations and the likelihood that all the tube-monitoring locations would exceed the 40 $\mu g.m^{-3}$ Objective / Limit Value level.

- Until possible reasons for the differing bias correction factors have been further investigated, it was inappropriate to simply recalculate the 12-month and annual mean concentrations, by applying a single factor produced from the average of those derived from the two co-location sites. The Hillingdon results are presented in Appendix C.

- In order to further investigate the possibility that the higher diffusion tube concentrations at LHR2 are the result of wind-effect, it is recommended that additional NO_2 diffusion tubes are exposed at this site. These would be fitted with an open-weave gauze, in-order to reduce the effect of higher wind speeds on the, normally, open end of the tube. The results from this additional monitoring will assist in the interpretation of the 2006 data.

5 References

1. Extended Investigation of Air Pollution from Transport Operations at Heathrow Airport. February 2004. Report Reference. AEAT/ENV/R/1662/Draft A.

2. A Continued Investigation of Air Pollution in The vicinity of Heathrow Airport. October 2003 to October 2004. AEAT/ENV/R/1898/ISSUE1.

3. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISDN 0-100-145482 + Addendum 2003, Ref. PB7874.

4. Technical Guidance document LAQM TG(03). Product code PB7514 ISBN code0-85521-021-4.

5. The Netcen Diffusion Tube precision Accuracy and Bias calculation spreadsheet can be found at http://www.airquality.co.uk/archive/tools/netcen_DifTPAB_v01.xls

6. Defra Air Quality website, Air Quality Headline Indicator, H10, at http://www.sustainable-development.gov.uk/indicators/headline/h10.htm

Appendices

CONTENTS

Appendix A
NO_2 Diffusion Tube Method

A.1 The NO_2 Diffusion Tube

Passive sampling involves the collection of air pollutants using an absorbing material without the use of pumps; hence, no power supply is required. This makes these samplers very easy to deploy and flexible in terms of siting.

A passive sampler for gaseous species is defined as a device which is capable of sampling gas or vapour pollutants from the atmosphere, at a rate controlled by a physical process such as diffusion through a static layer or permeation through a membrane, but which does not involve the active movement of air through the sampler.

Samplers are available for a wide range of pollutant species. The NO_2, SO_2, NH_3 and O_3 diffusion tubes supplied by AEA Technology are based on the work of Palmes, and consist of a cylindrical plastic tube, approximately 71 mm long and 11 mm in diameter. During sampling, one end is open and the other end holds an absorbent for the gaseous species to be monitored.

The basic principle on which diffusion tube samplers operate is that of molecular diffusion, with molecules of a gas diffusing from a region of high concentration (open end of the sampler) to a region of low concentration (absorber end of the sampler). The movement of molecules of gas (1) through gas (2) is governed by Fick's law, which states that the flux is proportional to the concentration gradient:

$$J = -D_{12}\frac{dc}{dz} \qquad (1)$$

Where:

- J = the flux of gas (1) through gas (2) across unit area in the Z direction ($\mu g/m^2/s$);
- c = the concentration of gas (1) in gas (2) ($\mu g\ m^{-3}$);
- z = the length of the diffusion path (m); and
- D_{12} = the molecular diffusion coefficient of gas (1) in gas (2) (m^2/s).

For a cylinder of cross-sectional area **a** (m^2) and length **l** (m), then **Q** (μg) the quantity of gas transferred along the tube in **t** seconds (taken as the quantity of gas absorbed during **t**) is given by:

$$Q = \frac{D_{12}(C_1 - C_o)at}{l} \qquad (2)$$

Where: C_o and C_1 are the gas concentrations at either end of the tube.

In a diffusion tube, the concentration of gas (1) is maintained at zero by an efficient absorber at one end of the tube (i.e. C_o = zero) and the concentration C_1 is the average concentration of the gas (1) at the open end of the tube over the period of exposure. Hence:

$$C = \frac{Ql}{D_{12}at} \qquad (3)$$

The diffusion coefficient for the gas to be monitored must be determined, or obtained from the literature. A best estimate of the area and length of a typical tube must be determined by measurement using Vernier callipers. Nominal tube dimensions are set at 11mm (diameter) and 71mm (length). The gas concentration C, can be readily derived from the quantity of gas absorbed Q, (assessed by desorption & chemical analysis of the tube), and the exposure time t.

A.2 Analysis of the NO_2 Diffusion Tube

The current NO_2 diffusion tube was of the Palmes design, with a cap containing woven wire cloth grids coated in a 50:50 absorbing solution of triethanolamine[1] and acetone. During transportation, the other end of the tube had a protective end cap in place. The site operator removed this protective cap during the tube exposure on site.

