

NPL REPORT AS 22

2007 Annual Report for the UK Black Smoke Network

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NOT RESTRICTED

April 2008

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DQL

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Approved on behalf of the Managing Director, NPL
by Martyn Sene, Director, DQL

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Executive Summary

The National Physical Laboratory (NPL) was awarded the contract to set up and run the UK Black Smoke Network by the Department for Environment, Food and Rural Affairs (Defra) in September 2006 under contract “RMP 2951, The Provision of Consultancy Services for the Monitoring of Black Smoke in the UK”. During 2007 the number of sites in the network expanded from 14 sites to 21 sites, as samplers were installed into mainly Automatic Urban and Rural Network (AURN) sites. By March 2007 all of the 21 sites were operational.

This report covers the operation of the UK Black Smoke Network and the data collected by the Network in 2007.

The average data capture for the Network over 2007 was 89%, compared with 86% for 2006.

Measured annual average Black Smoke Index ranged from 4.4 $\mu\text{g.m}^{-3}$ in Folkestone to 38.8 $\mu\text{g.m}^{-3}$ at Marylebone Road.

At those sites for which many years' data are available, annual average Black Smoke Index values were broadly similar to previous years. The drop in concentration at Strabane 2, attributable to the replacement of domestic coal-burning with oil-burning, was observed to continue. These sites all have annual average Black Smoke Index values of 5 to 12 $\mu\text{g.m}^{-3}$.

Black smoke concentrations measured by the Network were compared with TEOM PM_{10} , total oxides of nitrogen (expressed as nitrogen dioxide) and particle number concentrations, for those sites where these measurements were colocated. Correlation was generally best between Black Smoke Index and NO_x concentration.

Major changes to the Network instrumentation are planned for 2008. This replacement of the manual 8-port black smoke samplers with automatic aethalometers is discussed.

1.0 Introduction

1.1 General

The National Physical Laboratory (NPL) was awarded the contract to set up and run the UK Black Smoke Network by the Department for Environment, Food and Rural Affairs (Defra) in September 2006 under contract “RMP 2951, The Provision of Consultancy Services for the Monitoring of Black Smoke in the UK”. During 2007 the number of sites in the network expanded from 14 sites to 21 sites, as samplers were installed into mainly Automatic Urban and Rural Network (AURN) sites. By March 2007 all of the 21 sites were operational.

The report presents 2007 data recorded for the 21 core sites along with data for 3 affiliated sites. Comparisons are also made with earlier years, and with other measurements colocated with the Black Smoke samplers.

1.2 Measurement method

Black Smoke sampling in 2007 used the 8-port sampler that has historically been used in the UK network, based on the standard method BS 1747; ISO 9835. The principle of the 8-port sampler method involves drawing air at a constant flow rate of around 1.4 l/min through a Whatman Number 1 cellulose filter, so that about 2 m³ of air (at ambient conditions of temperature and pressure) is sampled for each daily sample. Suspended particulate matter is collected on the filter over an area determined by a choice of clamp – in this case with a one inch diameter - forming a dark stain. The inlet - an upturned funnel - is not designed to be size selective, and has been shown in one study to collect the approximate size fraction PM_{4.5}.

The 8-port sampler is designed with eight pairs of filter clamps for weekly operation, providing daily sampling on a midnight-to-midnight basis. The timed eight-port valve was set to switch over at midnight to expose a fresh filter paper each day. Weekly Local Site Operator visits were made to change filter papers and to record weekly sample volumes and flow rates.

Those sample filters returned to NPL had the darkness of the stain measured with an EEL M43D reflectometer, the reflectance being determined relative to a blank filter of the same type. The procedure for this measurement has been UKAS-accredited. The instrument uses a light bulb to give a broad band source that is reflected back from the smoke stain to a photo-sensitive element and produces a reading between 0% and 100% reflectance.

The measured reflectance is used to calculate the concentration of particulate matter in the sampled air, as Black Smoke Index, with units of µg/m³, using the relationship given in BS 1747: Part 2:

$$C = \frac{1}{V} (91679.22 - 3332.046R + 49.618884R^2 - 0.35329778R^3 + 0.0009863435R^4)$$

where:

- C = concentration in $\mu\text{g}/\text{m}^3$
- V = volume of sampled air in ft^3
- R = reflectometer reading (%)

This relationship is only valid for values of R above 40%. This was true for all samples in the study.

2.0 Site infrastructure

During 2007, seven new sites were installed and one site was closed and relocated. These modifications to the network are described in the following sections. The infrastructure of all the sites was inspected during the 2007 audit round^[1] and all of the sites were found to be in a good state of repair. A map and brief descriptions of the sites are given below.

2.1 Installations

During 2007 the number of sites in the network expanded from 14 sites to 21 sites, as samplers were installed into mainly Automatic Urban and Rural Network (AURN) sites. Table 1 gives the locations and installation dates for these sites.

Site	Installation Date
Folkestone	03/01/07
Sunderland 8	16/01/07
Bath 6	01/02/07
North Kensington	28/02/07
Birmingham Tyburn	07/03/07
Bradford Centre	21/03/07
Nottingham Centre	22/03/07

Table 1 Black Smoke Network, 2007 Site Installations

As part of the Sunderland 8 installation, the complete sample inlet system was replaced.

2.2 Site relocation

In October 2007 Defra reorganised the locations of the AURN sites so that the network would meet the siting requirements of the new EU Air Quality Directive. As consequence of this reorganisation, the Bradford Centre AURN site was closed and the Black Smoke sampler was removed and installed in Bradford Town Hall on 23/10/07.

