Annual Air Quality Monitoring Review 2011

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Executive Summary

Pollution levels in the City of London during 2011 were broadly similar to 2010, although roadside concentrations of nitrogen dioxide measured at automatic sites were lower than the previous three years. Similar weather patterns were seen in both years. Fine particulate episodes were lower than 2010, but higher than the average from the preceding 5 years.

There was higher than average rainfall in the summer of 2011, and significantly lower than average rainfall during the spring and autumn. These conditions do not appear to have influenced annual average concentrations, but may be partly responsible for a high number of episode days.
Monitoring at Upper Thames Street shows that PM_{10} continues to be a problem. Transport for London (TfL) has conducted a trial of dust suppressant liquid at this location, in an effort to reduce concentrations locally.
There were a number of air pollution episodes in 2011. There were eight PM_{10} episodes, two ozone episodes and one nitrogen dioxide episode.
Nitrogen dioxide levels continue to be high in the City. Particularly high levels were seen at Walbrook Wharf roadside , Walbrook Wharf Roof and Beech Street. Walbrook Wharf is beside Upper Thames Street, which has a high volume of traffic and low dispersion due to street canyon effects.
Based on the results presented here, a report submitted to Defra has concluded that detailed assessment is not required for any pollutants. This means that it is not appropriate to revise the “Air Quality Management Area” status of the City of London.

The City of London continues to work to improve air quality, by implementing the actions in its Air Quality Strategy 2011-2015, and by continuing to work closely with stakeholders such as the Greater London Authority, Department for the Environment Food and Rural Affairs , King’s College London, and other Central London Local Authorities.

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1 Introduction

1.1 Health Effects of Air Pollution

Exposure to air pollution can have both acute (abrupt, sharp and brief) and chronic (longer than 3 months duration) impacts on human health. Some people are more susceptible to the effects of air pollution than others. People with pre-existing heart or lung disease, young children and the elderly are particularly susceptible.

These health effects are discussed in greater detail at the end of this report.

The City operates a free service which alerts subscribers to levels of air pollution, called airTEXT. This service alerts people to pollution, and gives health advice, so that they may take steps to reduce the likelihood of any impacts. The website for the airTEXT service can be found at the following address: www.airtext.info

1.2 Air Quality in the City of London

The City of London experiences some of the worst air quality in the UK, and is designated an Air Quality Management Area (AQMA). The City's poor air quality is primarily due to the density of development and its geographical location. Road traffic is the main source of pollution, supplemented by commercial and domestic heating. Pollutants generated by traffic include hydrocarbons, nitrogen oxides, particulate matter and carbon monoxide. There are no industrial sources of pollution in the City. Being located at the heart of London, the City is heavily influenced by pollution generated in neighbouring authorities and across London as a whole. The southeast of England is also affected by pollutants (notably fine particulates) which are thought to originate in continental Europe.

In the spring of 2011, the City of London Air Quality Strategy received committee approval. The strategy outlines how air quality policy at the City will be developed from 2011 to 2015, and sets out 32 actions to achieve this. Although a lot of work has been undertaken since 1998 with a view to improving air quality in the City, levels of nitrogen dioxide and fine particulates continue to be a problem.

1.3 Air Quality Management – Legislation and Policy

The air quality objectives applicable to Local Air Quality Management **in England** are set out in the Air Quality (England) Regulations 2000 (SI 928), The Air Quality (England) (Amendment) Regulations 2002 (SI 3043), and are shown in Table 1.1. This table shows the objectives in units of micrograms per cubic metre μg/m^3 (milligrammes per cubic metre, mg/m^3 for carbon monoxide) with the number of exceedences in each year that are permitted (where applicable).

Table 1.1 Air Quality Objectives included in Regulations for the purpose of LAQM in England

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 μg/m^3	Running annual mean	31.12.2003
	5.00 μg/m^3	Running annual mean	31.12.2010
1,3-Butadiene	2.25 μg/m^3	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 μg/m^3	Annual mean	31.12.2004
	0.25 μg/m^3	Annual mean	31.12.2008
Nitrogen dioxide	200 μg/m^3 not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 μg/m^3	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 μg/m^3, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 μg/m^3	Annual mean	31.12.2004
Sulphur dioxide	350 μg/m^3, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 μg/m^3, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 μg/m^3, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

The Local Air Quality Management (LAQM) process is set out in Part IV of the Environment Act (1995), the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 and the relevant Policy and Technical Guidance documents.

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where exceedences are considered likely, the local authority must then declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives.

In 2001, the whole of the City of London was declared an Air Quality Management Area for Nitrogen dioxide (NO_2) and Particulate Matter (PM_{10}). The City has implemented a number of actions since the declaration, the latest are detailed in the City of London Air Quality Strategy 2011 to 2015.

In April 2012, an “Updating and Screening Assessment” report was submitted to Defra. It was based on the results shown here, and concluded that it is not yet appropriate to review the Air Quality Management Area status of the City of London.

2 Monitoring Data

2.1 Summary of Monitoring Undertaken

2.1.1 Automatic Monitoring Sites

The locations and details of all automatic monitoring sites are shown in Figure 2.1 and Table 2.1.

Quality assurance and quality control details for all automatic monitoring sites in the City are provided in Chapter 4. All results reported here may be subject to slight change, depending on the results of equipment audits in May 2012.