After exposure, the analyst extracted NO_2 from the tubes using a known volume of deionised water. The extract was analysed using an automated colorimetric method (Bran and Luebbe Segmented flow Auto-analyser III with ultraviolet detection). The analyst used the concentration found in the extract, the exposure period and the diffusion coefficient to calculate the concentration of NO_2. There has been no correction made for the sample travel blanks in the results. The levels found in the travel blanks inform the user on the level of uncertainty in the result. The calculation used to determine the concentration of NO_2 was as follows:

$$\mu g.m^{-3} = \left(\frac{QL}{D_{NO2} At} \right)$$

(Referenced in AERE Report: AERE R 12133)

Where:

Q = Mass of nitrogen dioxide in sample (µg);
L = Length of diffusion path (m);
D = Diffusion coefficient for nitrogen dioxide ($m^2\ s^{-1}$);
A = Tube area (m^2); and
t = Exposure time of tube (s).

Rearranging and simplifying this equation, gives:

$$\mu g.m^{-3} = 14088 \left(\frac{Q}{T} \right)$$

Where:

T = Exposure time of diffusion tube in hours.

It may also be useful to show the concentration in parts per billion (ppb) especially when comparing against older data. The conversion used was as follows:

ppb = $\mu g.m^{-3}$ x 0.52 (assuming 1 atm and 20^oC).

The analysis of nitrogen dioxide in the samples was within the scope of the Laboratory's UKAS accreditation. However, Harwell Scientifics UKAS accreditation does not cover the calculations and assessments of the exposure period, as these are factors are outside the control of the analyst.

The current limit of detection for NO_2 by the diffusion tube method was 0.03µg in the extracted solution. The method detection limit will depend on the length of exposure. Figure A1 shows the relationship between the method detection limit and exposure time.

[1] 2,2',2-Nitrilotriethanol trihydroxytriethylamine

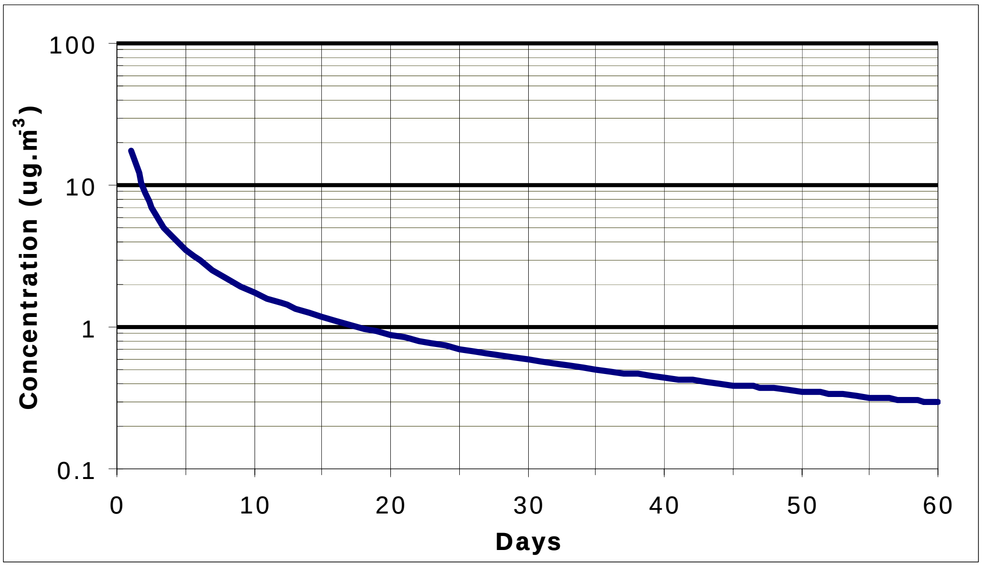

Figure A1: NO_2 Diffusion Tube Method Detection Limit

Appendix B
NO_2 Diffusion Tube-Individual Results

Table B1: Heathrow Transect Air Quality Monitoring, 2 Nov 2004 - 30 Nov 2004 (Period 25)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	101	95	90	95	5.6	5.9	GOOD
Imp Coll.1	75	68	71	71	3.5	4.9	GOOD
Harlington f/p	67	92	78	79	12	15	GOOD
West End Lane	65	78	67	70	6.8	10	GOOD
Boltons Lane	57	54	63	58	4.4	7.7	GOOD
Cheviot Close	62	66	64	64	2.3	3.6	GOOD
Neptune Rd	77	106	92	92	14	16	GOOD
LHR2	93	106	103	101	6.8	6.8	GOOD
Hillingdon AURN	60	63	62	62	1.6	2.5	GOOD