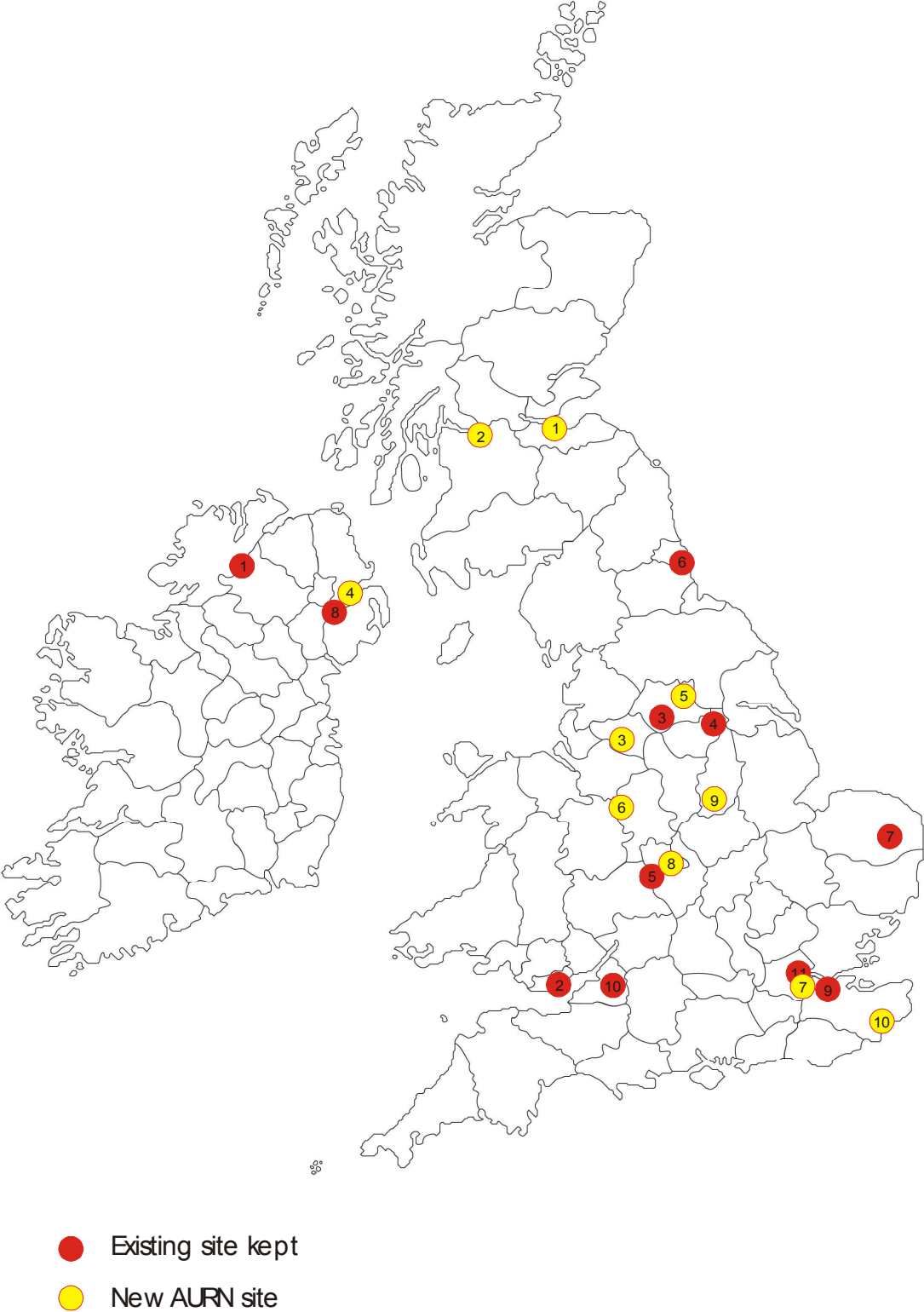


Figure 1 Location of UK Black Smoke Network Sites

Tables 2 and 3 below give the site names for the UK Black Smoke Network:

Key	Site Name	Start year
1	Strabane 2	1999
2	Cardiff 12	1961
3	Halifax 17	2003
4	South Kirkby 1	1970
5	Halesowen 8	2004
6	Sunderland 8	1961
7	Norwich 7	1961
8	Dunmurry 3	1993
9	Woolwich 9	1955
10	Bath 6	1981
11	Marylebone Road	1997

Table 2 Long-running Black Smoke sites

Key	Site Name	Site Type	Other Analysers
1	Edinburgh St Leonard's	Urban Background	TEOM PM ₁₀
2	Glasgow Centre	Urban Centre	TEOM PM ₁₀ + CPC
3	Manchester Piccadilly	Urban Centre	TEOM PM ₁₀ + CPC
4	Belfast Centre	Urban Centre	TEOM PM ₁₀ + carbon + CPC + nitrate
5	Bradford	Urban Centre	TEOM PM ₁₀
6	Stoke Centre	Urban Centre	TEOM PM ₁₀
7	North Kensington	Urban Background	TEOM PM ₁₀ + carbon + manual PM _{2.5}
8	Birmingham Tyburn	Urban Background	TEOM PM ₁₀
9	Nottingham Centre	Urban Centre	TEOM PM ₁₀
10	Folkestone, Kent Network	Rural	TEOM PM ₁₀ + PM _{2.5}

Table 3 AURN sites with Black Smoke recently installed

Three other sites, described in Section 5.6, produce data on an affiliate basis.

3.0 Quality Assurance and Quality Control (QA/QC)

Quality Assurance and Quality Control activities cover two main areas: site audits and reflectometer calibration. The first addresses sampling issues and the second ensures the consistency and accuracy of the reflectometry measurements.

3.1 Site audits

The results of the 2007 audit round can be found in the NPL Report AS (RES) 008, UK Black Smoke Network Audit Report For 2007^[1]. Specific issues that impact on data quality are described in the following two sections:

3.1.1 Sampler leak rates

Some of the 8-port samplers failed the initial leak rate test at the annual audit; this will affect the overall measurement uncertainty for these sites. The effect of these leaks on the measurement uncertainty is discussed in Section 4. Any leaks found at the audit were repaired at the audit, where possible, and included the replacement of flow splitters, filter holders being reground and internal pipe work. Tables 4 and 5 give the results of the sample leak rates for the samplers as they were found and after repair.

Site	Percentage Leak Rate							
	1	2	3	4	5	6	7	8
Bath 6	5.9	7.4	6.8	6.4	7.4	7.0	7.0	6.2
Belfast Centre	8.1	8.8	8.1	6.5	59.8	5.8	5.3	7.9
Birmingham Tyburn	4.8	4.9	5.1	4.8	4.6	5.4	5.4	5.1
Bradford	8.6	10.1	11.4	13.8	10.2	10.4	8.1	9.0
Bradford Town Hall	6.0	5.6	6.0	5.6	6.3	6.9	5.9	5.8
Cardiff 12	6.8	6.8	7.4	7.0	7.0	7.1	6.2	6.7
Dunmurry 3	7.5	7.4	8.0	7.6	7.6	7.6	8.2	8.0
Edinburgh St Leonard's	5.9	5.5	6.3	6.0	5.5	5.5	5.4	6.1
Folkestone	9.1	8.8	7.5	6.6	7.2	7.1	8.9	8.8
Glasgow Centre	8.7	8.7	8.7	8.2	8.7	9.0	8.8	8.6
Halesowen 8	6.9	7.4	6.9	6.8	8.2	8.1	7.4	6.8
Halifax 17	9.3	9.9	12.7	11.6	11.6	11.0	11.1	10.6
Manchester Piccadilly	5.2	5.1	5.0	5.4	5.8	5.3	5.6	5.0
Marylebone Road	15.4	13.2	9.1	5.8	7.2	7.0	9.0	6.9
North Kensington	6.3	5.4	6.3	6.9	6.7	6.7	5.8	6.3
Norwich 7	14.4	14.7	14.2	14.2	14.2	14.1	15.2	15.5
Nottingham Centre	7.8	7.3	7.2	7.1	6.2	6.7	7.4	8.9
South Kirkby 1	7.5	9.4	8.4	7.4	8.5	16.3	7.4	8.8
Stoke on Trent	4.3	4.3	7.6	4.5	4.3	4.3	4.7	4.7
Strabane 2	6.8	7.0	6.1	7.2	7.0	6.0	6.5	6.2
Sunderland 8	5.6	5.5	6.3	5.7	5.8	6.1	5.7	5.9
Woolwich 9	8.4	8.8	9.4	9.0	8.7	8.8	9.8	8.4

Table 4 As found leak rates

Site	Percentage Leak Rate Port								Remedial Action
	1	2	3	4	5	6	7	8	
Bath 6	5.7	5.9	5.9	5.6	6.6	6.1	6.6	6.0	1
Belfast Centre	5.6	5.7	5.9	5.3	5.2	5.1	5.3	5.6	6
Cardiff 12		6.3	5.9						1
Dunmurry 3	4.7	5.3	6.1	4.9	5.4	6.0	5.4	5.9	1
Edinburgh St Leonard's	4.6	4.7	5.3	4.8	4.7	4.4	4.8	5.5	1
Folkestone	7.1	6.3	5.5	5.1	5.6	5.3	6.2	6.2	1, 2
Glasgow Centre	3.5	3.5	3.3	3.5	3.7	3.4	3.5	3.5	1
Halifax 17	6.3	6.7	7.5	7.9	8.0	7.5	7.0	6.8	1, 2
Marylebone Road	6.9	6.5	6.1	5.1	6.9	6.5	6.4	6.3	1
Nottingham Centre	7.2	6.3	6.3	5.8	5.5	5.6	6.8	7.4	1, 2
Norwich 7	3.3	3.9	3.4	3.3	3.7	3.7	3.7	4.2	4
South Kirkby 1	6.4	6.4	6.2	5.9	6.4	19.6	6.6	5.8	1
Stoke on Trent			4.9						3
Strabane 2	5.8	5.9	5.5	6.5	6.4	6.1	6.2	6.1	1
Woolwich 9	0.9	1.6	2.2	1.2	1.3	1.3	1.8	0.8	5

