

Air Quality Annual Review 2009



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Air Quality Annual Review 2009

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1. Introduction

The Air Quality Annual Review 2009 outlines the results of air quality monitoring in the City of London, 1st January to 31st December 2009. This first chapter will introduce air pollution in the City of London, with a brief discussion of the legislative and scientific background.

The City's monitoring network is presented in Chapter 2. Chapter 3 sets out the results of all monitoring in 2009. These are discussed in Chapter 4. Further information is referred to in Chapter 5, and useful summaries and tables are included in Appendices A, B and C.

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. The general health impacts of major forms of air pollution are outlined in Appendix B.

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. This 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.

1.3 Air Quality Management – Legislation and Policy

National Air Quality Policy is set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Published in July 2007, this strategy updated a 1997 strategy document. It includes a new standard for PM_{2.5} (see section 3.6), and can be found at the web address: <http://www.defra.gov.uk/environment/quality/air/airquality/strategy/>

Under Part IV of the Environment Act 1995, local authorities are required to assess air quality, and to identify areas where air quality is unlikely to meet objectives prescribed in the Air Quality (England) Regulations 2000. These objectives (outlined in Appendix 1) are set for seven pollutants: carbon monoxide (CO); benzene; 1,3 butadiene; nitrogen dioxide (NO₂); lead; sulphur dioxide (SO₂); and PM₁₀ (fine particles $\leq 10\mu\text{m}$ in diameter). Objectives for pollutants which are monitored in the City are described individually in sections 3.2 to 3.7.

Where objectives are not achieved, Local Authorities must declare Air Quality Management Areas, and produce action plans indicating the actions they propose to take in pursuit of better air quality.

The City of London is an Air Quality Management Area for two pollutants, nitrogen dioxide and fine particulates. This was declared following a number of assessments from 1998 through to 2002. The Air Quality Action Plan was published in 2003. All Review and assessment and action plan documents can be found at this web address:

http://www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Pollution/air+quality.htm

The Mayor of London has produced an air quality strategy, with a view to improving air quality across Greater London. This strategy is being updated, and the most current draft (at time of writing) can be found at this web address:

<http://www.london.gov.uk/who-runs-london/mayor/publications/environment/mayors-draft-air-quality-strategy>

2. Air Quality Monitoring in the City.

2.1 Background to Air Quality Monitoring in the City.

The City of London has been monitoring air quality in the City since the late 1960's. Monitoring initially focussed on sulphur dioxide and black smoke, in response to the introduction of the clean air acts. Since then, the focus of air quality monitoring in the City has shifted to respond to changes in the predominant sources of pollution. Originally, the main sources were industry and coal burning, but this has changed to road vehicles.

The City is an Air Quality Management Area for nitrogen dioxide and fine particles, and air quality monitoring in the City focuses on these pollutants. A number of other pollutants are also monitored, to ensure continuing compliance with their relevant objectives. The monitoring programme within the City is regularly reviewed.

All monitoring is subject to quality assurance and quality control procedures. Details of these procedures can be found in the Review and Assessment reports undertaken as part of the air quality management process. All documents are available at the following address: http://www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Pollution/air+quality.htm

2.2 Air Quality Monitoring in 2009

Air quality monitoring was undertaken in 2009 with both continuous analysers and diffusion tubes. Figure 2.2.1 shows locations of all monitoring sites.

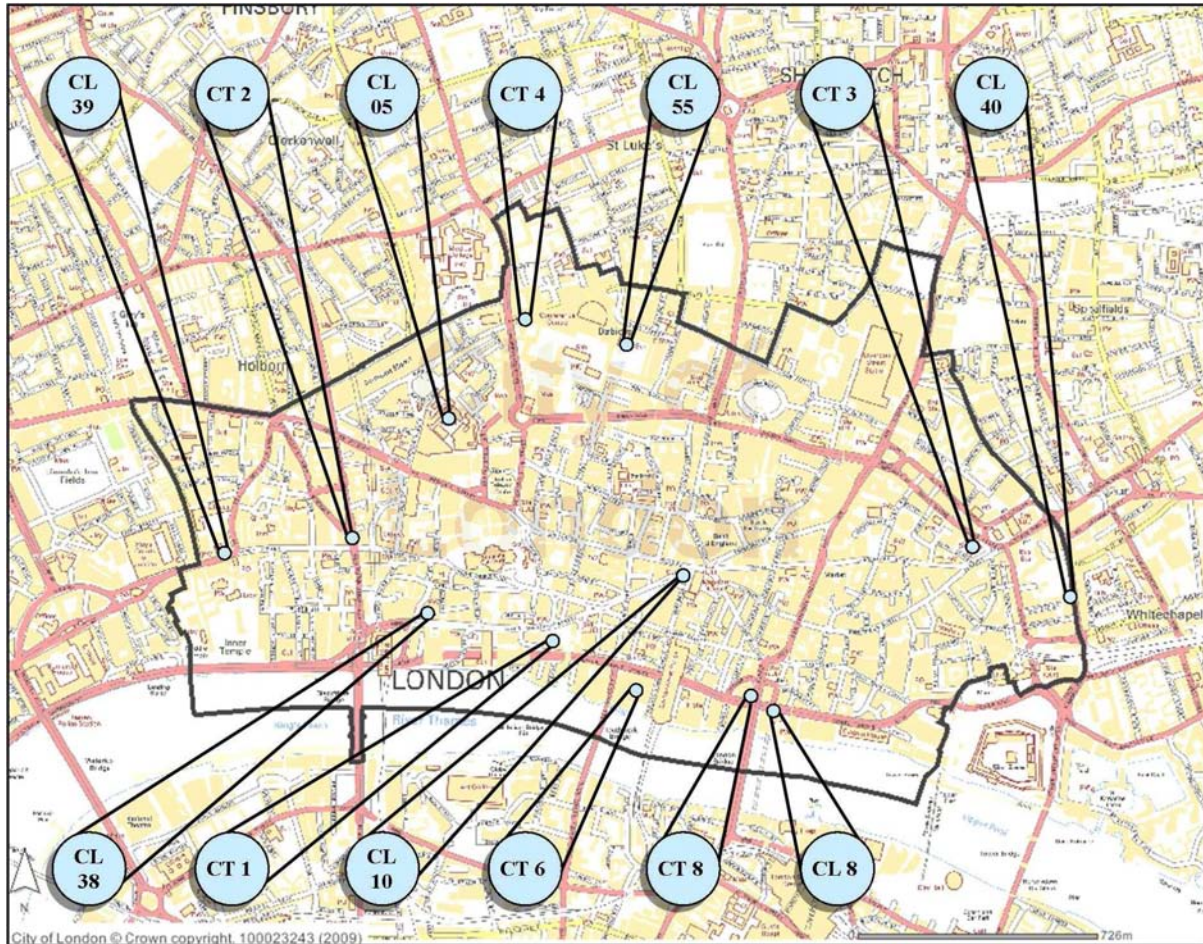


Figure 2.2.1 Monitoring locations in the City of London. Please refer to tables 2.2.1 and 2.2.2 for further detail.

Continuous analysers

Table 2.2.1 gives a summary of all monitoring which was undertaken in the City using continuous analysers. All data from continuous analysers was ratified, and data capture information was provided for each site and each pollutant. This is described and discussed further in sections 3.2 - 3.6.

Four continuous monitoring sites are included in the London Air Quality Network (LAQN). This is a network which is operated and managed by the Environmental Research Group (ERG) at King's College, London. Established in 1993, the LAQN has a role in coordinating and improving air pollution monitoring in London.

