Appendix 12

Data From Air Quality Measurement Programme

Air Quality
CONSULTANTS

London City Airport
Air Quality Measurement Programme:
Annual Report 2012

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Experts in air quality
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Client	London City Airport	**Principal Contact**	Gary Hodgetts

Job Number	J1188

Report Prepared By:	Suzanne Hodgson, Kieran Laxen and Stephen Moorcroft

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Air Quality Consultants Ltd
23 Coldharbour Road, Bristol BS6 7JT Tel: 0117 974 1086
12 Airedale Road, London SW12 8SF Tel: 0208 673 4313
aqc@aqconsultants.co.uk

Registered Office: 12 St Oswalds Road, Bristol, BS6 7HT
Companies House Registration No: 2814570

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Executive Summary

This document represents the 2012 Annual Report for the Air Quality Measurement Programme (AQMP) that is operated by Air Quality Consultants Ltd. on behalf of London City Airport. This programme measures concentrations of nitrogen dioxide (NO_2) and fine particles (the so called PM_{10} fraction, i.e. particles that are less than 10 micrometres in diameter).

Monitoring is carried out at two automatic monitoring stations. One is situated on the roof of City Aviation House (LCA-CAH) whilst the other is to the north of Royal Albert Dock, adjacent to the Newham Dockside building (LCA-ND). These automatic sites are supplemented by a network of passive monitoring devices (nitrogen dioxide diffusion tubes) located at a further 18 sites in and around the Airport boundary.

The Government has set a number of air quality objectives to protect human health. These are equivalent to, or are more stringent than the limit values set by the European Union. Both the objectives and the limit values are based on monitoring carried out over the period of a calendar year.

In some cases, these objectives and limit values refer to average concentrations of pollutants measured over the calendar year (the "annual mean"); in other cases they refer to the number of hours or days on which a specified pollutant concentration should not be exceeded (for example, no more than 35 days in each calendar year on which PM_{10} concentrations exceed 50 $\mu g/m^3$, and no more than 18 hours in each calendar year on which nitrogen dioxide concentrations exceed 200 $\mu g/m^3$).

In addition to the objectives and limit values, the Government has established a set of descriptors for the 1-hour mean concentrations of nitrogen dioxide and 24-hour mean concentrations of PM_{10}. Air quality is defined by these descriptors as being Low, Moderate, High and Very High (these descriptors have recently been modified and therefore differ from those reported previously).

Pollution concentrations measured in and around the Airport are associated with a wide range of sources at the local, regional, national and international scales. On occasions when pollution levels rise, these higher levels are often observed across the whole of London as a "regional pollution episode". To assist with the interpretation of the results, pollution levels measured at other London monitoring sites are included in this report.

Nitrogen Dioxide

The 2012 annual mean nitrogen dioxide concentration measured at the automatic station on the roof of City Aviation House was 34.8 $\mu g/m^3$ (microgrammes per cubic metre); a slightly lower concentration (29.8 $\mu g/m^3$) was measured at the Newham Dockside site. The annual mean objective (40 $\mu g/m^3$) was not exceeded at either site in 2012.

There were no recorded exceedences of the 1-hour mean objective at either site. At City Aviation House, there were no exceedences of the 1-hour mean objective value (200 $\mu g/m^3$), and all 1-hour mean

concentrations were classified as "Low". At Newham Dockside, there were three exceedences of the 1-hour mean objective value, compared with the 18 exceedences allowed. Most (99.9%) of the 1-hour mean concentrations were classified as "Low"; two hours were "Moderate" and one hour was "High"; there were no 1-hour mean concentrations within the "Very High" pollution band. As similar peak concentrations during these three episodes were not seen at City Aviation House, or at any of the other London sites, it is considered likely that these events were related to a very local pollution source, e.g. an idling vehicle adjacent to the monitoring inlet.

Annual mean concentrations of nitrogen dioxide at other background and roadside sites in London over this period ranged from 21.5 to 50.8 µg/m^3, with similar patterns in levels as seen at the two London City Airport sites. There was a good correlation between observed peaks at the Airport sites and other London sites, suggesting that these occurrences were principally due to regional sources and changing weather conditions that affect the dispersion and dilution of pollutant emissions. The concentrations over the monitoring period show similar patterns at all seven monitoring sites.

The annual mean nitrogen dioxide concentrations measured at the diffusion tube sites ranged from 28.4 to 43.5 µg/m^3 compared with the objective value of 40 µg/m^3. There were no measured exceedences at any location where there is relevant exposure, and where the air quality objective applies. As measured concentrations are well below 60 µg/m^3, it is highly unlikely that the 1-hour mean objective was exceeded.

Fine Particles (PM_{10})

The annual mean PM_{10} concentration measured at the automatic station on the roof of City Aviation House was 21.2 µg/m^3 (microgrammes per cubic metre). This compares with the objective value of 40 µg/m^3. There were no recorded exceedences of the 24-hour mean objective (compared with the 35 exceedences allowed in a calendar year). The majority of the 24-hour mean concentrations were classified as "Low" (97.5%); 24-hour mean concentrations were classified as "Moderate" and "High" for 2.2% and 0.3% of the time respectively. There were no 24-hour mean concentrations within the 'Very High' pollution band.

Concentrations of PM_{10} at other background sites in London over this period showed similar patterns as seen at the Airport site. There was a good correlation between observed peaks at the Airport site and other London sites, suggesting that these occurrences were principally due to regional sources and changing weather conditions that affect the dispersion and dilution of pollutant emissions.

1 Introduction

1.1 This document represents the 2012 Annual Report for the Air Quality Measurement Programme, operated on behalf of London City Airport (LCA).

1.2 Approval to expand Airport operations to 120,000 noise-factored aircraft movements per annum was granted in July 2009. A legal agreement between London City Airport and the London Borough of Newham associated with this planning approval sets out a number of obligations, one of which relates to an Air Quality Measurement Programme (AQMP).

1.3 The AQMP, as defined within the legal agreement, comprises an automatic air quality monitoring station situated on the roof of City Aviation House, and a network of nitrogen dioxide diffusion tubes, situated in and around the Airport site. In addition, London City Airport commissioned a second automatic air quality monitoring station at a site adjacent to the Newham Dockside building in September 2008. The operation of this additional site falls outside the AQMP, but the data are included in this Annual Report for the sake of completeness.

1.4 The monitoring programme is managed by Air Quality Consultants Ltd. (AQC) on behalf of London City Airport. Service support for the automatic monitoring stations is provided by Enviro Technology Services plc, with Ricardo-AEA providing independent audit checks.

1.5 Chapter 2 of this Report sets out the various standards and guidelines against which air pollution concentrations should be compared. Chapter 3 describes the monitoring methodology and provides a summary of the measured concentrations in 2012 with respect to these criteria, and compares the measured concentrations with other local monitoring sites. Chapter 4 then provides some analysis of the monitoring data with respect to trends and source contributions.

2 Assessment Criteria

2.1 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air Quality Regulations, 2000 (Stationery Office, 2000) and the Air Quality (England) (Amendment) Regulations 2002 (Stationery Office, 2002). The relevant objectives for this report are provided in Table 1.

Table 1: Relevant Air Quality Objectives

Pollutant	Time Period	Objective / Value
Nitrogen Dioxide	1-hour mean	200 µg/m^3 not to be exceeded more than 18 times a year
	Annual mean	40 µg/m^3
Fine Particles (PM_{10})[a]	24-hour mean	50 µg/m^3 not to be exceeded more than 35 times a year [b]
	Annual mean	40 µg/m^3

[a] Measured by the gravimetric method.

[b] Equivalent to a 90th percentile of 24-hour mean concentrations of 50 µg/m^3.

2.2 The objectives for nitrogen dioxide and PM_{10} were to have been achieved by 2005 and 2004 respectively, and continue to apply in all future years thereafter.

2.3 The European Union has also set limit values for both nitrogen dioxide and PM_{10}. Achievement of these values is a national obligation rather than a local one. The limit values for nitrogen dioxide are the same levels as the UK objectives, and are to be achieved by 2010 (Stationery Office, 2007). The limit values for PM_{10} are also the same level as the UK statutory objectives, and were to be achieved by 2005. The objectives are the same as, or more stringent than, the limit values, thus it is appropriate to focus the assessment on the objectives.

2.4 In addition to the objectives and limit values, Defra has established a set of descriptors for the 1-hour mean values for nitrogen dioxide, classifying the concentrations in an index from 1 to 10 and thus labelling the levels as Low, Moderate, High and Very High (Defra, 2011). The banding is referred to as the Daily Air Quality Index (DAQI). The DAQI criteria are set out in Table 2.

Table 2: DAQI Bandings (µg/m^3)

Band	Index	Nitrogen Dioxide 1-hour Mean (µg/m^3)	PM_{10} 24-hour mean (µg/m^3) [a]
Very High	10	601 or more	101 or more
High	9	535 – 600	92 – 100
	8	468 – 534	84 – 91
	7	401 – 467	76 – 83
Moderate	6	335 – 400	67 – 75
	5	268 – 334	59 – 66
	4	201– 267	51 – 58
Low	3	135 – 200	34 – 50
	2	68 – 134	17 – 33
	1	0 – 67	0 – 16

[a] Reference equivalent. 24-hour values are midnight to midnight.

3 Monitoring Methodology and Results

Automatic Monitoring Stations

3.1 Monitoring was carried out at two automatic stations as follows:

- City Aviation House (LCA-CAH): Nitrogen dioxide and PM_{10}
- Newham Dockside (LCA-ND): Nitrogen dioxide

3.2 The locations of the two automatic sites are shown in Figure 1.

3.3 The LCA-CAH automatic monitoring station measures PM_{10} using a Rupprecht and Patashnick TEOM 1400 Particulate Monitor, whilst both automatic stations measure nitrogen dioxide using M200E TAPI chemiluminescence analysers. The data are stored as 15-minute mean concentrations. Before further processing and ratification the raw PM_{10} concentrations have been adjusted to a "reference-equivalent" concentration using the Volatile Correction Model (VCM) as recommended by Defra (2009). This adjusts the TEOM data using the "purge" concentration measured by an FDMS analyser, assuming this represents the volatile component that has been lost. A "VCM web portal" has been established that allows this correction to be derived from the mean of up to three nearby FDMS analysers in the national network.