Table B2: Heathrow Transect Air Quality Monitoring, 30 Nov 2004 - 4 Jan 2005 (Period 26)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	85	101	87	91	8.5	9.4	GOOD
Imperial College 1	70	68	73	70	2.8	4.0	GOOD
Harlington f/p	70	85	73	76	7.9	10	GOOD
West End Lane	70	78	65	71	6.5	9.2	GOOD
Boltons Lane	68	53	68	63	8.3	13	GOOD
Cheviot Close	73	69	71	71	1.8	2.5	GOOD
Neptune Rd.	79	95	90	88	8.6	9.7	GOOD
LHR2	122	88	117	109	18	17	GOOD
Hillingdon AURN	52	61	63	59	5.6	9.6	GOOD

Table B3: Heathrow Transect Air Quality Monitoring, 4 Jan 2005 – 1 Feb 2005 (Period 27)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	76	104	83	88	15	17	GOOD
Imperial College 1	75	75	54	68	12	18	GOOD
Harlington f/p	78	86	63	75	12	15	GOOD
West End Lane	67	91	66	75	14	19	GOOD
Boltons Lane	59	60	54	58	3.3	5.7	GOOD
Cheviot Close	70	67	67	68	1.5	2.3	GOOD
Neptune Rd.	115	128	75	106	27	26[†]	POOR
LHR2	109	102	150	120	26	22[†]	POOR
Hillingdon AURN	44	48	57	50	6.7	13	GOOD

[†] Data has been omitted from the bias-adjustment calculation, where the C.O.V. was above 20%.

Table B4: Heathrow Transect Air Quality Monitoring, 1 Feb 2005 – 1 Mar 2005 (Period 28)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	53	81	83	73	17	24[†]	POOR
Imperial College 1	63	65	66	65	1.3	2.0	GOOD
Harlington f/p	48	65	60	58	8.9	15	GOOD
West End Lane	60	60	63	61	1.7	2.8	GOOD
Boltons Lane	54	54	38	49	9.2	19	GOOD
Cheviot Close	58	59	57	58	1.1	1.9	GOOD
Neptune Rd.	86	108	103	99	11	11	GOOD
LHR2	90	92	89	90	1.4	1.5	GOOD
Hillingdon AURN	50	54	52	52	2.0	3.8	GOOD

[†] Data has been omitted from the bias-adjustment calculation, where the C.O.V. was above 20%.

Table B5: Heathrow Transect Air Quality Monitoring, 1 Mar 2005 – 31 Mar. 2005 (Period 29)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	97	101	91	96	4.8	5.0	GOOD
Imperial College 1	71	42	72	62	17	28†	POOR
Harlington f/p	79	87	69	79	9.1	12	GOOD
West End Lane	68	72	68	69	2.0	2.9	GOOD
Boltons Lane	63	65	62	63	1.4	2.3	GOOD
Cheviot Close	58	52	61	57	4.8	8.3	GOOD
Neptune Rd.	104	110	108	107	3.3	3.1	GOOD
LHR2	105	91	108	101	9.2	9.1	GOOD
Hillingdon AURN	61	65	66	64	2.5	3.9	GOOD

† Data has been omitted from the bias-adjustment calculation, where the C.O.V. was above 20%.

Table B6: Heathrow Transect Air Quality Monitoring, 31 Mar 2005 – 3 May 2005 (Period 30)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	87	91	93	90	2.8	3.1	GOOD
Imperial College 1	61	61	57	60	2.2	3.7	GOOD
Harlington f/p	69	73	61	67	6.2	9.1	GOOD
West End Lane	57	66	64	62	4.5	7.2	GOOD
Boltons Lane	60	54	54	56	3.8	6.7	GOOD
Cheviot Close	60	67	46	58	11	19	GOOD
Neptune Rd.	78	91	93	88	8.4	10	GOOD
LHR2	70	90	85	82	10	13	GOOD
Hillingdon AURN	66	57	65	63	5.0	8.0	GOOD

Table B7: Heathrow Transect Air Quality Monitoring, 3 May 2005 – 31 May 2005 (Period 31)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	79	71	69	73	5.2	7.2	GOOD
Imperial College 1	35	43	42	40	4.0	10	GOOD
Harlington f/p	47	50	39	45	5.4	12	GOOD
West End Lane	38	43	42	41	3.0	7.3	GOOD
Boltons Lane	33	35	33	34	0.8	2.4	GOOD
Cheviot Close	44	50	42	45	4.2	9.3	GOOD
Neptune Rd.	77	89	72	80	8.9	11	GOOD
LHR2	66	75	59	67	7.8	12	GOOD
Hillingdon AURN	43	44	47	45	1.9	4.3	GOOD

