Report

A Continued Investigation of Air Pollution in The Vicinity of Heathrow Airport (October 2003 to October 2004)

Report to British Airways plc

AEAT/ENV/R/1898/Issue 1
February 2005

Title	A Continued Investigation of Air Pollution in The Vicinity of Heathrow Airport (October 2003 to October 2004)
Customer	British Airways plc
Customer reference	
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File reference	Netcen/ED48092
Reference number	AEAT/ENV/R/1898/ Issue 1

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Executive Summary

British Airways 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 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 land side locations used previously, located in the commercial/residential areas to the north of the airport. The 8th site, also retained from the previous survey, was the LHR2 airside continuous monitoring trailer, which remains as the co-location site for bias-adjustment purposes.

The bias adjusted mean NO_2 concentrations for the 2003/4 monitoring period are consistent with those from the 2002/3 sampling period. There is a strong agreement between the spatial-distribution of concentrations across the same eight sites, over the two 12-month periods. The 2003/4 results show a slight reduction in mean concentrations at five of the eight locations. These apparent reductions are, however, small compared to the overall uncertainty of the measurement technique.

The slight observed reduction in the 12-month mean NO_2 concentrations from the 2003/4 monitoring period, may be attributed to meteorology. U.K. Mean Pollution levels were generally lower in 2004, compared to 2003, when elevated levels resulted from the extended period of hot and sunny weather, during the summer of 2003.

The 2003/4 bias adjusted results continue to show the highest 12-month mean concentrations at the LHR2 trailer (airside) and the Neptune Road site, located between the northern perimeter road and the A4. Each site, displays a value of 57μg m^{-3}. The Shepiston Road site, close to the M4 motorway, displayed 54μg m^{-3} . All three remain well above the Air Quality Objective (AQO), annual mean value of 40μg m^{-3}, as was the case in the 2002/3-survey.

The Harlington footpath, semi-rural location, continues to display a slightly raised mean 12-month concentration of 40μg m^{-3}, compared to some of the more 'urban' locations. When the precision level of +/- 6μg m^{-3} is considered, there is a reasonable likelihood of the location exceeding the AQO level. The West End Lane location may also exceed AQO level, whilst the Imperial College location is less likely to exceed the 40μg m^{-3} level.

The remaining sampling locations of Boltons Lane and Cheviot Close, continue to display bias-adjusted, 12-month mean NO_2 concentrations around 35μg m^{-3}. When the precision levels taken into account, both are likely to remain below the AQO level.

The values resulting from the calculation of 2004 annual mean concentrations, do not significantly affect the likelihood, of any site exceeding the AQO (compared to assessing the 2003/4- period mean concentrations).

Monitoring at the same locations is continuing for a further 12-months. One additional location has been added, at the Hillingdon AURN 'continuous monitoring' site. This will enable a second true collocation study of diffusion tubes and chemiluminescent NO_X data.

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1 Introduction

British Airways 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, across Heathrow airport and extending 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 a continued survey of nitrogen dioxide, at eight of the previously selected sites, over the period October 2003 to October 2004.

Sampling continued uninterrupted across the two 12-month periods, using the same passive nitrogen dioxide (NO_2) diffusion tubes, supplied by the same laboratory. BA staff also continued to visit the sites on a monthly basis to exchange the exposed tubes, returning them to AEAT for analysis by Harwell Scientifics Ltd. Examples of the diffusion tubes, are shown in Figure 1.

Nitrogen dioxide is covered by the first EC Air Quality Daughter Directive (1999/30/EC) and also, more recently, by the Air Quality Strategy 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 the Air Quality (England) Regulations 2000 and the Air Quality (England) (Amendment) Regulations 2002. These Objectives are shown in Appendix 5.

The analysis was carried out by Harwell Scientifics Ltd, formerly AEA Technology's Analytical Services Group (ASG), 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

As a result of the earlier 12-month No_2 diffusion tube survey, British Airways plc (BA) reviewed the data and revised the number of sampling locations. Eight were chosen to continue with No_2 monitoring, for a further twelve months. All, except one, are located in the commercial/residential areas to the North of the airport. The exception being the LHR2 'continuous' air quality monitoring trailer, located approximately 10 metres airside of the northern Perimeter fence, in the vicinity of the Heathrow Visitor Centre. Tube-exposures, at all sites, continued uninterrupted, into the new 12-month monitoring period.

Triplicate diffusion tube samplers for nitrogen dioxide (NO_2) have continued to be exposed at monthly intervals, between 20th October 2003 and 18th October 2004. Table 1 shows a summary of the exposure dates for each period of the survey.

Table 1: Summary of Diffusion Tube Exposure Periods

Overall Period	Diffusion Tube Exposure Dates
13	20th. Oct. to 19th. Nov. 2003
14	19th. Nov. to 18th. Dec. 2003
15	18th. Dec. to 19th. Jan. 2004
16	19th. Jan. to 16th. Feb. 2004
17	16th. Feb. to 18th. Mar. 2004
18	18th. Mar to 19th. Apr. 2004
19	19th. Apr. to 19th. May 2004
20	19th. May to 21st. Jun. 2004
21	21st. Jun. to 19th Jul. 2004
22	19th. Jul. to 18th. Aug. 2004
23	18th. Aug. to 16th. Sep. 2004
24	16th. Sep to 18th. Oct. 2004

2.1 DIFFUSION TUBE MEASUREMENTS

Diffusion tubes are passive sampling devices, which require no mains or battery power and hence are ideal for this type of survey. Further details of diffusion tube samplers for NO_2 are provided in Appendix 1. For this continued survey, triplicate NO_2 tubes were, again, deployed at each site in order to increase the reliability and accuracy of the data. Also, in line with general guidance on the use of diffusion tube samplers, one site was collocated with a continuous automatic monitor for NO_2 at the airside 'automatic air quality monitoring' site LHR2, operated by Netcen on behalf of BAA.

A bias adjustment scaling-factor, for the NO_2 diffusion tubes exposed at LHR2, was calculated for each sampling period, from the comparison of the diffusion tube measurements and the collocated automatic NO_2 measurements, at this site.

For the 12-month mean results presented in this report, a single overall scaling factor, for the whole year of monitoring, has been calculated, from the LHR2 collocation study and applied to all of the monthly mean NO_2 diffusion tube results. This is in line with the defra Technical Guidance[2], on the use of diffusion tubes and the resulting data, from longer survey-periods.

For the monthly submission of Provisional data to BA, all diffusion tube results were re-scaled, using each 'monthly' factor, derived from the LHR2 co-location and hence, should provide more reliable measurements of NO_2 concentration. 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[2] .

Diffusion tube samplers are generally referred to as 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 automatic monitoring of NO_2 at the LHR2 site is undertaken with a chemiluminescent analyser, which is defined as the EU reference method of monitoring. Under the Directive, this reference method is required to have an accuracy of ±15%.

In this study, the NO_2 diffusion tubes were scaled to agree with the automatic monitoring result at the collocated monitoring site at LHR2. Hence, it is anticipated that the NO_2 diffusion tube results in the report will have an uncertainty between ±15% and ±25%. Given that the tubes were exposed in triplicate we would expect the uncertainty to be towards the lower end of this range. However, the potential uncertainty increases with concentration, resulting in those with higher bias adjusted concentrations, exhibiting uncertainties towards the upper end of stated range.

2.2 MONITORING LOCATIONS

Following the first extended 12-month survey at a total of 20 sites, eight were selected, following review by BA, for continued monitoring using NO_2 diffusion tubes. Apart from LHR2, these are all located in the residential areas to the North East of the airport and are listed in Table 2. 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. Figure 2 is a map extract showing all the monitoring locations.

Table 2: Monitoring Locations

Site	Easting	Northing	Comment
Shepiston Lane	508582	178453	Close to M4 motorway
Imp. Coll. 1	508270	177831	Opposite sports ground
Harlington f/p	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

* Denotes airside continuous monitoring trailer with collocated NO_2 tubes.

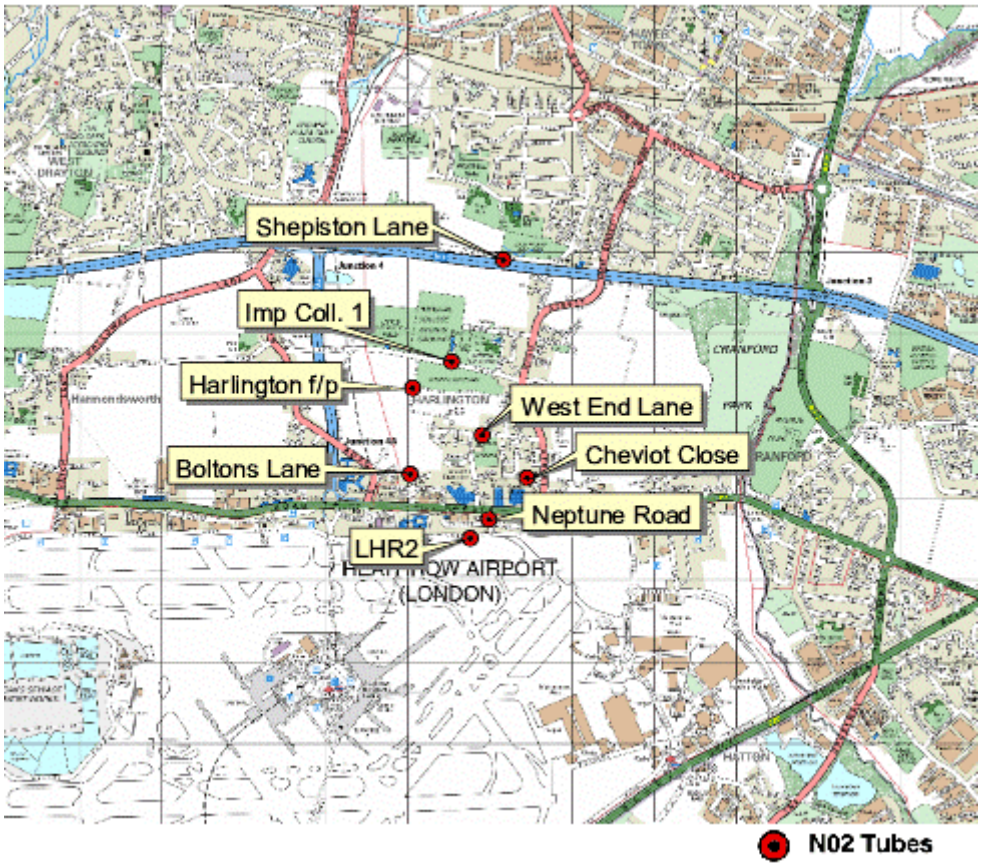


Figure 2: Geographic Representation of NO_2 Diffusion Tube Monitoring Sites Used in the 2003/04 Survey.

(It should be noted that the hand-held GPS, used to obtain the readings shown in Table 2, is reported as having a working accuracy of ± 10 Metres. Therefore, the locations, as shown, are only indicative).

3 Results

3.1 DIFFUSION TUBES - BIAS ADJUSTMENT

As was the case during the first 12 months monitoring, a collocation study, was, carried out at the LHR2 automatic monitoring station, over the full 2003/4-period of diffusion tubes exposure. The data capture of the automatic station for each period is well above 95% with the majority of periods above 99%. The bias correction factor has been worked out following the Technical Guidance LAQM.TG(03) by which the average of the chemiluminescence results are compared to the average of the diffusion tubes results.

During the production of this report, a newly developed spreadsheet became available, produced within Netcen at AEA Technology. In future, this will be used as a standard means of calculating the final data sets from NO_2 diffusion tube surveys in the U.K. and shortly to become available to all Local Authorities and interested parties through the defra Air Quality website. It will calculate annual/12-month bias adjustment factors from co-location-site data and identify possible sets of triplicate and duplicate tube-results, not to be included in the calculation of the final bias adjustment factor(s). This is achieved by a 'precision check'. Multiple tube results (from the same site/exposure period) with a Coefficient of Variation (C.o.V.) above 20%, will be flagged as 'poor precision' and discounted from the calculation of the 12-month or annual mean bias adjustment factor. This approach differs slightly from that used in the previous 12-month report, where outlier-identification was achieved via the application of the Dixons Q Test when the C.o.V. was above 10%. An introduction to the new spreadsheet is given in Appendix 4.

Table 3 shows the LHR2 diffusion tube data used for the 2003/4 bias-adjustment calculation.

Table 3: Bias-Correction Data Used from the Co-Location Study at LHR2

Overall Period	Tube1 ($\mu g\ m^{-3}$)	Tube2 ($\mu g\ m^{-3}$)	Tube3 ($\mu g\ m^{-3}$)	Mean ($\mu g\ m^{-3}$)	St Dev	CoV %	95% CL of mean
13	99	120	119	113	12	10	29
14	119	126	121	122	3.7	3	9.3
15	112	121	102	112	9.9	9	25
16	85	78	123	95	25	26	61
17	57	84[1]	94	78	20	25	48
18	72	89	101	87	14	17	35
19	79	73	75	76	2.9	4	7.1
20	58	65	56	59	4.8	8	12
21	80	105	101	95	13	14	33
22	85	66	80	77	9.9	13	25
23	83	105	116	101	17	17	42
24	98	103	103	101	2.7	3	6.7
25	93	106	103	101	6.8	7	17
26	122	8	117	109	18	17	45

[1] Split end cap on return to AEAT

X shows the monthly tube results not used in the calculation of the 12-month bias correction factor

Table 4 shows the LHR2 Chemiluminescent data used for the 2003/4 adjustment calculation.

Table 4: Summary of the LHR2 Chemiluminescent NO_2 Data, 2003/04

Period	Chemiluminescent Ref. Conc. ($\mu g\ m^{-3}$)	% Data Capture
13	63	99.3
14	50	99.6
15	58	99.5
16	59	97.9
17	65	99.9
18	65	97.9
19	57	96.0
20	46	99.7
21	40	99.1
22	55	98.9
23	53	99.4
24	55	96.1
25	58	97.4
26	64	98.7

3.2 DIFFUSION TUBE RESULTS – DATA HANDLING

In order to maximise the benefits of all the available data, an additional section has been added to this report. The section reviews the 2004 annual mean data set, which was available at the time of compiling this report. This will enable BA to compare data with quoted results from other long-term NO_2 diffusion tube surveys, which are typically reported as annual mean concentrations.

All individual monthly NO_2 diffusion tube results are given in Appendix 2. The mean, standard deviation and coefficient of variation (CoV) for each set of three tubes have been calculated, plus, for monthly submission to BA, all measurement data have been rescaled by the ratio of the collocated measurements at the LHR2 site, using non-standard monthly-derived adjustment factors. This enables monthly histograms to be produced, from results derived by the application of the monthly factors. Such histograms are useful in reviewing both the monthly results and any variations across the 12 months of NO_2 sampling.

However, the final NO_2 tube survey results have been derived using the appropriate Technical Guidance procedures[1]. These indicate that where 12 consecutive months of data are available, a, bias-adjusted, 12-month mean factor should be derived and applied to the non-adjusted 12-month mean concentrations from the other monitoring locations. These are shown in Table 3 and Figure 3. The derivation of the bias-adjustment applied to the NO_2 tube data, is explained in Section 3.1.