3.4 Independent site audits, conducted by Ricardo-AEA, confirmed that both automatic monitoring stations were operating above the minimum standards set for the national networks operated by Government. Audits were carried out on 5th March 2012, 12th September 2012 and 20th March 2013 and have been taken into account in producing the fully ratified dataset.

3.5 Ratification of the data has been based on calibration factors determined from the calibration reports, along with visual examination of the data and comparison with monitoring data from nearby national network background sites (Bexley, Bloomsbury and Eltham) (Defra, 2013). Any erroneous data have been flagged and removed from subsequent analysis. 1-hour, 24-hour, and period means have then been calculated.

3.6 Pollution concentrations measured at both automatic Airport monitoring stations are associated with a wide range of sources at the local, regional, national and international scales. On occasions when pollution levels rise, these higher levels are often observed across the whole of London as a "regional pollution episode". To assist with the interpretation of the results, comparable data have been obtained from the national Air Quality Archive (Defra, 2011a) for three background sites, Bexley, Bloomsbury and Eltham, and from the London Air Quality Network (KCL, 2013) for two sites within the London Borough of Newham at Wren Close, Canning Town (background) and Cam Road, Stratford (roadside).

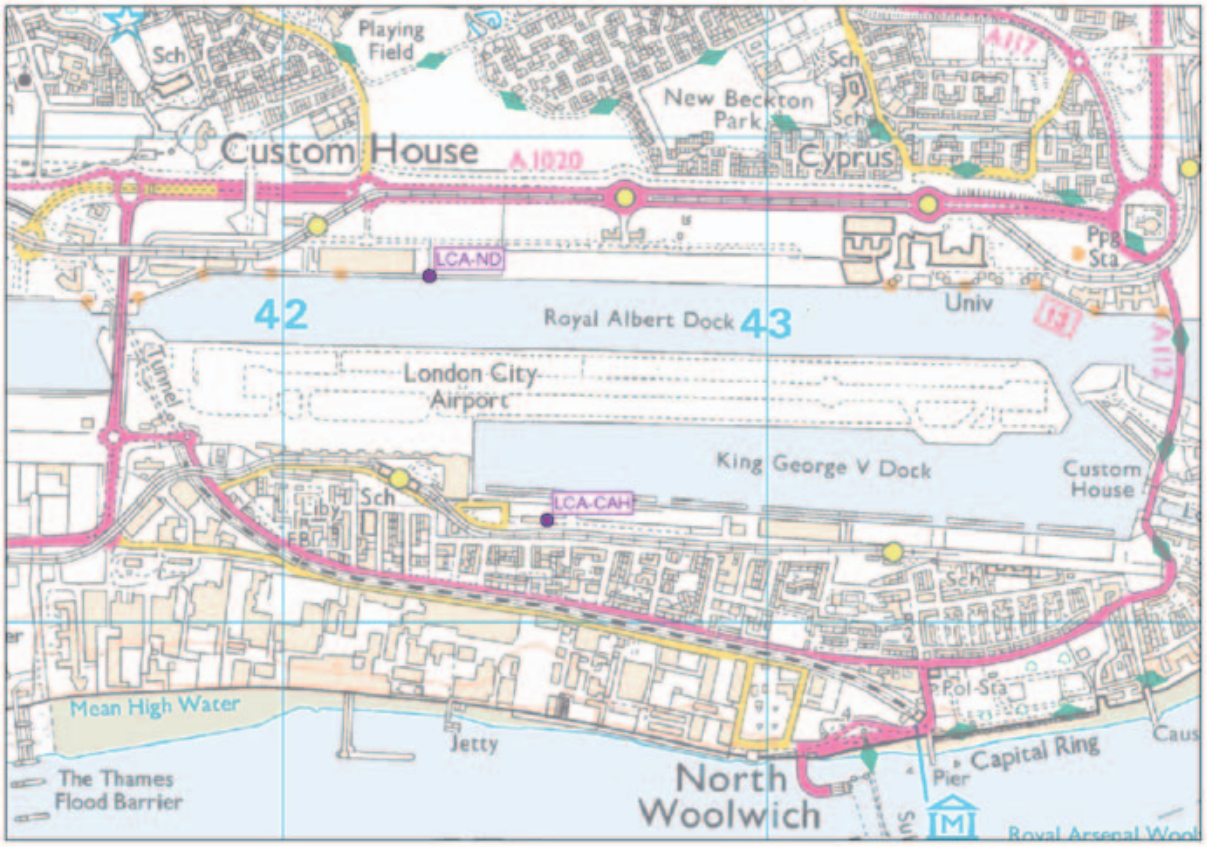

Figure 1: Automatic Monitoring Locations (red dots).

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Nitrogen Dioxide

3.7 The 2012 nitrogen dioxide results for the LCA-CAH and LCA-ND automatic monitoring stations are summarised in Table 3. Data capture for both sites was high at 95%[1]. The annual mean concentration did not exceed the objective of 40 µg/m^3 at either site. The 1-hour mean objective was also not exceeded at either site; there were no 1-hour mean concentrations above the objective value (200 µg/m^3) recorded at LCA-CAH, and three exceedences of the objective value at LCA-ND, compared with the 18 exceedences allowed.

Table 3: Nitrogen Dioxide (NO_2) Data Summary for LCA-CAH and LCA-ND, 2012[a]

Metric	LCA-CAH	LCA-ND	Objectives
	NO_2	NO_2	
Maximum 1- Hour Mean	179 µg/m^3	402 µg/m^3	-
No. 1-Hour Mean > 200 µg/m^3	0	3	200 µg/m^3; no more than 18 exceedences
Annual Mean	34.8 µg/m^3	29.8 µg/m^3	40 µg/m^3
Data Capture	95.0%	95.1%	-

[a] Nitrogen oxides concentrations are provided in Appendix 1.

3.8 Table 4 shows the distribution of the 1-hour mean values into the different pollution bands (DAQI).

Table 4: DAQI Bandings for Nitrogen Dioxide, 2012

Band	Index	LCA-CAH	LCA-ND
Very High [a]	10		
High [a]	9		
	8		
	7		1
Moderate [a]	6		
	5		1
	4		1
Low [a]	3	19	2
	2	733	454
	1	7138	7435

a Number of 1-hour values

3.9 At LCA-CAH, all measured 1-hour mean nitrogen dioxide concentrations fell into the 'Low' pollution band during 2012. At LCA-ND, the majority of 1-hour measured nitrogen dioxide concentrations fell into the 'Low' pollution band (99.9%) during 2012; there were two, 1-hour mean concentrations

[1] It is inevitable that a small amount of data will be "lost" in each year due to routine downtime for calibrations and site servicing.

within the 'Moderate' pollution band (0.03%) and one, 1-hour mean concentration within the 'High' pollution band (0.01%). There were no 'Very High' events.

3.10 Nitrogen dioxide concentrations for five monitoring sites across London in 2012 are summarised in Table 5. These sites range from central London (Bloomsbury) to outer London (Bexley). The measured annual mean concentrations at London City Airport (34.8 µg/m^3 at LCA-CAH and 29.8 µg/m^3 at LCA-ND) were lower than those at Canning Town, Bloomsbury and Stratford (37.7 µg/m^3, 50.8 µg/m^3 and 42.5 µg/m^3 respectively), and higher than those measured at Eltham and Bexley (21.5 µg/m^3 and 24.5 µg/m^3, respectively). This is broadly consistent with the location of London City Airport between the areas of high concentrations in central London and lower concentrations towards the outskirts. The maximum 1-hour mean concentration recorded at LCA-ND was higher than at any other of the other six sites within this study. The maximum 1-hour mean concentration recorded at LCA-CAH was lower than that recorded at Bloomsbury, Canning Town and Stratford, and higher than that at Eltham and Bexley.

Table 5: Nitrogen Dioxide (NO_2) Data Summary for London Monitoring Sites, 2012[a]

Metric	Background Site				Roadside Site
	Bexley	Bloomsbury	Eltham	Canning Town	Stratford
Max. 1-hr Mean (µg/m^3)	108	190	118	190	193
No. 1-hr >200 µg/m^3	0	0	0	0	0
Annual Mean (µg/m^3)	24.5	50.8	21.5	37.7	42.5
Data Capture (%)	96.1	93.5	95.2	98.2	94.9

[a] Includes provisional data. Nitrogen oxides concentrations are provided in Appendix 1.

Particulate Matter PM_{10}

3.11 The 2012 PM_{10} results for the LCA-CAH automatic monitoring station are summarised in Table 6. Data capture was 100%. The recorded annual mean concentration (21.2 µg/m^3) was well below the objective of 40 µg/m^3. There were nine measured exceedences of the 24-hour mean objective value of 50 µg/m^3 compared with the 35 exceedences that are allowed. In addition, the 90th percentile of daily mean concentrations (34.1 µg/m^3) was below 50 µg/m^3.

Table 6: PM_{10} Data Summary for LCA-CAH, 2012

Metric	TEOM, VCM-corrected	PM_{10} Objectives
	PM_{10}	
Maximum 24-hour Mean	74.9 µg/m^3	-
No. 24-Hour Means >50 µg/m^3	9	50 µg/m^3; no more than 35 exceedences
90th Percentile	34.1 µg/m^3	50 µg/m^3
Annual Mean	21.2 µg/m^3	40 µg/m^3
Data Capture	100%	-

3.12 Table 7 shows the distribution of the 24-hour mean values into the different pollution bands (DAQI).

Table 7: DAQI Bandings for PM_{10}, 2012

Band	Index	LCA-CAH
Very High [a]	10	
High [a]	9	
	8	
	7	1
Moderate [a]	6	1
	5	3
	4	4
Low [a]	3	33
	2	199
	1	125

[a] Number of 24-hour mean values.