Table B8: Heathrow Transect Air Quality Monitoring, 31 May 2005 – 28 June 2005 (Period 32)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	92	99	82	91	8.5	9.3	GOOD
Imperial College 1	49	50	45	48	2.8	5.8	GOOD
Harlington f/p	41	52	51	48	5.8	12	GOOD
West End Lane	47	53	50	50	2.8	5.6	GOOD
Boltons Lane	45	45	46	45	0.6	1.3	GOOD
Cheviot Close	52	54	52	53	1.4	2.6	GOOD
Neptune Rd.	86	85	79	83	3.9	4.7	GOOD
LHR2	78	87	86	83	5.1	6.2	GOOD
Hillingdon AURN	52	55	60	56	4.1	7.4	GOOD

Table B9: Heathrow Transect Air Quality Monitoring, 28 June 2005 – 2 Aug 2005 (Period 33)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	86	82	80	83	2.8	3.4	GOOD
Imperial College 1	47	45	46	46	0.8	1.6	GOOD
Harlington f/p	49	56	49	51	4.2	8.2	GOOD
West End Lane	45	51	49	49	3.0	6.1	GOOD
Boltons Lane	35	41	42	40	3.8	9.7	GOOD
Cheviot Close	44	49	47	47	2.5	5.3	GOOD
Neptune Rd.	84	80	83	82	2.2	2.7	GOOD
LHR2	80	84	68	77	8.5	11	GOOD
Hillingdon AURN	40	39	47	42	4.1	9.8	GOOD

Table B10: Heathrow Transect Air Quality Monitoring, 2 August 2005 - 30 August 2005 (Period 34)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	77	74	69	73	4.2	5.8	GOOD
Imperial College 1	45	46	40	44	3.2	7.3	GOOD
Harlington f/p	49	67	54	57	9.5	17	GOOD
West End Lane	†	†	†	†	†	†	†
Boltons Lane	42	43	34	40	4.8	12	GOOD
Cheviot Close	46	48	48	48	1.0	2.2	GOOD
Neptune Rd.	70	74	76	74	3.0	4.0	GOOD
LHR2	76	69	70	72	3.8	5.3	GOOD
Hillingdon AURN	42	40	42	41	0.8	2.0	GOOD

† All tubes missing form the West End Lane at end of period.

Table B11: Heathrow Transect Air Quality Monitoring, 30 August 2005 - 4 October 2005 (Period 35)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	93	99	92	94	3.7	3.9	GOOD
Imperial College 1	66	57	58	60	5.1	8.4	GOOD
Harlington f/p	54	77	58	63	12	20	GOOD
West End Lane	57	56	56	56	0.5	0.8	GOOD
Boltons Lane	53	58	55	55	2.8	5.0	GOOD
Cheviot Close	61	59	62	61	1.4	2.3	GOOD
Neptune Rd.	95	98	96	96	1.9	2.0	GOOD
LHR2	84	112	95	97	14	15	GOOD
Hillingdon AURN	67	54	64	62	6.7	11	GOOD

Table B12: Heathrow Transect Air Quality Monitoring, 4 October 2005 – 1 November 2005 (Period 36)

Location	NO_2 Tube 1 (µg m^{-3})	NO_2 Tube 2 (µg m^{-3})	NO_2 Tube 3 (µg m^{-3})	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	100	88	98	95	6.2	6.5	GOOD
Imperial College 1	70	68	64	68	3.0	4.4	GOOD
Harlington f/p[2]	78	80	80	79	0.9	1.1	GOOD
West End Lane	60	70	63	64	4.9	7.6	GOOD
Boltons Lane[2]	73	75	67	72	3.9	5.4	GOOD
Cheviot Close	64	68	66	66	1.8	2.7	GOOD
Neptune Rd.	93	81	96	90	7.7	8.6	GOOD
LHR2	104	109	85	100	13	13	GOOD
Hillingdon AURN	78	76	72	75	2.8	3.8	GOOD

Table B13: Heathrow Transect Air Quality Monitoring, 1 November 2005 - 29 November 2005 (Period 37)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	95	103	92	97	5.5	5.7	GOOD
Imperial College 1	79	77	75	77	2.2	2.8	GOOD
Harlington f/p	70	98	80	83	14	17	GOOD
West End Lane	71	70	66	69	2.7	4.0	GOOD
Boltons Lane	62	66	64	64	2.3	3.5	GOOD
Cheviot Close	74	78	74	75	2.1	2.7	GOOD
Neptune Rd.	108	120	105	111	8.2	7.4	GOOD
LHR2	112	111	115	113	2.4	2.1	GOOD
Hillingdon AURN	62	52	62	59	6.0	10	GOOD

Table B14: Heathrow Transect Air Quality Monitoring, 29 November 2005 – 3 January 2006 (Period 38)