It should be noted that, the individual monthly results tables in Appendix 2, each display a 'bias-adjusted' final column. Such a calculation is not strictly applicable to monthly results (under the Technical Guidance instructions).

The bias-adjusted 12-month mean NO_2 concentrations from the diffusion tubes exposed at each location, are shown in Table 5, which also shows the calculated uncertainty, associated with each concentration.

The bias adjustment factor obtained from the LHR2 co-location study, for the contract-period of October 2003 to October 2004, is 0.602. This factor has been derived from the LHR2 Chemiluminescent 12-month mean NO_2 concentration, divided by the LHR2 survey-mean diffusion tube concentration (from 10 'good' months of tube results i.e. with C.o.V < 20%). This factor is then used to recalculate the 12-month mean concentrations from each of the other survey-sites.

For comparison, mean Chemiluminescent NO_2 concentrations, at a range of National AURN automatic air-quality monitoring stations, are given in Table 8.

A discussion of the 2003/04 12-month period results is given in section 3.3.
Section 3.5 reviews the bias-adjusted 2004 annual mean NO_2 concentrations.

3.3 NO_2 DIFFUSION TUBE RESULTS-OCT 03 TO OCT 04

Figure 3 shows the bias-adjusted 12-month mean NO_2 concentrations for each site. (Please note that, strictly speaking, the Technical Guidance indicates that the bias-adjustment technique, is applicable only to annual-mean or 12-month-mean data sets. However, plots of bias-adjusted monthly data, obtained by applying the individual monthly factors, are presented in Appendix 3).

Figure 3 shows that the highest mean concentrations of 57μg m^{-3} continue to be measured at the southerly sites of Neptune Road, between the perimeter road and the main A4 carriageway and also at the LHR2 site, just airside of the Northern Perimeter Road. The two locations immediately north of the Main A4 (and equidistant from it) are Boltons Lane and Cheviot Close. These display very similar mean concentrations of 34 and 35μg m^{-3}, which are the lowest measured over the 2003/4 monitoring period.

Continuing north, the following two sites, West End Lane and Harlington, appear to show a slight elevation, approaching the 40μg m^{-3} level, dropping back slightly, at the Imperial College 1 site. The 'transect' is completed by the raised mean levels measured at the Shepiston Lane site, in the vicinity of the M4 eastbound hard shoulder.

Table 5: 12-month Mean, Bias-Adjusted NO_2 Diffusion Tube Results

Site	Bias adjusted 12-month mean NO_2 concentration (μg m^{-3}) Oct 03 to Oct 04
Shepiston Lane	54 ± 8
Imperial College 1	37 ± 5
Harlington Footpath	40 ± 6
West End Lane	38 ± 6
Boltons Lane	34 ± 5
Cheviot Close	35 ± 5

Neptune Road	57 ± 8
LHR2	57 ± 8

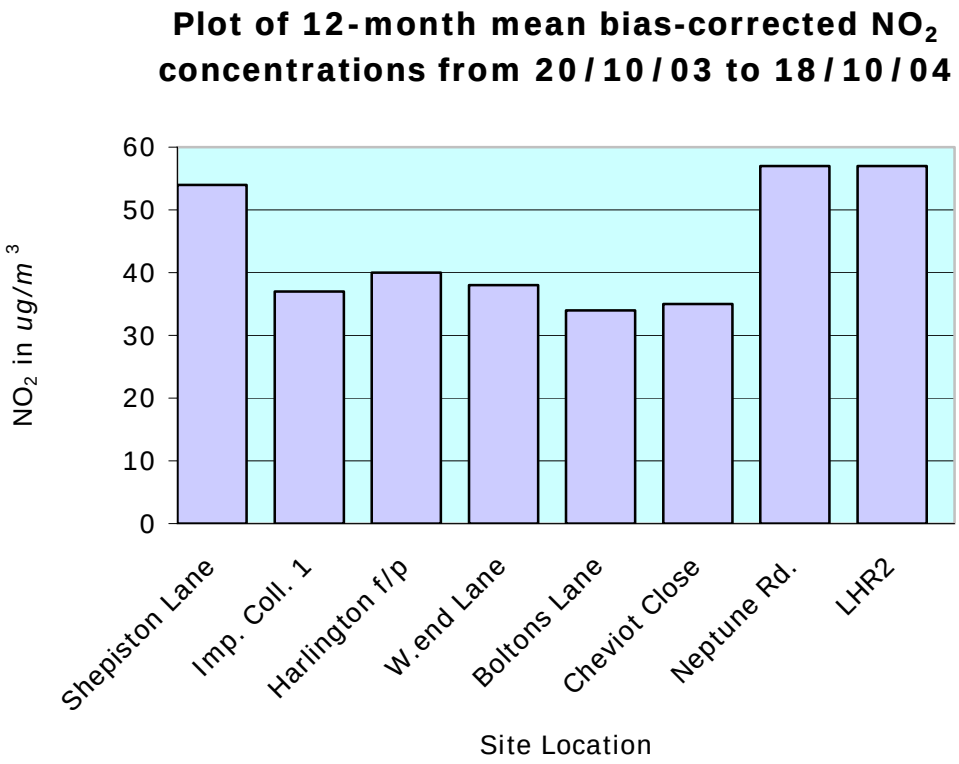


Figure 3: Bias-Adjusted, Oct.03 to Oct. 04, Mean NO_2 Concentrations.

3.4 COMPARISON WITH 2002/3 NO_2 RESULTS

Figure 3, shows a similar concentration-profile, across the sampled locations, to that obtained in the 2002/3 survey. Table 6 and Figure 4, show the comparison between the bias adjusted NO_2 concentrations from the 2003/4 monitoring period, compared to the equivalent period over 2002/3.

Table 6: Bias Corrected 12-month Mean NO_2 Concentrations

Site	NO_2 tube bias adjusted 12-month mean result ($\mu g\ m^{-3}$)- 2003/4 survey	NO_2 tube bias adjusted 12-month mean results ($\mu g\ m^{-3}$)- 2002/3 survey
Shepiston Lane	54	56
Imperial College 1	37	36
Harlington Footpath	40	39
West End Lane	38	40
Boltons Lane	34	35

Cheviot Close	35	36
Neptune Road	57	59
LHR2	57	57

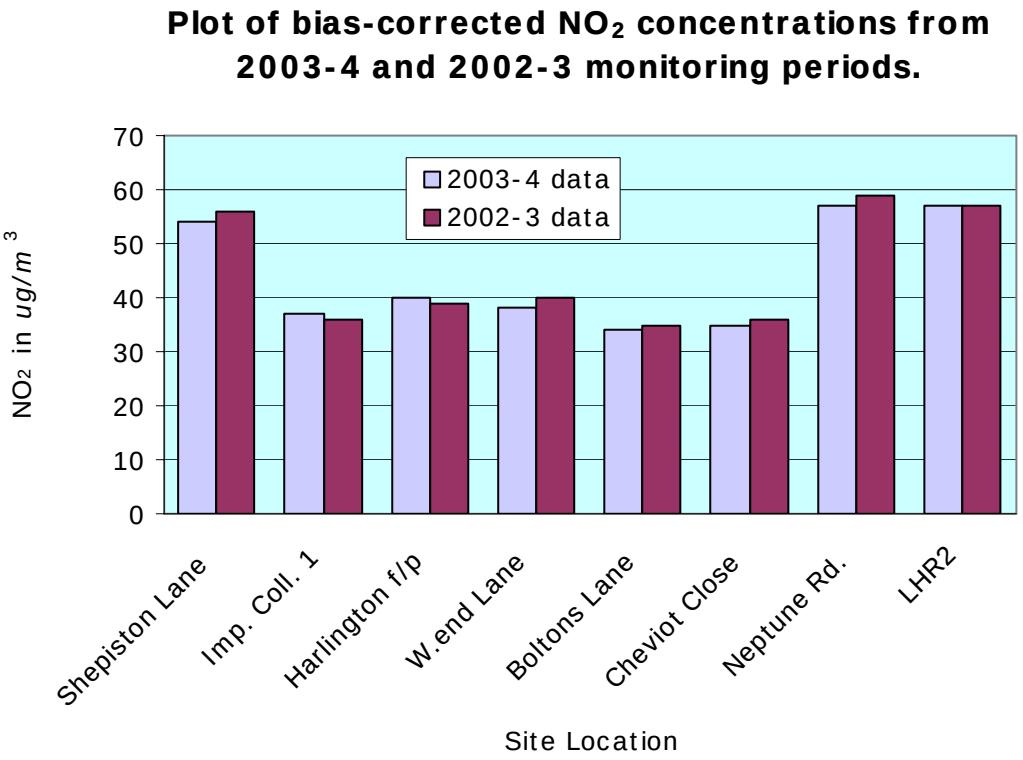


Figure 4: Plot of bias-adjusted NO_2 concentrations from 2003/4 & 2002/3, showing site-locations from north to south.

The histogram demonstrates that the bias adjusted concentrations from the 2003/4 12-month period, are consistent with those from the equivalent 2002/3 12-month period.

The majority of sampling locations show a slight reduction in NO_2 concentration, in the 2003/4 results. This may be explained by the, generally, lower annual mean U.K. pollution levels, recorded during 2004. Annual mean Pollution levels for 2003, were elevated due to the extended period of hot and sunny weather, during the summer of that year. However, the apparent reduction small, compared to the general uncertainty associated with the monitoring technique.

Of the sampled locations, only two displayed slightly higher annual mean concentrations for 2004, compared to 2003. These were Imperial College 1 and Harlington, which are located in the same general more rural area and are, also, furthest away from the airport.

The bias adjusted 12-month mean concentration recorded at the LHR2 trailer, remained unchanged, at 57 μg m^{-3}.

3.5 2004 ANNUAL MEAN NO_2 CONCENTRATIONS & COMPARISON WITH SELECTED AURN SITES

The provisional data, from the LHR2 continuous NO_X analyser, is scrutinised on a regular basis. However, each annual data set is fully ratified only once per year, becoming available during late January to early February.

Therefore, in order to maximise the accuracy of the bias adjusted tube data, it has previously been agreed to await the ratified LHR2 data, before compiling the 'end report' from each 'contract period' – historically, October to October.

In awaiting the final ratification of the 2004 LHR2 data set, the results became available from the first two periods of tube-exposure, from the new 2004/5 contract-period, these being, November and December 2004. It should be noted that, for the 2004/5 contract-period, the monthly exposure-periods have been harmonised with those used in the National NO_2 Diffusion Tube Survey. Therefore, a short delay occurred between the end of the 03/04 contract and the start of the 04/05 contract periods.

The availability of the November and December 04 Tube results, enables the calculation of full 2004 annual mean NO_2 concentrations from both LHR2 and the group of diffusion tube locations in the survey. These standardised concentrations can then be more readily compared with annual means from diffusion tube locations in other surveys.

The bias adjustment factor, obtained from the LHR2 co-location study, for the period January to December 2004, is 0.609. This has been used to recalculate the 2004 annual mean concentrations, from each of the other survey-sites, via the same method as for the October 2003 to October 2004 data-set.

Table 7. shows the 2004 annual mean concentrations from the Heathrow sites, whilst Table 8. shows the 2004 annual mean concentrations from a selection of AURN air quality monitoring stations. This information appears to confirm the profile of the apparent concentration gradient, across the site-locations, with the Harlington Automatic monitoring station concentration of 38 $\mu g\ m^{-3}$, falling between the Harlington and Imperial College 1 values of 40 and 36 $\mu g\ m^{-3}$, respectively.

The London Hillingdon continuous monitoring site is located in a suburban area which borders the M4 Motorway, to the north of the airport. It shows an annual mean NO_2 concentration of 47$\mu g\ m^{-3}$, 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 110 $\mu g\ m^{-3}$, twice that of the highest mean levels from the Heathrow survey.

Table 7: 2004 Annual Mean Bias-Adjusted NO_2 Diffusion Tube Results

Site	Bias adjusted annual mean NO_2 concentration ($\mu g\ m^{-3}$) for 2004
Shepiston Lane	54
Imperial College 1	36
Harlington Footpath	40
West End Lane	37
Boltons Lane	32
Cheviot Close	35
Neptune Road	55
LHR2	54

Table 8: 2004 Annual Mean NO_2 Concentrations at LHR2 & Selected AURN Sites

Monitoring site:	Location:	2004 Annual Mean NO_2 concentrations ($\mu g\ m^{-3}$)
Heathrow LHR2	10M airside of the Northern perimeter Rd, Heathrow Airport	54 (98% data capture)
Harlington AURN	Just south of the Imperial College sports training ground	38 (79% data capture)
London Hillingdon	A suburban site approximately 30m from the M4 in Hillingdon	47 (99% data capture)
London N. Kensington	An Urban Background location	40 (99% data capture)
London Marylebone Rd	Kerbside of Marylebone Road – a 6-lane urban highway	110 (98% data capture)

NOTE: With the exception of LHR2, the concentrations for the sites, above, were calculated from Chemiluminescent NO_2 data, for calendar year 2004, ratified up to 1st. October. LHR2 data is ratified up to end of 31st. December 2004.

3.6 LIKELIHOOD OF 'A.Q. OBJECTIVE' EXCEEDENCES

The table in appendix 5 shows a summary of the Air Quality Objectives associated with NO_X monitoring. The relevant Objective limit is the 40 $\mu g\ m^{-3}$ level for nitrogen dioxide, equivalent to 21 ppb and measured as an annual mean concentration, to be achieved by December 31st 2005.

Table 9, summarises the bias adjusted mean NO_2 concentrations from both the Oct. 03 to Oct. 04 monitoring period and the 2004 calendar year.

Table 9: Bias Adjusted NO_2 Concentrations (With Precision Estimate)

Site	Bias adjusted 12-month mean NO_2 concentration ($\mu g\ m^{-3}$) Oct 03 to Oct 04	Bias adjusted 2004 annual mean NO_2 concentration ($\mu g\ m^{-3}$)
Shepiston Lane	54 ± 8	54 ± 8
Imperial College 1	37 ± 5	36 ± 5
Harlington Footpath	40 ± 6	40 ± 6
West End Lane	38 ± 6	37 ± 6
Boltons Lane	34 ± 5	32 ± 5
Cheviot Close	35 ± 5	35 ± 5
Neptune Road	57 ± 8	55 ± 8
LHR2	57 ± 8	56 ± 7

As can be seen from the data above, in some cases there is a small reduction in concentration, when calculated as a 2004 annual average.

However, when assessing the likelihood of a sampling location exceeding the 40 $\mu g\ m^{-3}$ Air Quality objective (AQO), the precision level associated with each mean concentration, should be taken into account. It is therefore evident from Table 3 that recalculating the results as 2004 annual means is unlikely to affect the possibility of individual sites either exceeding or not exceeding the Objective.

As a result of assessing the quoted precision levels of the 2004 annual mean concentrations, the sampling locations at LHR2, Shepiston lane and Neptune Road, would remain well above the AQO. Harlington Footpath may be close to, or just exceed, the AQO, whilst, West End Lane may be close to exceeding 40 $\mu g\ m^{-3}$. Cheviot Close and Boltons Lane would not exceed this AQO level.