3.13 The majority of 24-hour measured PM_{10} concentrations fell into the 'Low' pollution band (97.5%) during 2012; there were eight, 24-hour mean concentrations within the 'Moderate' pollution band (2.2%) and one, 24-hour mean concentration within the 'High' pollution band (0.3%). There were no 'Very High' events.

3.14 PM_{10} concentrations for five sites across London in 2012 are summarised in Table 8. These sites range from central London (Bloomsbury and Eltham) to outer London (Bexley), with two in east London (Canning Town and Stratford). The measured annual mean concentration at London City Airport (21 µg/m^3) was lower than that at Stratford (27 µg/m^3), and higher than that measured at Bexley (19 µg/m^3 using VCM-corrected TEOM, 16 µg/m^3 using FDMS), Bloomsbury (19 µg/m^3), Eltham (20 µg/m^3) and Canning Town (20 µg/m^3). The number of 24-hour mean exceedences of 50 µg/m^3 was lower than at Bloomsbury, Eltham and Stratford and higher than at Bexley and Canning Town.

Table 8: PM_{10} Data Summary of Background London Monitoring Sites, 2012[a]

	Background Sites					Roadside Site
	Bexley (TEOM)	Bexley (FDMS)	Bloomsbury (FDMS)	Eltham (FDMS)	Canning Town (FDMS)	Stratford (FDMS)
Maximum 24-hr mean (µg/m^3)	72	72	77	73	52	89
Annual Mean (µg/m^3)	18.7	16.0	18.6	19.9	19.9	26.5
No. 24-hr mean >50 µg/m^3	6	7	11	10	3	14
90th Percentile	31.3	31.0	32.0	33.9	34.0	42.5
Data Capture (%)	93.4	90.5	98.0	89.4	46.2	73.6

[a] All values are reference equivalent. All data, except where stated, are reported as VCM-corrected TEOM concentrations.

Nitrogen Dioxide Diffusion Tube Network

3.15 London City Airport also operates a network of passive diffusion tube samplers for nitrogen dioxide. The intent of this network is to establish the wider spatial pattern of nitrogen dioxide concentrations in the area surrounding the Airport. The locations of the monitoring sites are shown in Figure 2, and are described in Table 9; grid references and the monthly mean data are provided in Appendix 3. The diffusion tubes are exposed for approximately 4-week intervals. They are supplied and analysed by Gradko International Ltd., and are prepared using the 20% TEA in water method.

3.16 The diffusion tubes record monthly mean concentrations, which have been averaged to give the annual mean. The results cannot therefore be directly compared with the 1-hour mean objective. However, measurements across the UK have shown that the 1-hour mean nitrogen dioxide objective is unlikely to be exceeded where the annual mean concentration is below 60 µg/m^3 (Defra, 2009).

Table 9: Description of Diffusion Tube Monitoring Sites [a]

Location	Site ID
Lamp post at top of Parker Street, adjacent to housing	LCA 01
Lamp post on Camel Road, adjacent to nearest property on Hartmann Street	LCA 02
Lamp post on access road in Silvertown Quay. Approx. 36 metres from kerbside of main road	LCA 03
Lamp post at waterfront to east end of Newham Dockside	LCA 04
Lamp post on Straight Road, at kerbside	LCA 05
Lamp post on pedestrian walkway adjacent to nearest housing at Gallions Way	LCA 06
Landing Lights	LCA 07
Lamp post on Brixham Street	LCA 08
City Aviation House (triplicate tubes)	LCA 09
Jet Centre – airside	LCA 10
Lamp post at waterfront, eastern end of the University of East London	LCA 11
ILS, to north of runway and south of Royal Albert Dock	LCA 12
Lamp post at north west corner of Newham Dockside	LCA 13
Lamp post on waterfront at western end of Newham Dockside	LCA 14
Lamp post at kerbside (approx 1 m) of Royal Albert Way	LCA 15
Waterfront, approx 180 m east of Newham Dockside	LCA 16
Newham Dockside analyser	LCA 18
Waterfront, approximately 460m east of Newham Dockside	LCA 19

a LCA-17 has been discontinued from January 2012 as the lamppost on which diffusion tubes were deployed has been removed. The Council was advised of this in February 2012, and agreed that the AQMP would not be significantly affected.

3.17 It is important to note that not all of these monitoring sites represent relevant public exposure for annual mean concentrations of nitrogen dioxide; thus the objectives are not strictly applicable at all of these sites. For instance, the sites at Landing Lights (LCA 07), the Jet Centre (LCA 10) and the ILS (LCA 12) are located on land that is not generally accessible by the public, or is owned by the Airport. The sites at LCA 04 (at the waterfront of Newham Dockside), LCA 11 (at the waterfront of the University of East London) and LCA 13, 14, 15 and 16 (in the vicinity of Newham Dockside and Royal Albert Way) would also not represent relevant exposure for annual mean concentrations according to the criteria defined in LAQM.TG(09)[2], but are relevant for the 1-hour mean objectives. Site LCA 03 is located within an area of land allocated for redevelopment at Silvertown Quay, but public access is currently prohibited. These sites have been included in the study to better understand the spatial pattern of nitrogen dioxide concentrations around the Airport.

2 Defra Technical Guidance Note LAQM.TG(09) suggests that in the case of the annual mean objective, a relevant location might be where a member of the public would be exposed for a cumulative period of 6 months in a year.

3.18 Diffusion tubes are known to show systematic bias in relation to automatic (reference) monitors. For this reason, a co-location study has been carried out, with triplicate tubes exposed alongside the inlet to the automatic monitor at LCA-CAH, and a single tube exposed in close proximity to the inlet of the LCA-ND automatic monitor. Comparison of the matched period results shows that the diffusion tubes were over-reading by an average of 36%. An adjustment factor of 0.744 has therefore been applied to all diffusion tube results to ensure that they give the best representation of true concentrations (see Appendix 3). The results from the triplicate tubes indicate "good" precision (±5.4%) in 2012, see Appendix 4 (Defra, 2009).

3.19 The bias-adjusted results are summarised in Table 10, and are also shown in Figure 3. The results show that the annual mean objective of 40 µg/m^3 was exceeded at two locations (LCA 04 and LCA 16) during 2012. However, it is important to note that there is no relevant exposure to the annual mean objective at either LCA 04 or LCA 16. The measured concentration at LCA 16 was higher in 2012 compared with previous years; it is considered likely that this site was influenced by emissions from the coach parks, shipping and generators located in this area during the Olympic Games. It is also of note that monitoring site LCA 12, which lies just to the north of the main runway, recorded a much lower concentration (29.5 µg/m^3) in 2012, suggesting that the Airport is not significantly contributing to the elevated levels at LCA 04 and LCA 16.

3.20 All measured annual mean nitrogen dioxide concentrations were well below 60 µg/m^3, and it is thus unlikely that the 1-hour mean objective was exceeded at any location.

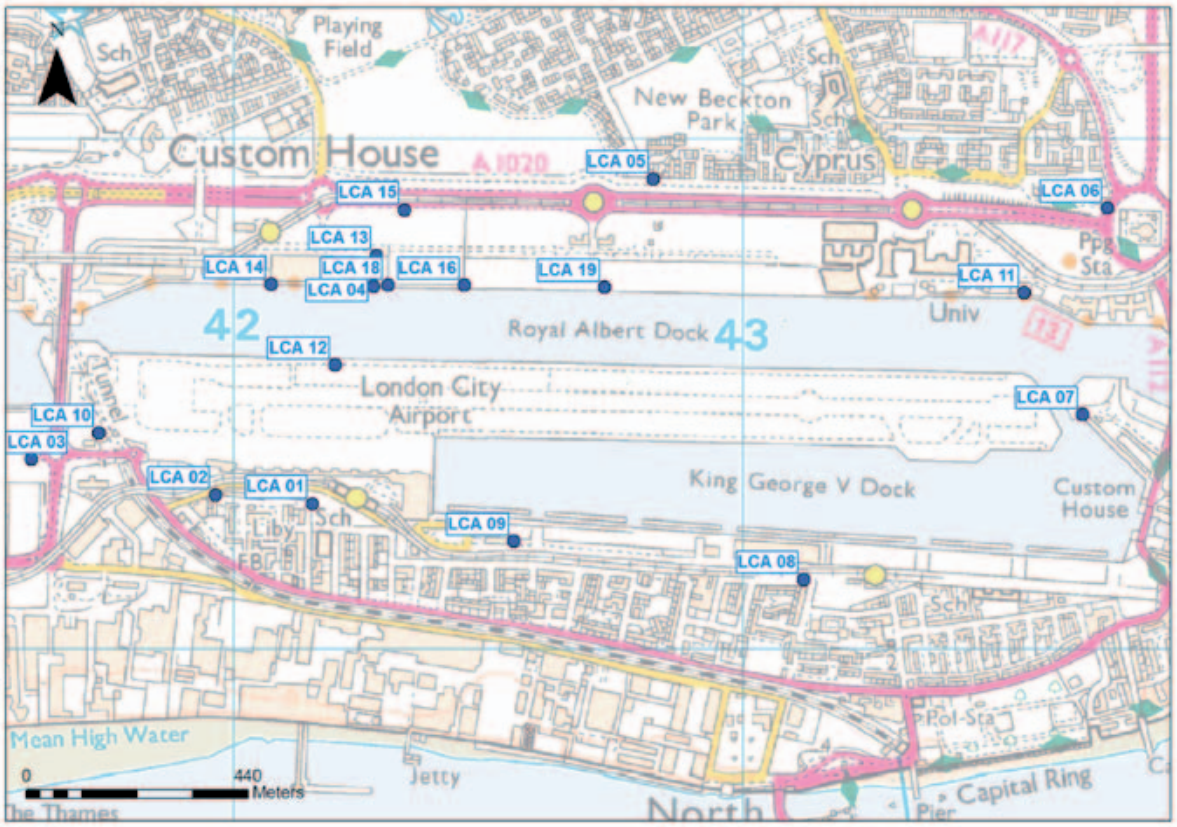

Figure 2: Diffusion Tube Monitoring Locations (blue dots).