Location	NO_2 Tube 1 ($\mu g\ m^{-3}$)	NO_2 Tube 2 ($\mu g\ m^{-3}$)	NO_2 Tube 3 ($\mu g\ m^{-3}$)	Triplicate mean	Standard deviation	Coefficient of variation (%)	Tubes precision check
Shepiston Lane	66	99	93	86	18	21†	POOR
Imperial College 1	77	59	74	70	10	14	GOOD
Harlington f/p[2]	59	96	71	75	19	25†	POOR
West End Lane	64	69	46	59	12	21†	POOR
Boltons Lane[2]	62	64	60	62	1.9	3.1	GOOD
Cheviot Close	65	66	68	66	1.8	2.6	GOOD
Neptune Rd.	104	105	97	102	4.3	4.2	GOOD
LHR2	85	102	92	93	9	10	GOOD
Hillingdon AURN	64	63	61	63	1.3	2.0	GOOD

† Data has been omitted from the bias-adjustment calculation, where the C.O.V. was above 20%.

Table B15: Period-Mean Chemiluminescence NO2 Concentrations from Heathrow-Area and Selected AURN Sites - 02/11/2004 – 03/01/2006 (µg m^{-3})

Location	Period 25	Period 26	Period 27	Period 28	Period 29	Period 30	Period 31	Period 32	Period 33	Period 34	Period 35	Period 36	12-month mean	Period 37	Period 38	2005 annual mean
LHR2	58	63	54	57	62	53	47	51	48	46	54	51	54	62	58	54
Hillingdon	53	55	41	40	46	54	40	40	38	34	51	56	46	53	50	45
Harlington	45	46	36	42	44	41	29	33	30	32	39	42	38	47	44	38
N. Kensington	50	53	35	45	48	40	26	30	33	31	41	44	40	58	47	40
Marylebone Rd	119	121	101	93	105	129	100	109	102	97	133	127	111	124	118	112

The P36, 37 and 38 values for all sites, except LHR2, are from, as yet, unratified data sets. All other data was fully ratified.

All Chemiluminescence NO_2 concentrations are in µg m^{-3} at Standard Temperature/pressure of 1013 mb & 20 degrees Centigrade.

Appendix C
Review of data from Hillingdon co-location site

Hillingdon AURN (Source: Defra Site Information Archive http://www.stanger.co.uk/siteinfo/)

Figure C1: Photograph of the area surrounding the Hillingdon AURN air quality monitoring station. Passing the hut is a 'no-through' road

At the time of production of the report the fully ratified dataset for the Hillingdon AURN site was not available. The ratification of this site will be completed in early April.
The high data capture rates from the chemiluminescence NO_2 monitor, for the 2004-05 contract period and 2005 annual mean period, are shown below:

- Hillingdon AURN 12 month contract-period = 94.1%.
- Hillingdon AURN 2005 monitoring period = 93.5%.

Table C1: NO_2 Data from the Co-Location Site at Hillingdon

Overall Period	Tube 1 ($\mu g.m^{-3}$)	Tube 2 ($\mu g.m^{-3}$)	Tube 3 ($\mu g.m^{-3}$)	Mean ($\mu g.m^{-3}$)	CoV (%)	Precision Check	Analyser ($\mu g.m^{-3}$)	Data Capture (%)	Data Ratification Status
25	60	63	62	62 (1.6)	2.5	Good	53	98.5	R
26	52	61	63	59 (5.6)	10	Good	55	99.3	R
27	44	48	57	50 (6.7)	13	Good	41	91.4	R
28	50	54	52	52 (2.0)	3.8	Good	40	99.1	R
29	61	65	66	64 (2.5)	3.9	Good	46	99.0	R
30	66	57	65	63 (5.0)	8.0	Good	54	99.1	R
31	43	44	47	45 (1.9)	4.3	Good	40	84.4	R
32	52	55	60	55 (4.1)	7.4	Good	40	88.2	R
33	40	39	47	42 (4.1)	10	Good	40	93.2	R
34	42	40	42	41 (0.8)	2.0	Good	38	99.1	R
35	60	63	62	62 (1.6)	2.5	Good	34	81.2	R
36	52	61	63	59 (5.6)	10	Good	51	96.4	P
37	62	52	62	58 (6.0)	10	Good	53	91.8	P
38	64	63	61	63 (1.3)	2.0	Good	50	98.8	P

S – Standard Deviation. R – Fully ratified automatic data. P – Provisional data subject to change on full ratification

The bias adjustment factor obtained from the Hillingdon AURN co-location study, for the monitoring period of 2/11/2004 to 1/11/2005, was 0.829. The equivalent bias adjustment factor for the stated 2005 annual mean period was 0.821.