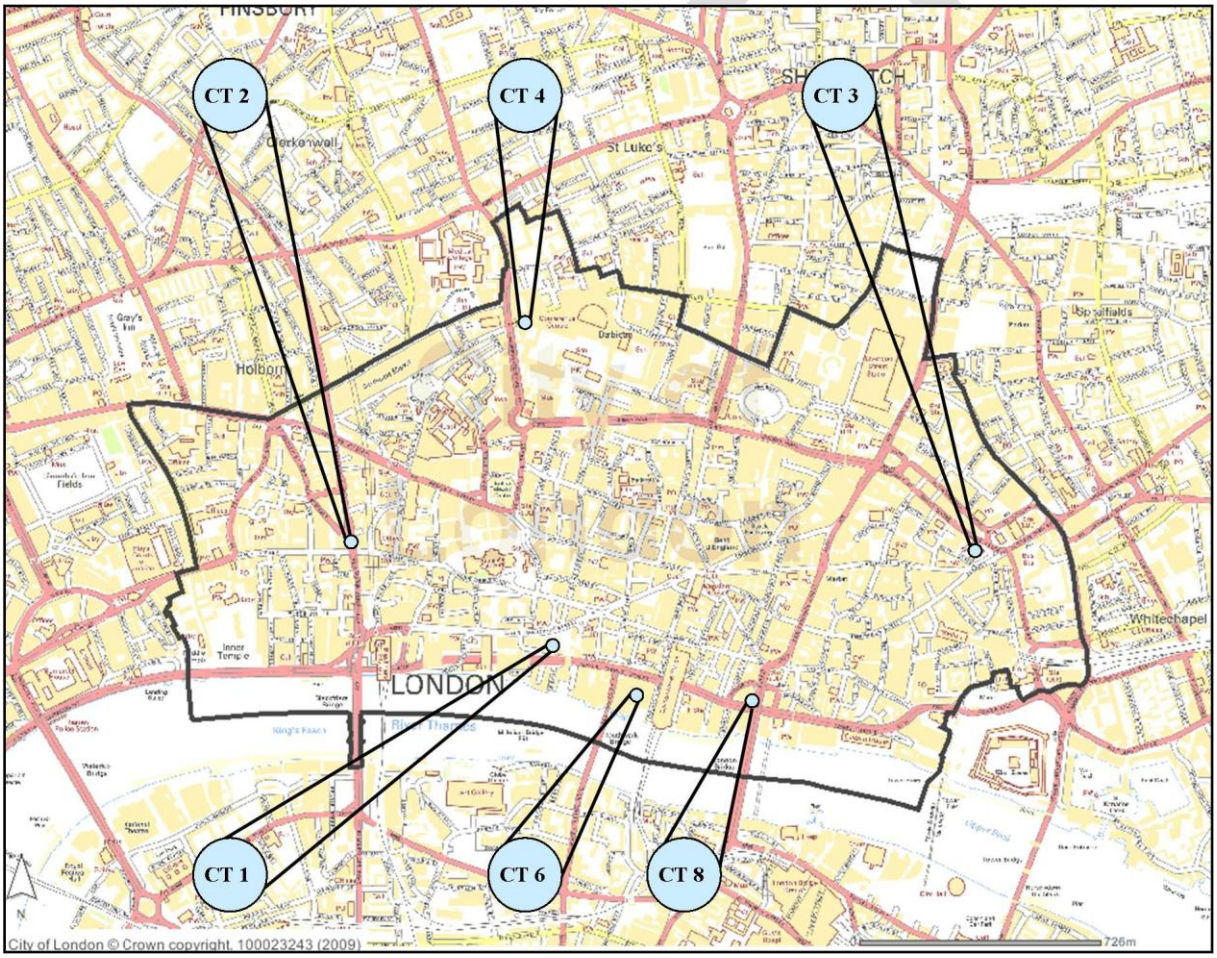

Figure 2.1 Map of Automatic Monitoring Sites

Table 2.1 Details of Automatic Monitoring Sites

Site Name	Site Type	X OS GridRef	Y OS Grid Ref	Pollutants Monitored	In AQMA?	Monitoring Technique	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to kerb of nearest road *(N/A if not applicable)*	Does this location represent worst-case exposure?
CT 4 - Beech Street	Roadside	532141	181861	PM_{10}	Y	TEOM	Yes (5m)	1m	Y
CT 4 - Beech Street	Roadside	532176	181862	NO_2	Y	Chemolumine scence	Yes (5m)	1m	Y
CT 3 - John Cass School	Urban Background	533475	181179	PM_{10}	Y	BAM	Yes (in school playground)	N/A	N/A
CT 3 - John Cass School	Urban Background	533475	181179	NO_2	Y	Chemolumine scence	Yes (in school playground)	N/A	N/A
CT 1 - Senator House	Urban Background	532234	180894	SO_2	Y	Flourescence	Yes (on top of a building)	N/A	N/A
CT 1 - Senator House	Urban Background	532234	180894	O_3	Y	Photometric	Yes (on top of a building)	N/A	N/A
CT 1 - Senator House	Urban Background	532234	180894	NO_2	Y	Chemolumine scence	Yes (on top of a building)	N/A	N/A
CT 8 - Upper Thames Street	Roadside	532834	180691	PM_{10}	Y	TEOM	Yes (3m)	2m	Y
CT 6 - Walbrook Wharf Foyer	Roadside	532528	180784	NO_2	Y	Chemolumine scence	Yes (3m)	1m	Y
CT 2 – Farringdon Street	Kerbside	531625	181201	$PM_{2.5}$	Y	BAM	Yes (4m)	1m	Y
Walbrook Wharf Roof	Urban Background	532528	180784	NO_2	Y	Chemolumine scence	Yes (on top of a building)	N/A	N/A

2.1.2 Non-Automatic Monitoring Sites

Diffusion tubes were used in 2011 to monitor nitrogen dioxide. The tubes used are managed by Bureau Veritas as part of the London-Wide Environment Programme (LWEP). All diffusion tubes employed in the LWEP programme are prepared and analysed by UKAS accredited Gradko International Ltd.

Diffusion tubes are prepared using the 50% v/v triethanolamine with acetone method and analysed using UV spectrometry. The diffusion tubes are labelled, and kept refrigerated in plastic bags prior to and after exposure. The City did not conduct its own co-location study, and laboratory bias adjustment factor is supplied by Bureau Veritas. For 2011 the factor was 1.02. Further QA/QC data is included in Chapter 4.

Figure 2.2 shows a map of diffusion tube sites in the City of London. Table 2.2 provides details of all sites.