3.7 METEOROLOGICAL ANALYSIS OF 2003/4 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 is not possible and mean wind direction analysis therefore gives a good over view of the situation.

The meteorological and NO_2 data used in this report has been obtained from the LHR2 continuous monitoring trailer, which was also used as the collocation site for diffusion tubes and Chemiluminescent NO_x analyser, for the purposes of the calculation of the bias adjustment factor, described earlier. Due to operational problems, the LHR2 met. Data became unreliable after the 11th October 2004. Hence the plots in Figures 5 and 6, are produced from data covering 7 days short of the full 12-month period. This also applies to the meteorology plots presented in Appendix 3.

Figure 5 shows a wind rose analysis plot of mean wind direction and also mean NO_2 concentration against mean wind direction. This plot confirms that over the 12-months of diffusion tube monitoring, the mean wind direction was predominantly from a west and south westerly direction, which coincides with the general prevailing wind direction over the United Kingdom.

Figure 6, a nitrogen dioxide pollution rose, shows that the lowest mean NO_2 concentrations were recorded when the wind direction was from the both the west and

south east. The highest mean concentrations coincided with winds from the east and north east.

There appears 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 2003/4 period, may be attributable to the prevailing meteorology. It is accepted that the extended period of hot, sunny weather during the summer of 2003, produced elevated concentrations of pollution[4]. This elevation was reflected in the annual mean concentrations for that year.

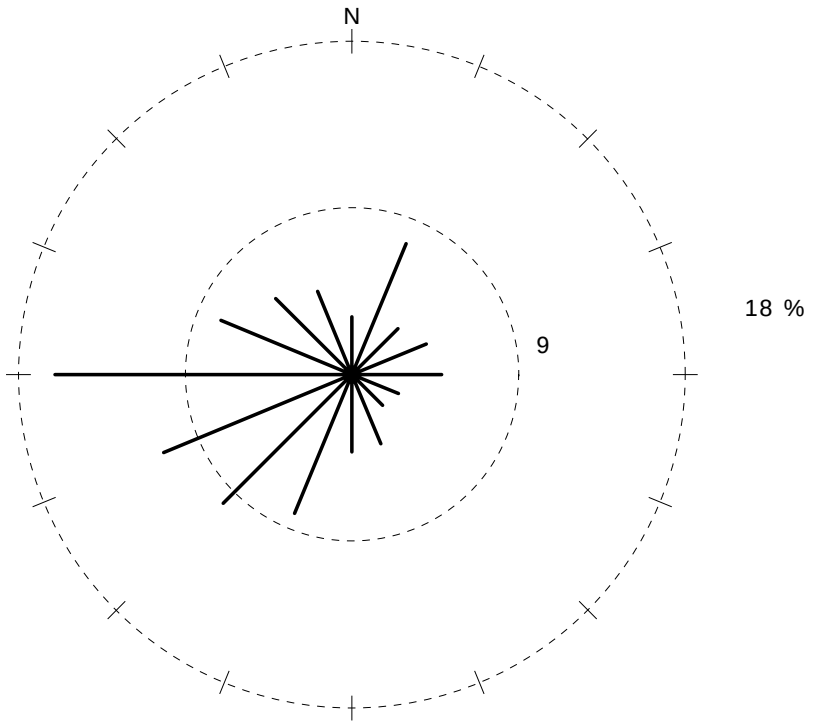
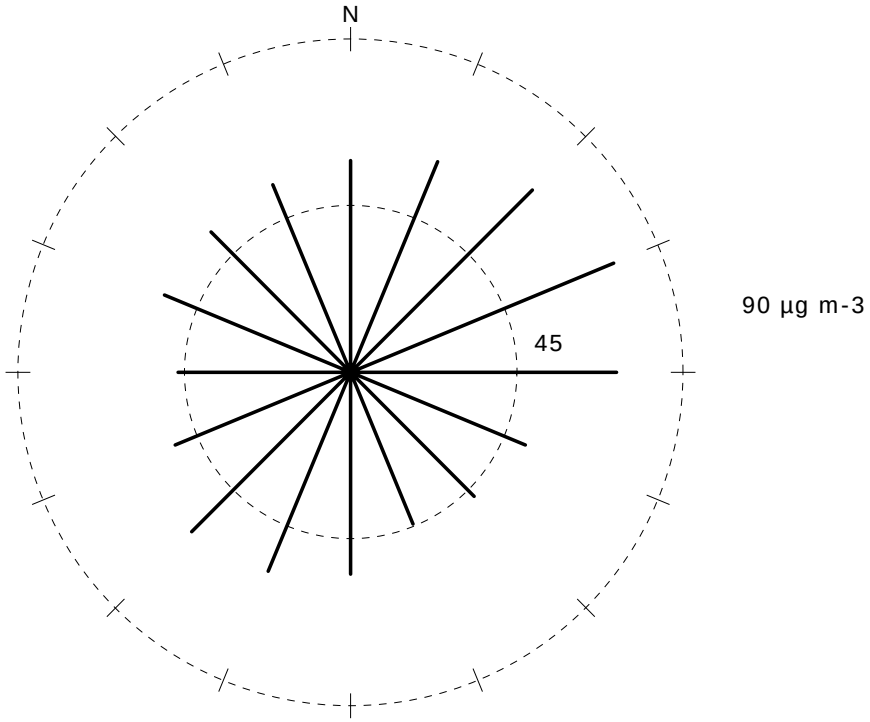


Figure 5: LHR2 Wind Direction Analysis for the Period Oct. 03 to Oct. 04



WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 20/10/2003 to 11/10/2004

Windspeed Threshold set at 0.1 m/s

Figure 6. LHR2 NO_2 vs Wind Direction Analysis for the Period Oct. 03 to Oct. 04 (Produced from data standardised to 20° C and 1013 mb)

4 Conclusions

The bias adjusted mean NO_2 results from the 2003/4 survey, show the following:

- Concentrations at each location, remain consistent with those from the 2002/3 survey. However, a slight reduction is evident at 5 of the 8 locations (< 3 μg m^{-3}). These small fluctuations are, however, within the uncertainty of the overall measurement technique. The concentration-profile across the eight sites, remains virtually unchanged.

- A slight increase is evident, over the 2003/4-period, at the Imperial College 1 and Harlington sites, again, < 3 μg m^{-3}. The LHR2 concentration remained unchanged, over the two 12-month periods.

- The Shepiston Lane, Neptune Road and LHR2 sites show very similar concentrations of between 54 and 57 μg m^{-3} . The remaining non-airside locations show NO_2 concentrations of between 34 and 40 μg m^{-3}.

- The NO_2 results from the LHR2 trailer, may continue to be influenced by its proximity to the northern perimeter road.

- As a result of assessing the calculated precision levels which accompany the 12-month mean concentrations, levels at LHR2, Shepiston Road and Neptune Road, remain well above the 40 μg m^{-3} Air quality Objective (AQO).

- Imperial College 1, West End Lane and Harlington 12-month mean levels may be approaching the AQO, whilst, cheviot Close and Boltons Lane would continue to remain below the AQO.

- Recalculating the bias adjusted mean concentrations, for the 2004 calendar year, reduces the mean concentrations at 5 of the 8 locations but by only 1 or 2 μg m^{-3}. This has no significant effect on the likelihood, or not, of any site exceeding the AQO.

- The slight reduction in annual mean concentrations, at the majority of sampling locations, over the “2004” period, may legitimately be attributed to differences in meteorology, compared to 2003. It is generally accepted that the extended period of hot weather during the summer of 2003[4], contributed to an elevation of annual mean pollution levels during that year.

5 Reference

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

2. Technical Guidance document LAQM TG(03). Product Code PB7514 ISBN code 0-85521-021-4.

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

4. defra Air Quality web site, Air Quality Headline Indicator, H10, at http://www.sustainable-development.gov.uk/indicators/headline/h10.htm

Appendices

CONTENTS

Appendix 1
NO_2 Diffusion Tubes

NO_2 Diffusion Tube Samplers

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)
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.

Appendix 2
NO_2 Diffusion Tube-~~Individual Results~~

HEATHROW TRANSECT AIR QUALITY MONITORING, 20 OCT - 19 NOV 2003 (Period 13)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	104.1	95.4	99.9	99.8	4.35	4.36%	53
Imp Coll.1	83.4	86.1	83.1	84.2	1.65	1.96%	45
Harlington f/p	84.3	98.8	67.2	83.4	15.82	18.96%	44
WestEnd Lane	84.3	88.1	81.0	84.5	3.55	4.21%	45
Boltons Lane	74.2	77.1	74.0	75.1	1.73	2.31%	40
Cheviot Close	69.6	68.5	71.7	69.9	1.63	2.32%	37
Neptune Rd	112.5	107.2	109.2	109.6	2.68	2.44%	58
LHR2	99.2	120.1	118.5	113	11.6	10%	63

The individual tube results, shown above, are uncorrected. However, to enable a month by month comparison, the bias corrected column[1] has been calculated by multiplying the' valid tubes' mean by each monthly-derived factor. No value has been calculated where the Coefficient of Variation is greater than 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th NOV - 18th DEC 2003 (Period 14)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	98.2	102.9	98.1	99.7	2.74	2.75%	56
Imp.Coll. 1	78.2	81.7	82.2	80.7	2.18	2.70%	45
Harlington f/p	71.4	86.4	80.9	79.6	7.59	9.54%	44
West End Lane	74.7	83.5	81.5	79.9	4.61	5.9%	45
Boltons Lane	74.2	75.7	77.4	75.8	1.60	2.11%	43
Cheviot Close	72.7	70.6	72.4	71.9	1.14	1.58%	40
Neptune Rd.	114.7	119.0	111.9	115.2	3.58	3.1%	64
LHR2	119.3	126.4	120.9	122	3.7	3.0%	68

The individual tube results, shown above, are uncorrected. However, to enable a month by month comparison, the bias corrected column[1] has been calculated by multiplying the' valid tubes' mean by each monthly-derived factor. No value has been calculated where the Coefficient of Variation is greater than 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 18th DEC. 2003 - 19th JAN. 2004 (Period 15)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	70.7	97.0	92.7	86.9	14.11	16.25%	49
Imp.Coll. 1[2]	83.4	57.4	60.3	67.0	14.25	21.25%	31
Harlington f/p	68.4	62.3	77.3	69.3	7.54	10.88%	36
West End Lane	75.4	89.9	69.6	78.3	10.46	13.35%	38
Boltons Lane	63.6	71.3	64.8	66.6	4.14	6.22%	35
Cheviot Close[2]	63.6	127.1[3]	74	88	33.9	38.3%	36
Neptune Rd.	107.3	111.9	105.3	108.2	3.38	3.13%	56
LHR2	111.7	121.3	101.5	112	9.9	9%	58

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.
[3] Split end-cap on return to AEAT.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th. JAN. - 16 th. FEB. 2004 (Period 16)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	94.3	107.5	90.5	97.4	8.92	9.16%	71
Imp.Coll. 1	71.5	69.3	78.8	73.2	4.97	6.79%	50
Harlington f/p	78.8	79.5	77.7	78.7	0.91	1.15%	57
West End Lane	60.1	79.9	70.2	70.1	9.90	14.13%	50
Boltons Lane	63.2	58.1	62.5	61.3	2.76	4.51%	44
Cheviot Close	66.0	65.7	62.6	64.8	1.88	2.91%	47
Neptune Rd.	105.5	111.4	100.4	105.8	5.50	5.20%	76
LHR2[2]	84.6	77.8	123.3	95.0	24.5	26%	59

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 16th. Feb. - 18th. Mar. 2004 (Period 17)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	62.4	78.0	80.0	73.5	9.64	13.12%	58
Imp.Coll. 1	56.0	59.4	63.6	59.7	3.81	6.38%	44
Harlington f/p	62.7	74.7	51.4	62.9	11.65	18.51%	46
West End Lane	58.8	55.2	63.1	59.0	3.96	6.70%	43
Boltons Lane	54.2	41.1	61.3	52.2	10.25	19.63%	38
Cheviot Close	62.9	62.3	57.6	60.9	2.90	4.76%	45
Neptune Rd.	90.9	100.3	100.3	97.2	5.43	5.59%	71
LHR2[2]	56.7	83.9	94.4	78.0	19.5	25%	65

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 18th Mar. – 19th Apr. 2003 (Period 18)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	95.9	101.5	92.8	96.7	4.41	4.56%	59
Imp.Coll. 1	66.5	52.5	60.6	59.9	7.03	11.74%	37
Harlington f/p[3]	-	-	-	-	-	-	-
West End Lane	63.6	71.3	55.7	63.5	7.80	12.28%	39
Boltons Lane[2]	56.7	63.3	36.0	52.0	14.24	27.39%	37
Cheviot Close	57.1	60.8	59.0	59.0	1.85	3.14%	36
Neptune Rd.	78.1	107.6	95.8	93.8	14.85	15.82%	62
LHR2	72.2	88.6	100.5	87.0	14.2	16%	58

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.
[3] Tubes removed by local authority, when Public Footpath sign was replaced.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th Apr. – 19th May. 2004 (Period 19)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	82.1	74.3	86.7	81.0	6.27	7.74%	61
Imp.Coll. 1	54.3	51.4	56.4	54.0	2.51	4.65%	41
Harlington f/p[2]	32.6	51.0	40.1	41.2	9.25	22.44%	28
West End Lane	49.7	50.3	35.7	45.2	8.26	18.26%	38
Boltons Lane	43.4	41.7	41.5	42.2	1.04	2.47%	32
Cheviot Close	41.0	51.9	53.1	48.7	6.67	13.70%	40
Neptune Rd.	95.2	75.5	87.3	86.0	9.91	11.53%	65
LHR2	79.0	73.4	75.1	76	2.9	4%	57

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th May. – 21st June. 2004 (Period 20)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	82.5	68.2	74.8	75.2	7.16	9.52%	58
Imp.Coll. 1[2]	42.8	32.2	48.7	41.2	8.36	20.28%	35
Harlington f/p	38.4	45.5	32.9	38.9	6.32	16.22%	30
West End Lane[2]	22.0	45.3	42.1	36.5	12.63	34.64%	34
Boltons Lane	32.9	40.0	39.0	37.3	3.84	10.3%	31
Cheviot Close	41.2	36.7	35.6	37.8	2.97	7.84%	29
Neptune Rd.	53.8	60.5	60.2	58.2	3.78	6.51%	45
LHR2	57.5	64.6	55.5	59.2	4.8	8.1%	46

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 21st June – 19th July 2004 (Period 21)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	97.2	88.2	91.1	92.2	4.59	4.98%	53
Imp.Coll. 1	41.6	52.1	43.4	45.7	5.62	12.29%	31
Harlington f/p	53.0	55.9	58.0	55.6	2.51	4.51%	28
West End Lane	41.6	59.4	52.1	51.0	8.95	17.53%	36
Boltons Lane	50.5	51.0	49.0	50.2	1.04	2.07%	28
Cheviot Close	56.3	54.5	54.4	55.1	1.07	1.94%	27
Neptune Rd.	86.6	94.9	79.9	87.1	7.51	8.62%	41
LHR2	80.2	104.8	100.8	95.0	13.2	14%	73