Remedial action codes

- 1 Greased glass joints with vacuum grease
- 2 Improved seal between piping and connector tubing
- 3 Loose filter clamp
- 4 Replacement of hardened tubing
- 5 Filters installed incorrectly
- 6 Replacement filter clamps

Table 5 Leak rates after repairs

3.1.2 Inline flow meter

In September 2007 an inline flow meter was installed into the 8-port sampler at Manchester Piccadilly, as this sampler had not been upgraded at the previous site audit. The sampler was also relocated in the cabin at this visit to improve the access for the LSO. The methodology behind the installation of the inline flow meter is discussed in the 2006 Annual Report on the UK Black Smoke Network^[2].

During the 2007 audit round it was noticed that at Belfast, Glasgow and Stoke sites the inline flow meter had been contaminated with water. It is assumed that this water was due to condensation out of the flow stream within the sampler, after the bubbler. The flow meters were dried and the LSO instructed on how to perform this procedure. Due to this water contamination the readings from the inline flow meter were considered to be invalid at the data ratification stage.

3.2 Reflectometer calibration

The smoke stains on all of the filters from the individual sites are centrally measured by NPL on one reflectometer. A multi-point calibration curve for this reflectometer is generated using calibration tiles that have been calibrated under UKAS procedures at NPL. The uncertainty of each calibration tile value is $\pm 0.71\%$, expressed with a level of confidence of 95%. By using a multi-point calibration curve, the calibration uncertainty is reduced. The uncertainty associated with the multi-point calibration is $\pm 0.74\%$, expressed with a level of confidence of 95%. As well as performing regular multi-point calibrations, check tiles are also measured on each measurement day. Figure 2 shows the calibration history of the NPL reflectometer when using these three check tiles.

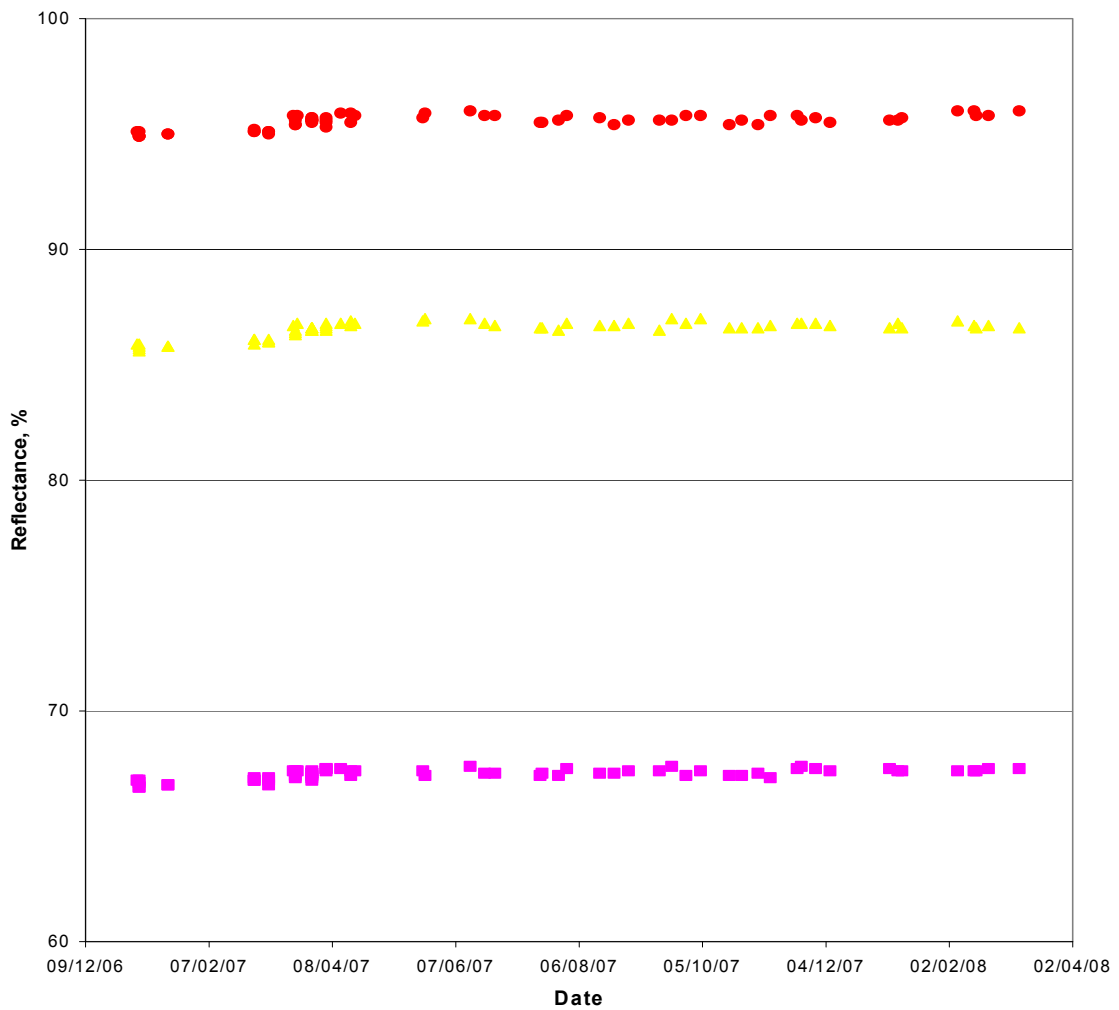


Figure 2 Reflectometer Calibration History

4.0 Measurement uncertainty

The measurement uncertainty for Black Smoke Index is dominated at high values by the sampling leak rate, and at low values by the repeatability of the reflectance measurement on real filter samples.

A more detailed uncertainty budget for the Black Smoke method was given the 2006 Annual Report^[2]. This uncertainty budget assumed a maximum sampling leak rate of 6%. At the 2007 audits some of the samplers failed this leak rate criteria, so the overall measurement uncertainty will increase. The largest annual mean leak rate measured at Norwich 7 with a value of 10.0%. The effect of this leak rate on the overall measurement uncertainty can be seen in Table 6:

	Uncertainty (95%) in BSI as % mid range					
	BSI ($\mu\text{g.m}^{-3}$)	157 - 97	97 - 58	58 - 31	31 - 12	12 - 0
	Leak rate, %					
Typical site	6.0	9.5	10.2	11.9	17.2	41
Norwich 7	10.0	15.4	15.8	17.0	21.0	43

Table 6 Measurement uncertainty

At the low average concentrations at the majority of sites the provisional uncertainty is around 30%, dominated by the repeatability of the reflectance measurement on real filter samples. The provisional uncertainty at Marylebone Road is around 14%.