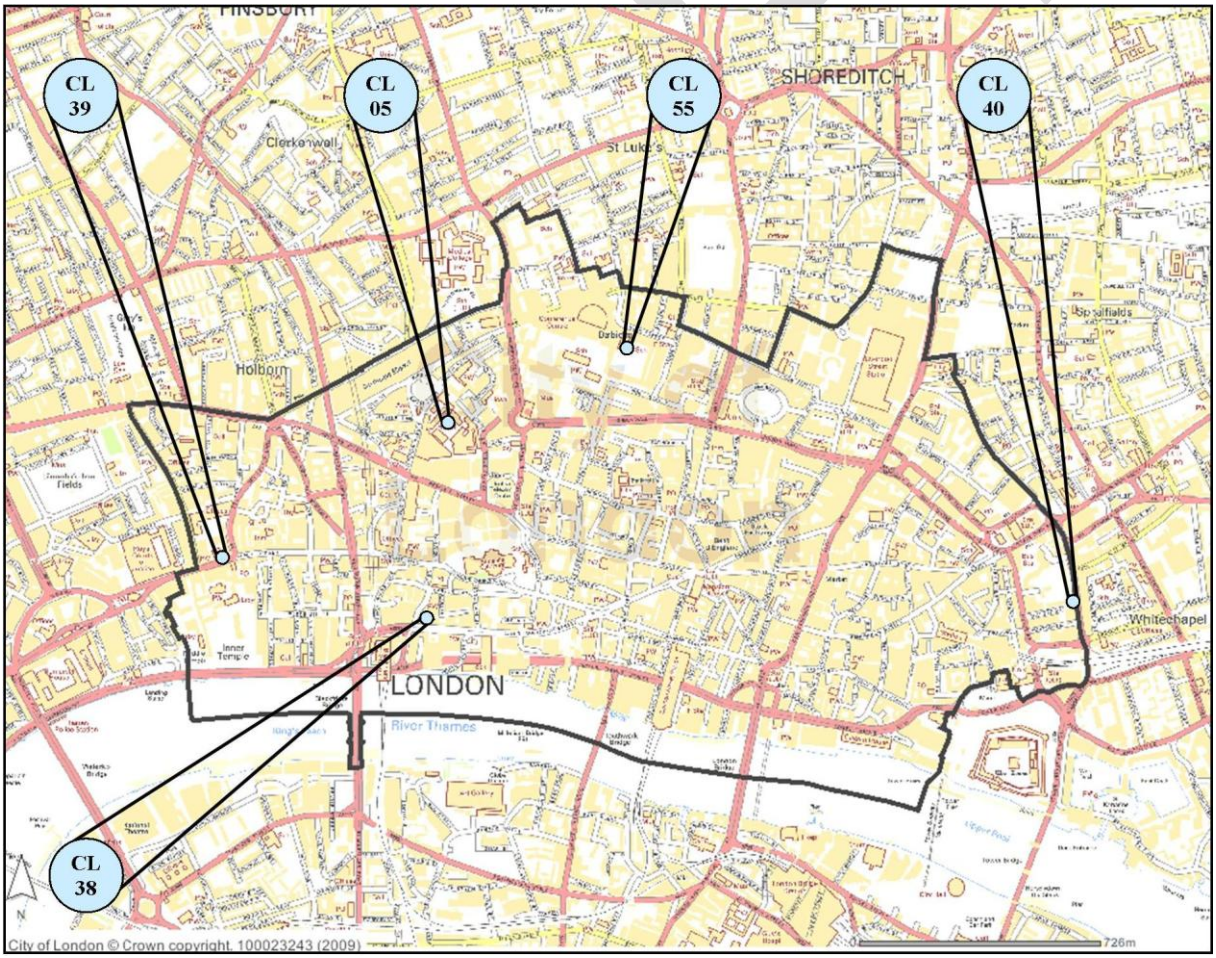

Figure 2.2 Map of Non-Automatic Monitoring Sites

Table 2.2 Details of Non-Automatic Monitoring Sites

Site Name	Site Type	X OS Grid Ref	Y OS Grid Ref	Pollutants Monitored	In AQMA?	Is monitoring collocated with a Continuous Analyser (Y/N)	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to kerb of nearest road *(N/A if not applicable)*	Does this location represent worst-case exposure?
CL 5 St. Bartholomew's Hospital courtyard	Urban Centre	531901	181571	NO_2	Y	N	Y	N/A	N/A
CL 38 St. Andrew's Church, Queen Victoria Street	Roadside	531851	180962	NO_2	Y	N	Y (4m)	2m	N
CL 39 St. Dunstan's Church, Fleet Street	Roadside	531235	181155	NO_2	Y	N	Y (4m)	2m	Y
CL 40 Guinness Trust Estate, Mansell Street.	Roadside	533791	181027	NO_2	Y	N	Y (3m)	3m	N
CL 55 Speed House, Barbican Centre	Urban Background	532482	181799	NO_2	Y	N	Y	N/A	N/A

2.2 Comparison of Monitoring Results with AQ Objectives

All of the City's monitoring sites are located within the existing AQMA.

The NO_2 annual mean objective was achieved at Speed House, Barbican.
The annual mean objective was exceeded at all other sites in the City of London.
The NO_2 hourly mean objective was exceeded at Beech Street and Walbrook Wharf.
The PM_{10} daily mean objective was exceeded at Upper Thames Street.
The PM_{10} annual mean objective was achieved at all sites.
The SO_2 15 minute, 1-hour and 24-hour mean objectives were all achieved.
All monitoring results (including $PM_{2.5}$ and O_3, for which there is no obligation on local authorities to meet the objectives) are discussed in greater detail in the following sections.

2.2.1 Nitrogen Dioxide

In the City, nitrogen dioxide (NO_2) is monitored using both (automatic) continuous analysers and (non-automatic) diffusion tubes. Continuous monitoring data is used to measure against both an hourly average objective and an annual average objective value. Diffusion tubes are used to measure against the annual average objective only.
There are four continuous monitors in the City. Two are roadside sites (Beech Street and Walbrook Wharf), and two are urban background sites (Senator House and Sir John Cass School).
There are five diffusion tube sites in the City. One is an urban centre site (St. Bartholomew's Hospital). Three are roadside/kerbside sites (St. Andrew's by the Wardrobe, Queen Victoria Street; St. Dunstan's in the West, Fleet Street and The Guinness Trust Estate, Mansell Street). One is an urban background site (Speed House, The Barbican).

Automatic Monitoring Data

In 2011, the hourly average objective was not achieved at three sites: Walbrook Wharf, Walbrook Wharf Roof and Beech Street. In 2011 the annual objective was not achieved at any automatic site. There was one NO_2 episode in the City in 2011, where moderate levels were seen in Walbrook Wharf in Early October. Data capture at Walbrook Wharf was low, due to a significant problem which arose when third party equipment was removed from site. Between early May and late July, the data from this site was invalid. The annual mean has been estimated in accordance with Defra guidance, and the calculations are set out in Appendix 1.

Tables 2.3 and 2.4 show the results of automatic monitoring in 2011. Figure 2.3 shows trends in annual mean concentrations since 1999.

Table 2.3 Results of Automatic Monitoring of Nitrogen Dioxide: Comparison with Annual Mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Annual Mean Concentration μg/m^3				
				2007	2008	2009	2010	2011
CT1	Urban Background	Y	94	43	49	48	51	52
CT3	Urban Background	Y	85	52	58	56	55	48
CT4	Roadside	Y	100	93	85	90	81	67
CT6	Roadside	Y	74	96	126	131	117	101
Walbrook Wharf Roof	Urban Background	Y	99	76	93	91	93	95

NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

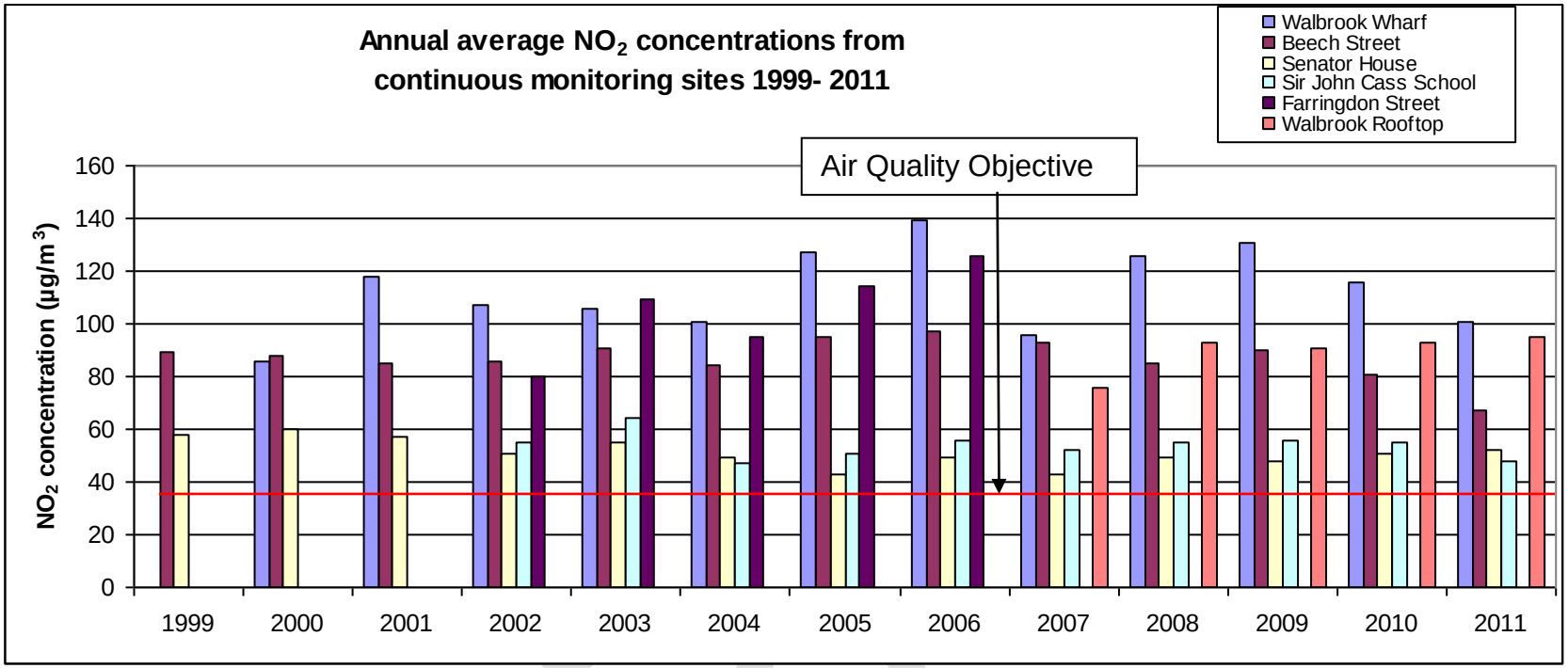

Figure 2.3 Trends in Annual Mean Nitrogen Dioxide Concentrations measures at Automatic Monitoring Sites

Table 2.4 Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with 1-hour mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Number of Exceedences of Hourly Mean (200 μg/m^3)				
				2007	2008	2009	2010	2011
CT1	Urban Background	Y	94	0	0	0	2	0
CT3	Urban Background	Y	85	0	0	2	3	0
CT4	Roadside	Y	100	302	106	189	134	42
CT6	Roadside	Y	74	n/a	810	955	646	-*
Walbrook Wharf Roof	Urban Background	Y	99	26	13	4	40	118

*There were 231 exceedences recorded at CT6, but 2011 data capture was too low for this figure to be reliable.
NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

Diffusion Tube Monitoring Data

Annual concentrations are summarised in table 2.5. Table 2.6 and Figure 2.4 show trends in Annual mean NO_2 concentrations measured at diffusion tube sites since 2001. In 2011, the annual objective was achieved at one site, Speed House, Barbican Centre. None of the sites are collocated with continuous analysers, and there were no triplicate tubes exposed in 2011.

Table 2.5 Results of Nitrogen Dioxide Diffusion Tubes in 2011

Site ID	Location	Site Type	Within AQMA ?	Data Capture 2011 (Number of Months or %)	Confirm if data has been distance corrected (Y/N)	Annual mean concentration (Bias Adjustment factor = 1.02) 2011 ($\mu g/m^3$)
CL5	St. Bartholomew's Hospital courtyard	Urban Centre	Y	100%	N	45
CL 38	St. Andrew's Church, Queen Victoria Street	Roadside	Y	100%	N	63.1
CL 39	St. Dunstan's Church, Fleet Street	Roadside	Y	100%	N	97.5
CL 40	Guinness Trust Estate, Mansell Street	Roadside	Y	100%	N	64.5
CL 55	Speed House, Barbican Centre	Urban Background	Y	91.7%	N	37.8

Table 2.6 Results of Nitrogen Dioxide Diffusion Tubes (2007 to 2011)

Site ID	Site Type	Within AQMA?	Annual mean concentration (adjusted for bias) µg/m^3				
			2007 (Bias Adjustment Factor = 1.01)	2008 (Bias Adjustment Factor = 0.93)	2009 (Bias Adjustment Factor = 1)	2010 (Bias Adjustment Factor = 0.99)	2011 (Bias Adjustment Factor = 1.02)
CL5	Urban Centre	Y	50.2	43.3	42.7	42.1	45
CL 38	Roadside	Y	68.7	74.7	66.9	60.7	63.1
CL 39	Roadside	Y	100.1	82.4	102.3	86.7	97.5
CL 40	Roadside	Y	75.6	61.9	66.8	54.6	64.5
CL 55	Urban Background	Y	40.5	38.3	42.6	37.3	37.8

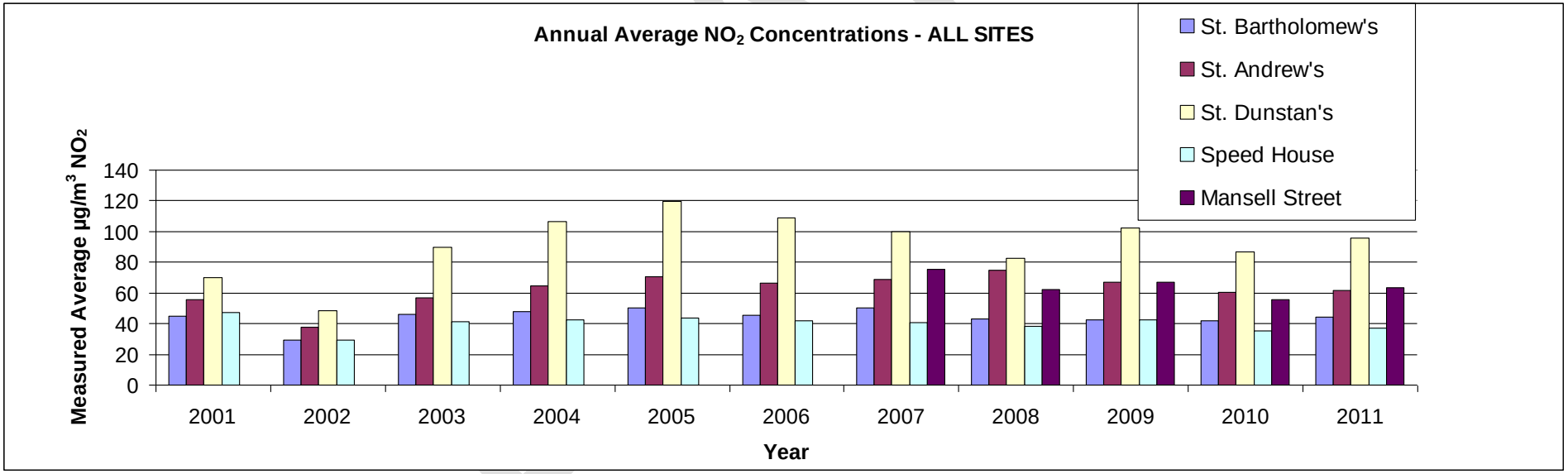

Figure 2.4 Trends in Annual Mean Nitrogen Dioxide Concentrations measured at Diffusion Tube Monitoring Sites