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th July - 18th Aug. 2004 (Period 22)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane[2]	66.3	82.2	38.3	62.3	22.23	35.7%	49
Imp.Coll. 1	49.6	35.3	40.4	41.8	7.25	17.35%	28
Harlington f/p[2]	44.2	102.4	53.6	66.7	31.24	46.82%	32
West End Lane	40.4	44.5	42.8	42.6	2.06	4.84%	28
Boltons Lane	45.4	44.0	43.1	44.2	1.16	2.62%	29
Cheviot Close	48.2	52.5	42.9	47.9	4.81	10.05%	32
Neptune Rd.[2]	46.9	90.1	75.2	70.7	21.94	31.02%	55
LHR2	85.3	66.2	80.0	77.0	9.9	13%	55

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 18th Aug - 16th Sept. 2004 (Period 23)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	87.4	98.5	92.0	92.6	5.58	6.02%	45
Imp.Coll. 1	55.8	55.9	57.7	56.5	1.07	1.89%	27
Harlington f/p	54.8	56.3	67.8	59.6	7.11	11.93%	27
West End Lane	61.1	53.2	60.6	58.3	4.42	7.59%	28
Boltons Lane	54.3	56.3	58.3	56.3	2.0	3.6%	27
Cheviot Close	57.3	57.5	56.0	56.9	0.81	1.43%	27
Neptune Rd.[2]	95.0	137.3	99.5	110.6	23.23	21.01%	47
LHR2[2]	82.5	104.9	115.5	101.0	16.8	17%	53

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW TRANSECT AIR QUALITY MONITORING, 16th Sept. - 18th Oct. 2004 (Period 24)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-adjusted monthly mean[1]
Shepiston Lane	88.1	97.1	72.8	86.0	12.29	14.29%	50
Imp.Coll. 1	53.4	64.3	61.1	59.6	5.60	9.40%	32
Harlington f/p[2]	57.2	91.7	77.3	75.4	17.33	22.98%	36
West End Lane	-	62.8	54.9	59	5.7	9.6%	32
Boltons Lane[2]	65.4	60.2	43.5	56.4	11.44	20.30%	34
Cheviot Close	53.9	64.9	57.9	58.9	5.57	9.45%	32
Neptune Rd.	-	96.5	81.4	89	11.3	12.7%	48
LHR2	98.1	102.6	102.9	101.2	2.7	2.7%	55

[1] Unofficial monthly corrected concentration, produced from the 12-month mean bias adjustment factor.
[2] Data from this period has been omitted from bias-adjustment calculation, due to C.O.V. above 20%.

HEATHROW AIR QUALITY MONITORING, NO_2 tube bias-corrected monthly mean NO_2 results ($\mu g\ m^{-3}$) – Oct 02 to Oct 03													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Bias-adjusted 12-month mean
Shepiston Lane	60	60	52	54	52	52	64	63	60	55	52	45	56
Imp Coll.1	45	53	22	43	43	37	33	30	30	33	32	34	36
Harlington f/p	44	53	44	46	43	38	35	32	32	33	35	38	39
West End Lane	50	55	47	43	46	-	35	35	30	35	33	33	40
Boltons Lane	42	47	35	38	39	34	35	30	31	32	31	29	35
Cheviot Close	41	41	42	37	38	32	39	36	31	30	31	37	36
Neptune Rd	64	68	55	61	63	58	60	56	65	51	52	56	59
LHR2	70	60	63	58	58	54	65	50	48	50	50	52	57

Note. It should be noted that the bias corrected monthly mean data, shown above, is of a non-standard format. The defra technical guidance recommends bias-correcting annual mean data only. However, monthly results can be of interest. The bias adjustment correction factor, calculated from the 2002/3 LHR2 co-location study, was 0.55

HEATHROW AIR QUALITY MONITORING, NO_2 tube bias-corrected monthly mean NO_2 results ($\mu g\ m^{-3}$) – OCT 03 TO Oct 04													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Bias-adjusted 12-month mean
Shepiston Lane	53	56	49	71	58	59	61	58	53	49	45	50	54
Imp Coll.1	45	45	31	50	44	37	41	35	31	28	27	32	37
Harlington f/p	44	44	36	57	46	-	28	30	28	32	27	36	40
West End Lane	45	45	38	50	43	39	38	34	36	28	28	32	38
Boltons Lane	40	43	35	44	38	37	32	31	28	29	27	34	34
Cheviot Close	37	40	36	47	45	36	40	29	27	32	27	32	35
Neptune Rd	58	64	56	76	71	62	65	45	41	55	47	48	57
LHR2	63	68	58	59	65	58	57	46	73	55	53	55	57

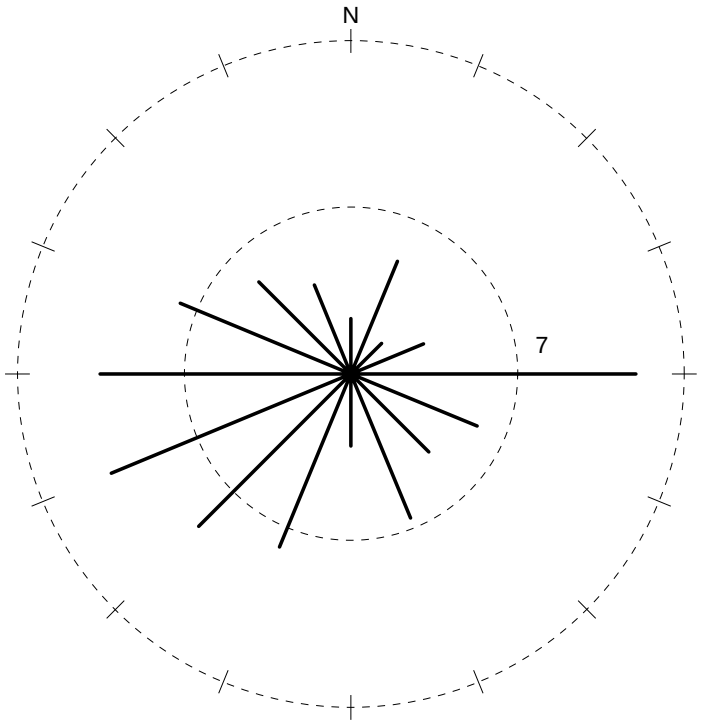
Calculated using fully ratified LHR2 chemiluminescent data. The bias adjustment correction factor, calculated from the 2003/4 LHR2 co-location study, was 0.60.

Period-Mean Chemiluminescence NO_2 concentrations from LHR2 and selected AURN sites - in $\mu g\ m^{-3}$ (20/1003 – 18/10/04)													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
LHR2	63	68	58	59	65	58	57	46	40	55	55	53	61
Hillingdon	55	59	47	44	46	49	42	38	40	53	47	46	47
Harlington	-	50	40	40	45	39	40	33	25	37	33	35	37
N. Kensington	51	53	42	41	49	38	39	27	24	35	32	33	39
Marylebone Rd	122	114	112	111	100	106	99	92	104	91	109	108	106

Hillingdon P1 produced nulled data, in the Ratified data set. Also, the P12 values for the three AURN sites are from, as yet, unratified data sets.
All Chemiluminescence NO_2 concentrations are in $\mu g\ m^{-3}$ at Standard Temperature/pressure of 1016 mb & 20 degrees Centigrade.

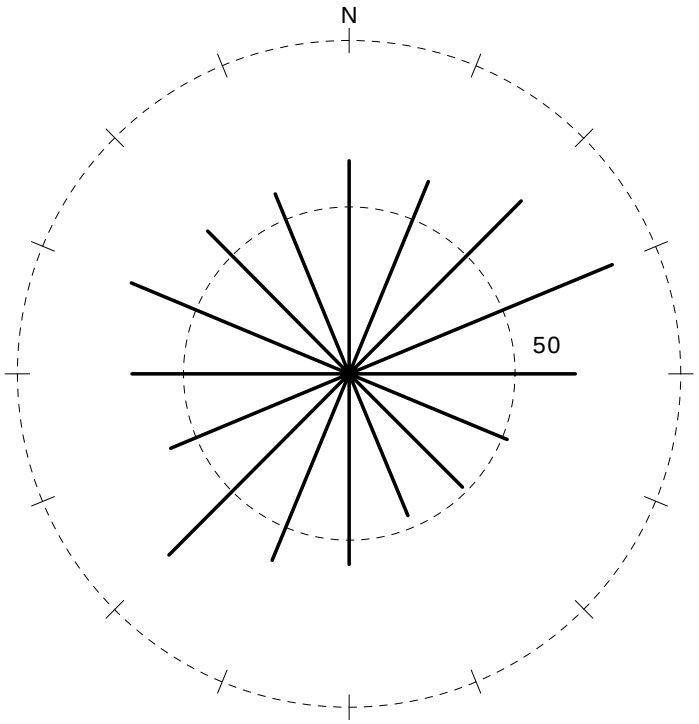
Appendix 3 Meteorology plots and survey histograms

The wind rose vs NO_2 plots are standardised to 20'C and 1013mb.



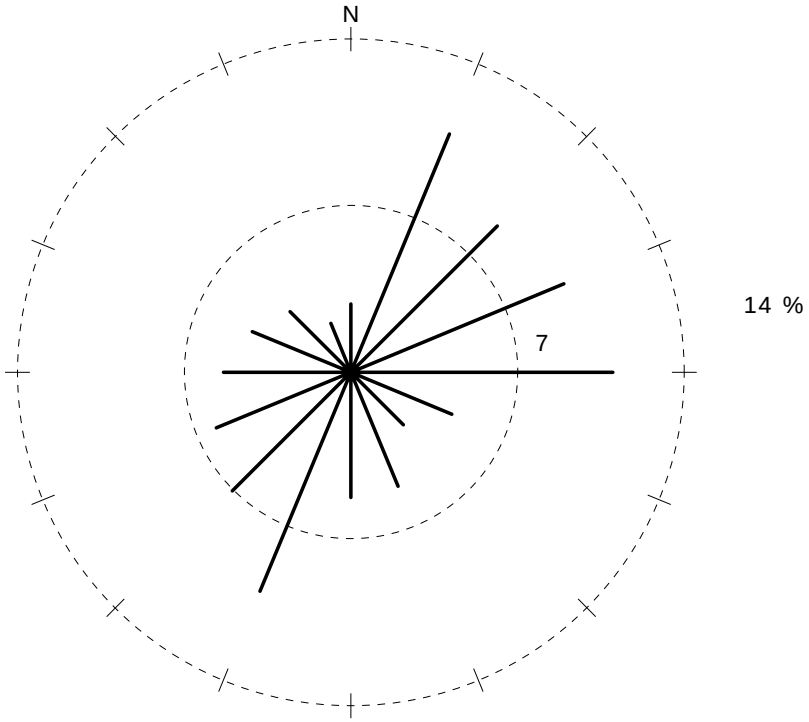
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 20/10/2003 to 19/11/2003

Windspeed Threshold set at 0.1 m/s



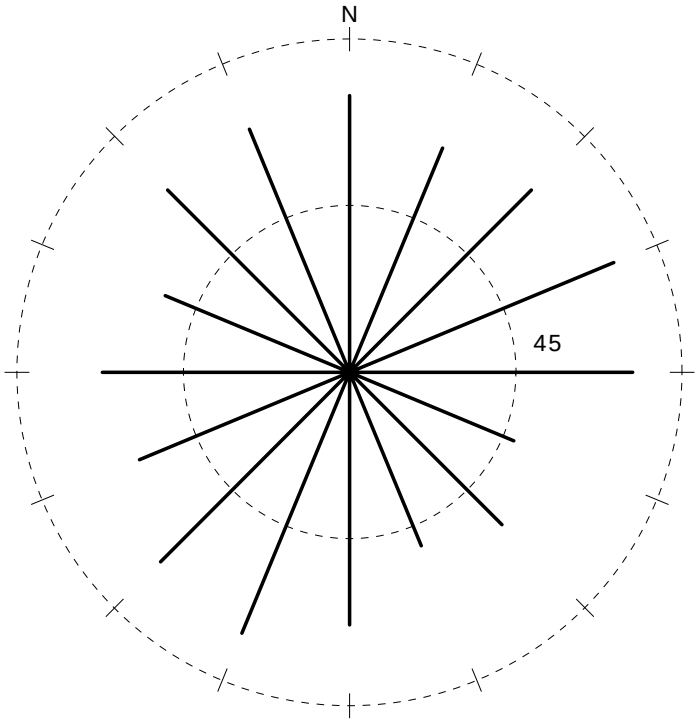
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 20/10/2003 to 19/11/2003

Windspeed Threshold set at 0.1 m/s



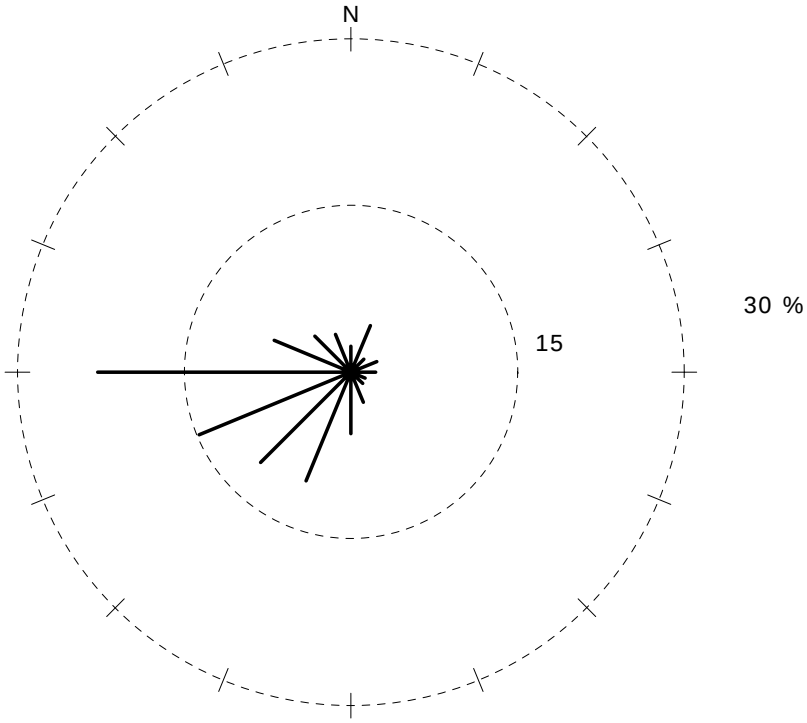
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 19/11/2003 to 18/12/2003