Table 2.2.1 Air quality monitoring in 2009 using continuous analysers

Site Address	Site Classification	Nitrogen dioxide (NO ₂)	Fine Particulates (PM ₁₀)	Fine Particulates (PM _{2.5})	Carbon monoxide (CO)	Sulphur dioxide (SO ₂)	Ozone (O ₃)
CT 4 Beech Street	Roadside (1m from kerb)	✓	✓				
CT 6 Walbrook Wharf	Roadside (2m from kerb)	✓			✓		
CT 1 Senator House	Urban background	✓				✓	✓
Walbrook Wharf Rooftop	Urban background	✓					
CT 3 Sir John Cass School	Urban Background	✓	✓				
CT 8 Upper Thames Street	Roadside (2m from kerb)		✓				
CT 2 Farringdon Street	Kerbside			✓			

Diffusion tubes

Table 2.2.2 gives a summary of all monitoring which was undertaken in the City using diffusion tubes. Diffusion tubes are a less accurate tool for monitoring air quality than continuous analysers, but are useful for obtaining annual averages.

Tubes are exposed every month, for a period lasting either the entire month (NO₂), or two weeks in the month (benzene). Tubes are then collected, and sent to a laboratory for analysis. At the end of every year, annual average results are adjusted to account for a laboratory bias. This is done using a factor which is calculated each year for each laboratory and method of analysis. This is described and discussed further in sections 3.3 and 3.7.

Table 2.2.2 Air quality monitoring in 2009 using diffusion tubes

Site Address	Site Classification	Nitrogen dioxide (NO ₂)	Benzene, Ethylbenzene, Xylene, (BTEX)	Toluene, M+P-O-Xylene
CL 10 Mansion House	Kerbside			✓
CL 55 Speed House, Barbican Centre	Urban Background		✓	
CL 5 St. Bartholomew's Hospital courtyard	Urban Centre		✓	
CL 39 St. Dunstan's Church, Fleet Street	Roadside		✓	
CL 38 St. Andrew's Church, Queen Victoria Street	Roadside		✓	
CL 8 St. Magnus the Martyr, Upper Thames Street	Roadside			✓
CL 40 Guinness Trust Estate, Mansell Street.	Roadside		✓	

3. Air Quality Results

3.1 Seasonal Variation

There are general seasonal trends in air quality related to weather conditions. The air quality in summer and winter tends to be slightly worse than in autumn and spring. This is generally due to the following conditions:

- **Summer:** In summer, sunlight reacts with pollution from vehicles, petrol and other industrial sources, and fuel used for heating and cooling. The action of sunlight on these pollutants produces low-level ozone and increased levels of nitrogen dioxide and fine particles.
- **Winter:** In winter, pollution from vehicles and fuel from heating build up at ground level and can become trapped when the air above the city is warmer than the air at ground level. This action effectively forms a lid that prevents the pollution from dispersing and is known as a temperature inversion. They are particularly prevalent on cold, calm days, often after a clear, cloudless night and an early morning frost.

The City of London Pollution team have 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 3.1.1 and 3.1.2 show the meteorological trends in the City during 2009.

The average annual temperature in the City during 2009 was 12°C. There was higher than average rainfall during the Spring, Summer and Autumn, and this could explain why concentrations of fine particles (PM₁₀) were lower than expected in 2009.

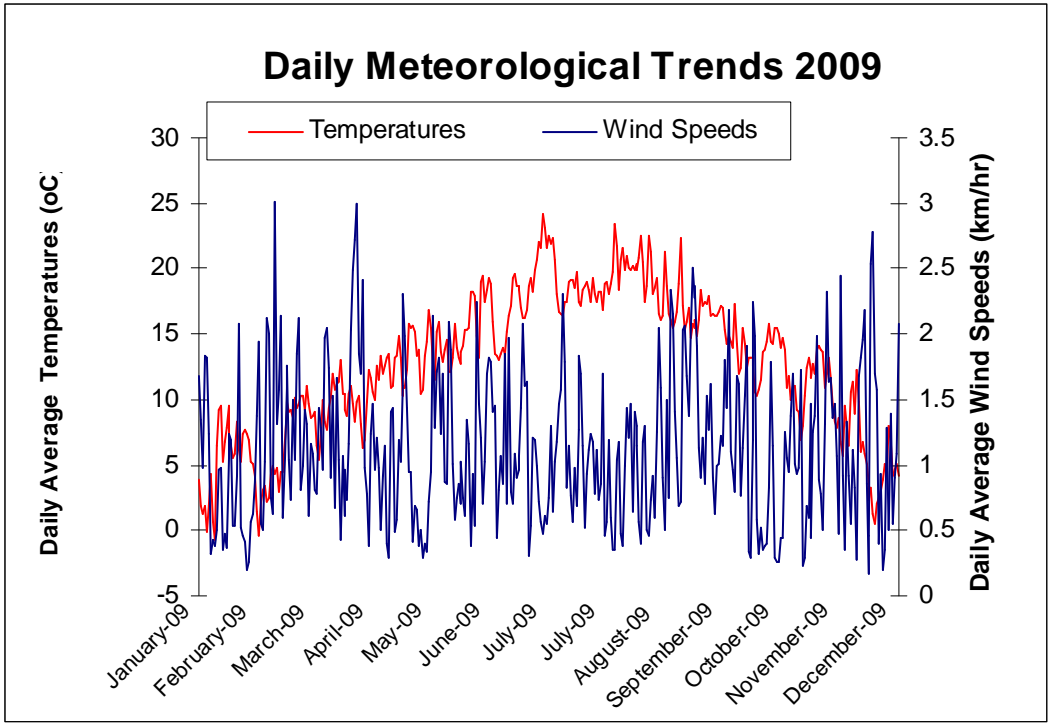


Figure 3.1.1 Daily average temperature and wind speed in the City during 2009.

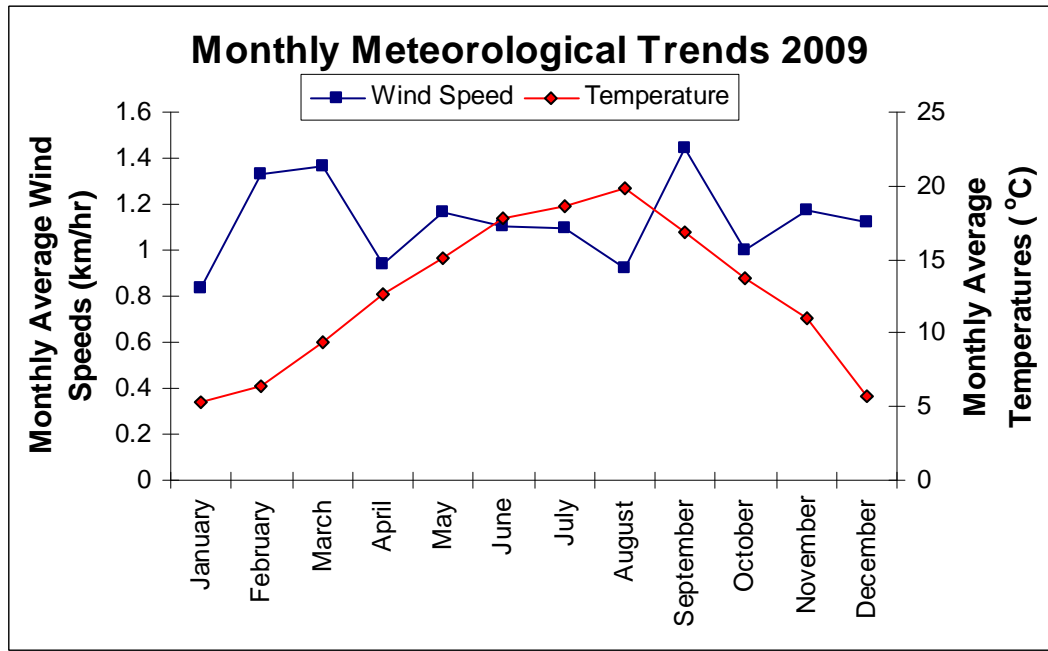


Figure 3.1.2 Monthly average temperature and wind speed in the City during 2009.

3.2 Carbon Monoxide (CO)

Table 3.2.1 Results of automatic monitoring for carbon monoxide: comparison with objective.