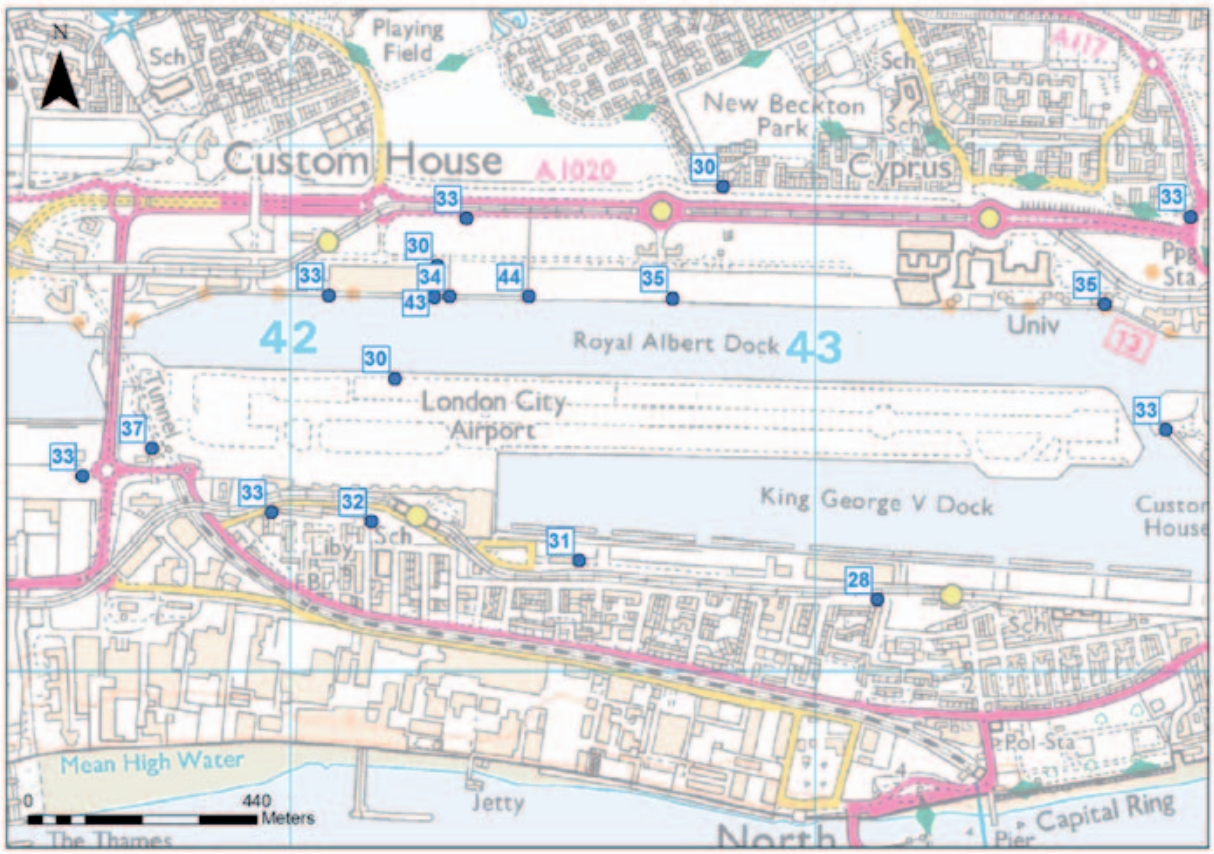

Figure 3: Nitrogen Dioxide Diffusion Tube Results, 2012 (µg/m^3).

Appendix 12

Table 10: Diffusion Tube Data Summary for London City Airport, 2012 (Adjusted for Bias)

Site ID	Adjusted Value (µg/m^3) [a b]
LCA 01	32.2
LCA 02	32.7
LCA 03	33.0
LCA 04	**43.2**
LCA 05	29.9
LCA 06	32.7
LCA 07	33.1
LCA 08	28.4
LCA 09	30.8
LCA 10	36.7
LCA 11	34.7
LCA 12	29.5
LCA 13	29.6
LCA 14	33.3
LCA 15	33.2
LCA 16	**43.5**
LCA 18	34.2
LCA 19	34.8

[a] Data have been adjusted using a local bias adjustment factor for 2012 of 0.744. The co-location studies are carried out at LCA-CAH using triplicate tubes and at LCA-ND with a single tube located at the automatic monitors. Diffusion tubes were exposed for the period between 6th January 2012 and 4th January 2013.

[B] It should be noted that the land between Royal Albert Dock and the A1020 was used as an Olympic Coach Park during July and August 2012. Construction of the coach park commenced in January 2012, and there was intermittent, on-going use of the site for coaches during this time. It is possible that higher concentrations may have been recorded at locations within the vicinity of this area (i.e. the automatic monitor LCA-ND and diffusion tubes LCA 04, LCA 05, LCA 13, LCA 15, LCA 16, LCA18 and LCA 19) due to emissions from 'idling' coaches using this area. There were also berthed ships in the Royal Albert Dock and generators at the coach park, which may also have contributed to measured concentrations.

4 Data Analyses

4.1 This chapter provides analyses of the data, including time series, trends and source contributions.

Time Series

4.2 The measured 1-hour mean nitrogen dioxide concentrations at LCA-CAH and LCA-ND, and at Bexley, Bloomsbury, Eltham, Canning Town and Stratford, are shown as a time series in Figures 4 and 5 respectively.

4.3 The concentrations over the monitoring period show similar patterns at all seven monitoring sites. The concurrence of periods with elevated concentrations at all sites suggests that these episodes were due to regional changes in concentrations. There were three 1-hour mean periods at the Newham Dockside site (between 9 to 10am on 19th January, between 6 to 7pm on 12th April 2012 and between 6 to 7am on 14th April 2012), when concentrations exceeded the 1-hour mean objective value; similar peak concentrations were not seen at City Aviation House or at any of the other London sites. It is considered likely that these peak concentrations were caused by a very local pollution source (e.g. an idling vehicle close to the analyser inlet).

4.4 The measured daily mean PM_{10} concentrations at LCA-CAH and at the two Bexley monitors, Bloomsbury, Eltham, Canning Town and Stratford, are shown in Figures 6 and 7 respectively. Once again, the analysis suggests that periods of high pollution were principally due to regional changes in concentrations.

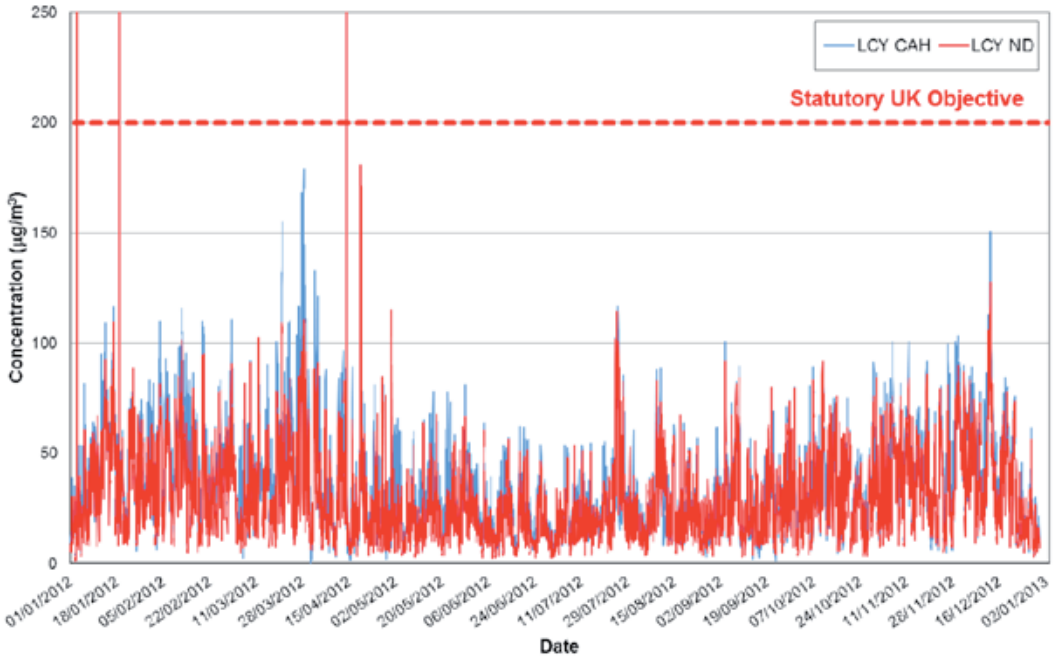

Figure 4: 1-Hour Mean Nitrogen Dioxide Concentrations at London City Airport, 2012