2.2.2 PM_{10}

In the City, the majority (85%) of PM_{10} is emitted outside the City boundary. The rest is believed to come from road vehicles travelling within the City (10%) and other local sources, such as construction works, domestic heaters and industrial boilers (5%). This means that the capacity to manage overall PM_{10} concentrations at a local level is limited. Overall, levels in the City have been consistently high over the last decade. TEOM measurements at Beech Street and Upper Thames Street have had the Volatile Correction Model (VCM) applied. Results appear lower from 2007 onwards, but this is likely to be due in part to the application of the VCM.
In 2011, the annual mean objective was achieved at all sites. The daily average objective was not achieved at Upper Thames Street.
There were eight PM_{10} episodes in 2011. One in February, four in March, one in April, one in October and one in November. Moderate PM_{10} levels were recorded at Upper Thames Street during all episodes, and moderate levels were recorded at Sir John Cass School during six episodes.
Table 2.7 shows annual mean concentrations at all sites, and table 2.8 shows the number of times the 24-hour mean was exceeded. Figure 2.5 shows the trend in annual mean concentrations at City of London sites since 1999, and the influence of the VCM.

Two trial applications of dust suppressant were undertaken by Transport for London (TfL) along Upper Thames Street in 2011. These were undertaken from 12th January to 31st January and from 1st February to 10th March. Data from the Upper Thames Street station was offered up by the City of London to assist in the study, but the TEOM was not a compatible measurement method, and so data from this site was not used.
The TfL trial report suggested an improvement of as much as 10-14% (i.e. reduction in the number of times the 24 hour averages objective was exceeded). This may be of increased interest in years to come, should year-round application have a more significant impact on the 24-hour PM_{10} objective.

Table 2.7 Results of Automatic Monitoring of PM_{10}: Comparison with Annual Mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Confirm Gravimetric Equivalent (Y or NA)	Annual Mean Concentration μg/m³				
					2007	2008	2009	2010	2011
CT3	Urban Background	Y	94	Y	30	26	27	26 (90th percentile 52.5μg/m³)	28
CT4	Roadside	Y	98.6	Y	34	26	28	30	28.6
CT8	Roadside	Y	99	Y	41	34	36	37	37

NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

Table 2.8 Results of Automatic Monitoring for PM_{10}: Comparison with 24-hour mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Confirm Gravimetric Equivalent	Number of Exceedences of 24-Hour Mean (50 μg/m³)				
					2007	2008	2009	2010	2011
CT3	Urban Background	Y	94	Y	31	15	11	10 (90th percentile 52.5μg/m³)	22
CT4	Roadside	Y	98.6	Y	60	20	23	26	35
CT8	Roadside	Y	99	Y	49	37	44	57	**53**

NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

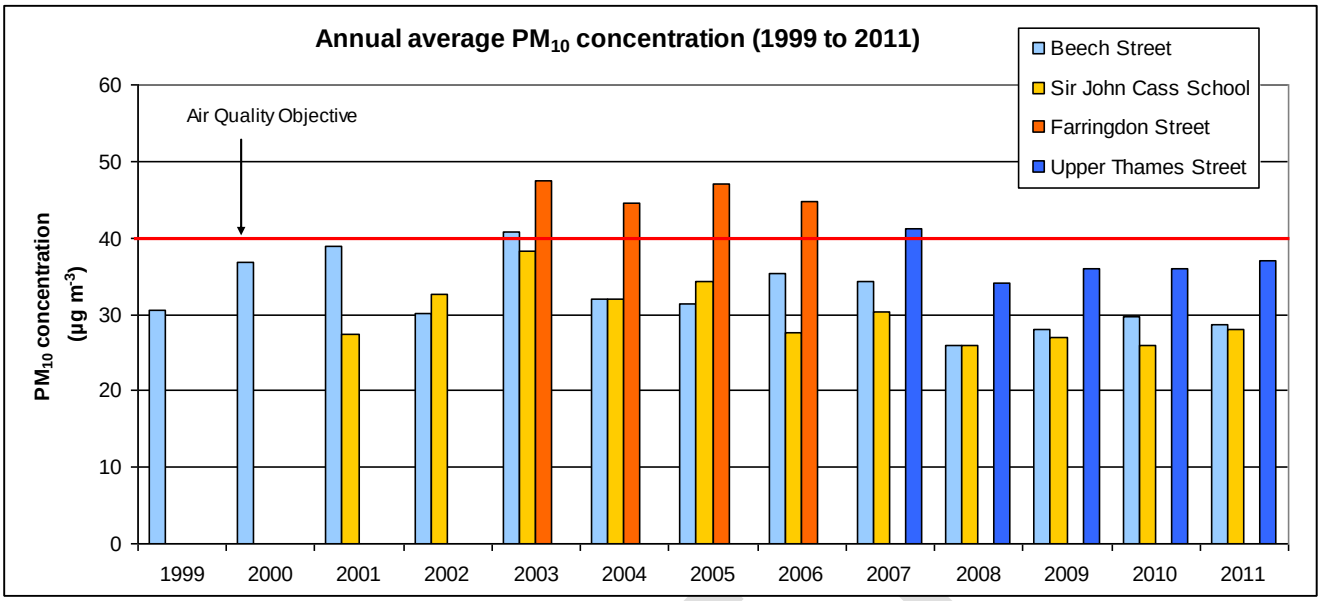

Figure 2.5 Annual Mean PM_{10} Concentrations

2.2.3 Sulphur Dioxide

The City of London typically sees very low levels of SO_2. Local concentrations are predominantly influenced by distant industrial point sources. Easterly winds occasionally give rise to increased concentrations by bringing SO_2 from power stations along the Thames corridor. Even with this contribution, concentrations are found to be very low.

In 2011, levels of SO_2 were broadly similar to previous years, and all three objectives were met.