Site ID	Location	Within AQMA?	Data Capture for full calendar year 2009	Number of days where the 8 hour mean was in exceedance of 10 mg/m ³		
				2007	2008	2009
CT6	Walbrook Wharf	Yes	97%	0	0	0

Carbon Monoxide (CO) is a tasteless, colourless, odourless gas. The main source in ambient air is road transport. Residential and industrial combustion are also significant sources.

In the City of London, the main source is from the incomplete combustion of fuel in road vehicles and concentrations are highest close to major roads.

Concentrations of carbon monoxide are determined by emission rates and dispersion. They are highest during winter months when atmospheric dispersion is weakest. CO in the atmosphere is eventually oxidised to carbon dioxide (CO₂).

Monitoring for CO in the City of London began in 1999. Since then, the carbon monoxide air quality objective has not been exceeded. Table 3.2.2 shows that there has been a downward trend in annual CO concentrations since 1999. Figure 3.2.1 shows that the concentration of CO remained low throughout the year of 2009. The highest running 8 hour maximum observed in 2009 was 2.9 mg/m³.

During 2009, CO was monitored using a continuous analyser at Walbrook Wharf. The site adjoins Upper Thames Street, which has one of the highest traffic flow rates in the City. The air quality objective was not exceeded at this monitoring site.

Table 3.2.2: Annual Average CO concentrations and Air Quality Objective Exceedances 1999 – 2009.

Site	Year	Annual Average CO Conc. (mg m ⁻³)	No. of Times Objective Exceeded
Beech Street	1999	1.6	0
	2000	1.7	0
	2001	1.7	0
	2002	1.3	0
Walbrook Wharf	1999	2.6	0
	2000	2.2	0
	2001	2.1	0
	2002	1.4	0
	2003	1.0	0
	2004*	0.7	0
	2005**	0.5	0
	2006	0.4	0
	2007❖	0.4	0
	2008	0.7	0
	2009	0.8	0

* Analyser only operational until mid-September

** Analyser moved from Walbrook Wharf to Upper Thames Street, operational from April 2005

❖ 66 % Data capture (analyser moved from Upper Thames Street to Walbrook Wharf – 2007 data starts from May 2007).

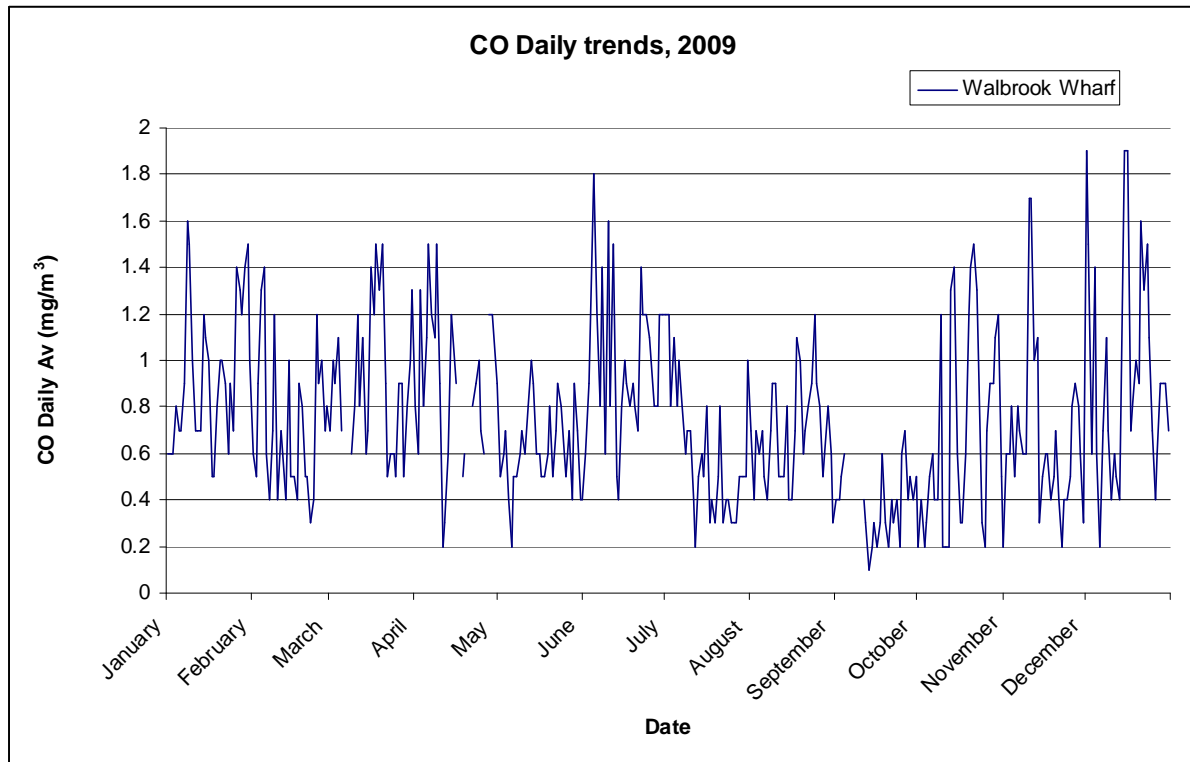


Figure 3.2.1 Daily mean CO concentrations 2009

3.3 Nitrogen dioxide (NO₂)

Table 3.3.1 Results of automatic monitoring for nitrogen dioxide: comparison with objectives.

Site ID	Location	Within AQMA?	Data Capture for full calendar year 2009	Number of times the following were exceeded:	
				Hourly mean (200 µg/m ³ , not to be exceeded more than 18 times a year)	Annual mean (40 µg/m ³)
CT1	Senator House	Yes	93	0	Exceeded 48 µg/m ³
CT 3	Sir John Cass School	Yes	99	2	Exceeded 56 µg/m ³
CT 4	Beech Street	Yes	99	Exceeded 189	Exceeded 90.2 µg/m ³
CT 6	Walbrook Wharf	Yes	97	Exceeded 955	Exceeded 131 µg/m ³
N/A	Walbrook Wharf Roof	Yes	99	4	Exceeded 90.8 µg/m ³
CL 5	St. Bartholomew's Hospital Courtyard	Yes	92	n/a	Exceeded 42.7 µg/m ³
CL 38	St. Andrew's Church, Queen Victoria Street	Yes	100	n/a	Exceeded 66.9 µg/m ³
CL 39	St. Dunstan's Church, Fleet Street	Yes	100	n/a	Exceeded 102.3 µg/m ³
CL 40	Guinness Trust Estate, Mansell Street	Yes	100	n/a	Exceeded 66.8 µg/m ³
CL 55	Speed House, Barbican Centre	Yes	100	n/a	Exceeded 42.5 µg/m ³

Nitrogen dioxide is largely a secondary pollutant, formed by the oxidation of nitric oxide. In the City, the primary source of nitric oxide is road vehicles, although the relative contribution from buildings (heating and cooling) is increasing. The health impacts of nitrogen dioxide are discussed in Appendix B. As with carbon monoxide, concentrations tend to be greatest during the winter months, when dispersion is poor. This is particularly apparent at background sites. While there have been significant developments in reduction of UK emissions since 1989 (due largely to the introduction of catalytic converters and new fuel standards), levels in the City have been consistently high over the last ten years.

In the City, nitrogen dioxide is monitored using both continuous monitors and 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. A map of all monitoring sites is included in section 2.2.

There are five continuous monitors in the City, of which two are roadside/kerbside sites, and three are background sites. Roadside sites are located at Beech Street and Walbrook Wharf. Background sites are located at Senator House, Sir John Cass School and Walbrook Wharf (Rooftop).

There are five NO₂ diffusion tube sites in the City. One is an urban centre site, and is located at St. Bartholomew's Hospital. Three are roadside/ kerbside sites, and are located at: St. Andrew's by the Wardrobe, Queen Victoria Street; St. Dunstan's, Fleet Street; and the Guinness Trust Estate, Mansell Street. One is an urban background site, and is located at Speed House, The Barbican.