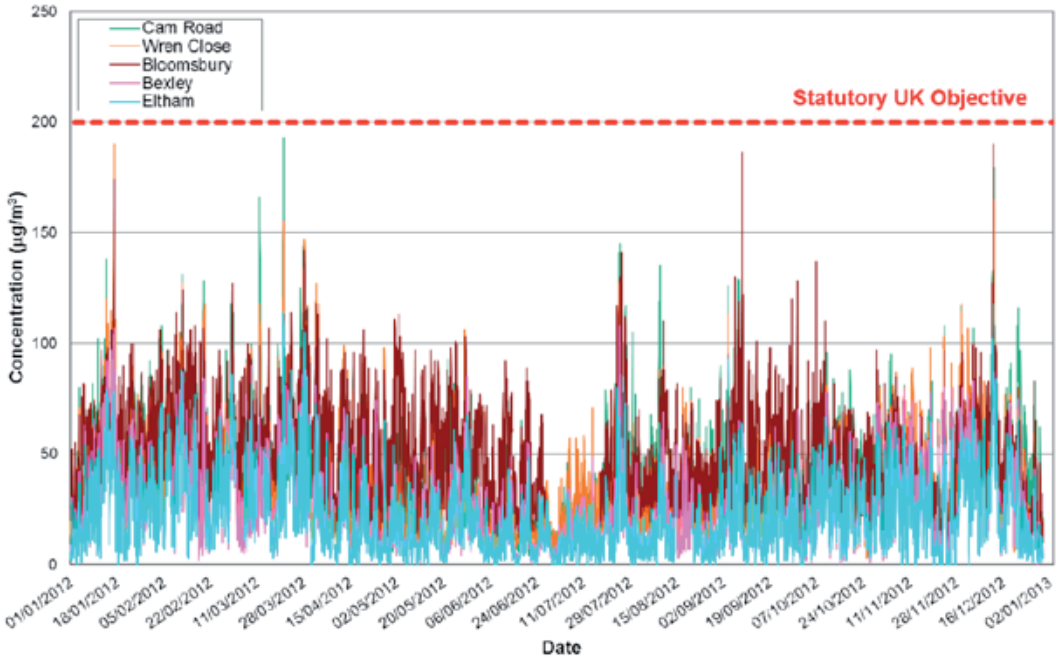

Figure 5: 1-Hour Mean Nitrogen Dioxide Concentrations at London Monitoring Sites, 2012

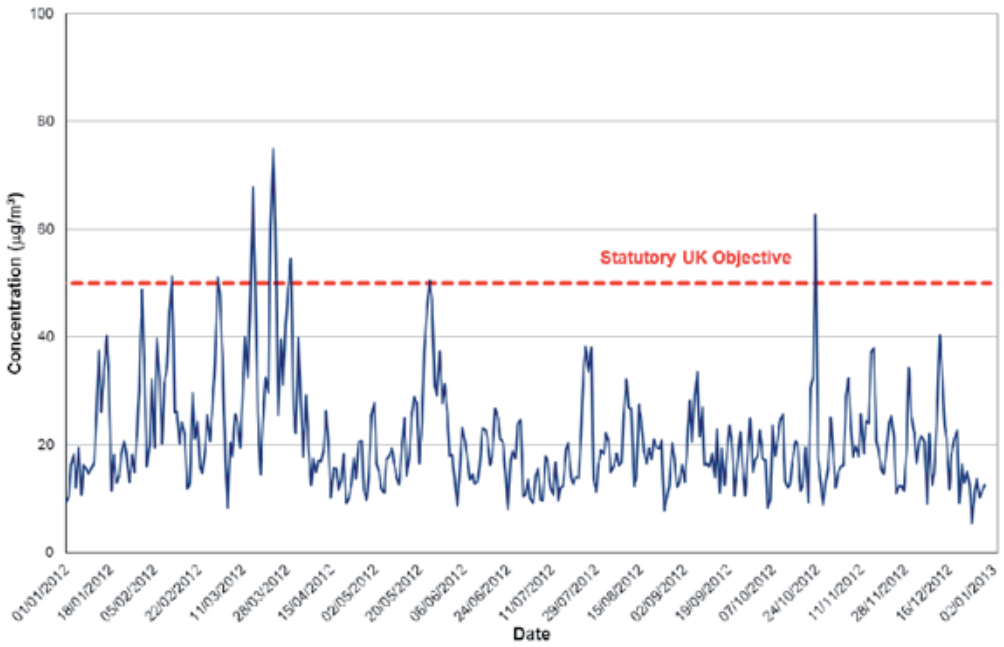

Figure 6: Daily Mean PM_{10} Concentrations at London City Airport (LCA-CAH), 2012

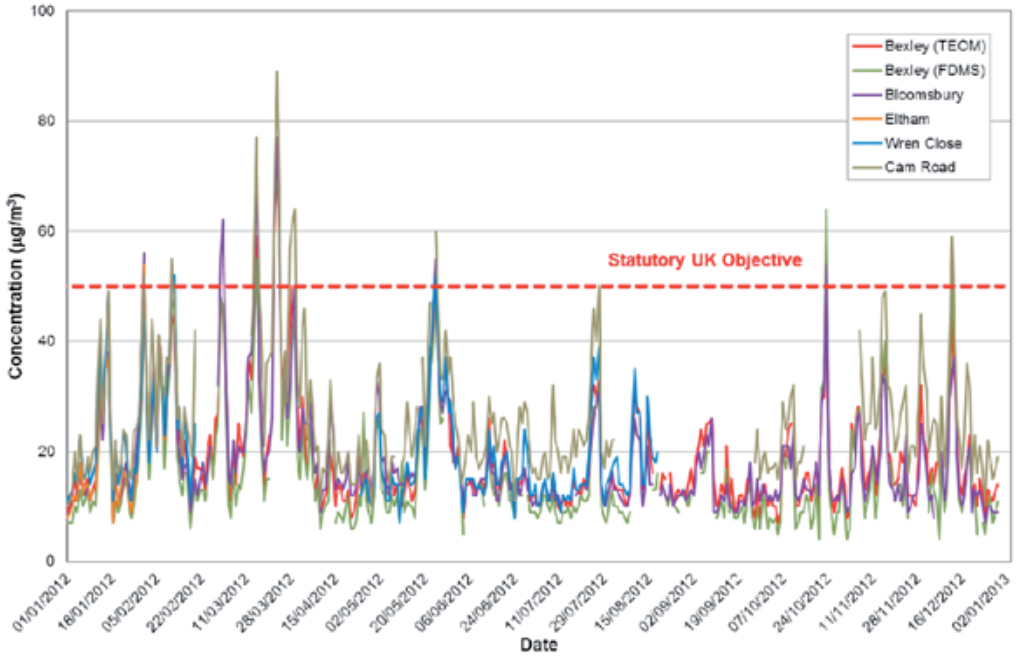

Figure 7: Daily Mean PM_0 Concentrations at London Monitoring Sites, 2012

Trends in Pollutant Concentrations

4.5 The automatic station at the LCA-CAH site has now been in operation since September 2006 and it useful to identify whether there are any trends in the measured pollutant concentrations over time.

4.6 Figure 8 shows the trends in measured annual mean nitrogen dioxide concentrations at LCA-CAH and at the five other monitoring locations identified for the regional evaluation of pollution episodes (Bexley, Bloomsbury, Eltham, Canning Town and Stratford). From a visual examination of Figure 8, there appears to be a downward trend at some sites (Stratford and Bexley), but not at others. This mirrors the conclusions of a report prepared on behalf of Defra (Carslaw et al, 2011); while the national emissions projections suggest that nitrogen dioxide concentrations should be declining, at many monitoring sites levels have remained relatively stable over the past 6 to 8 years, or have even shown a slight increase.

4.7 Because of this interest, a more detailed analysis of trends has been carried out, focusing on monitoring sites in the east London area. The results of the detailed analysis are provided in Appendix 5. In summary, there is a statistically significant downward trend at some London monitoring sites for nitrogen dioxide and nitrogen oxides (NO_x), but there is no clear trend at other sites, including LCA-CAH.

4.8 The trends in annual mean PM_{10} concentrations are shown in Figure 9, for the LCA-CAH site and three other monitoring locations, for which six years data are available. Between 2007 and 2012, there appears to have been a slight downward trend in annual mean PM_{10} concentration at all of the monitoring sites..

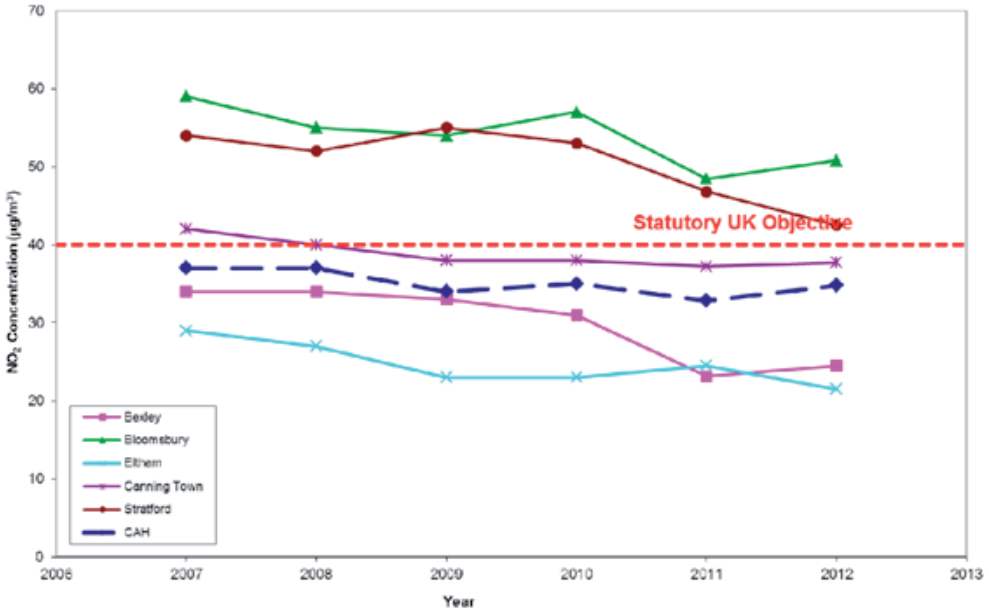

Figure 8: Annual Mean Nitrogen Dioxide Concentrations, 2007 – 2012 (µg/m^3)