Table C2: Mean NO_2 Concentrations (November 2004 – November 2005)

Site	NAEI† Predicted 2005 NO_2 Background ($\mu g.m^{-3}$)	Unadjusted Mean NO_2 ($\mu g.m^{-3}$)	LHR2 adjusted mean NO_2 ($\mu g.m^{-3}$)	Hillingdon adjusted mean NO_2 ($\mu g.m^{-3}$)	'Average' adjusted mean NO_2 ($\mu g.m^{-3}$)
Shepiston Lane	32	88	54 ± 3	73 ± 5	64
Imperial College 1	35	58	36 ± 2	48 ± 3	42
Harlington Footpath	35	65	40 ± 3	54 ± 4	47
West End Lane	35	61	37 ± 2	50 ± 3	44
Boltons Lane	35	53	32 ± 2	44 ± 3	38
Cheviot Close	35	58	36 ± 2	48 ± 3	42
Neptune Road	39	89	55 ± 3	74 ± 5	65
LHR2	39	89	55 ± 4	74 ± 5	65
Hillingdon AURN	30	56	34 ± 2	46 ± 3	40
Bias factor applied	-	-	0.614	0.829	-

† predicted background levels from the National Atmospheric Emissions Inventory (NAEI) for 2005.

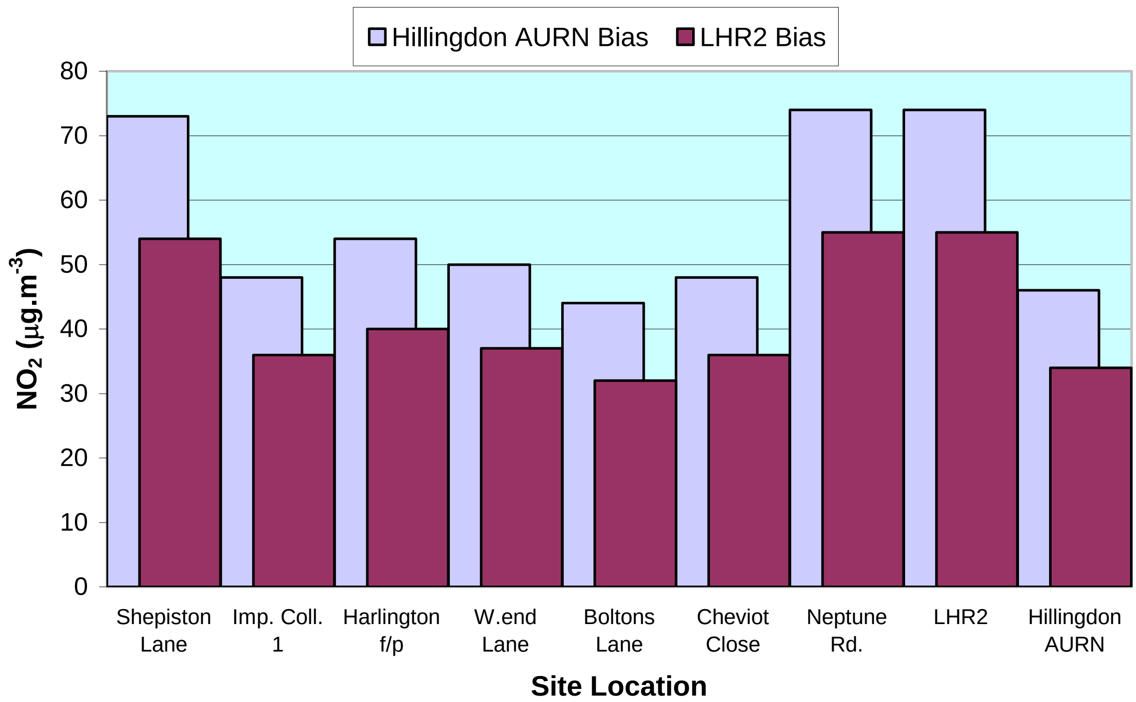

Figure C2: Bias-Adjusted Mean NO_2 Concentrations Using Both Co-location Sites, 2004-05 Adjustment Factors

The available Hillingdon data was fully ratified up to the end of September 2005, remaining 'provisional' for the period October to the end of December 2005.