In 2009, the hourly average objective was not achieved at two sites: Beech Street and Walbrook Wharf. Table 3.3.1 shows the annual average concentrations, and number of times the hourly limit value was exceeded at each of the continuous monitoring sites in 2009. Figure 3.3.1 graphs the number of exceedances in every month at each site.

Overall, levels of NO₂ in 2009 were close to the averages from previous years, and in some cases levels were slightly higher. Figures 3.3.2-3.3.4 illustrate trends in NO₂ levels over the last 10-16 years. Figure 3.3.2 shows year-on-year exceedances of the hourly mean at continuous monitoring sites in the City.

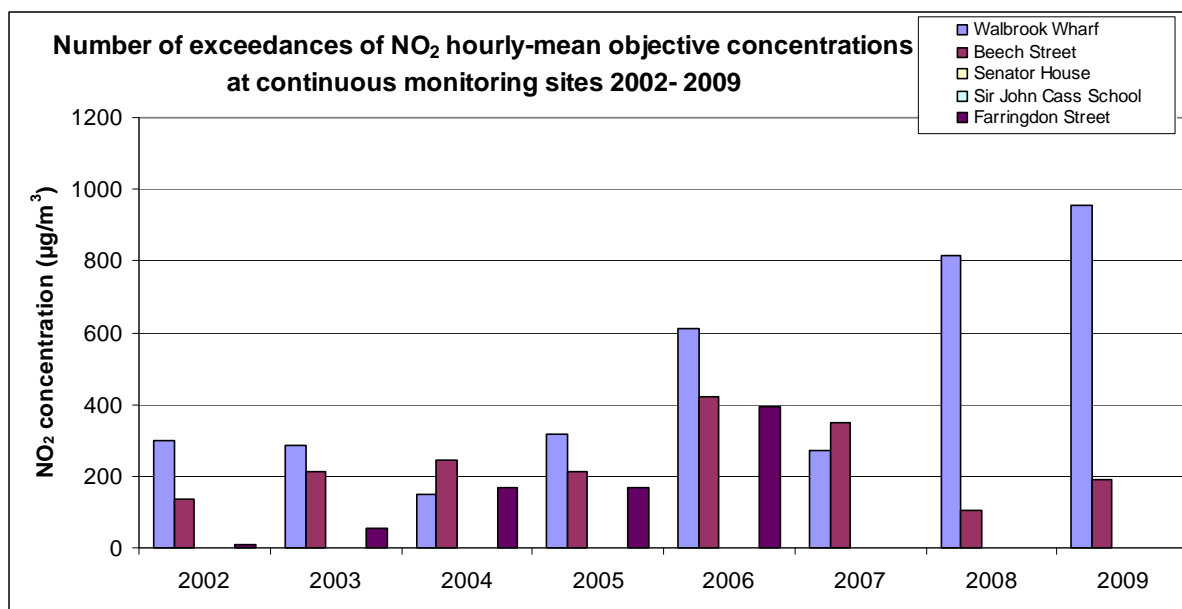


Figure 3.3.2 Number of times hourly mean exceeded 200µg/m³ at continuous monitoring sites, 2002-2009. Objective is no more than 18 exceedances.

Figure 3.3.3 shows year on year annual averages at continuous monitoring sites in the City.

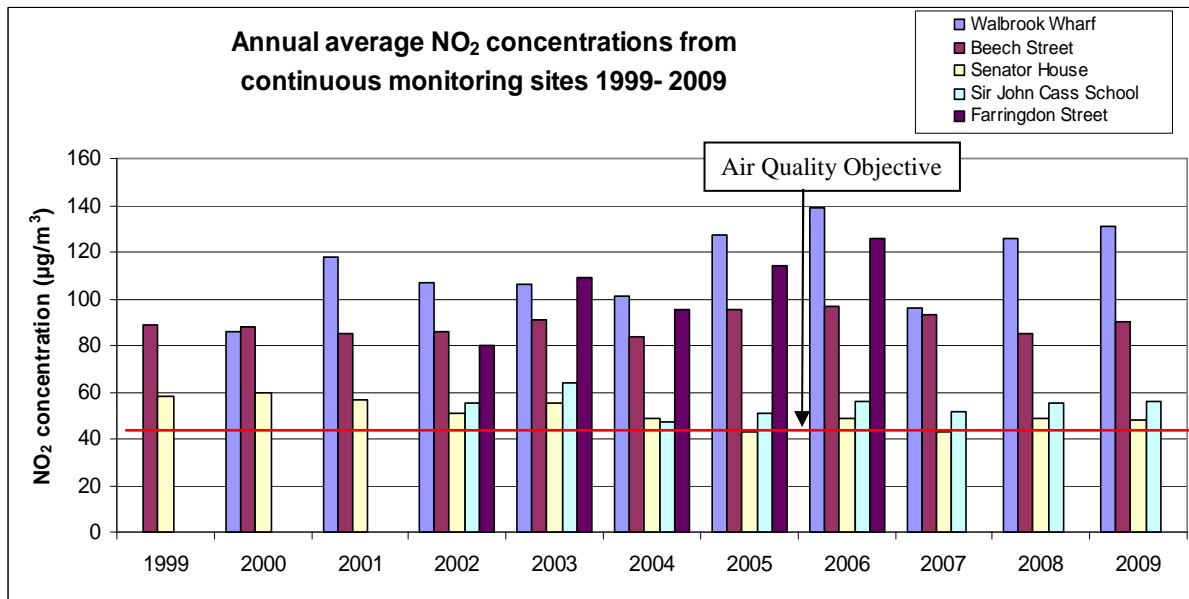


Figure 3.3.3 Annual Average concentrations at continuous monitoring sites, 1999-2009.

Figure 3.3.4 shows year-on-year annual averages at diffusion tube sites in the City.

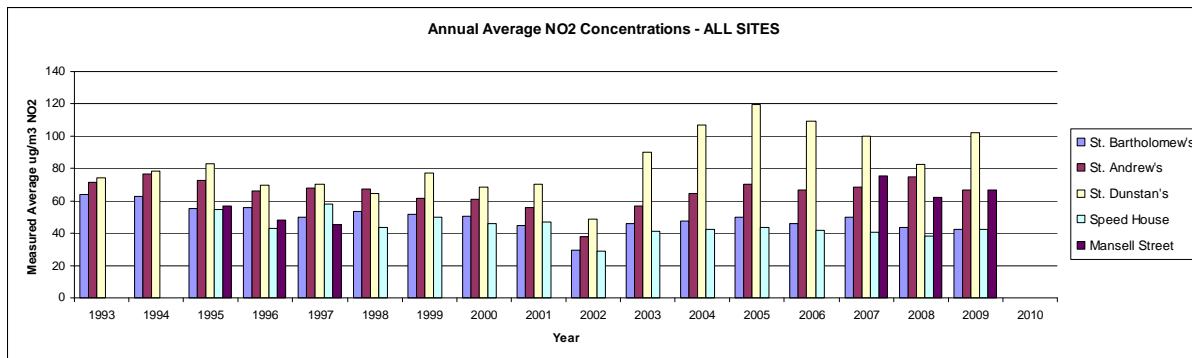


Figure 3.3.4 Annual average NO₂ concentrations at diffusion tube sites, 1993-2009. Note objective value of 40 µg/m³

3.4 Sulphur dioxide (SO₂)

Table 3.4.1 Results of automatic monitoring for sulphur dioxide: comparison with objectives.

Site ID	Location	Within AQMA?	Data Capture for full calendar year 2009	Number of times the following were exceeded:		
				15 minute objective (266 µg/m ³)	1 hour objective (350 µg/m ³)	24 hour objective (125 µg/m ³)
CT1	Senator House.	Yes	93	0	0	0

Sulphur dioxide (SO₂) is a colourless gas, which at high concentrations exhibits a taste and odour. It can be both man-made and naturally occurring, and is one of a range of precursors to ‘secondary’ particulate matter.