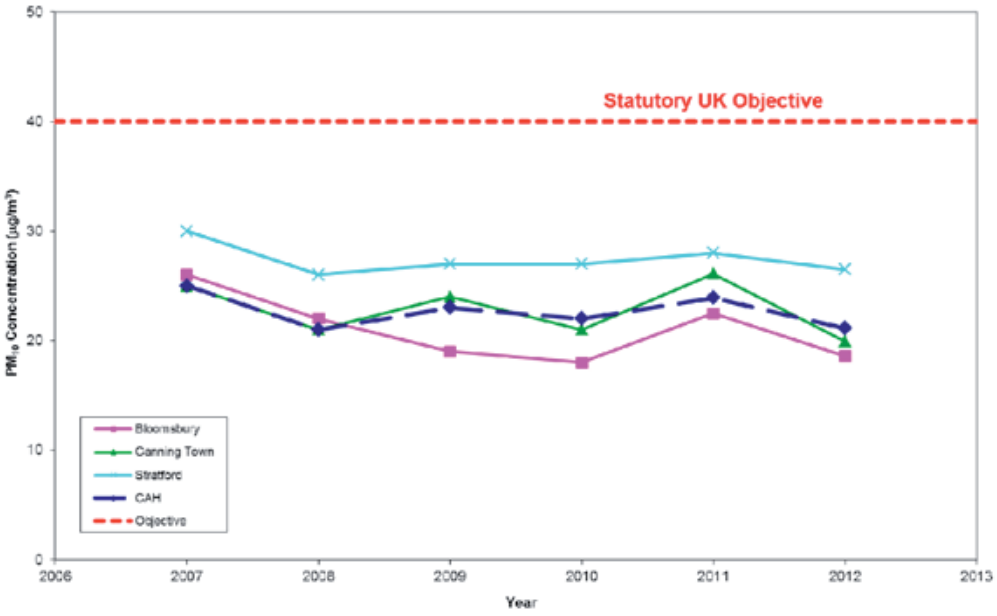

Figure 9: Annual Mean PM_{10} Concentrations, 2007 – 2012 (µg/m^3)

Bivariate Pollution Roses

4.9 Pollution roses are a useful technique for exploring the influence of different sources of air pollution at a monitoring site. Usually, the data are processed into average concentrations by wind direction, such that it is possible to identify whether elevated pollution concentrations are associated with different wind directions.

4.10 Data analysis tools available via the "Openair" website[3] include the preparation of "bivariate pollution roses". These bivariate roses process average pollution concentration data by both wind direction and wind speed. They provide a powerful tool in identifying source contributions to measured concentrations at monitoring sites. The concentrations are shown by colour shading, with the distance from the centre point representing increasing wind speed.

4.11 It is known from both modelling studies and the analysis of empirical data that emissions from different source types behave differently in low and high wind speed conditions. For emissions from ground-level sources (such as road traffic), concentrations are highest during low wind speeds, and decrease rapidly with increasing wind speed (due to greater dilution and dispersion). In contrast, emissions released from elevated (e.g. chimney) sources, give rise to higher concentrations at higher wind speeds, as the plume is more likely to come down to ground close to the source. Emissions from the buoyant plumes of jet aircraft engines tend to behave in a similar manner to elevated sources. Carslaw *et al* (2006) showed how these bivariate plots could be used to identify the contribution of aircraft emissions to measured concentrations at Heathrow Airport.

4.12 Figure 10 shows bivariate pollution roses for NOx concentrations in 2012 at the LCA-CAH and LCA-ND sites, using wind data from the meteorological station at London City Airport. During low wind spends, dispersion is reduced. It can be seen at both monitoring sites that the highest NOx concentrations occur during low wind speeds (i.e. towards the centre of the rose), indicating that the highest concentrations are associated with ground-level source releases (the wind speed scale runs from 0 to 20 m/s, with the concentration scale running from 0 to just over 100 µg/m^3). The source of these high concentrations is difficult to determine since they occur from all wind directions. The LCA-CAH bivariate plot indicates a higher contribution to NOx concentrations with winds from the north-west, at moderate wind speeds; this likely to be associated with emissions from aircraft and airside vehicles and plant on the apron. There is no other evidence of a significant contribution from Airport operations to measured NOx concentrations at either monitoring site.

[3] www.openair-project.org/about_us.php

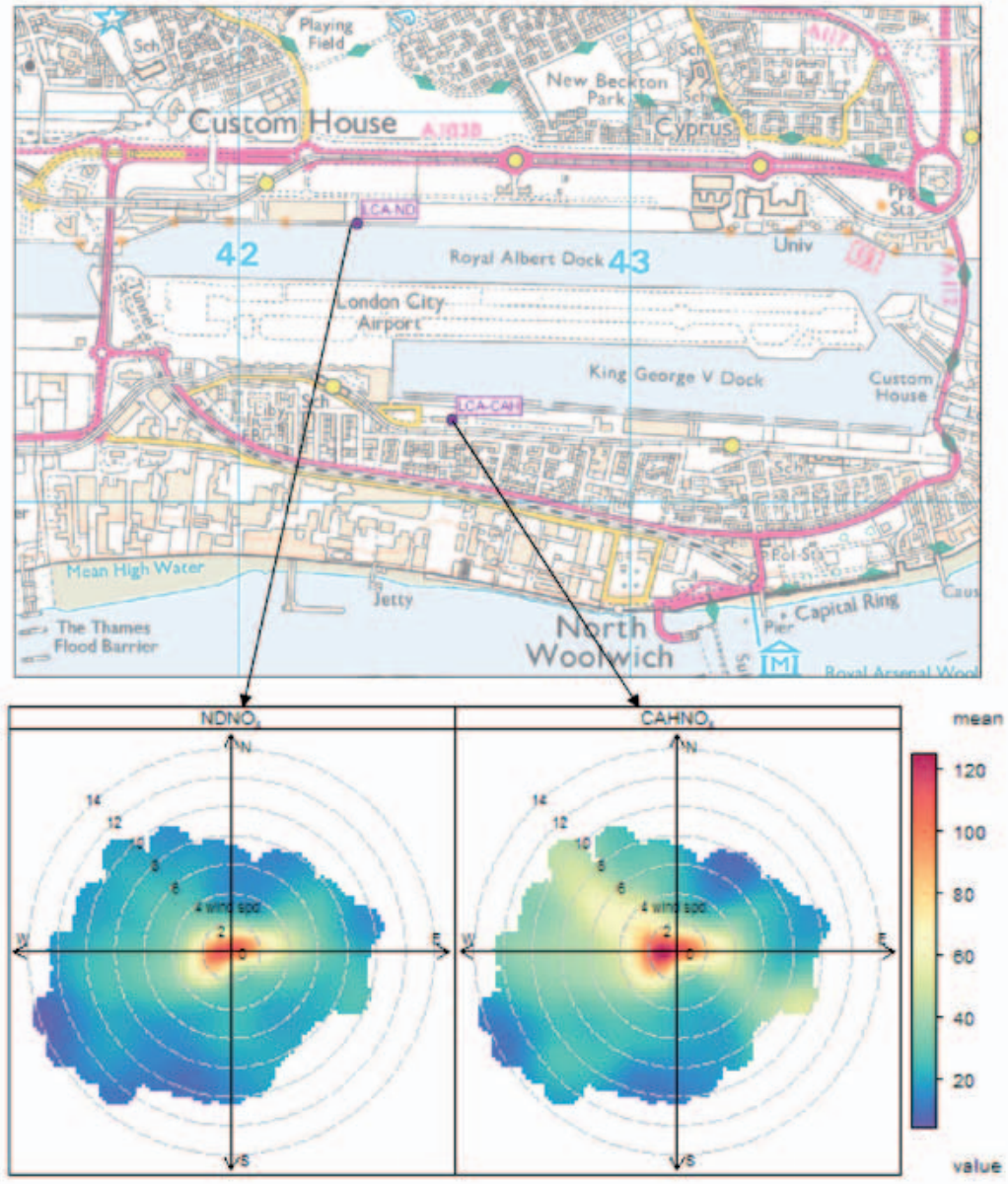

Figure 10: Bivariate Pollution Roses at LCA-CAH and LCA-ND Sites, 2012 (NO_x, µg/m^3)

5 References

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6 Glossary

Exceedence	A period of time where the concentration of a pollutant is greater than the appropriate air quality objective.
FDMS	Filter Dynamics Monitoring System.
LAQN	London Air Quality Network.
LCA-CAH	London City Airport – City Aviation House monitoring site.
LCA-ND	London City Airport – Newham Dockside monitoring site
µg/m^3	Microgrammes per cubic metre.
NO_2	Nitrogen dioxide.
NO_x	Nitrogen oxides (taken to be NO_2 + NO).
NO	Nitric oxide.
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date, taking into account costs, benefits, feasibility and practicality. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides.
PM_{10}	Small airborne particles, more specifically particulate matter less than 10 micrometers in aerodynamic diameter.
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal.
TEA	Triethanolamine – absorbent for nitrogen dioxide used in diffusion tubes.
TEOM	Tapered Element Oscillating Microbalance.
VCM	Volatile Correction Model.

A1 Appendix 1 – Nitrogen Oxides Results

A1.1 Nitrogen oxides (NO_x) concentrations, which are essentially the sum of nitrogen dioxide and nitric oxide, are presented in Table A1.1 for the automatic monitoring stations at London City Airport and for five sites across London in Table A1.2.