Table 2.9 shows the results of SO_2 monitoring in 2011, and Figure 2.6 shows that annual average concentrations have remained low since 2002. None of the objectives have been exceeded in this time.

Table 2.9 Results of Automatic Monitoring of SO_2: Comparison with Annual Mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Number of Exceedences (percentile in bracket μg/m^3)		
				15-minute Objective (266 μg/m^3)	1-hour Objective (350 μg/m^3)	24-hour Objective (125 μg/m^3)
CT1	Urban background	Y	93	0	0	0

NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

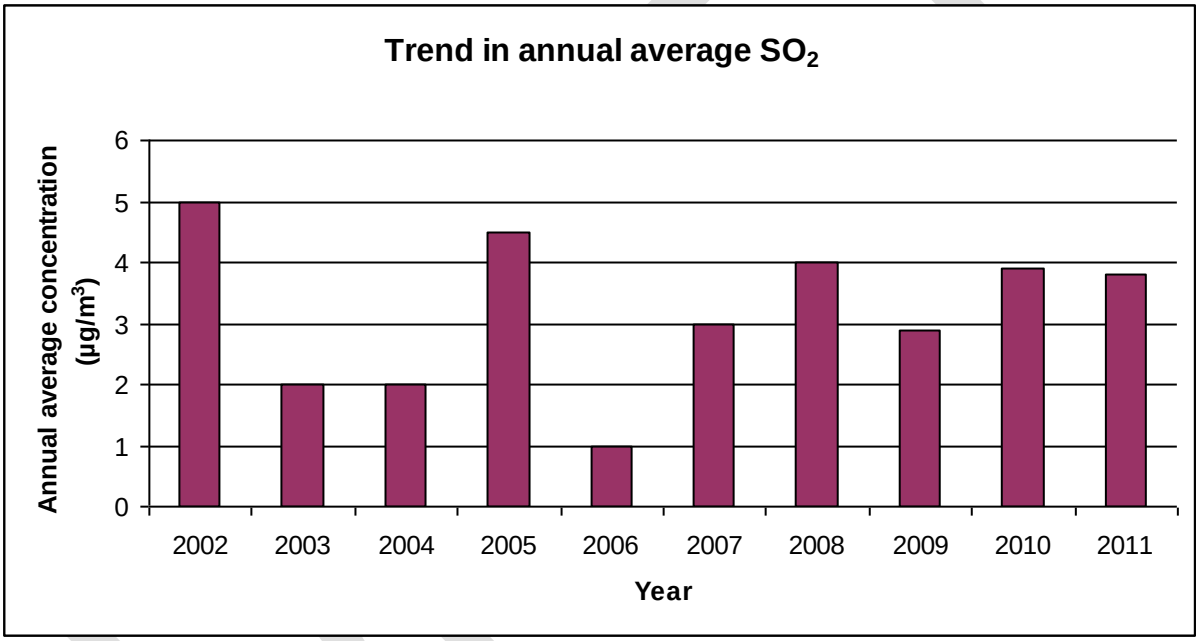

Figure 2.6 Trends in SO_2 Concentrations

2.2.4 $PM_{2.5}$

In July 2009, a site at Farringdon Street was set up to monitor $PM_{2.5}$, in anticipation of proposed new regulation. There are two new objectives proposed, one relating to an annual mean concentration (25µg/m^3 by 2020), and the other a 15% net reduction in concentrations at urban background locations, measured as a 3-year mean.
The site at Farringdon Street is a kerbside site, and so the only relevant objective is the annual mean concentration. The proposed objective is for an annual mean concentration of 25µg/m^3 to be achieved by 2020. Table 2.10 shows the annual mean result in 2011. Raw data has been scaled by dividing by a factor of 1.21.

Table 2.10 Results of Automatic Monitoring of $PM_{2.5}$: Annual Mean

Site ID	Site Type	Within AQMA?	Valid Data Capture 2011 %	Annual Mean
CT2	Kerbside	Y	94	24

NOTE: The results shown above may be subject to slight change, depending on the results of equipment audits in May 2012.

2.2.5 Ozone (O_3)

Local objectives for improving ground level ozone are not included in the Air Quality Regulations 2000. The UK Air Quality Strategy suggests a running 8-hour average of 50ppb (100µg/m^3) should not be exceeded more than 10 times per year.
In 2011 there were 9 days when the running 8 hour average exceeded this level, and these were all at Senator House. There were two O_3 episode days at Senator House, one in April and one in October.
The annual average ozone concentration in 2011 was 31.2 µg/m^3 at Senator House.

2.2.6 MET monitoring

The City of London has a meteorological station on the roof of their office building at Walbrook Wharf. This measures wind speed, wind direction and wind vector every fifteen minutes, and measures ambient temperature every hour.

Figures 2.7 and 2.8 show the meteorological trends in the City during 2011.

The average annual temperature in the City during 2011 was 13.28°C. The average wind speed was 1.02 m/s, and the most common wind directions were northerly and south westerly. There was significantly higher than average rainfall in the summer, and significantly lower than average rainfall during the spring and autumn. Winter rainfall was average.