Industrial scale oil and coal combustion, domestic fires, and shipping are all significant sources of SO₂, and there are very low levels found in the City. Local concentrations are predominantly influenced by distant industrial point sources. Easterly winds occasionally give rise to increased concentrations, by bringing sulphur dioxide from power stations along the Thames corridor. Even with this contribution, concentrations are found to be very low.

In recent decades, policy measures and technological advances have led to reduced SO₂ concentrations, across London and the rest of the UK.

Since the late 1960’s, sulphur dioxide has been monitored in the City at Senator House. This is a background site, and collected data is submitted to the London Air Quality Network (LAQN), which is operated by the Environment Research Group at Kings College, London.

During 2009, all three SO₂ air quality objectives were met. Figure 3.4.1 shows daily average SO₂ concentrations at Senator House for 2009. Table 3.4.2 summarises annual average concentrations since 2002, along with the number of times the objective limit had been exceeded in those years.

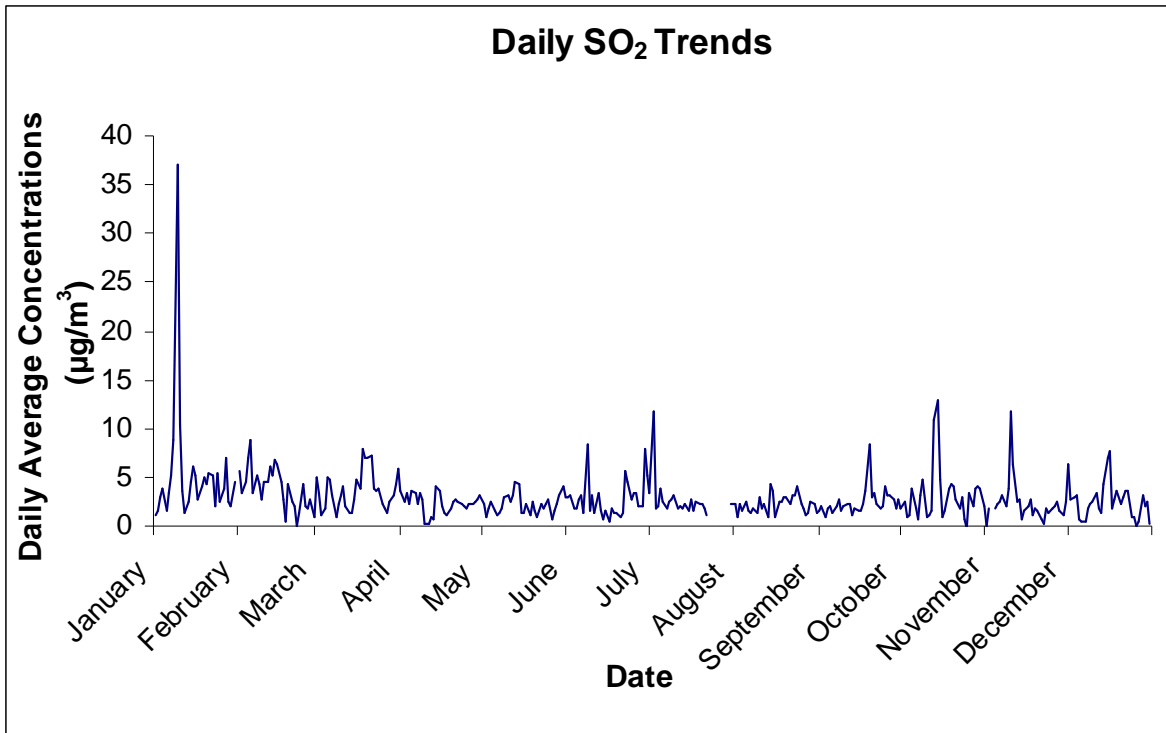


Figure 3.4.1 Average daily SO₂ concentrations, 2009

Table 3.4.2 Annual average SO₂ concentrations and objective exceedances at Senator House, 2002 to 2009

Year	Annual average SO ₂ concentration (µg m ⁻³)	Number of times 24-hour objective exceeded	Number of times 1-hour objective exceeded	Number of times 15-min objective exceeded
2002	5	0	0	0
2003	2	0	0	0
2004	2	0	0	0
2005	4.5	0	0	0
2006	1	0	0	0
2007	3	0	0	0
2008	4	0	0	0
2009	2.9	0	0	0

3.5 Ozone (O₃)

Table 3.5.1 Results of automatic monitoring for ozone: comparison with objectives.

Site ID	Location	Within AQMA?	Data Capture for monitoring period	Data Capture for full calendar year 2009	Number of days where the 8 hour mean was in exceedance of 10 mg/m ³		
					2007	2008	2009
CT1	Senator House	Yes	n/a	93%	4	9	1

Ozone (O₃) is a highly reactive gas, which arises in the both the lower atmosphere and the troposphere. It does not have any significant man-made sources, and is formed by chemical reactions between various other air pollutants, often initiated by strong sunlight. Given its characteristic as a secondary pollutant, measures to manage ozone on a local level have limited effectiveness.

Ground level ozone can occur at considerable distances from the source of primary pollutants which form it, and maximum concentrations are not usually found at the source location.

In urban areas, nitric oxide (NO) can react with ozone to form nitrogen dioxide (NO₂). This can lead to a reduction in ground level concentrations of ozone, while increasing concentrations of nitrogen dioxide. In rural areas, this reaction does not occur to the same extent, and ozone levels are found to be higher in rural areas than in urban.

High concentrations of ozone can impair lung function, and cause irritation to the respiratory tract. Asthmatics are particularly susceptible to high levels. The health effects of exposure to ozone are discussed further in Appendix B.

Ozone is monitored at Senator House, Queen Victoria Street. The Air Quality Regulations 2000 do not include local objectives for reducing concentrations of ground level ozone. The UK Air Quality Strategy suggests that a running 8 hour average of 100 µg/m³ should not be exceeded more than 10 times in a year. In 2009 there was one day where the rolling 8 hour mean was greater than 100 µg/m³ (2nd July 2009).

Elevated levels of ozone are often experienced in the summer months due the increased amount of sunlight as well as the movement of air masses from Central Europe. Elevated levels were seen in the summer of 2009 at Senator House, as shown in Figure 3.5.1 overleaf.