4.1 Limit of quantification

Prior to NPL taking over the running of the Black Smoke Network in 2006, the measurement of the individual filter reflectances was reported with a precision of 1.0%. NPL report reflectances with a precision of 0.1%

While this does not affect the accuracy of measurements in general, because the repeatability of the reflectance measurements is more than 1%, there will be a small effect arising from the changed limit of quantification. Previously, the maximum reflectance measurement of 99% led to a minimum reported Black Smoke concentration of $0.9 \mu\text{g.m}^{-3}$. The new quantification limit is close to $0.1 \mu\text{g.m}^{-3}$.

5.0 Results

The concentration data for 2007 is presented in the following sections as time series graphs, summary graphs and tables of the annual mean concentration and data capture.

5.1 Time series

The following charts show the Black Smoke concentrations measured by the UK Black Smoke Network for 2007. Data has been split into regions of the UK for presentation purposes.

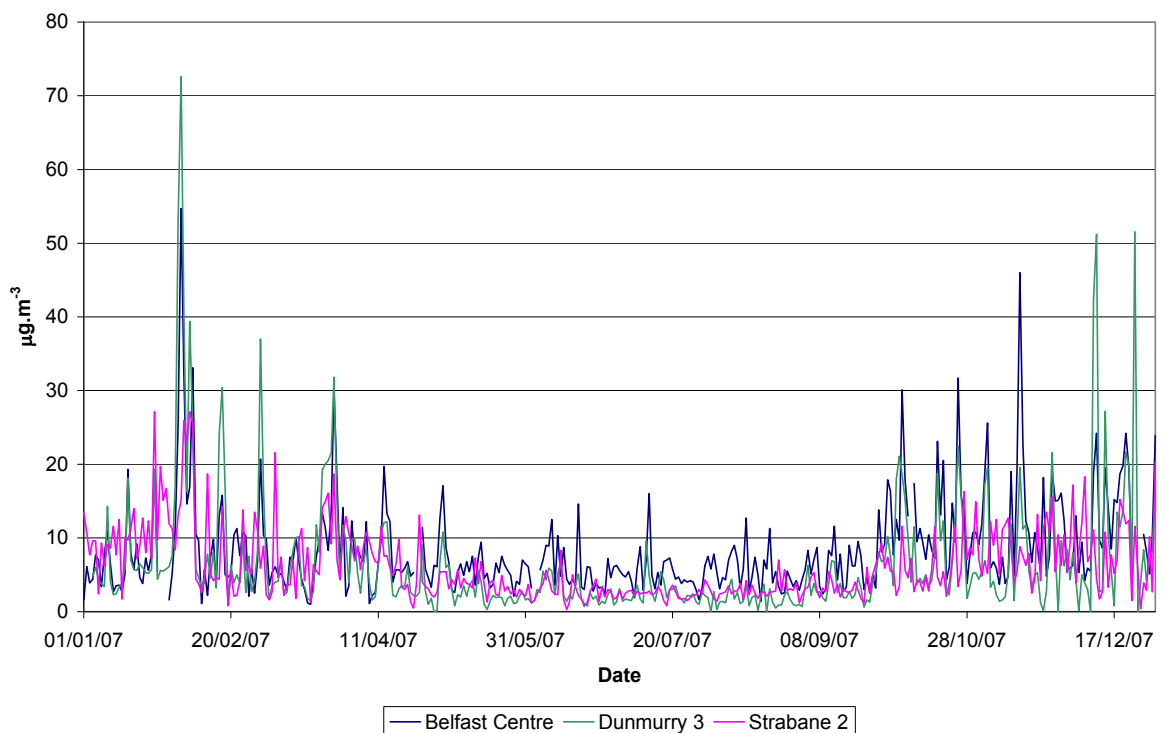


Figure 3 Black Smoke concentrations during 2007 in Northern Ireland

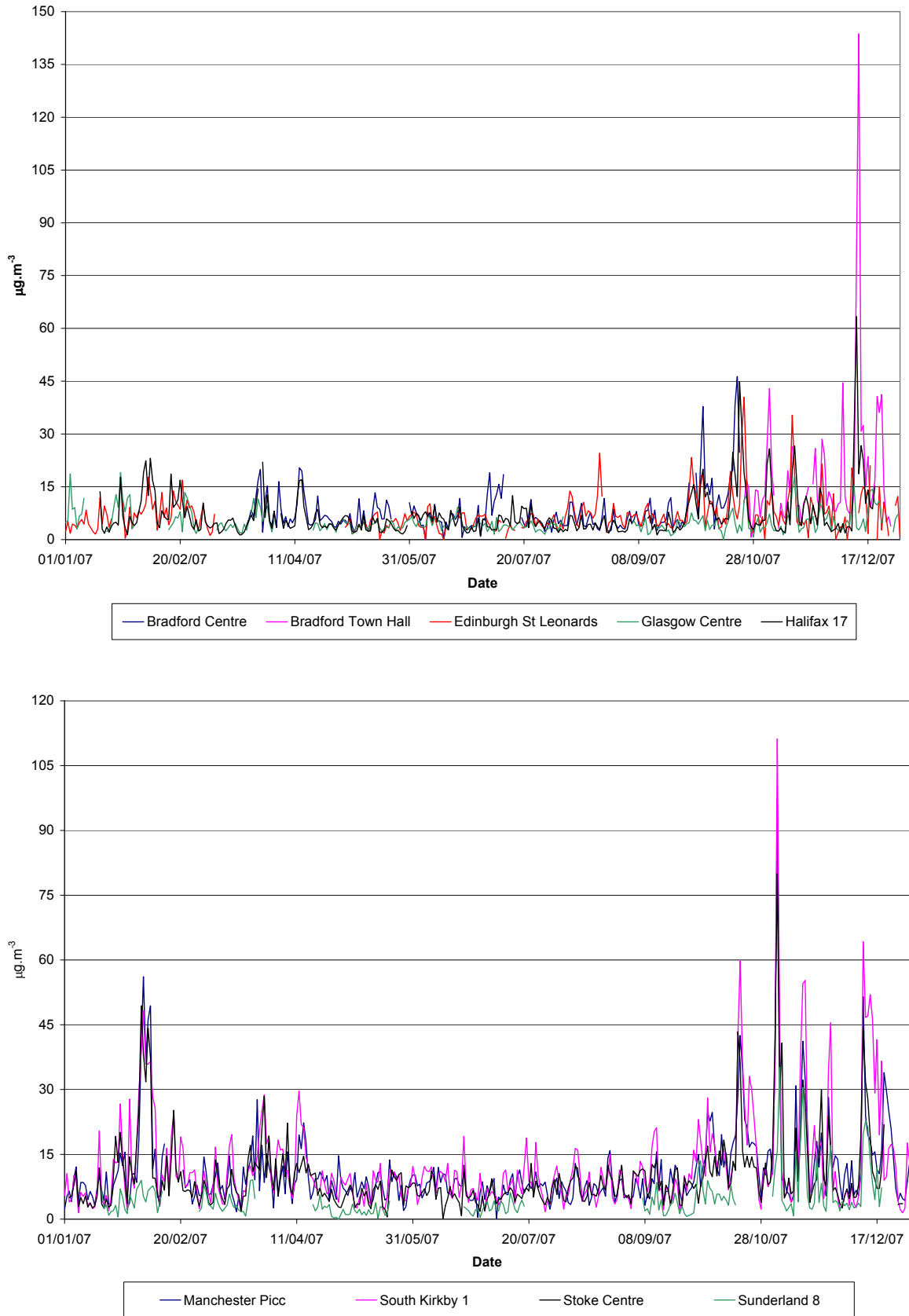


Figure 4 + 5 Black Smoke concentrations during 2007 in Scotland and Northern England