Windspeed Threshold set at 0.1 m/s



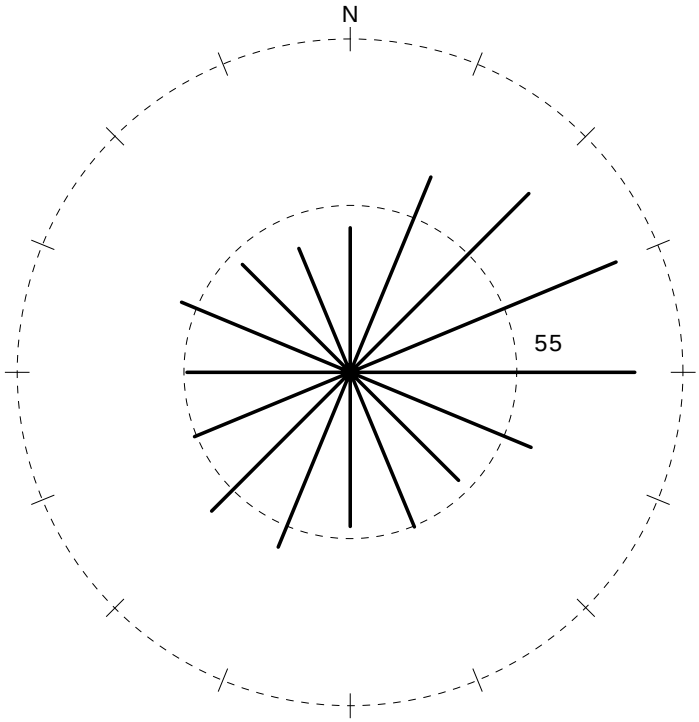
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 19/11/2003 to 18/12/2003

Windspeed Threshold set at 0.1 m/s



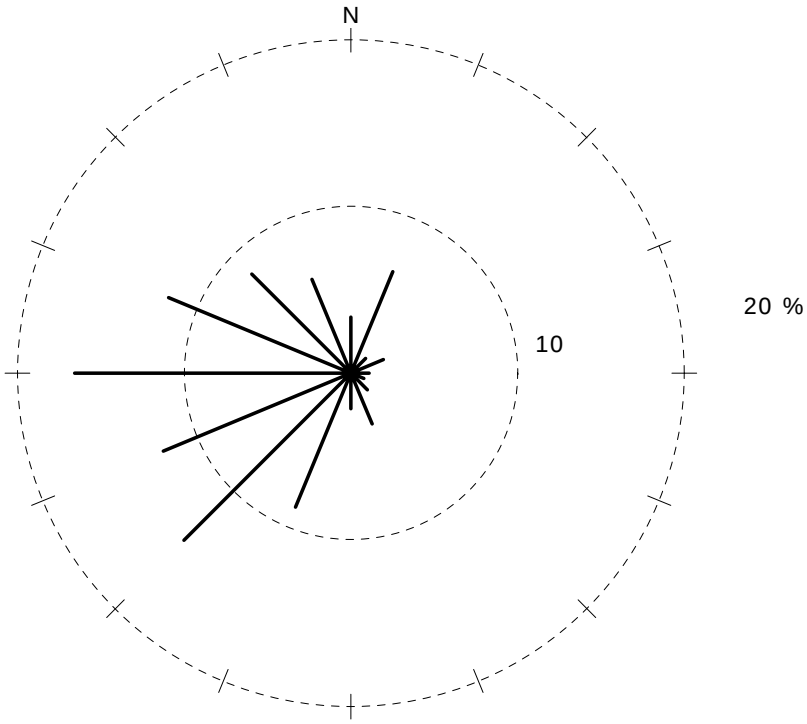
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 18/12/2003 to 19/01/2004

Windspeed Threshold set at 0.1 m/s



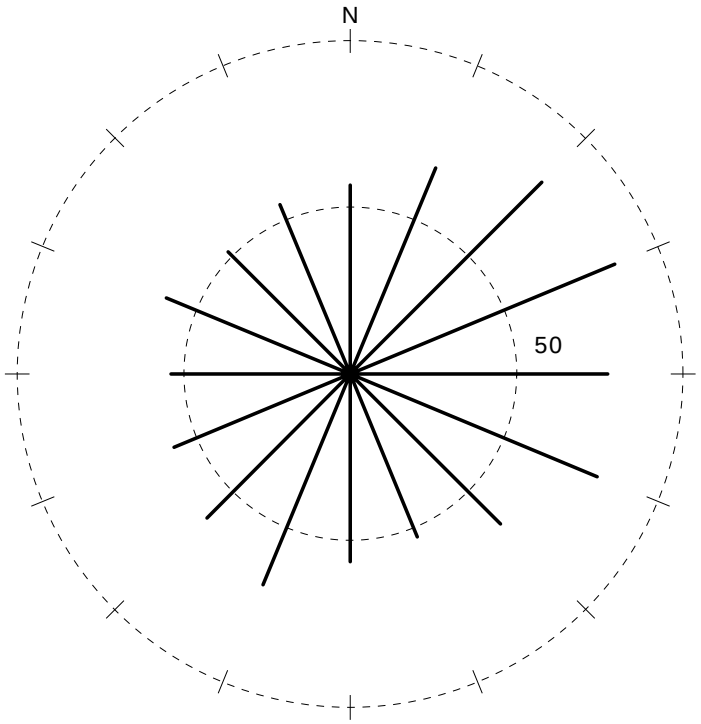
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 18/12/2003 to 19/01/2004

Windspeed Threshold set at 0.1 m/s



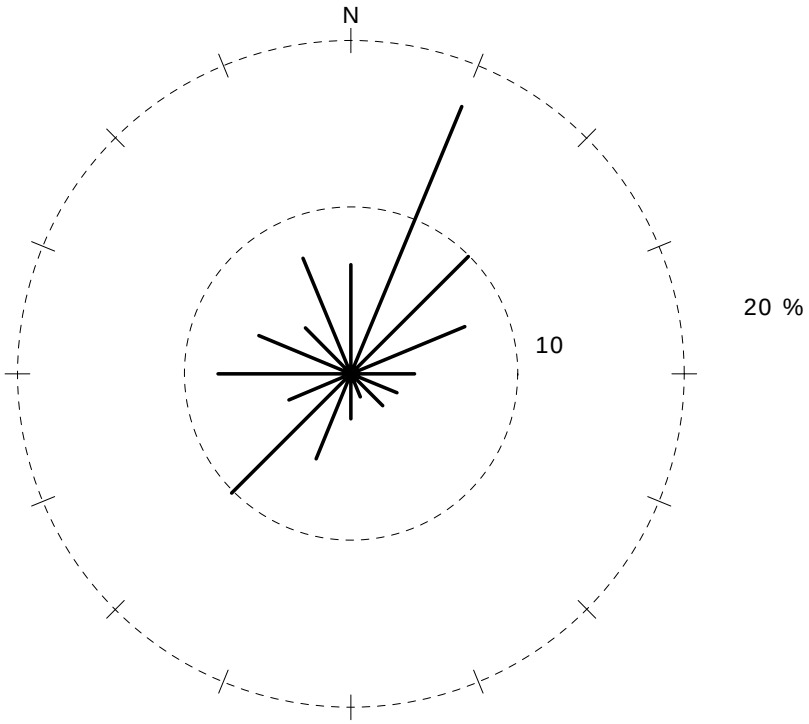
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 19/01/2004 to 16/02/2004

Windspeed Threshold set at 0.1 m/s



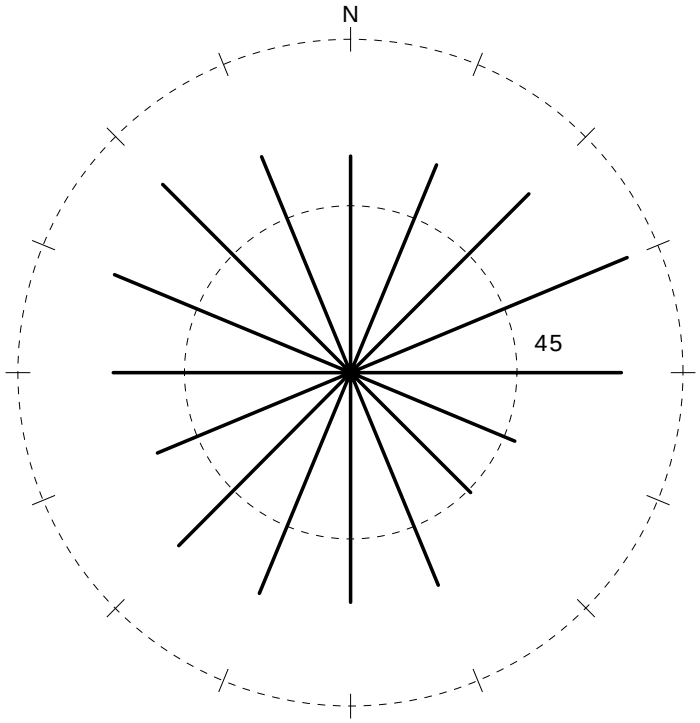
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 19/01/2004 to 16/02/2004

Windspeed Threshold set at 0.1 m/s



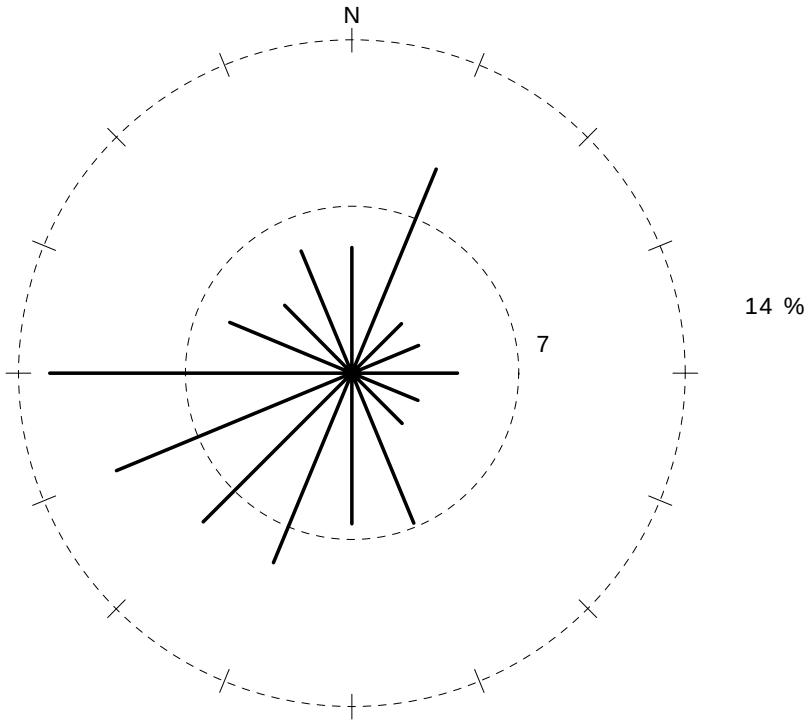
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 16/02/2004 to 18/03/2004

Windspeed Threshold set at 0.1 m/s



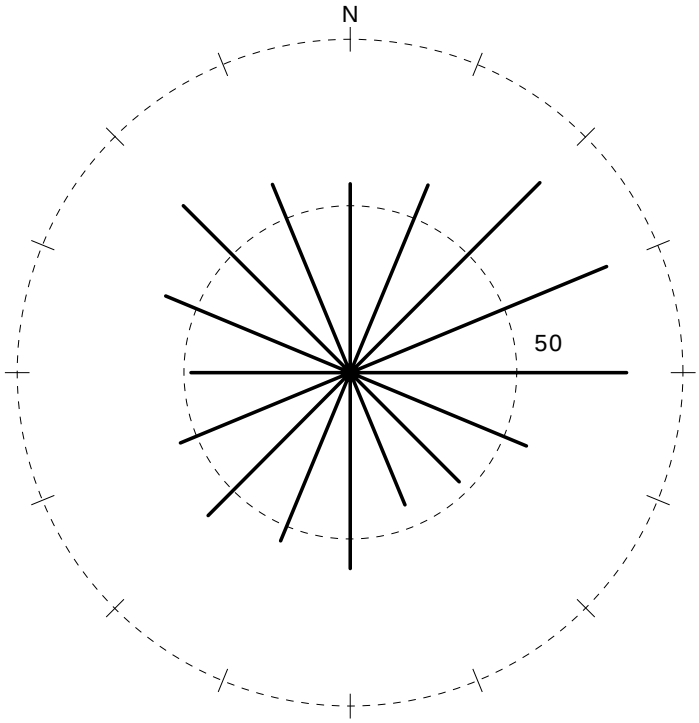
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 16/02/2004 to 18/03/2004

Windspeed Threshold set at 0.1 m/s



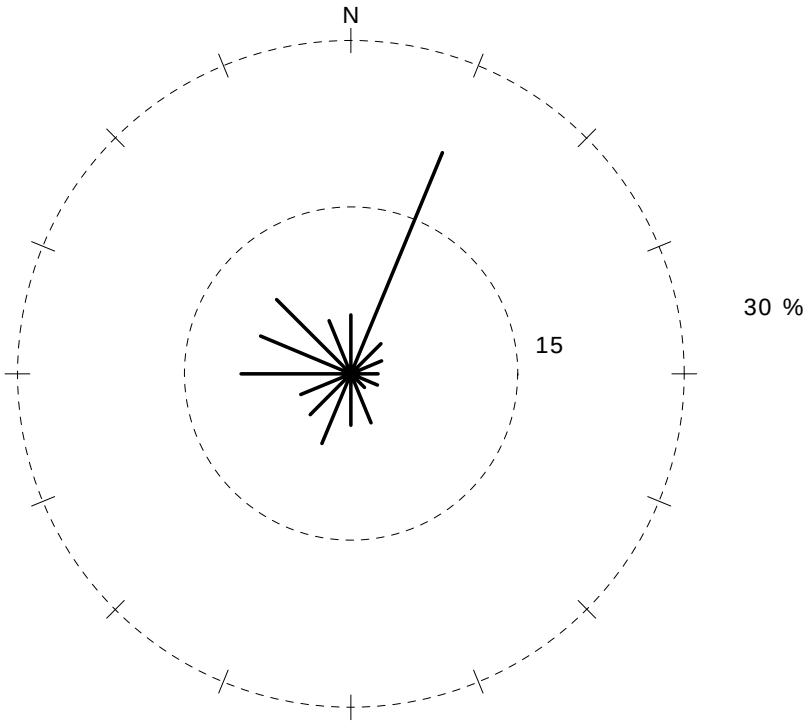
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 18/03/2004 to 19/04/2004

Windspeed Threshold set at 0.1 m/s



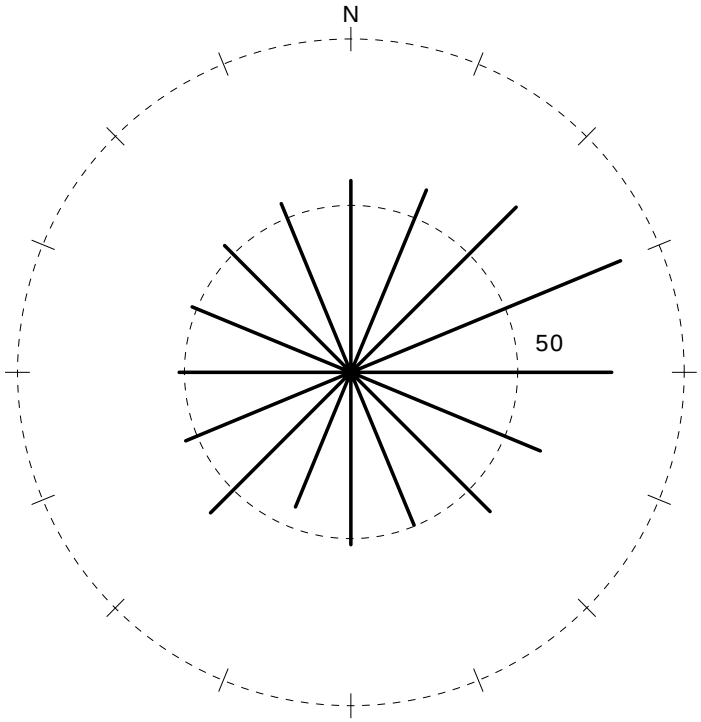
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 18/03/2004 to 19/04/2004