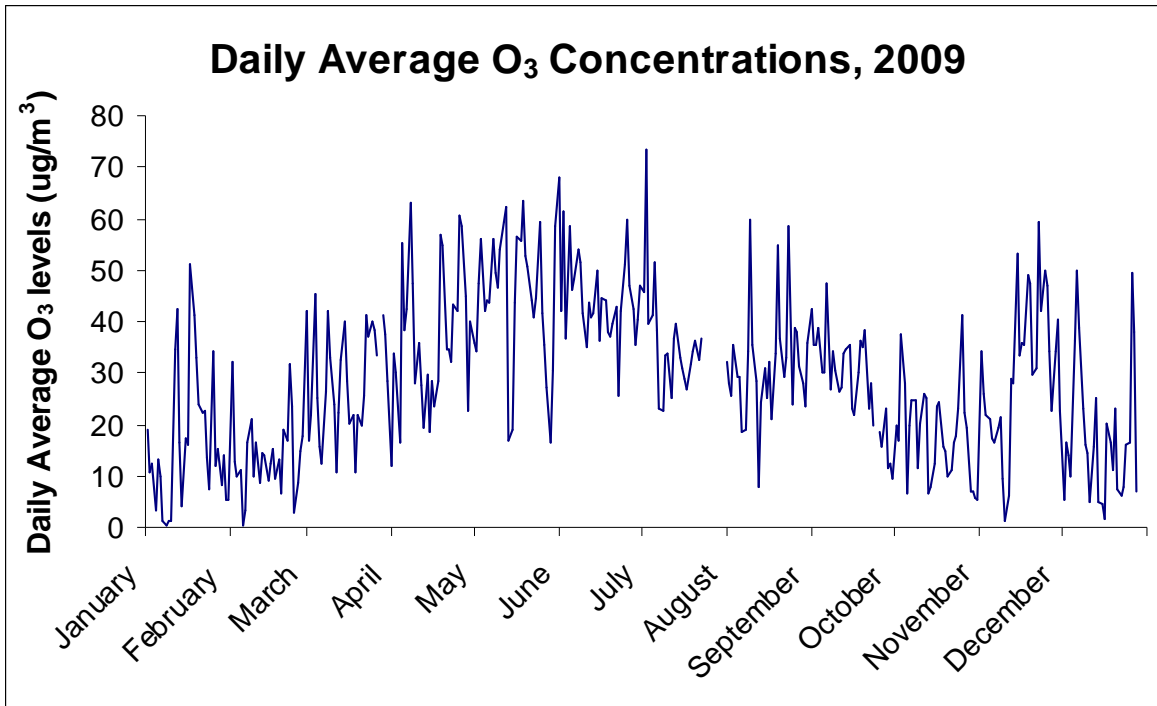


Figure 3.5.1 Daily average ozone concentrations at Senator House, 2009

Table 3.5.2 shows annual average O_3 concentrations at Senator House between 2002 and 2009. The annual average ozone concentration for 2009 was $29.1 \mu\text{g}/\text{m}^3$, which was lower than the average for preceding years.

Table 3.5.2 Annual average ozone concentrations at Senator House, 2002 – 2009

Year	Annual average ozone concentration ($\mu\text{g}/\text{m}^3$)
2002	27.8
2003	40.7
2004	27.5
2005	28.2
2006	34.6
2007	33.5
2008	32.9
2009	29.1

3.6 Fine Particulate Matter (PM₁₀ and PM_{2.5})

Table 3.6.1 Results of automatic monitoring for PM₁₀: comparison with objectives.

Site ID	Location	Within AQMA?	Data Capture for full calendar year 2009	Annual mean concentrations (µg/m ³). Objective = 40 µg/m ³			Number of Exceedances of daily mean objective (50µg/m ³)		
				2007	2008	2009	2007	2008	2009
CT3	Sir John Cass's School (PM ₁₀)	Yes	92%	30.4	26	26.7	31	15	11
CT4	Beech St. (PM ₁₀)	Yes	99.5%	34.3	26	28.1	60	20	23
CT8	Upper Thames St. (PM ₁₀)	Yes	95%	41.2	34	36	49	37	44

Table 3.6.2 Results of automatic monitoring for PM_{2.5}: comparison with objectives.

Site ID	Location	Within AQMA?	Data Capture for monitoring period (since 1 July 2009)	Annual mean concentrations (µg/m ³). Target = 25 µg/m ³			Percentage reduction in concentrations at urban background. Target = 15% by 2020		
				2007	2008	2009	2007	2008	2009
CT2	Farringdon St. (PM _{2.5})	Yes	91.4%	n/a	n/a	36.13	n/a	n/a	n/a

PM₁₀ is very fine particulate matter, which is less than 10 microns in diameter. It has two main types of source, primary (directly emitted) and secondary (chemically and/or physically altered in the atmosphere).

Episodes of significant atmospheric pollution in London are often attributed to air masses travelling to the UK from Central Europe. In 2008, a source apportionment study was undertaken for the City of London, investigating this. The study determined that: approximately 85% of PM₁₀ is emitted outside of the City boundary; approximately 10% originates from road vehicles travelling within the City; and the remaining 5% comes from other local sources, such as construction works, domestic heaters and industrial boilers.

PM₁₀ is monitored at three locations in the City, using a range of analyser types.

At Beech Street and Upper Thames Street, PM₁₀ is monitored using Tapered Element Oscillating Microbalance (TEOM) analysers. At Sir John Cass's School, PM₁₀ is monitored using a Beta Attenuation Monitor (BAM). Another BAM at Farringdon Street is used to monitor PM_{2.5}.

The TEOM is widely used in the UK for monitoring PM₁₀. Investigations have shown that the instrument under-reads when compared to conventional gravimetric samplers. Due to a high sampling temperature, volatile components are lost. The data has been corrected to account for this, using data from the following website: www.volatile-correction-model.info. The Beta Attenuation Monitor over-reads when compared to conventional gravimetric samplers, and consequently, the BAM data has been divided by a factor of 1.2.

In January 2001, following various stages of review and assessment against Government air quality objectives, the City designated the entire City as an Air Quality Management Area for PM₁₀. The 2008 source apportionment study revealed that the vast majority of PM₁₀ in the City actually originates from fugitive, distant sources. This means that the capacity to manage overall PM₁₀ concentrations at a local level is limited.

Figure 3.6.1 shows average daily PM₁₀ levels at all three sites. The 50µg/m³ daily average objective value was exceeded 44 times at Upper Thames Street.

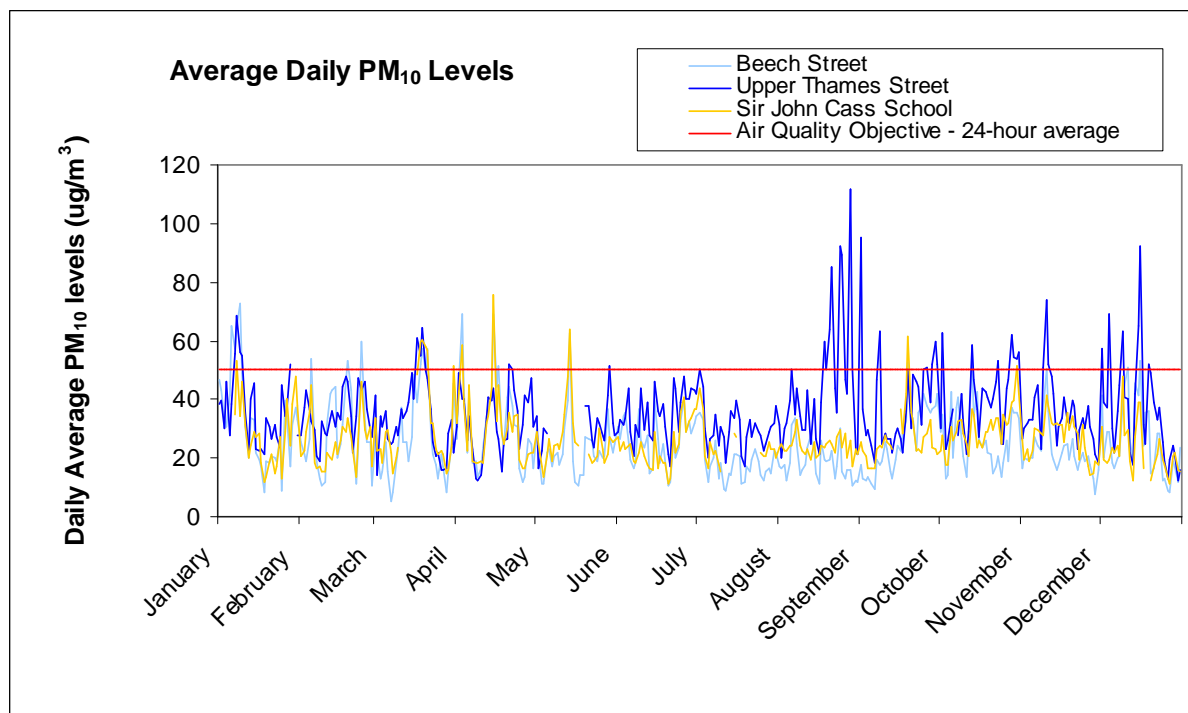


Figure 3.6.1 Daily average PM₁₀ concentrations at Beech St., Upper Thames St. and Sir John Cass School.