Table A1.1: Nitrogen Oxides (NO_x) Data Summary for LCA-CAH and LCA-ND, 2012

Site	LCA-CAH	LCA-ND
Maximum 1-Hour Mean	749 µg/m^3	775 µg/m^3
Annual Mean	57 µg/m^3	48 µg/m^3
Data Capture	95.0%	95.1 %

Table A1.2: Nitrogen Oxides (NO_x) Data Summary for London Monitoring Sites, 2012

Site	Bexley	Bloomsbury	Eltham	Canning Town	Stratford
Maximum 1-Hour Mean (µg/m^3)	859	941	546	997	912
Annual Mean (µg/m^3)	39	88	34	57	79
Data Capture %	96.1	93.5	95.2	98.2	94.9

A2 Appendix 2 – Diffusion Tube Data

A2.1 Raw monthly average diffusion tube data, along with the location details and monitoring periods, are presented in Table A2.1.

Table A2.1: Raw Monthly Diffusion Tube Data for 2012, Not Bias Adjusted (µg/m^3)

Site ID	Grid ref	06/01/12 to 03/02/12	03/02/12 to 02/03/12	02/03/12 to 29/03/12	23/03/12 to 04/05/12	04/05/12 to 11/06/12	11/06/12 to 06/07/12	06/07/12 to 02/08/12	02/08/12 to 07/09/12	07/09/12 to 05/10/12	05/10/12 to 02/11/12	02/11/12 to 30/11/12	30/11/12 to 04/01/13	Unadjusted Annual Mean	Data Capture (%)
LCA 01	542142,180295	54.7	58.3	61.1	36.2	31.7	27.3	36.4	31.5	36.5	52.3	51.9	40.7	43.2	100%
LCA 02	541946,180296	50.6	57.8	57.3	41.6	32.8	-	40.1	16.7	44.0	53.4	45.9	43.4	44.0	92%
LCA 03	541587,180372	44.6	61.1	68.4	35.8	35.2	25.7	40.2	37.9	39.0	51.4	-	47.9	44.3	92%
LCA 04	542257,180710	52.0	82.2	76.8	43.7	32.2	38.5	54.0	56.0	64.8	60.2	78.6	-	58.1	92%
LCA 05	542838,180920	39.6	54.2	55.6	26.6	27.5	28.7	40.0	38.3	37.7	40.8	46.1	47.4	40.2	100%
LCA 06	543713,180869	36.3	56.8	63.6	41.4	32.3	34.6	46.0	37.1	39.6	51.3	48.7	39.3	43.9	100%
LCA 07	543640,180474	55.9	65.2	62.9	33.2	22.4	27.2	31.2	34.1	44.5	51.2	52.3	54.2	44.5	100%
LCA 08	543122,180136	37.3	55.6	51.9	33.3	27.3	24.8	34.2	32.7	34.8	42.4	41.4	43.0	38.2	100%
LCA 09	542527,180199	51.5	62.4	58.0	31.9	25.3	26.5	33.1	27.3	38.7	48.2	49.5	46.5	41.6	100%
		49.2	60.9	59.0	35.5	26.6	27.1	32.5	22.6	-	47.6	54.9	47.7	42.1	92%
		41.2	51.8	57.6	34.7	27.0	24.5	34.7	31.4	38.5	48.6	53.0	45.0	40.7	100%
LCA 10	541731,180419	71.0	46.6	68.3	40.9	32.2	35.6	47.1	25.4	49.0	60.5	59.3	55.3	49.3	100%
LCA 11	543560,180687	43.1	66.7	62.9	34.3	-	29.0	43.7	39.6	46.0	54.0	-	46.9	46.6	83%
LCA 12	542181,180561	25.9	59.0	56.7	31.1	27.2	28.2	34.3	31.9	39.8	44.4	54.6	42.1	39.6	100%
LCA 13	542291,180770	56.0	59.8	56.5	32.1	17.4	21.2	39.0	31.1	36.0	49.1	42.2	37.2	39.8	100%
LCA 14	542075,180714	37.0	58.4	60.8	33.3	31.9	26.8	42.7	37.0	42.8	57.8	54.3	54.5	44.8	100%
LCA 15	542430,180857	42.8	63.3	67.5	-	33.7	27.3	44.1	30.0	38.0	50.2	52.6	41.3	44.6	92%
LCA 16	542452,180710	61.4	64.9	90.0	32.8	-	40.5	53.3	43.2	57.7	51.3	75.9	72.1	58.5	92%
LCA 18	542298,180684	53.0	56.6	53.9	36.1	22.7	24.6		29.8		55.5	67.4	59.8	45.9	83%
LCA 19	542757,180688	63.6			33.5	27.3	35.2	48.1	39.9	49.8	55.0	59.9	55.5	46.8	83%

- – not available

A3 Appendix 3 – Bias Adjustment Factor for Diffusion Tubes

A3.1 Diffusion tubes are known to exhibit bias when compared to results from automatic analysers. Therefore diffusion tube results need to be adjusted to account for this bias. One of the main factors influencing diffusion tube performance is thought to be the laboratory that supplies and analyses the tubes. The diffusion tubes exposed at London City Airport are supplied and analysed by Gradko International Ltd. (20% TEA in water).

A3.2 In order to determine the bias exhibited by these tubes, studies are carried out using triplicate tubes co-located at LCA-CAH and a single tube at LCA-ND. All diffusion tube data presented in this report have been adjusted using the overall factor calculated from the data presented in Table A3.1, with the optimum relationship defined using orthogonal regression.

Table A3.1: Results of Diffusion Tube and Continuous Monitor Co-location Studies in 2012 [a]

	Diffusion Tube	Automatic	Adjustment Factor
LCA-CAH	41.4	35.0	0.846
LCA-ND	45.9	30.1	0.654
Overall Factor [b]			**0.744**

[a] Diffusion tubes were exposed for the period between 6th January 2012 and 4th January 2013. The automatic monitoring data correspond to this period.

[b] The overall factor has been determined using orthogonal regression.

A3.3 Table A3.2 presents the bias adjustment factors applied to the data for the last six years. The factors have remained fairly consistent over this period.

Table A3.2: Previous Bias Adjustment Factors

Year	Factor
2007	0.764
2008	0.786
2009	0.717
2010	0.801
2011	0.738
2012	0.744

A4 Appendix 4 – Diffusion Tube Precision

A4.1 Diffusion tube precision describes the ability of a measurement to be consistently reproduced, i.e. how similar the results of duplicate or triplicate tubes are to each other. It is an indication of how carefully the tubes have been handled in either the laboratory and/or the field. Tube precision is separated into two categories 'Good' or 'Poor' as follows: tubes are considered to have **'Good'** precision where the coefficient of variation (CV) of duplicate or triplicate diffusion tubes for eight or more periods during the year is less than 20%, and the average CV of all monitoring periods is less than 10%. Tubes are considered to have **'Poor'** precision where the CV of four or more periods is greater than 20% and/or the average CV is greater than 10%.

A4.2 Table A4.1 shows that for each of the twelve periods of monitoring there was 'Good' precision, with the average precision of <10% and none of the periods having a CV >20%. Overall, therefore, the precision of the diffusion tubes is 'Good', which is consistent with the performance of 20% TEA in water tubes supplied by Gradko International in other co-location studies (Defra, 2013).

Table A4.1: Precision of Triplicate Diffusion Tubes

Period	Start Date	End Date	Tube 1	Tube 2	Tube 3	Mean	Standard Deviation	CV	Tube Precision
1	06/01/2012	03/02/2012	51.5	49.2	41.2	47	5.4	11	Good
2	03/02/2012	02/03/2012	62.5	60.9	51.8	58	5.7	10	Good
3	02/03/2012	29/03/2012	58.0	59.0	57.6	58	0.7	1	Good
4	29/03/2012	04/05/2012	31.9	35.5	34.7	34	1.9	6	Good
5	03/02/2012	11/06/2012	25.3	26.6	27.0	26	0.9	3	Good
6	11/06/2012	06/07/2012	26.5	27.1	24.5	26	1.4	5	Good
7	06/07/2012	02/08/2012	33.1	32.5	34.7	33	1.2	3	Good
8	03/02/2012	07/09/2012	27.3	22.6	31.4	27	4.4	16	Good
9	07/09/2012	05/10/2012	38.7	-	38.5	39	0.1	0	Good
10	05/10/2012	02/11/2012	48.2	47.6	48.6	48	0.5	1	Good
11	02/11/2012	30/11/2012	49.5	54.9	53.0	52	2.8	5	Good
12	30/11/2012	04/01/2013	46.5	47.7	45.0	46	1.4	3	Good
Average CV								5	-

A5 Appendix 5 – Detailed Trend Analysis

Nitrogen Dioxide

A5.1 Figure A.5.1 shows the smooth-trend analyses of 1-hour mean nitrogen dioxide concentrations for LCA-CAH and eight other, nearby monitoring sites (Greenwich Burrage Grove, Greenwich Millennium Village, Greenwich Eltham, Greenwich Woolwich Flyover, Newham Cam Road, Newham Wren Close, Tower Hamlets Poplar, Tower Hamlets Blackwall), over the period 2007 to 2012.

A5.2 A Mann Kendall analysis has been applied to the data to identify statistically significant trends and slopes, and the results are described in Table A.5.1. There is a statistically significant downward trend in nitrogen dioxide concentrations at three monitoring sites (Greenwich Burrage Grove, Greenwich Millennium Village and Newham Cam Road). There is no statistically significant trend at LCA-CAH or at the other four monitoring sites presented.

Table A5.1: Mann Kendall Analysis, Nitrogen Dioxide Concentrations at City Aviation House and Other Monitoring Sites, 2007 to 2012.

Monitoring Site	Mann Kendall Analysis [a]	Statistically Significant Trend?
City Aviation House (LCA-CAH)	-0.63 [-1.85, 0.53]	No
Greenwich Burrage Grove	-2.38 [-3.71, -1]	**Yes**
Greenwich Millennium Village	0.01 [-1.38, 1.41]	No
Greenwich Eltham	-1.3 [-2.26, -0.31]	**Yes**
Greenwich Woolwich Flyover	-0.56 [-2.05, 0.95]	No
Newham Cam Road	-2.13 [-3.77, -0.76]	**Yes**
Newham Wren Close	-6.3 [-1.97, 0.53]	No
Tower Hamlets Poplar	-0.79 [-2.14, 0.38]	No
Tower Hamlets Blackwall	-0.7 [-2.02, 0.9]	No

[a] The first value is the slope. The number in brackets is the upper and lower 95th percentile confidence interval.