Windspeed Threshold set at 0.1 m/s



WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 19/04/2004 to 19/05/2004

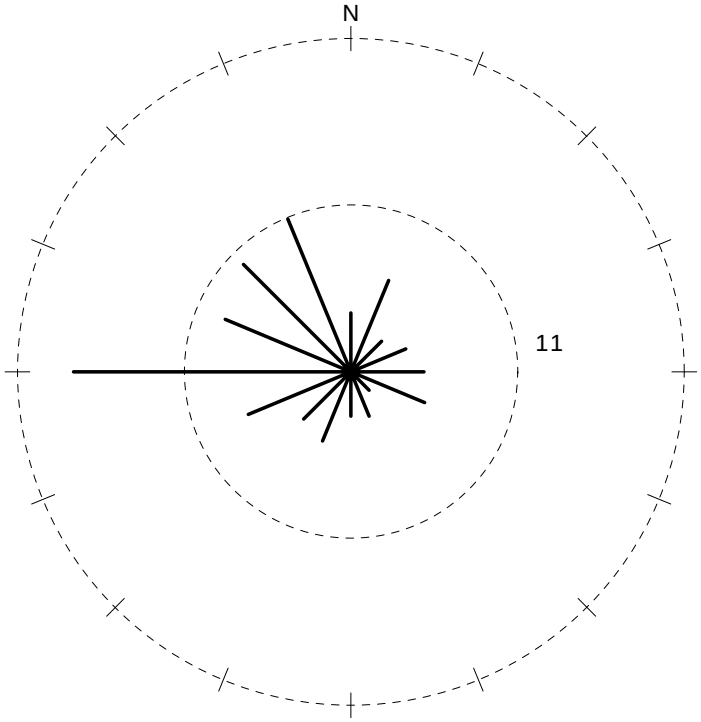
Windspeed Threshold set at 0.1 m/s



100 µg m-3 (20'C 1013

WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 19/04/2004 to 19/05/2004

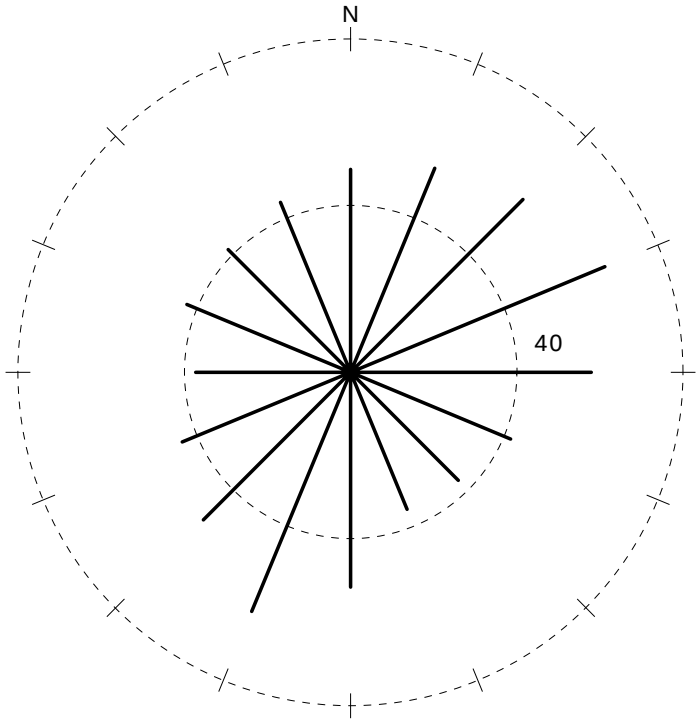
Windspeed Threshold set at 0.1 m/s



22 %

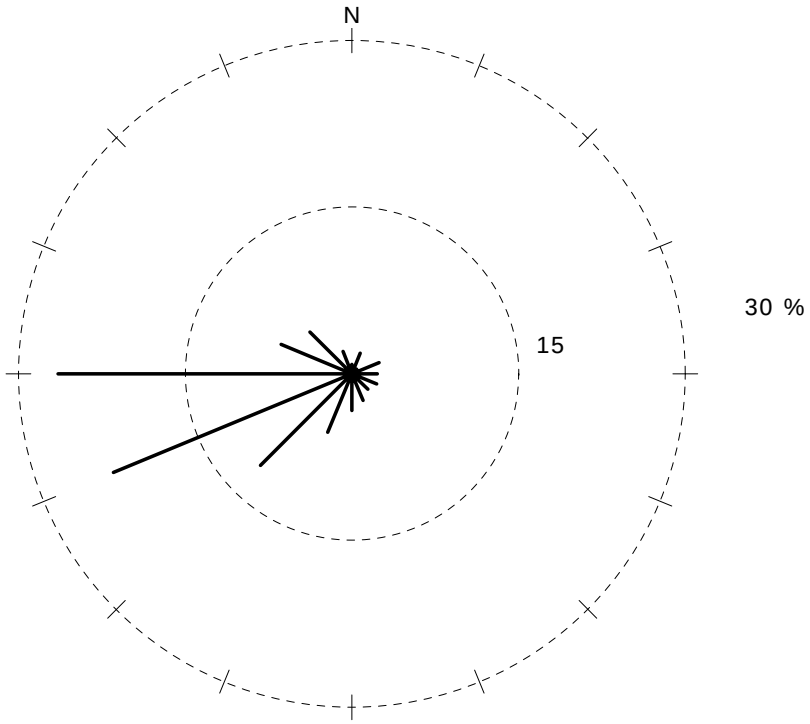
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 19/05/2004 to 21/06/2004

Windspeed Threshold set at 0.1 m/s



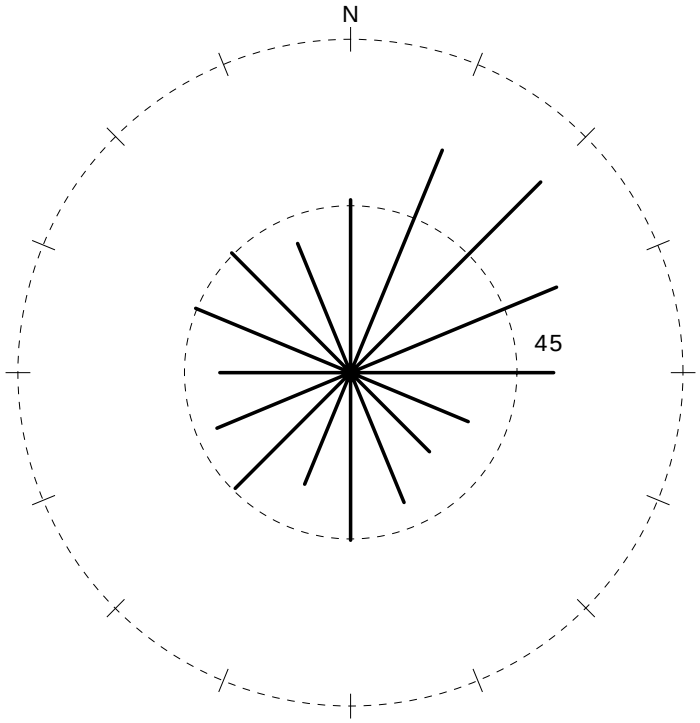
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 19/05/2004 to 21/06/2004

Windspeed Threshold set at 0.1 m/s



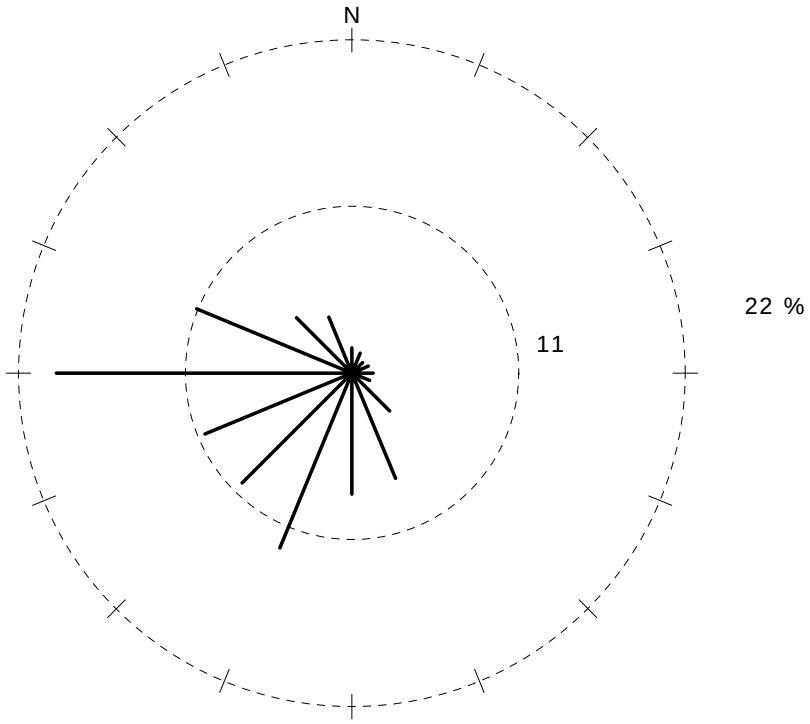
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 21/06/2004 to 19/07/2004

Windspeed Threshold set at 0.1 m/s



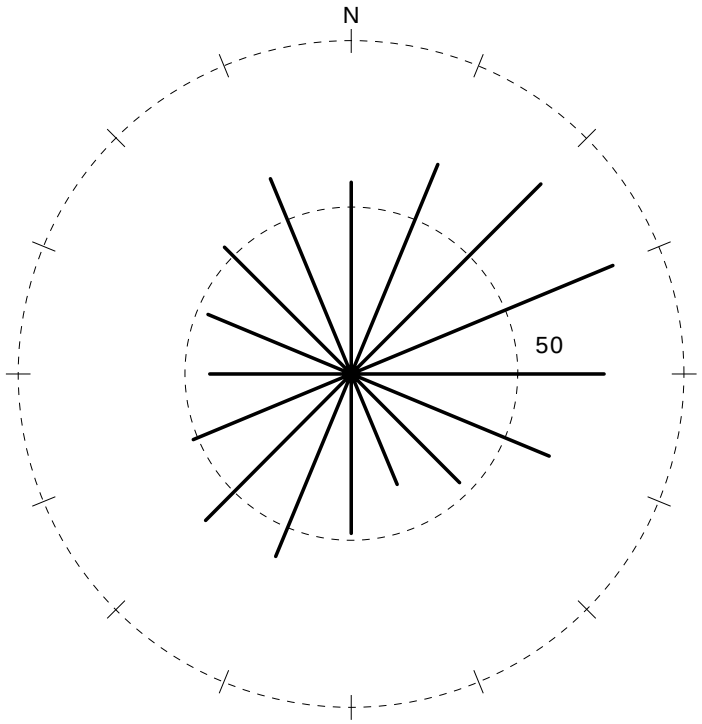
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 21/06/2004 to 19/07/2004

Windspeed Threshold set at 0.1 m/s



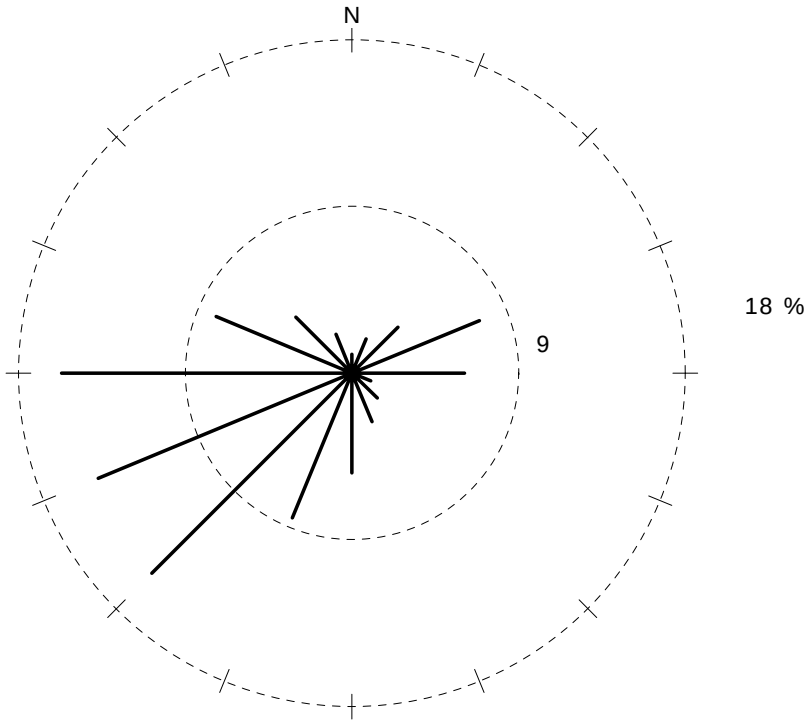
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 19/07/2004 to 18/08/2004

Windspeed Threshold set at 0.1 m/s



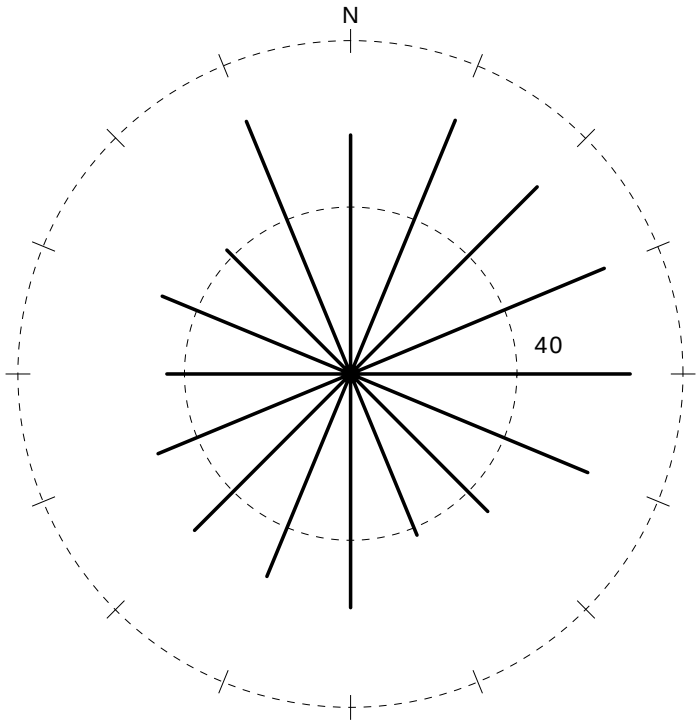
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 19/07/2004 to 18/08/2004