Figure 3.6.2 shows the annual average trend in PM₁₀ concentrations in the city since 1999. All sites complied with the annual average PM₁₀ objective in 2009.

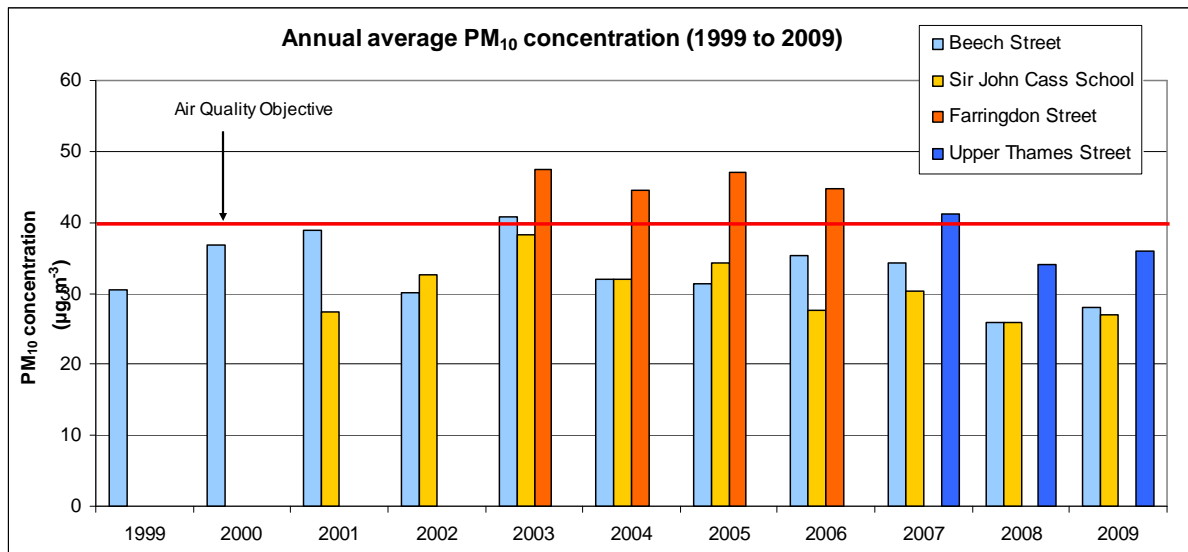


Figure 3.6.2 Annual average concentrations at City of London Sites, 1999-2009

Figure 3.6.3 shows the number of times that the 50 µg/m³ objective has been exceeded at each site since 1999. Upper Thames Street has not met the objective since the site was set up.

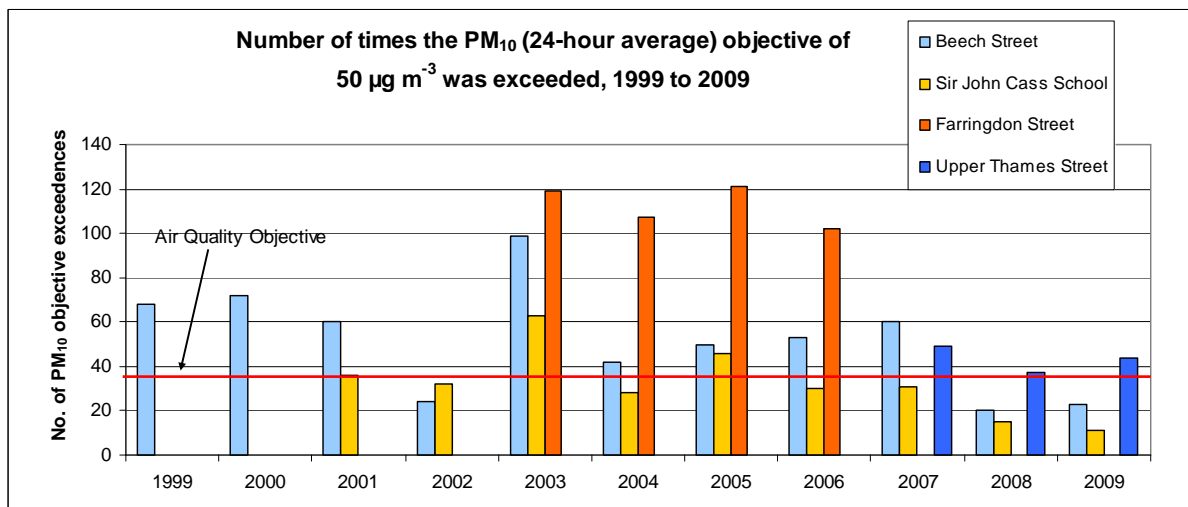


Figure 3.6.3 Number of times the daily objective was exceeded at City of London sites, 1999-2009.

3.7 Benzene

Table 3.2.1 Results of automatic monitoring for carbon monoxide: comparison with objective.

Site ID	Location	Within AQMA?	Valid samples, as a percentage of annual total (i.e. not missing or invalid)	Annual average concentration ($\mu\text{g}/\text{m}^3$) Objective = $5 \mu\text{g}/\text{m}^3$		
				2007	2008	2009
CL 10	Mansion House	Yes	76.9%	2.5	2.8	2.6
CL 8	Upper Thames St.	Yes	69.2%	2.4	1.9	2.4

Benzene is an aromatic hydrocarbon. In the City, the primary source of benzene is motor vehicle exhausts. The air quality objective for benzene has been met consistently since 2000, and as a result, monitoring has been scaled down to just two sites: CL 10, Mansion House; and CL 8, Upper Thames Street. In 2009, benzene was monitored using diffusion tubes, which were exposed monthly for two weeks in the month. The results were then used to produce an estimate of annual average concentrations.

Benzene concentrations in the city continue to comply with both 2003 and 2010 objectives.

Figure 3.7.1 shown the long term trend in benzene concentrations in the City.

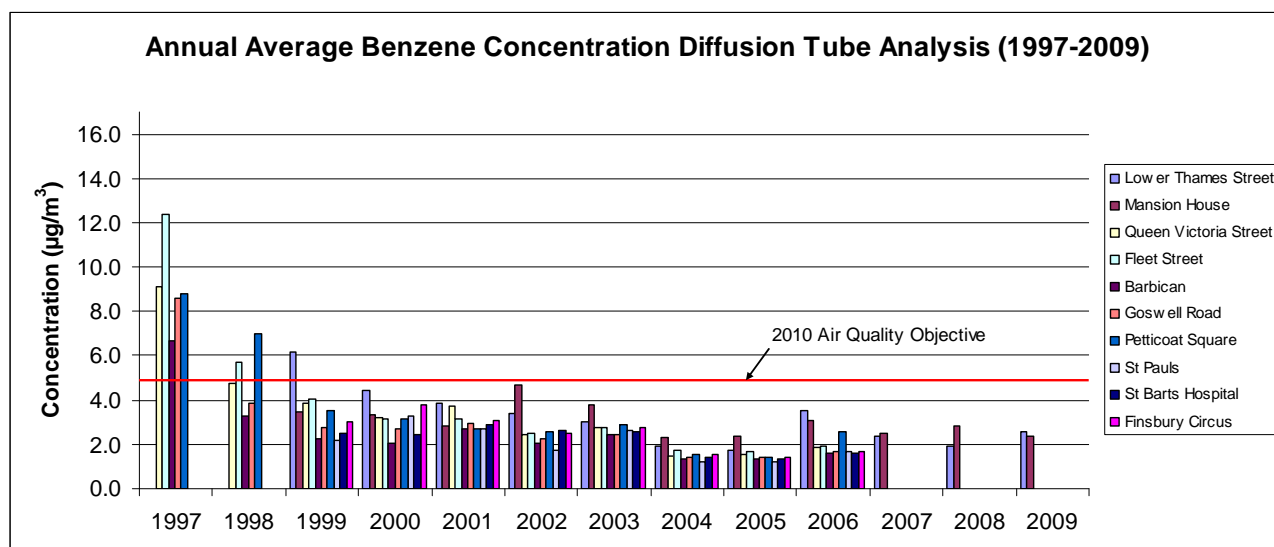


Figure 3.7.1: Annual average benzene concentrations (1997 – 2009)

4. Discussion

Pollution levels in the City of London during 2009 were broadly similar to 2008. Similar weather patterns were seen in both years. Fine particulate episodes were lower than in the preceding 8 years. This can be attributed to two main factors: higher than average rainfall, and the revision of the measurement method in 2008, which resulted in an apparent reduction in concentrations.