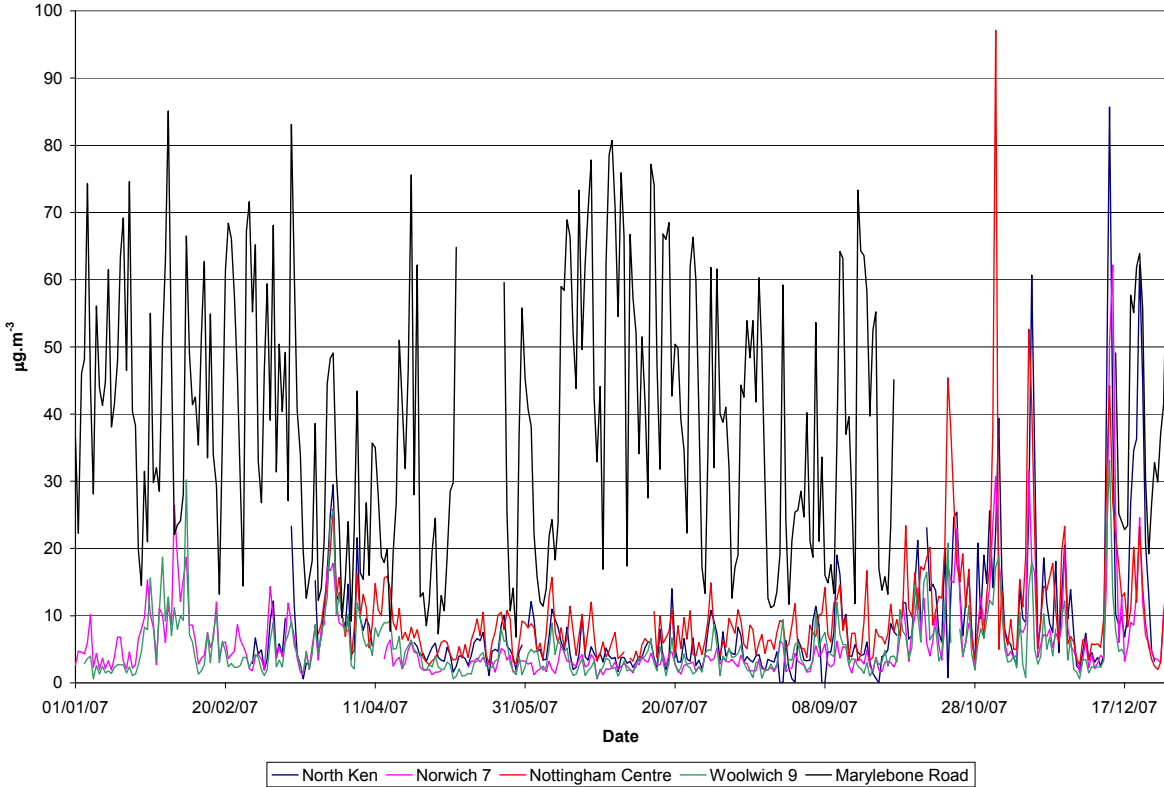
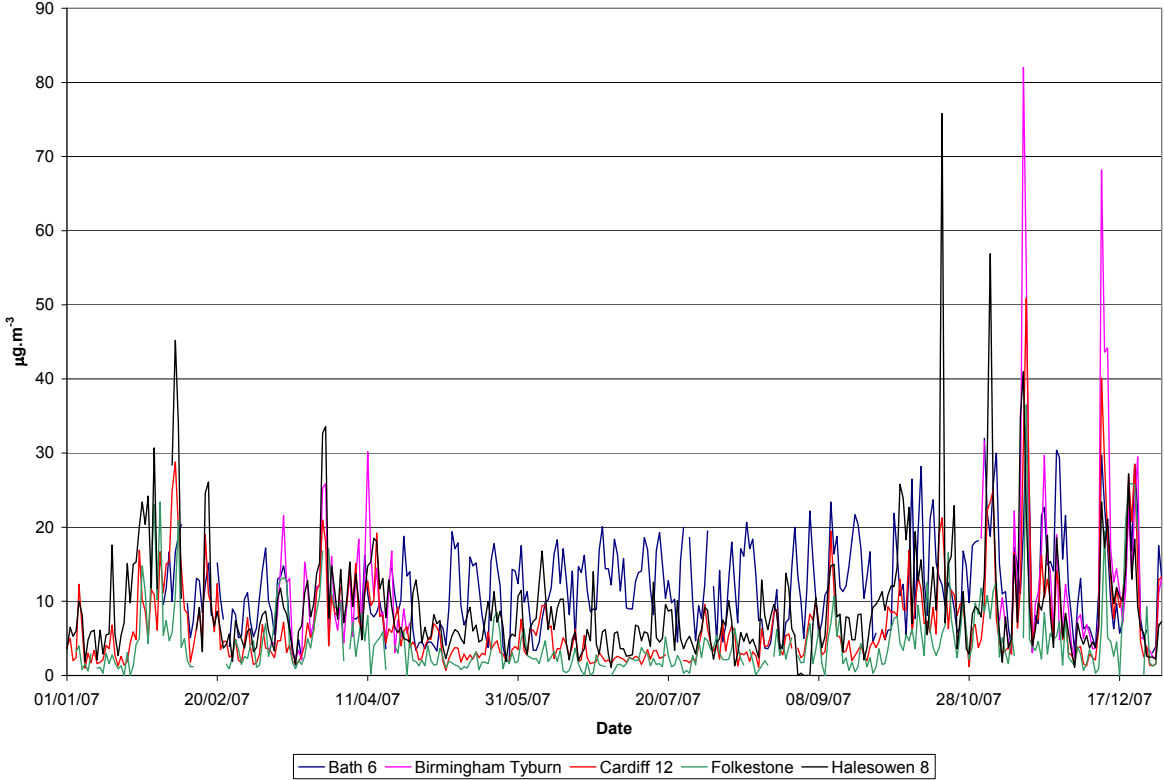


Figure 6 + 7 Black Smoke concentrations during 2007 in Southern England and Wales

5.2 Annual averages and data capture

Table 7 gives the annual averages and data capture for each site for 2007.

Site	Black Smoke Concentration, $\mu\text{g}\cdot\text{m}^{-3}$	Data Capture %
Bath 6	12.0	92
Belfast Centre	8.4	97
Birmingham Tyburn	13.0	35
Bradford Centre	7.8	93
Bradford Town Hall	18.5	90
Cardiff 12	6.7	98
Dunmurry 3	6.4	99
Edinburgh St Leonard's	7.0	79
Folkestone	4.4	94
Glasgow Centre	5.0	78
Halesowen 8	9.2	98
Halifax 17	6.9	90
Manchester Piccadilly	10.9	98
Marylebone Road	38.8	76
North Ken	8.7	93
Norwich 7	6.0	95
Nottingham Centre	10.0	99
South Kirkby 1	12.3	100
Stoke Centre	9.7	97
Strabane 2	6.1	100
Sunderland 8	4.6	58
Woolwich 9	5.2	95

Table 7 Annual mean Black Smoke concentration and data capture for 2007

Data capture for Bath 6, Birmingham Tyburn, Bradford centre, Bradford Town Hall, Folkestone, North Kensington and Nottingham Centre are based on the available operating period and hence are not full calendar year averages.

The average data capture for the Network over the year was 89%, compared with 86% for 2006.