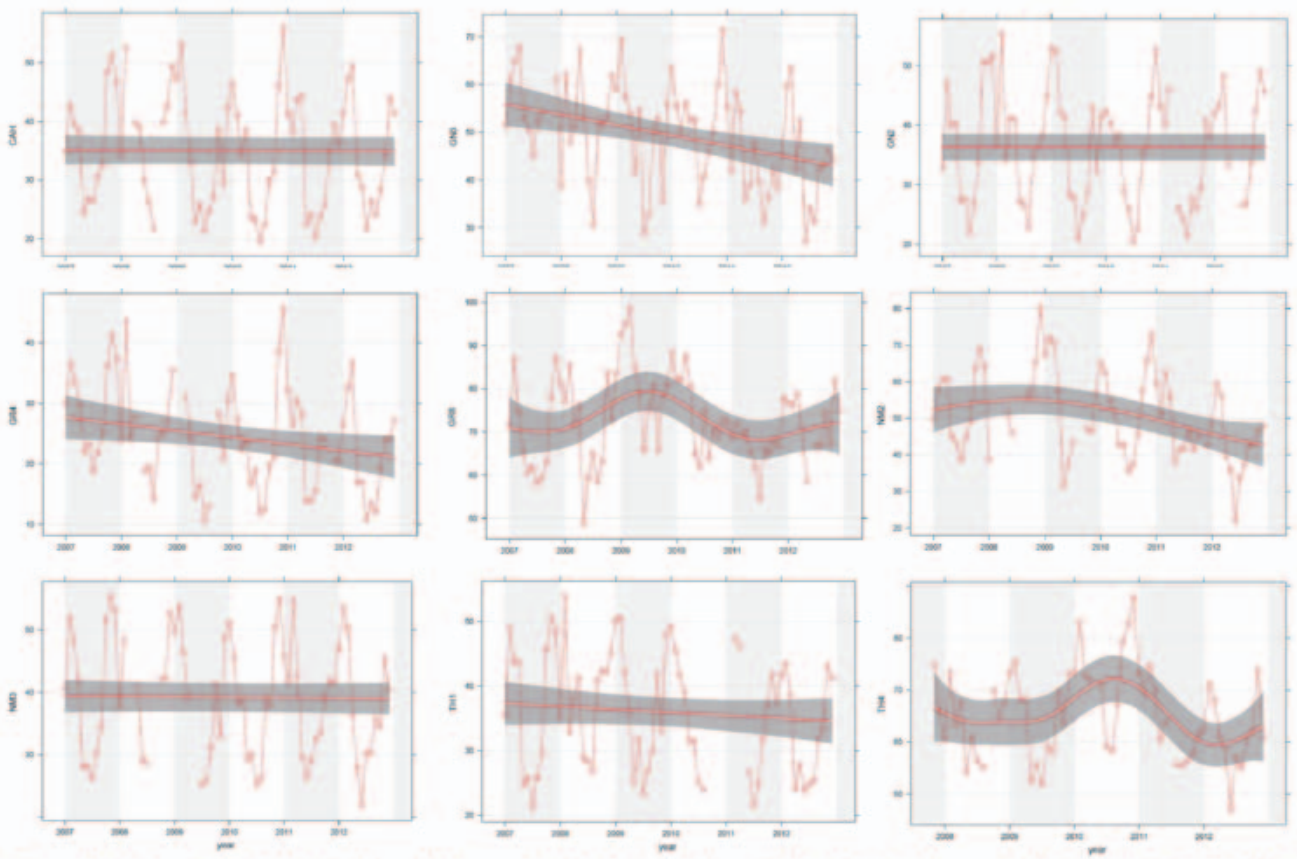

Figure A.5.1: Smooth Trend Analysis, Hourly Nitrogen Dioxide Concentrations at City Aviation House and Other Monitoring Sites, 2007 – 2012 (Left to Right: City Aviation House, Greenwich Burrage Grove, Greenwich Millennium Village, Greenwich Eltham, Greenwich Woolwich Flyover, Newham Cam Road, Newham Wren Close, Tower Hamlets Poplar, Tower Hamlets Blackwall)

Nitrogen Oxides (NO_x)

A5.3 Figure A.5.2 shows the smooth trend analysis of 1-hour mean NO_x concentrations for LCA-CAH and other monitoring sites (Greenwich Burrage Grove, Greenwich Millennium Village, Greenwich Eltham, Greenwich Woolwich Flyover, Newham Cam Road, Newham Wren Close, Tower Hamlets Poplar, Tower Hamlets Blackwall) for the period 2007 to 2012.

A5.4 The Mann Kendall analysis, shown in Table A.5.2, indicates a statistically significant downward trend in NOx concentrations at two monitoring sites (Greenwich Burrage Grove and Newham Cam Road).

Table A5.2: Mann Kendall Analysis, NO_x Concentrations at City Aviation House and Other London Monitoring Sites, 2007 to 2012.

Monitoring Site	Mann Kendall Analysis [a]	Statistically Significant Trend?
City Aviation House (LCA-CAH)	-1.85 [-5.07, 0.88]	No
Greenwich Burrage Grove	-5.71 [-9.96, -1.5]	**Yes**
Greenwich Millennium Village	0.55 [-3.53, 4.06]	No
Greenwich Eltham	-1.65 [-3.69, 0.34]	No
Greenwich Woolwich Flyover	-3.81 [-11.14, 3.28]	No
Newham Cam Road	-6.83 [-12.06, -2.9]	**Yes**
Newham Wren Close	-1.52 [-5.46, 0.79]	No
Tower Hamlets Poplar	-1.21 [-4.59, 1.09]	No
Tower Hamlets Blackwall	-5.21 [-12.11, 0.59]	No

[a] The first value is the slope. The value in brackets is the upper and lower 95 percentile confidence interval.

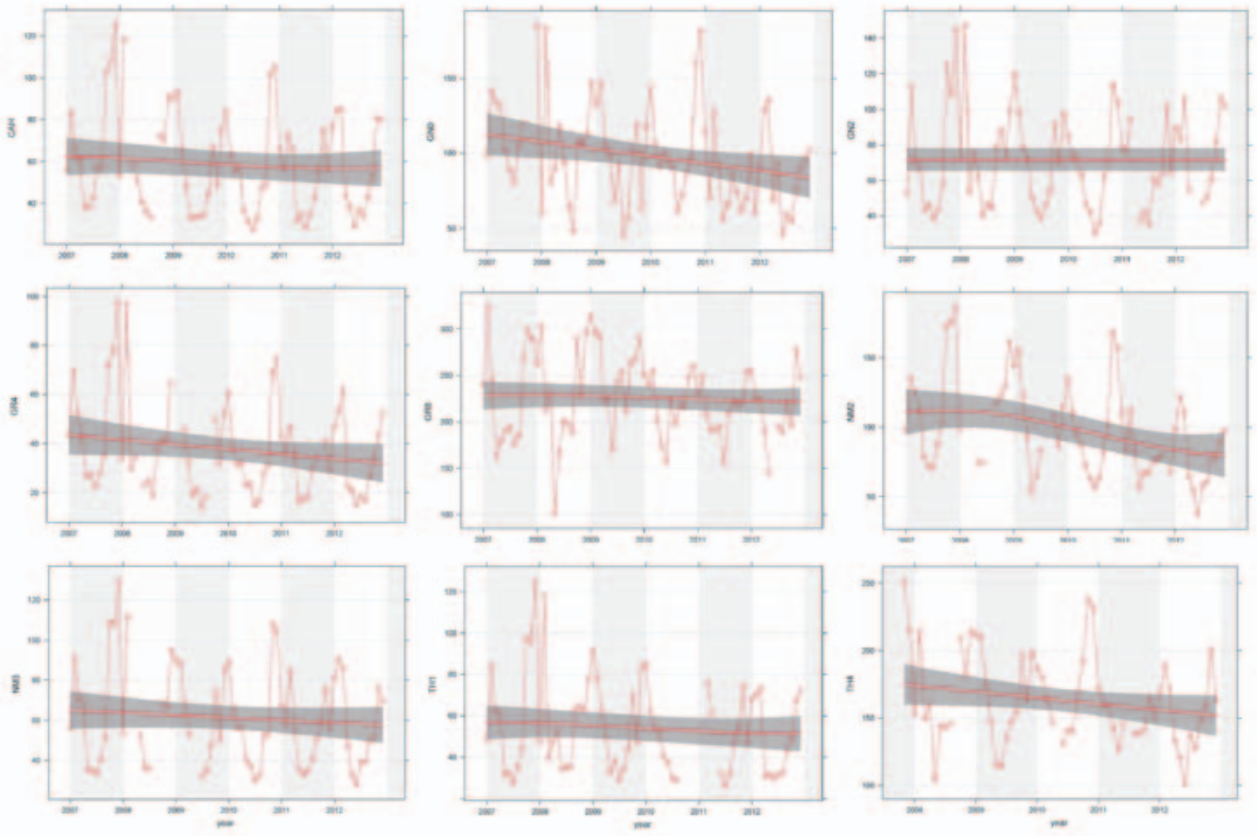

Figure A.5.3 Smooth Trend Analysis, Hourly NO_x Concentrations at City Aviation House and Other London Monitoring Sites, 2007 - 2012(Left to Right: Aviation House, Greenwich Burrage Grove, Greenwich Millennium Village, Greenwich Eltham, Greenwich Woolwich Flyover, Newham Cam Road, Newham Wren Close, Tower Hamlets Poplar, Tower Hamlets Blackwall