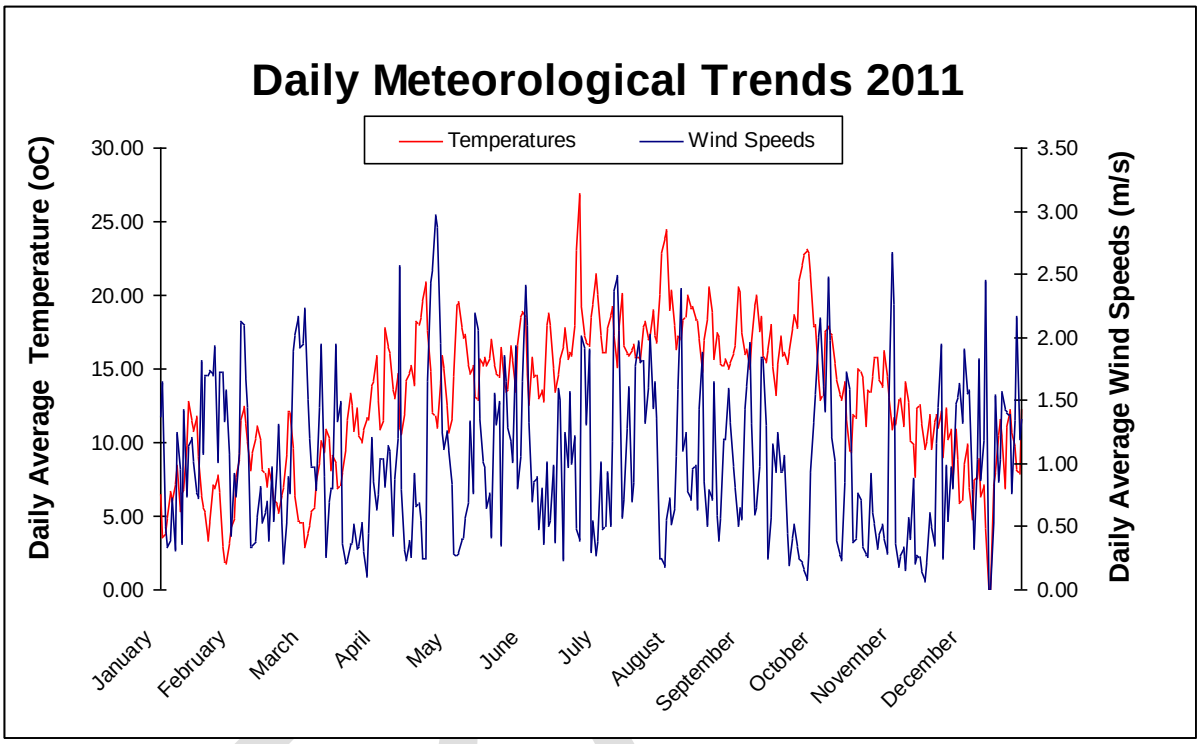

Figure 2.7 Daily average temperatures and wind speed in 2011

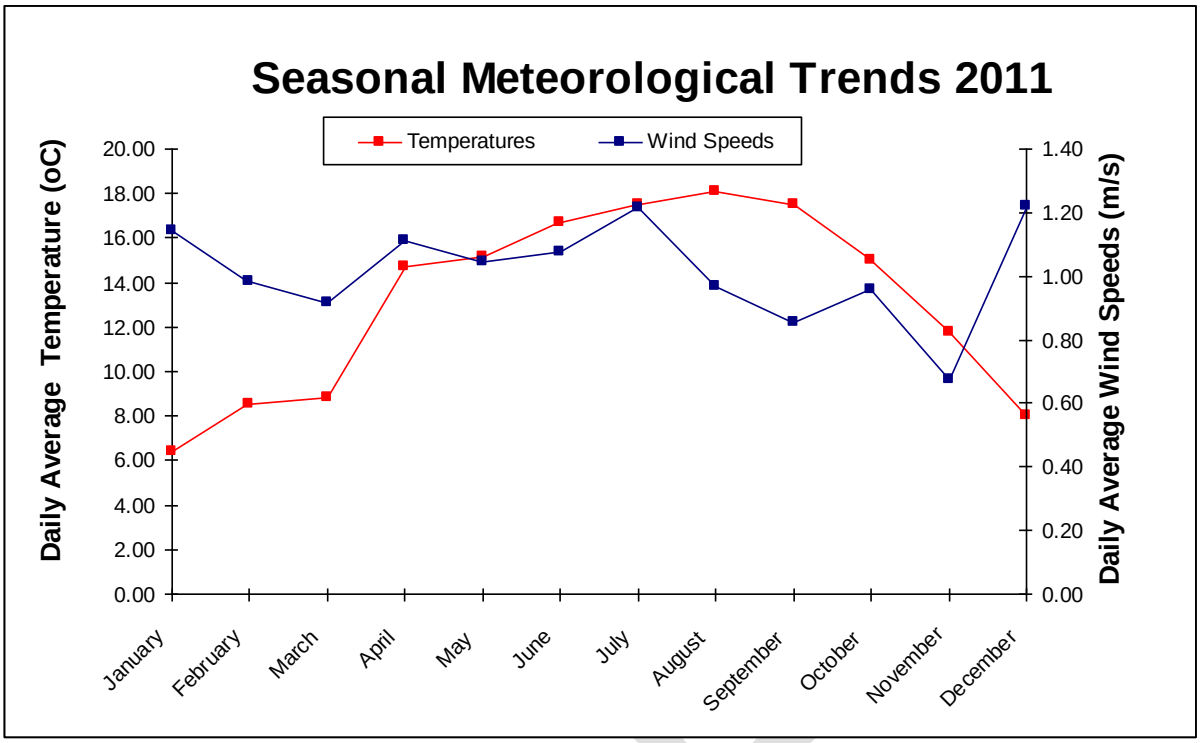

Figure 2.8 Monthly average temperatures and wind speed in 2011

2.2.7 Summary of Compliance with AQS Objectives

In the City of London, concentrations of PM_{10} exceed the daily average objective adjacent to the Upper / Lower Thames street corridor. The annual average PM_{10} objective is being met. Annual average nitrogen dioxide concentrations are exceeded almost everywhere in the City and the hourly average objective is not being met adjacent to busy roads.

Concentrations of all other pollutants are below the objectives.

3 Conclusions and Proposed Actions

3.1 Conclusions from Monitoring Data

Nitrogen dioxide was monitored at ten sites in the City, and the annual mean objective was exceeded at nine out of ten sites. This was similar to results in previous years. The hourly mean objective for NO_2 was exceeded at two of the four continuous monitoring sites; Beech Street and Walbrook Wharf. This has occurred in previous years.

PM_{10} was monitored at three sites in the City. The annual mean objective was not exceeded at any site, and the 24-hour mean objective was exceeded at Upper Thames Street only. This was similar to previous years. PM_{10} levels were higher prior to 2008, when the new volatile correction model (VCM) was first used.

A detailed assessment in not required and it is not appropriate to revoke the AQMA.

3.2 Proposed Actions

The new monitoring data from 2010 has not identified the need to proceed to a detailed assessment for any pollutant. The data has not identified a need for any additional monitoring, or changes to the existing monitoring programme. There are no changes required for any existing AQMAs.

The next course of action will be to continue to implement the actions set out in the City of London Air Quality Strategy 2011-2015, and to submit another progress report in early 2013, which will discuss the monitoring data collected during 2012.

4 Supplementary information

4.1 References

London Air Quality Network. 2011. Statistics.
www.londonair.org.uk

City of London air quality management documentation, including the City of London Air Quality Strategy 2011-2015
www.cityoflondon.gov.uk/air

Information on the Transport for London dust suppressant trial
http://www.tfl.gov.uk/corporate/projectsandschemes/17246.aspx

The Volatile Correction Model
www.volatile-correction-model.info

Dr. Gary Fuller's "Pollution Watch" series in the Guardian
www.guardian.co.uk/environment/series/pollutionwatch

4.2 Health Effects of Air Pollution

The health effects of major air pollutants are described below.