The annual average concentrations are better presented as a bar graph (Figure 8) to aid the intercomparison of sites:

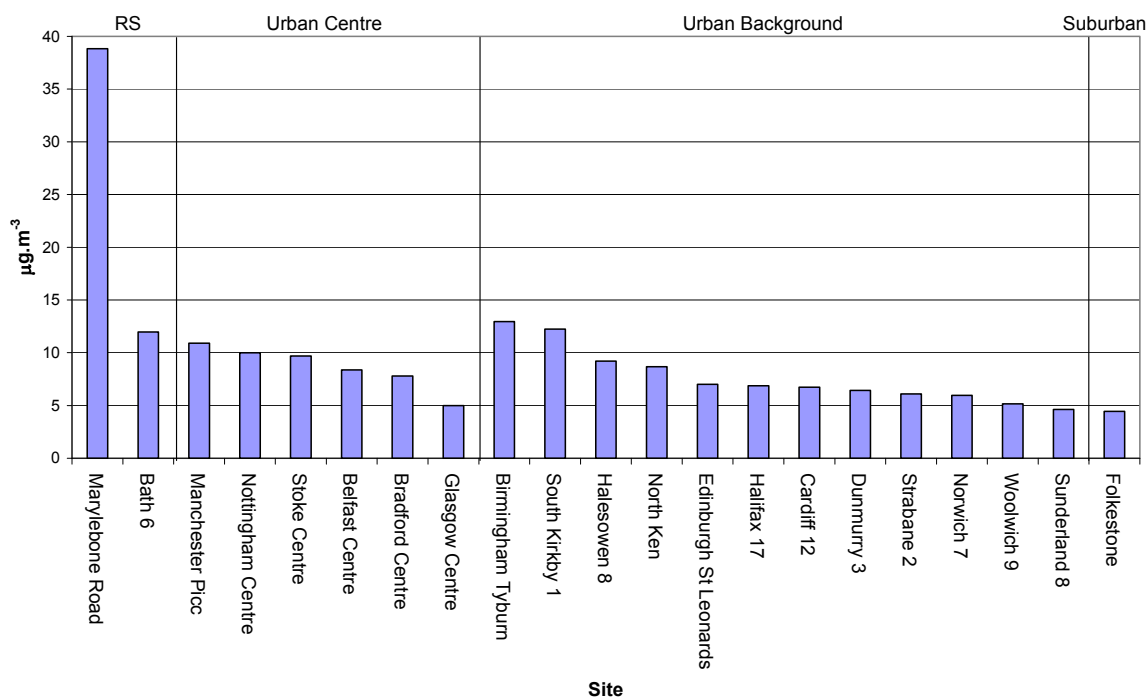


Figure 8 Annual average Black Smoke concentrations for 2007.

Data capture at Birmingham Tyburn was very low (35%) due to a water leak in the roof of the monitoring station directly above the sampler, requiring the sampler to be turned off. Repairs to the roof were delayed due to the extremely wet summer.

Data capture at Edinburgh St Leonard's was low (79%) due to an incorrectly set digital clock on the 8-port valve of the sampler. The clock had been set 12 hours out, so that filters were being exposed midday to midday, and data for the period 14/03/07 to 01/05/07 were lost.

Data capture at Glasgow Centre was low (78%) due to a pump failure between 03/04/07 and 10/04/07, an incorrectly programmed digital 8-port valve between 10/04/07 and 18/04/07 and due to back sampling of water from the bubblers, causing the sampler to malfunction between 15/08/07 to 04/09/07.

Data capture at Marylebone Road was low (76%) due to faulty 8-port valves between 02/10/07 and 13/12/07. The problem was compounded by the first replacement 8-port valve failing after 2 days of running.

Data capture from Sunderland is very low (58%) due to the lack of site access during school holidays, resulting in the multiple losses of 2 weeks of data. Installation of the real-time aethalometer will remove this problem. The replacement of the manual 8-port method with aethalometers is discussed in a following section.

5.3 Weekly periodicity

Figures 9 to 12 show plots of the average concentrations on each day of the week for Roadside, Urban Centre, Urban Background and Suburban site classifications respectively.