Nitrogen dioxide levels continue to be high, with particularly high levels at Walbrook Wharf. This site is beside Upper Thames Street which has a high volume of traffic, and low dispersion due to the street canyon effect.

The UK has recently received a final written warning from the European Commission over failure to comply with the PM₁₀ limit value. The concentrations measured in 2009 along Upper Thames Street demonstrate that there is a problem with PM₁₀ along this route, and we will not meet the limit value without further intervention.

The City of London continues to work to improve air quality, both within the organisation, and with other stakeholders such as the GLA, DfT, Defra, King's College London and other central London boroughs.

In 2009, monitoring of PM_{2.5} began at Farringdon Street. This will serve as a baseline for comparison, as the City works toward the new objectives for the pollutant. These are expected to be a 15% reduction in urban background exposure from 2010 to 2020; and an annual average concentration of 25µg/m³ by 2020.

5. Further information

This report and other reports relating to air quality in the City of London can be found at the following web address:

http://www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Pollution/air+quality.htm

Anyone wishing to comment on this report, or on Air Quality Management in general, can contact the Environmental Services Department 0207 7606 3030, or email DES.GeneralENQ@cityoflondon.gov.uk

Appendix A

Air Quality Objectives and Guidelines

The Air Quality (England) Regulations 2000 sets out a number of objectives for the purposes of Local Air Quality Management. These objectives represent the standard of air quality which the Government expect can be achieved having regard to: actual costs, benefits and feasibility. Each objective relates to a prescribed date, by which it should be achieved. Air quality objectives are listed in table A.1 (below).

Table A.1 Objectives included in the Air Quality (England) Regulations 2000 for the purpose of Local Air Quality Management.

Pollutant	Air Quality Objective	Measured as	Date to be achieved by
Benzene	16.25 $\mu\text{g}/\text{m}^3$	Running annual average	31.12.2003
	5 $\mu\text{g}/\text{m}^3$	Annual average	31.12.2010
1, 3 Butadiene	2.25 $\mu\text{g}/\text{m}^3$	Running annual average	31.12.2003
Carbon monoxide	10 mg/m^3	Running 8-hour average	31.12.2003
Lead	0.5 $\mu\text{g}/\text{m}^3$	Annual average	31.12.2004
	0.25 $\mu\text{g}/\text{m}^3$	Annual average	31.12.2008
Nitrogen dioxide	200 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 18 times a year	Hourly average	31.12.2005
	40 $\mu\text{g}/\text{m}^3$	Annual average	31.12.2005
Particulates (PM ₁₀)	50 $\mu\text{g}/\text{m}^3$ (gravimetric) not to be exceeded more than 35 times per year	24-hour average	31.12.2004
	40 $\mu\text{g}/\text{m}^3$ (gravimetric)	Annual average	31.12.2004
Particulates (PM _{2.5})	25 $\mu\text{g}/\text{m}^3$ (gravimetric)	Annual average	2020
	15 % cut	Urban background exposure	2010 - 2020
Sulphur dioxide	350 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 24 times per year	1-hour average	31.12.2004
	125 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 3 times per year	24-hour average	31.12.2004
	266 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 35 times per year	15-minute average	31.12.2005

The results of air quality monitoring in the City are represented in relation to these objectives. This assists in the development of policy and actions to improve air quality, and also serves as a benchmark against which progress can be assessed.

There is no objective ascribed to Ozone for the purpose of Local Air Quality Management. This is due to difficulties in controlling ozone levels locally. There are Defra guidelines which inform the provision of public information on air quality, and Ozone levels are presented using these criterion. These guidelines, the Air Pollution Information Guidelines, are used to provide information on five pollutants, using four health-risk bands. The Defra Air Pollution Information Guidelines are listed in Table A.2 (below).

Table A.2 Defra Air Pollution Information Guidelines

<u>Pollutant/ Description</u>	<u>Low</u>	<u>Moderate</u>	<u>High</u>	<u>Very High</u>
Sulphur dioxide ($\mu\text{g}/\text{m}^3$, 15 minute average)	≤ 265	266 - 531	532 – 1063	≥ 1064
Ozone ($\mu\text{g}/\text{m}^3$, see right)	≤ 99 (8 hour running average)	100 – 179 (hourly average)	180 – 359 (hourly average)	> 360
Carbon monoxide (mg/m^3, 8 hour average)	≤ 11.5	11.6 – 17.3	17.4 – 23.1	≥ 23.2
Nitrogen dioxide ($\mu\text{g}/\text{m}^3$, hourly average)	≤ 286	287 - 572	573 - 763	≥ 764
Fine particulates ($\mu\text{g}/\text{m}^3$ gravimetric, 24 hour average)	≤ 64	65 - 96	97 - 129	≥ 130

The Pollutants included are Sulphur dioxide, Ozone, Carbon monoxide, Nitrogen dioxide and Fine particulates. The bands are health based, and are explained below:

Low – Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.

Moderate – Mild effects, unlikely to require action may be noticed among sensitive individuals.

High – Significant effects may be noticed by sensitive individuals, and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted

areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reduce the effects on the lungs.

Very High – The effects on sensitive individuals may worsen.

For healthy individuals, the risk to health is small at all levels of air pollution which are likely to be experienced in the UK. When concentrations of pollutants move into the 'very high' band (which has no upper limit), it is possible that individuals who are not usually sensitive to pollution may notice effects; including eye irritation, coughing and pain on breathing deeply.

Appendix B

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, NO₂ 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 NO₂ 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. SO₂ 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 SO₂ 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 SO₂.

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 NO_x 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 PM₁₀ (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, and is monitored in the City. 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 is also monitored in the City. 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.

Appendix C

Summary of annual average pollutant levels in 2009

Pollutant	Annual Average $\mu\text{g}/\text{m}^3$	Monitoring Location	Achieved objective/ acceptable level?	Comments
Carbon monoxide	0.8 (mg/m^3)	CT 6 Walbrook Wharf	Yes	Measured in mg/m^3
Nitrogen dioxide	48	CT 1 Senator House	No	
	56	CT 3 Sir John Cass School	No	
	90.2	CT 4 Beech Street	No	
	131	CT 6 Walbrook Wharf	No	
	90.8	Walbrook Wharf Rooftop	No	
	42.7	CL 5 St. Bartholomew's	No	
	66.9	CL 38 St. Andrew's, Queen Victoria Street	No	
	102.3	CL 39 St. Dunstan's, Fleet Street	No	
	66.8	CL 40 Guinness Trust Estate, Mansell Street	No	
	42.5	CL 55 Speed House Barbican	No	
Sulphur dioxide	2.9	CT 1 Senator House	Yes	
Ozone	29.1	CT 1 Senator House	Yes	Only one exceedance was recorded.
Fine Particulates (PM₁₀)	26.7	CT 3 Sir John Cass School	Yes	
	36	CT 8 Upper Thames Street	No	Within acceptable annual mean, but exceeded daily mean objective more than 35 times
	28.1	CT 4 Beech Street	Yes	
Very Fine Particulates (PM_{2.5})	36.13	CT 2 Farringdon Street	N/A	Average value, July to December 2009 (not annual mean)
Benzene	2.4	CL 8 Upper Thames Street	Yes	
	2.6	CL 10 Mansion House	Yes	