Carbon monoxide

Carbon monoxide is an odourless, colourless gas, and is produced by incomplete combustion. It is more readily taken up by red blood cells than oxygen, and interferes with the take up of oxygen into the body. It is toxic at high concentrations, which are not normally observed outdoors. At low concentrations it can exhibit a slight reduction in the maximum physical performance of healthy individuals, and has been observed to speed up the onset of angina in individuals with coronary artery disease. (WHO, 2000)

Nitrogen dioxide

Nitrogen dioxide is an irritant gas, which has a red colour and acrid smell at very high concentrations. At high levels, NO_2 causes inflammation of the airways (Defra - Air Quality Strategy, 2007). In mild asthmatics, exposure has been shown to bring about reversible effects on lung function, and is thought to bring about exaggerated responses to allergens, cold air and exercise. Exposure puts children at increased risk of respiratory illness (WHO, 2000). Nitrogen dioxide is used as a marker for a 'cocktail of combustion related pollutants' (WHO, 2005). While the aforementioned health effects are specifically related to nitrogen dioxide, high levels of NO_2 can indicate high levels of other pollutants which contribute to additional adverse health effects.

Sulphur dioxide

Sulphur dioxide is a colourless gas with a faintly sweet, suffocating odour. SO_2 is produced by industrial and domestic fossil fuel combustion, and shipping (House of Commons EAC - Briefing Note, 2009). Short term exposure to high concentrations of SO_2 results in a reduction in lung function. In the long term, exposure is thought to lead to childhood respiratory disease and increased mortality in all ages (WHO, 2005) Young children, and people suffering from asthma and chronic respiratory diseases are particularly susceptible to SO_2.

Ozone

Ozone is a pale blue gas with a sharp smell. It is a secondary pollutant, which arises as a result of chemical reactions between various other air pollutants; primarily NOx and Volatile Organic Compounds, initiated by strong sunlight (Defra - Air Quality Strategy, 2007). Short term effects include respiratory symptoms, such as coughing (WHO, 2000), and irritation to the eyes and nose (Defra, 2007). Longer term exposure has been shown to reduce lung function and increase the incidence of respiratory symptoms, respiratory hospital admissions and mortality rates (Defra, 2007).

Particulates

Particulate pollution is composed of a variety of compounds and is defined by aerodynamic diameter, an indicator of where in the respiratory tract the particles will deposit. Particles are identified as either PM_{10} (particles with an aerodynamic diameter smaller than 10 µm) or $PM_{2.5}$ (particles with an aerodynamic diameter smaller than 2.5 µm) (WHO – Factsheet, Air Quality and Health, 2008). Both short-term and long-term exposure have been shown to cause respiratory and cardiovascular illness, other ill-health effects and mortality (Defra, 2007). Long term exposure contributes to the risk of lung cancer (WHO, 2008). The UK Air Quality Strategy says of particulates: 'it is not currently possible to discern a threshold concentration below which there are no effects on the whole population's health.'(Defra, 2007)

Aromatic Hydrocarbons: BTEX

Aromatic hydrocarbons are known carcinogens, which have a variety of sources. Benzene is one which receives particular attention. It is noted that 'no absolutely safe level can be specified in ambient air' (Defra, 2007). Domestic and industrial combustion, and road transport are among the main sources.

Toluene also receives particular attention. Both short and long term exposure to Toluene affect the central nervous system, and Toluene is thought to cause birth and developmental defects (WHO, 2000).

Aromatic hydrocarbons are easily ignited, producing carbon monoxide and carbon dioxide on combustion. Breathing aromatic hydrocarbons at highly elevated

concentrations for extended periods has been known to cause fatigue, headache, nausea and drowsiness.

4.3 QA/ QC data

Factor from Local Co-location Studies (if available)

There were no co-location studies conducted in 2011

Diffusion Tube Bias Adjustment Factors

Diffusion tubes were supplied by Bureau Veritas. Tubes were analysed by Gradko international, using the preparation method 50% v/v TEA in Acetone, and analysed using U.V. Spectrophotometry. The 2011 LWEP Bias Adjustment factor was used, supplied by Bureau Veritas.

Discussion of Choice of Factor to Use

The LWEP bias adjustment factor was used, as it is the most appropriate factor to use for London sites. At time of writing, a national factor was not available, so the impact of choosing the LWEP factor over the National factor is not clear.

PM Monitoring Adjustment

PM_{10} data from the two TEOM sites (CT4 Beech Street and CT8 Upper Thames Street) has been adjusted using the Volatile Correction Model (VCM).
$PM_{2.5}$ data from the BAM at Farringdon Street has been divided by a factor of 1.21, in accordance with guidance.

Short-term to Long-term Data adjustment

Walbrook Wharf NO_2 results have been adjusted to estimate an annual mean. Valid data is not available from 2nd May to 27th July 2011. The long-term sites used for the calculation are: Horseferry Road (Westminster); Poplar (Tower Hamlets); Bloomsbury (Camden); and North Kensington (Kensington & Chelsea).

Site	Site Type	Annual Mean	Period Mean (1 Jan- 2 May, & 27 Jul to 1 Jan)	Ratio
Westminster Horseferry Road	Urban Background	40.3	44	91.74%
Tower Hamlets Poplar	Urban Background	34.2	39	87.50%
Camden Bloomsbury	Urban Background	48.5	51	95.96%
Kensington & Chelsea North Kensington	Urban Background	36	38	94.06%
			Average	92.3%

QA/QC of automatic monitoring

All automatic monitoring sites which measure gas are calibrated fortnightly, serviced once every six months, and audited by the National Physical Laboratory once every 6 months. Sites which are on the London Air Quality Network are monitored closely by King's College London to ensure data quality.

QA/QC of diffusion tube monitoring

The table below shows both “raw” and adjusted monthly average diffusion tube results for 2011.

RAW (UNCORRECTED) RESULTS												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St. Bartholomew's	49.23	51.28	49.44	46.22	36.68	36.13	32.83	39.25	36.35	44.24	50.47	56.49
St. Andrew's	61.27	67.07	57.65	83.76	65.36	58.42	46.41	56.61	58.94	59.56	59.49	68.35
St. Dunstan's	87.55	79.24	67.35	107.24	157.22	106.24	90.40	89.04	94.89	86.59	91.03	90.17
Speed House	38.78	40.26	46.83	42.70	30.17	28.95	28.06	32.13	32.63	-	45.89	41.32
Mansell Street	62.43	59.60	61.22	75.81	77.21	57.67	61.66	56.49	63.50	57.72	59.41	66.28
Bias Correction Factor	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
BIAS CORRECTED RESULTS												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St. Bartholomew's	50.21	52.30	50.43	47.14	37.41	36.86	33.49	40.04	37.07	45.12	51.48	57.62
St. Andrew's	62.50	68.41	58.80	85.44	66.67	59.59	47.34	57.74	60.12	60.76	60.68	69.72
St. Dunstan's	89.30	80.83	68.70	109.39	160.37	108.37	92.20	90.82	96.78	88.32	92.85	91.97
Speed House	39.55	41.06	47.76	43.55	30.77	29.53	28.63	32.77	33.28	-	46.81	42.15
Mansell Street	63.68	60.80	62.45	77.33	78.75	58.82	62.89	57.62	64.77	58.87	60.60	67.61