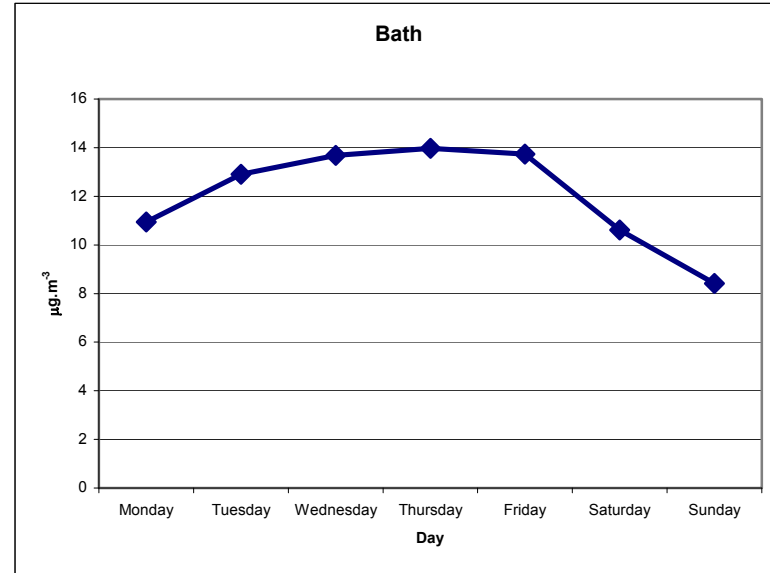
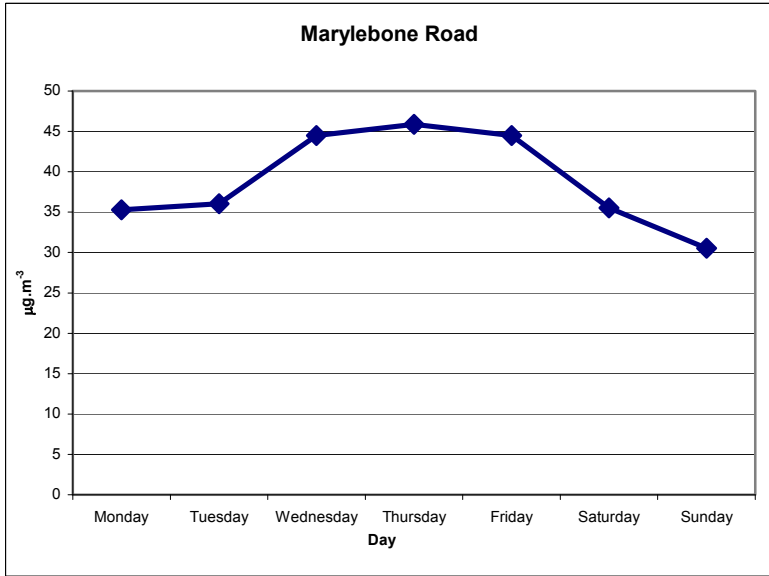
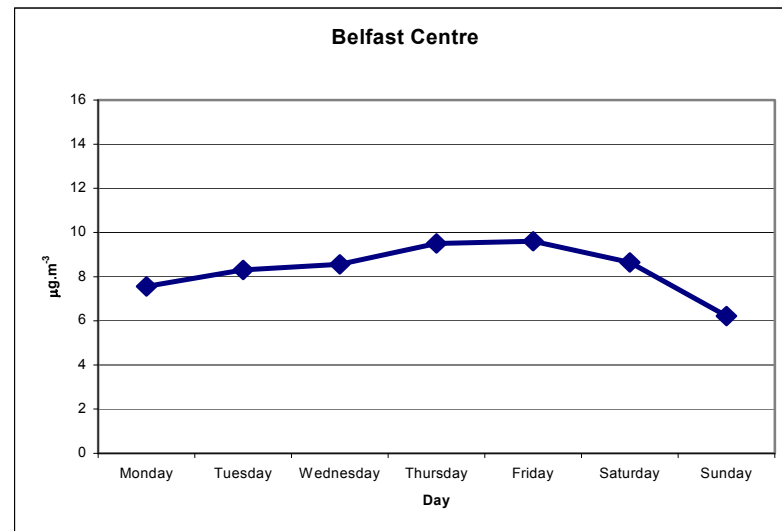
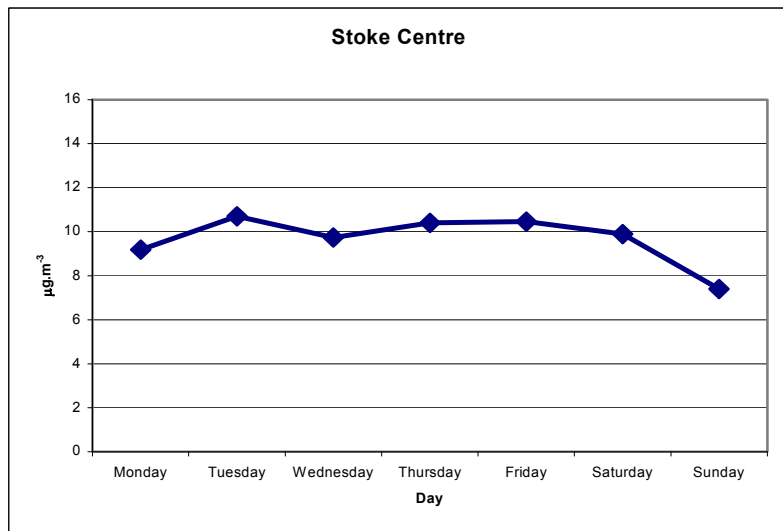
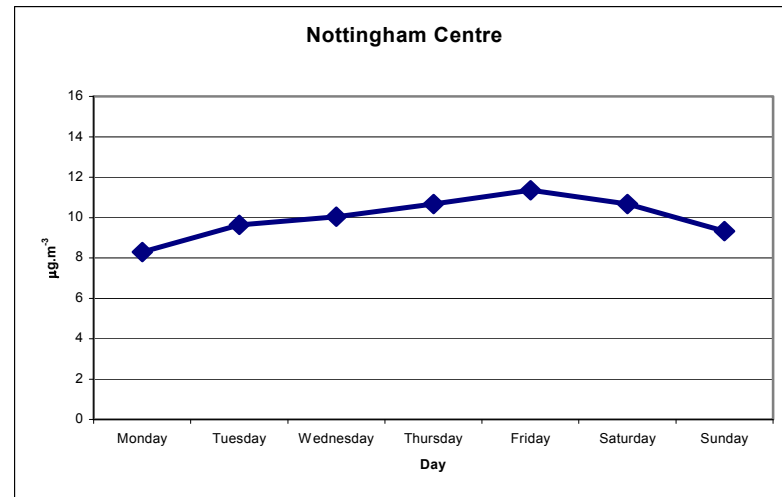
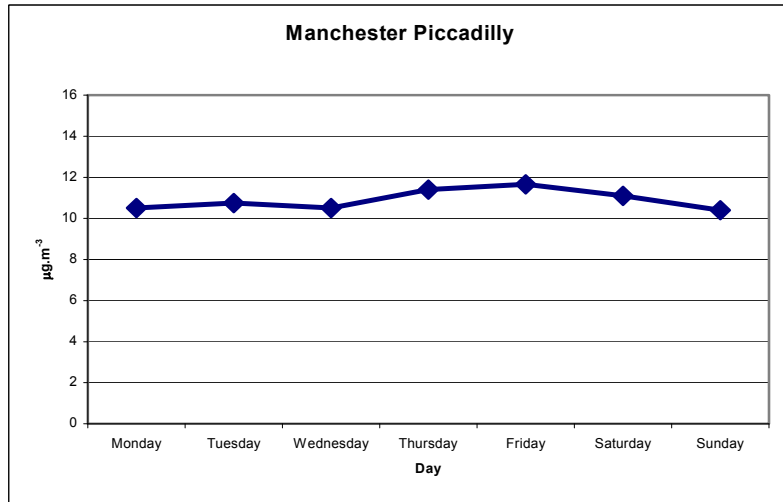