Table C3: Bias-Corrected Mean NO_2 Concentrations (4 Jan. 2005 to 3 Jan. 2006)

Site	NAEI† Predicted 2005 NO_2 Background ($\mu g.m^{-3}$)	Unadjusted Mean NO_2 ($\mu g.m^{-3}$)	LHR2 adjusted mean NO_2 ($\mu g.m^{-3}$)	Hillingdon adjusted mean NO_2 ($\mu g.m^{-3}$)	'Average' adjusted mean NO_2 ($\mu g.m^{-3}$)
Shepiston Lane	32	88	54 ± 4	72 ± 5	63
Imperial College 1	35	59	36 ± 2	48 ± 3	42
Harlington Footpath	35	64	39 ± 3	53 ± 4	46
West End Lane	35	60	37 ± 2	49 ± 3	43
Boltons Lane	35	53	33 ± 2	44 ± 3	39
Cheviot Close	35	58	36 ± 2	48 ± 3	42
Neptune Road	39	92	57 ± 4	76 ± 5	67
LHR2	39	89	54 ± 4	73 ± 5	64
Hillingdon AURN	30	56	34 ± 2	46 ± 3	40
Bias factor applied	-	-	0.615	0.821	-

† Predicted background levels from the National Atmospheric Emissions Inventory (NAEI) for 2005.

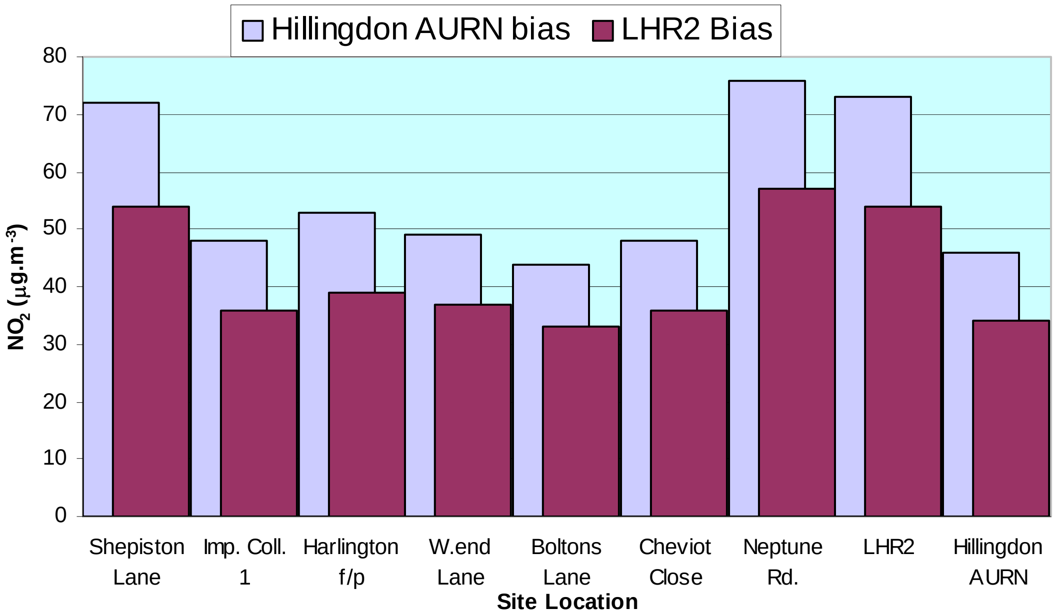

Figure C3: Bias Adjusted 2005 Annual Mean NO2 Concentrations Calculated Using Each Bias Factor

It was evident from the data that the mean levels of NO_2 resulting from the application of the Hillingdon bias adjustment factor are substantially higher than those derived from applying the LHR2 factor. This difference was due to the disparity in the levels of NO_2 measured by the diffusion tubes at each site, compared to the NO_X monitors. The difference, between the factors from the two co-location sites, appears to indicate a difference in the sampling environment. At present, the underlining reason was unconfirmed. However, it may be wind-related, as the LHR2 site was considerably more exposed than the Hillingdon site. Ratified data analysed from 2005, shows that mean wind speeds may be over 1 $m.s^{-1}$ higher at LHR2. It may also relate to more spikes of pollution, evident at the LHR2 site, due to the proximity of both the northern perimeter road and runway. Further monitoring is recommended at LHR2, using diffusion tubes protected from the direct effects of higher wind speeds at exposed locations.

Appendix D Description of the Netcen Spreadsheet

Introduction to the AEAT (Netcen) designed spreadsheet, refered to as ‘DT_PrecisionAccuracyBias’, developed by Netcen, for use with nitrogen dioxide diffusion tube survey data-sets

During early 2005, the spreadsheet was released by Netcen to assist Passive Diffusion Tube users in calculating the precision and accuracy(bias) of their co-location studies. It also assists in adjusting diffusion tube results, using the calculated bias adjustment.

A new feature of this spreadsheet, is the introduction of precision and 95% confidence intervals, in bias adjustment calculations. Thease are important calculations, needed when working with passive diffusion tubes. Precision can be used as a quality check on the diffusion tube data and confidence intervals give an idea of the uncertainty to both the bias adjustment factor and tube results.