Windspeed Threshold set at 0.1 m/s



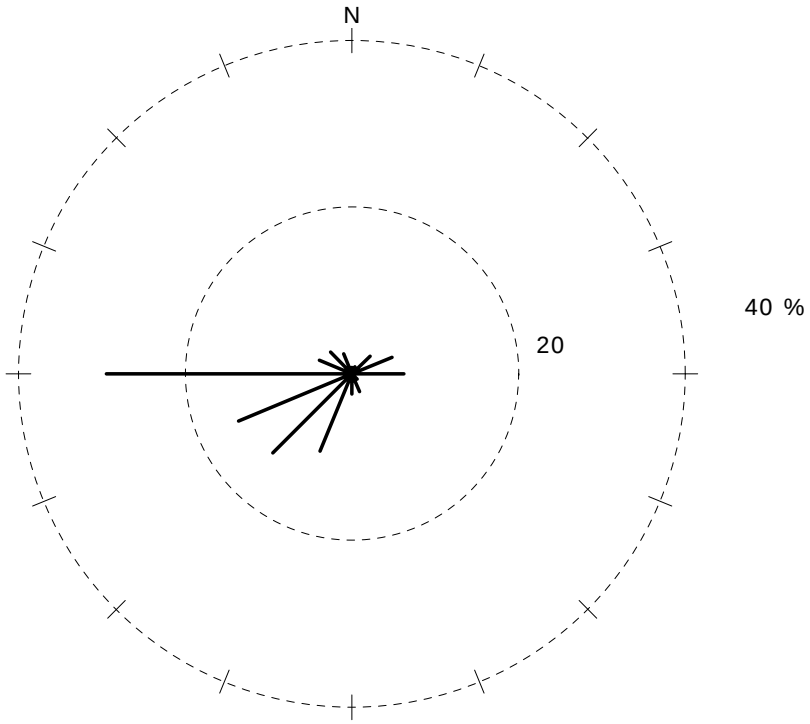
WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 18/08/2004 to 16/09/2004

Windspeed Threshold set at 0.1 m/s



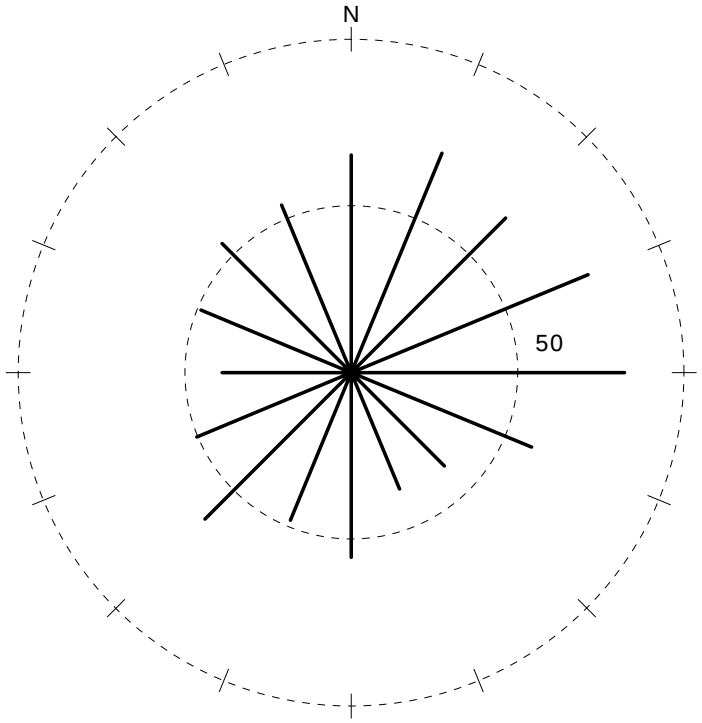
WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 18/08/2004 to 16/09/2004

Windspeed Threshold set at 0.1 m/s



WIND ROSE ANALYSIS
Heathrow LHR2 Wind Direction Rose : 16/09/2004 to 11/10/2004

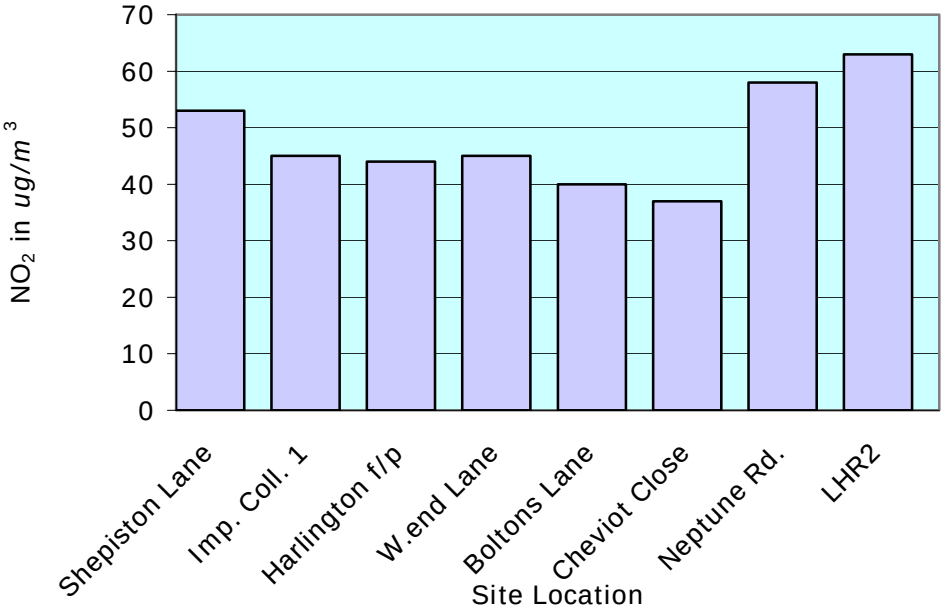
Windspeed Threshold set at 0.1 m/s

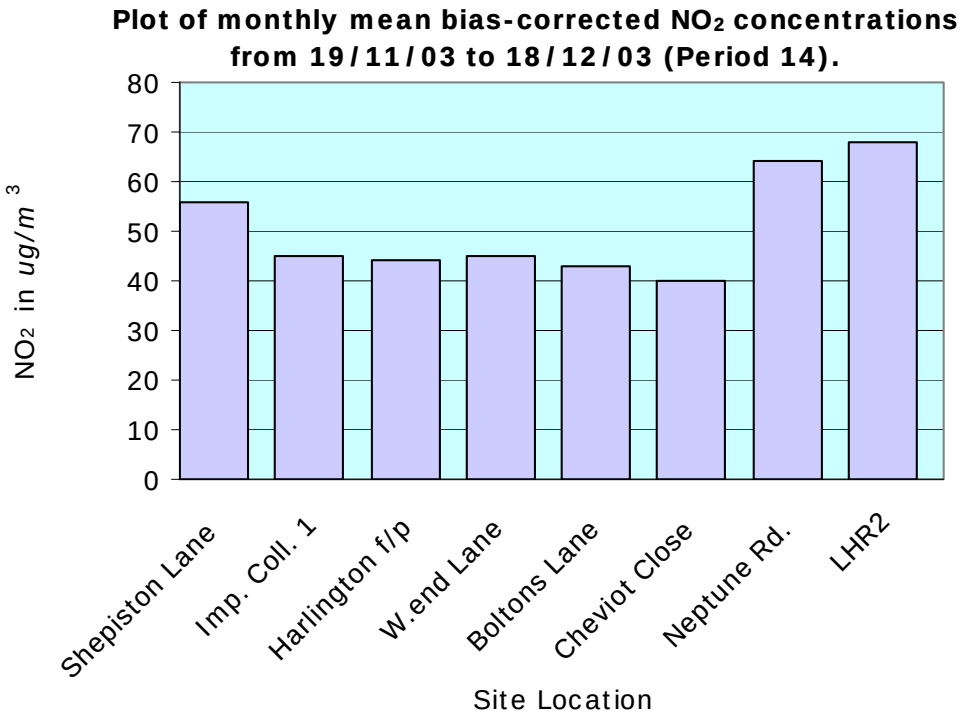


WIND ROSE ANALYSIS
Heathrow LHR2 Nitrogen Dioxide Rose : 16/09/2004 to 11/10/2004

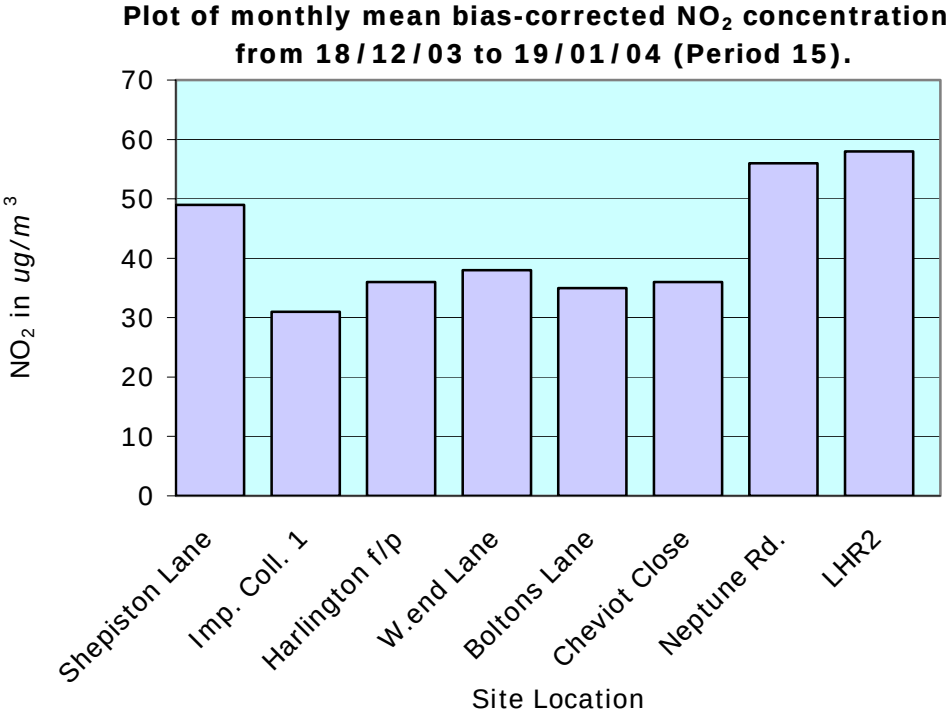
Windspeed Threshold set at 0.1 m/s

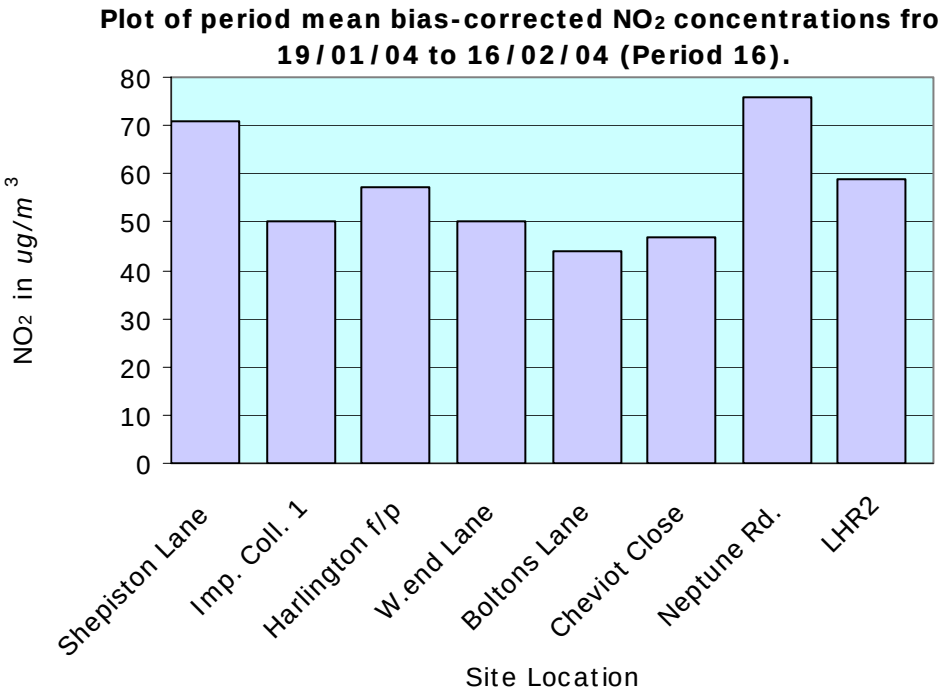
Plot of period-mean bias-corrected NO_2 concentrations from 20/10/03 to 19/11/03 (Period 13).



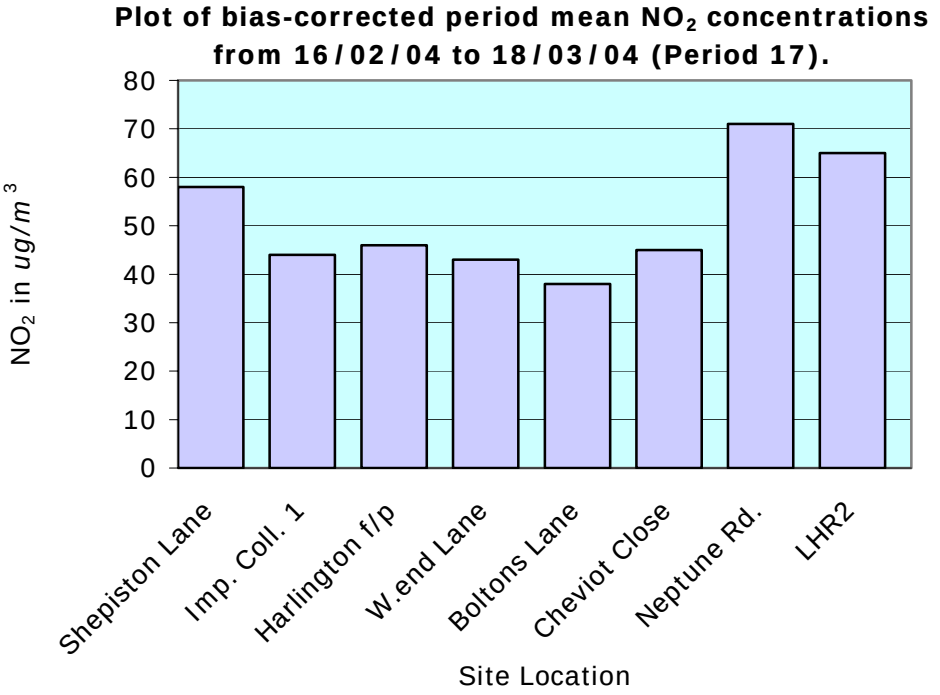


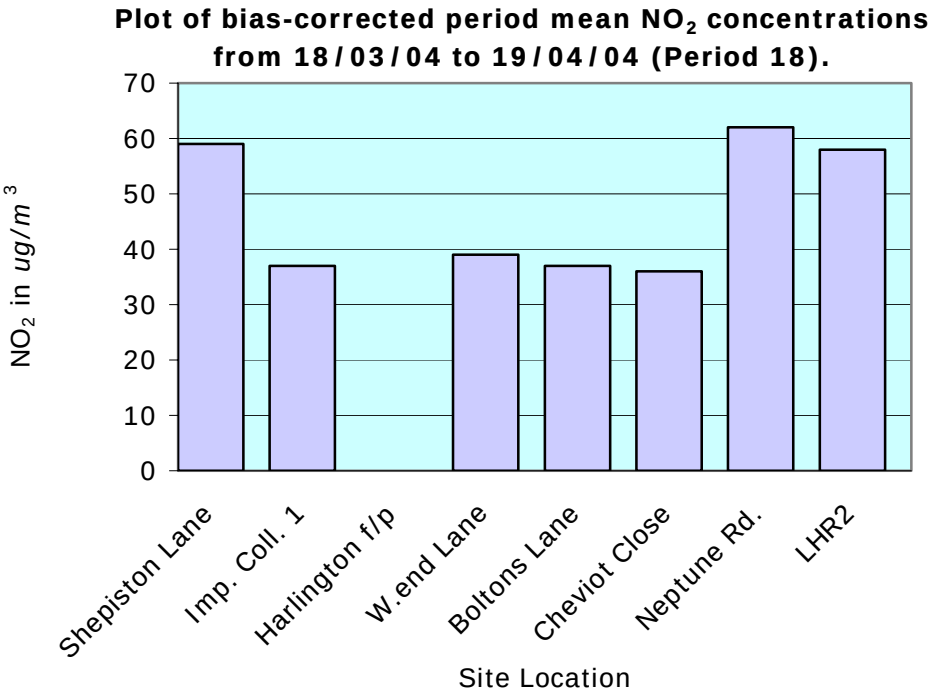
Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data and standardised to 20°C and 1013mb.



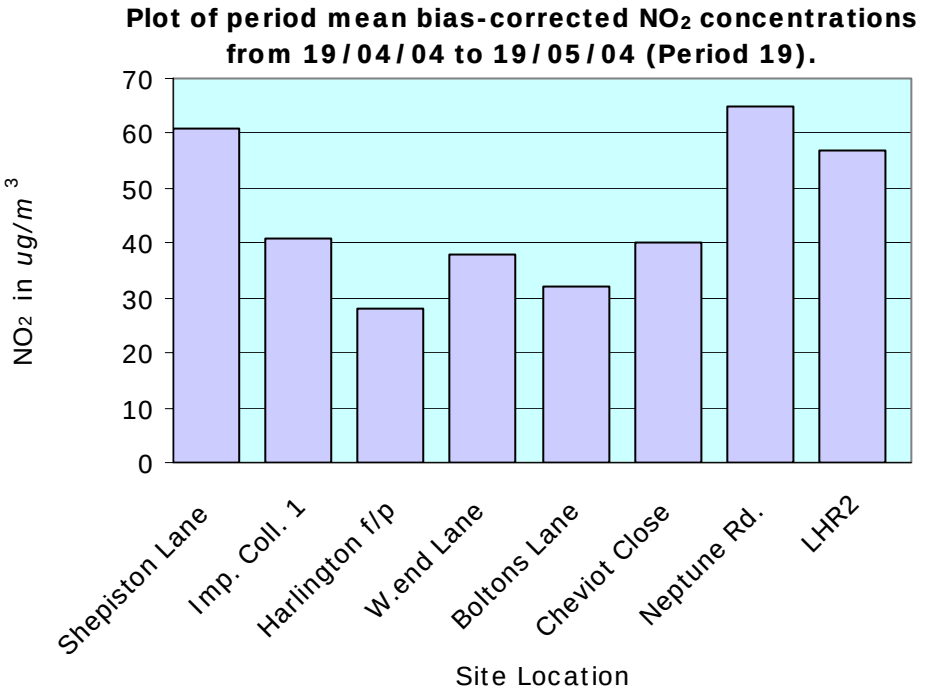


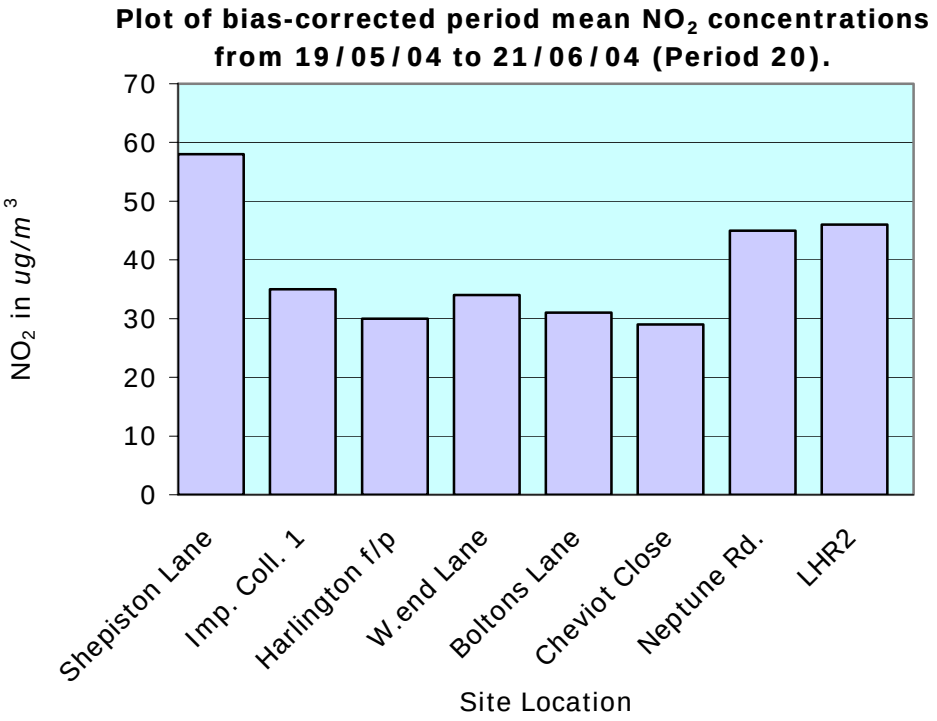
Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data and standardised to 20°C and 1013mb.



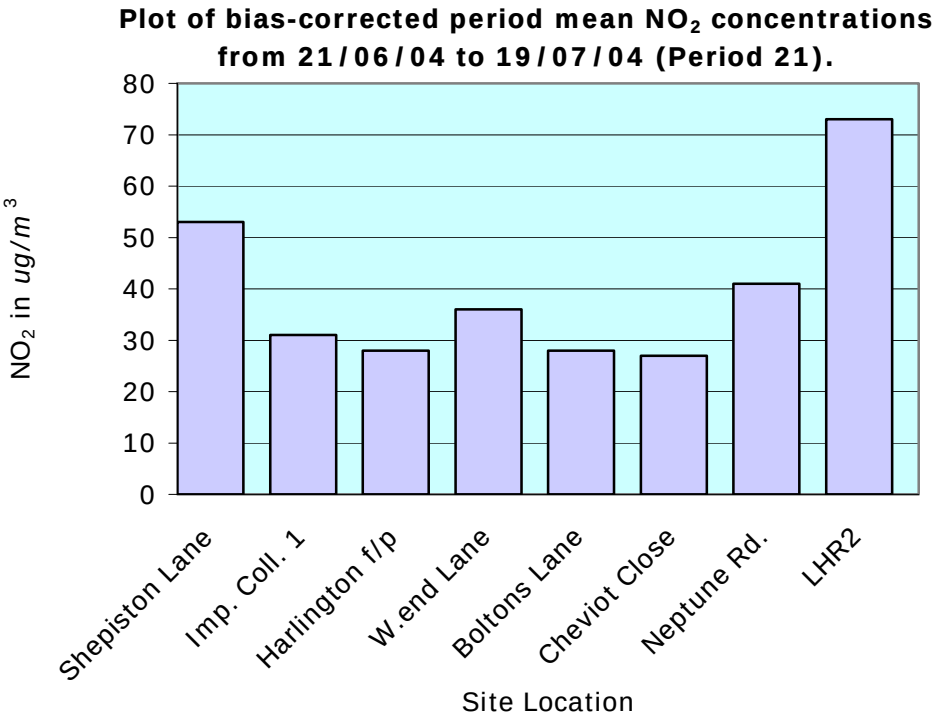


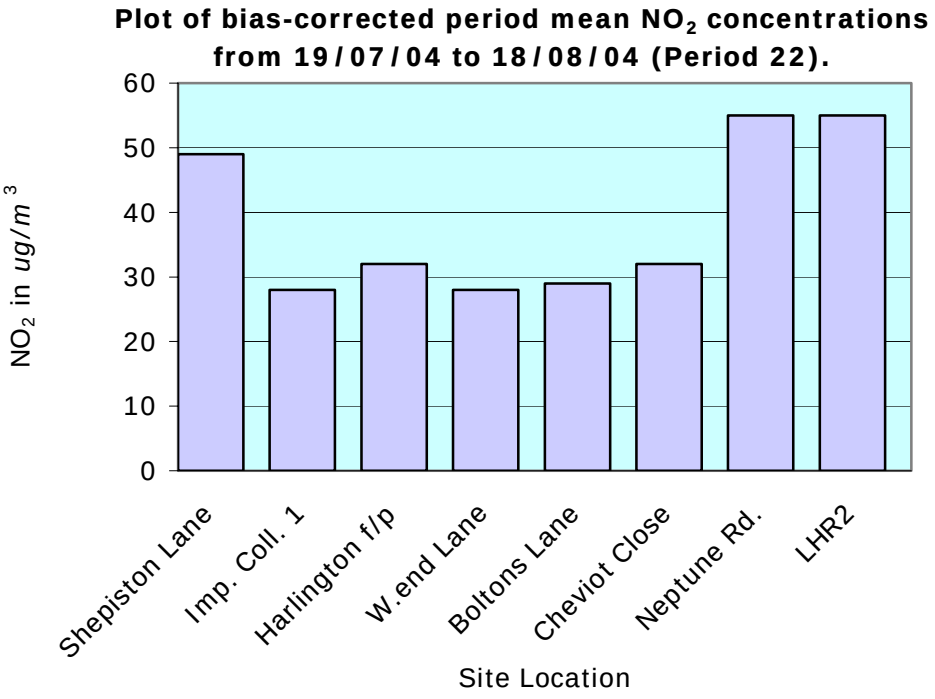
Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data and standardised to 20°C and 1013mb.



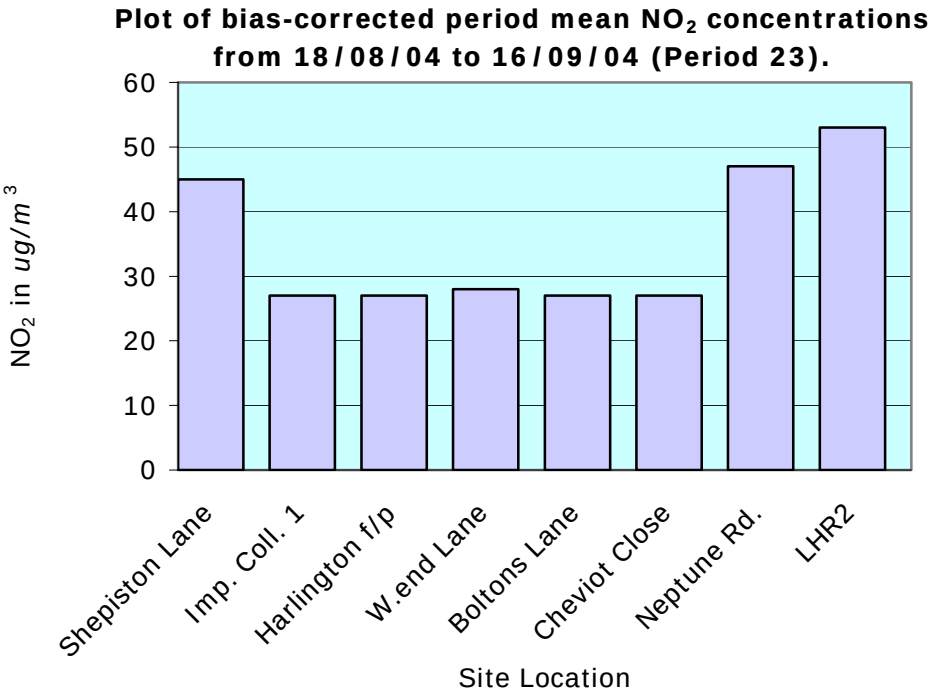


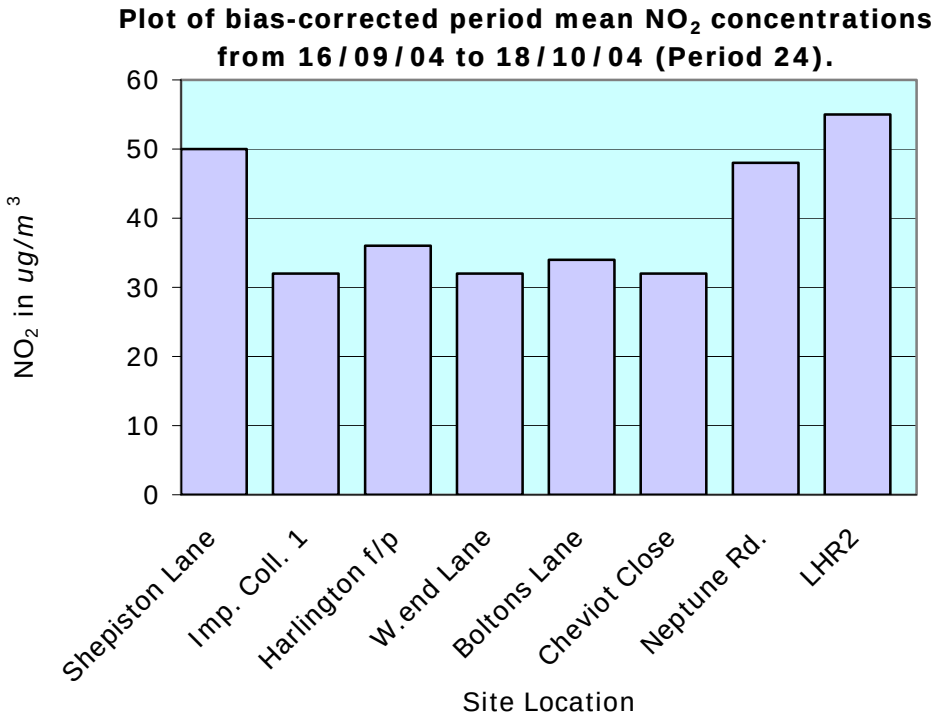
Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data standardised to 20°C and 1013mb.





Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data and standardised to 20°C and 1013mb.





Note: Calculated using monthly bias correction factor from ratified Chemiluminescent data and standardised to 20°C and 1013mb.

Appendix 4 Introduction to New Netcen Spreadsheet

Introduction to the newly design spreadsheet, refered to as 'DT_PrecisionAccuracyBias', developed by Netcen, for use with nitrogen dioxide diffusion tube survey data-sets

The spreadsheet has been designed 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 5
Relevant Air Quality Standards

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.			

First EC Air Quality Daughter Directive Limit Values (1999/30/EC)

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	1 January 2010
	40 μg m^{-3} (21 ppb)	Annual Mean	1 January 2010
Nitrogen Oxides*	(V) 30 μg m^{-3} (16 ppb)	Annual Mean	19 July 2001
Notes: μg m^{-3} - micrograms per cubic metre. * (V) = Applies only to 'rural' areas, for protection of vegetation.			