Netcen’s DT_Precision Accuracy Bias spreadsheet contains the following sheets:-

- ‘Intructions’ sheet, to provide instructions and background to the different calculations in the spreadsheet.
- ‘Precision and Accuracy’ sheet, assists in calculating the precision of any campaign with duplicate or triplicate tube exposure. Moreover, if the site has been co-located with a reference method, the user will be able to calculate the accuracy of the co-location study, by means of the Bias Adjustment Factor A and Diffusion Tube Bias B (as per LAQM. TG(03)). Period results with data for only one tube will be ignored from the calculations.
- ‘Single Tube Adjustment’ sheet, assists the user in bias adjusting single tube surveys, using the calculations in the previuos spreadsheet. This will use the accuracy (bias) results obtained using all the data.
- ‘Multiple-tube adjustment’ sheet, assists the user in bias adjusting tubes using the calculations in the previous spreadsheet.These calculations take into account whether the site to be corrected used duplicate or triplicate tubes and calculates the precision of that survey.

The user needs to be cautious when adjusting diffusion tube data and latest guidance/recommendations should be used.

All data is expressed in µg m^{-3} and includes 95% confidence intervals.

Appendix E
Relevant Air Quality Standards

The legislation and air quality objectives/limits relevant to this study are contained and discussed in the following publications:

- Part IV of the Environment Act 1995 (Local Air Quality Management);
- Directive 1996/62/EC of the European Parliament and of the Council of 27 September 1996 on ambient air quality assessment and management and amendment Regulation 1882/2003 – The Framework Directive; and
- Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxides and oxides of nitrogen, particulate matter and lead in air – The 1st Daughter Directive.

The Government has published a number of Statutory Instruments relevant to England for the direct assessment of air quality and air pollution levels. These are:

- SI 2000/928 - The Air Quality (England) Regulations 2000;
- SI 2002/3043 - The Air Quality (England) (Amendment) Regulations 2002;
- SI 2003/2121 - The Air Quality Limit Values Regulations 2003 (this is the main enabling SI for the first, second and third Daughter Directives); and
- SI 2004/2888 - The Air Quality Limit Values (Amendment) (England) Regulations 2004.

The objectives and limit values from these Statutory Instruments are summarised as follows. The Limits in the Air Quality Limit Values Regulations 2003 are essentially identical with the First Daughter Directive.

Table E1: UK Air Quality Strategy Objectives

Pollutant	Objective	Measured as	To be achieved by
Nitrogen dioxide	200 µg m^{-3} (105 ppb) Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 µg m^{-3} (21 ppb)	Annual Mean	31 December 2005
Nitrogen oxides*	(V) 30 µg m^{-3} (16 ppb)	Annual Mean	31 December 2000
Notes: µg m^{-3} - micrograms per cubic metre. * (V) = Applies only to 'rural' areas, for protection of vegetation.			

Table E2: The Air Quality Limit Values Regulations 2003: Limit Values

Pollutant	Limit Value	Measured as	To be achieved by
Nitrogen dioxide annual limit value for the protection of human heath	200 µg m^{-3} (105 ppb) Not to be exceeded more than 18 times per calendar year. A margin of tolerance is granted of 70 µg.m^{-3} for 2003, which reduces by 10 µg.m^{-3} each year until 2010. Hence, the effective limit value for 2005 is 250 µg.m^{-3}	1 Hour Mean	1 January 2010
	40 µg m^{-3} (21 ppb). A margin of tolerance is granted of 14 µg.m^{-3} for 2003, which reduces by 2 µg.m^{-3} each year until 2010. Hence, the effective limit value for 2005 is 50 µg.m^{-3}	Calendar Mean	1 January 2010
Nitrogen Oxides annual limit value for the protection of vegetation	(V) 30 µg m^{-3} (16 ppb)	Calendar Mean	19 July 2001
Notes: µg m^{-3} - micrograms per cubic metre. ppb – parts per billion			

Table E3: The Air Quality Limit Values Regulations 2003: Assessment Threshold

Threshold	Hourly limit value for the protection of human health (NO_2)	Annual limit value for the protection of human health (NO_2)	Annual limit value for the protection of vegetation (NO_X)
Upper assessment threshold (UAT)	70% of limit value (140 µg.m^{-3}), not be exceeded more than 18 times in any calendar year	80% of limit value (32 µg.m^{-3})	80% of limit value (24 µg.m^{-3})
Lower assessment threshold (LAT)	50% of limit value (100 µg.m^{-3}), not be exceeded more than 18 times in any calendar year	65% of limit value (26 µg.m^{-3})	65% of limit value (19.5 µg.m^{-3})