Figure 9 Daily Average Concentrations For Roadside Sites



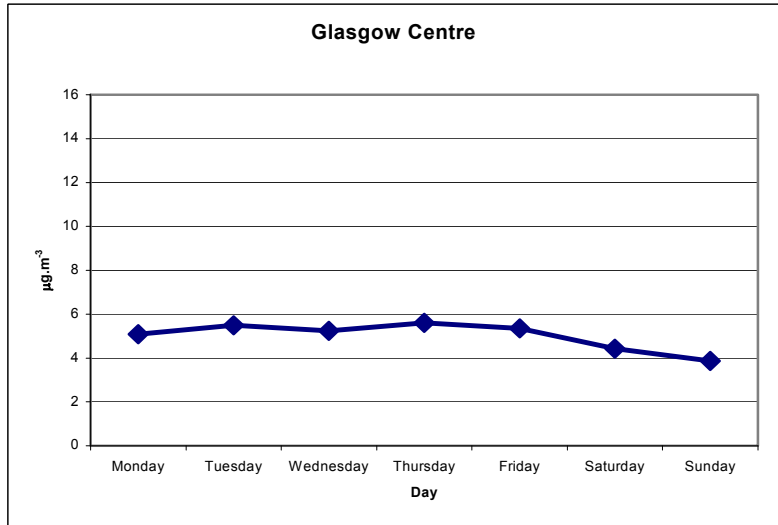
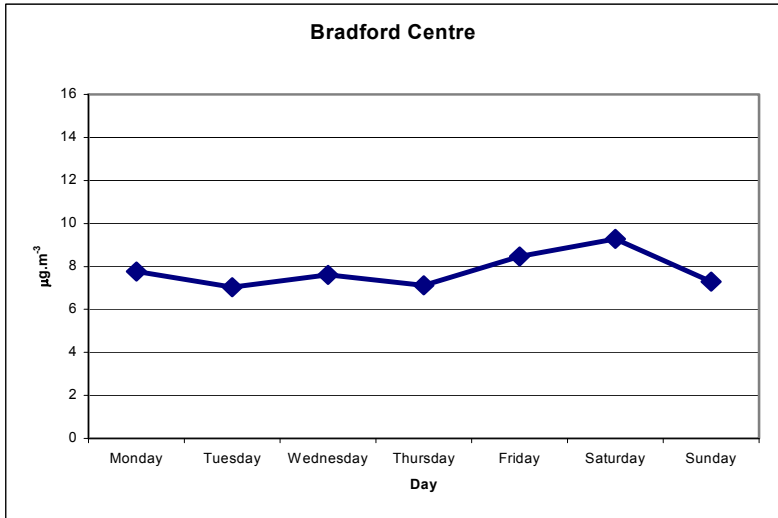
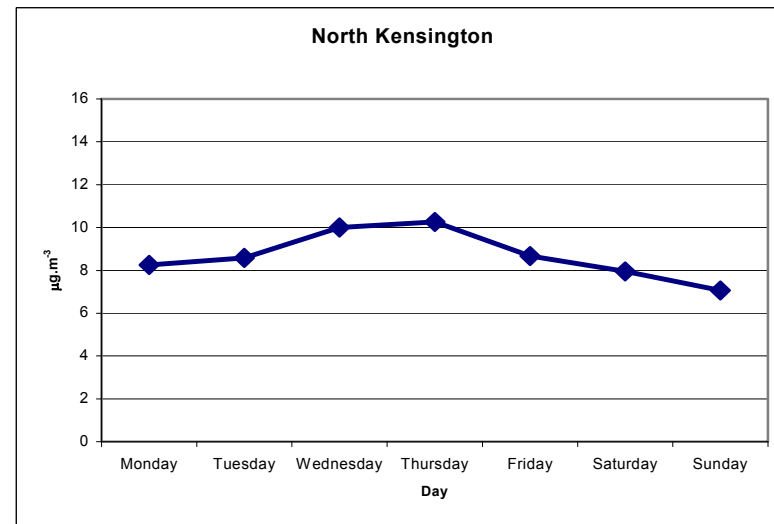
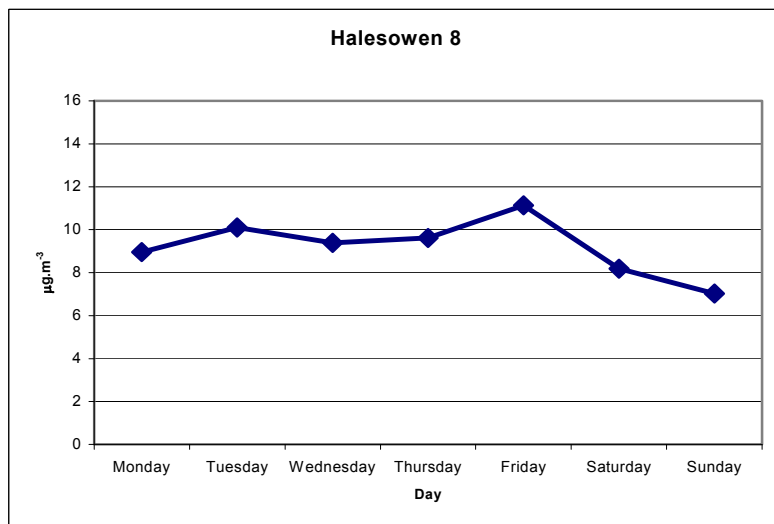
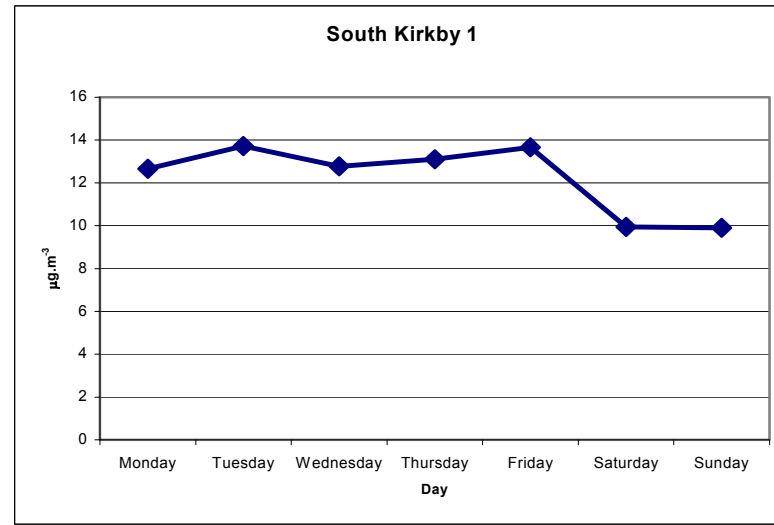
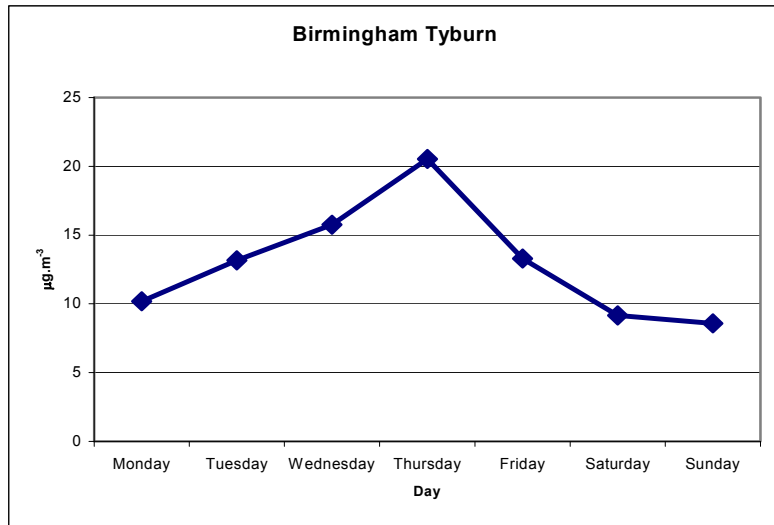
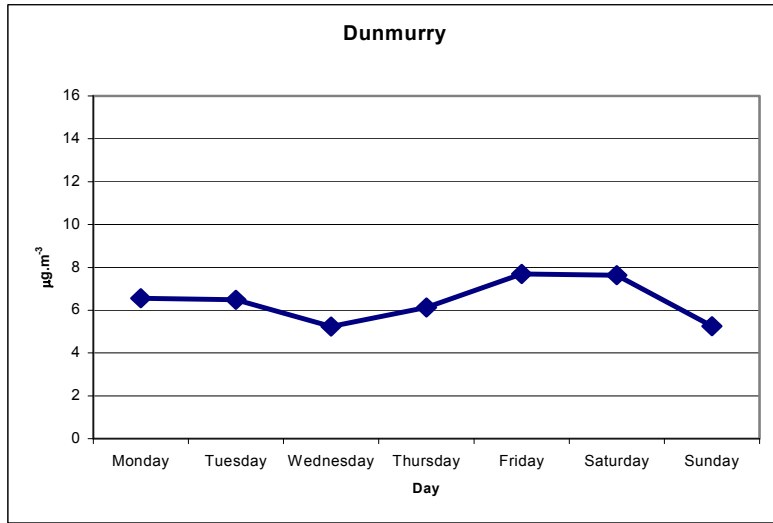
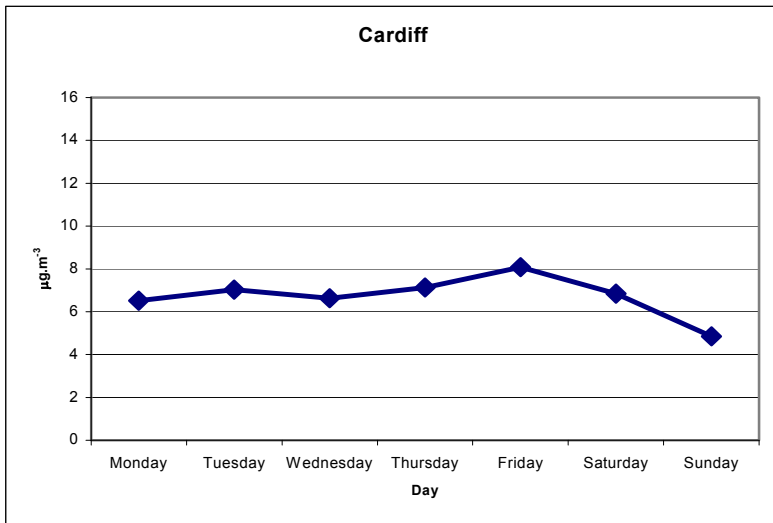
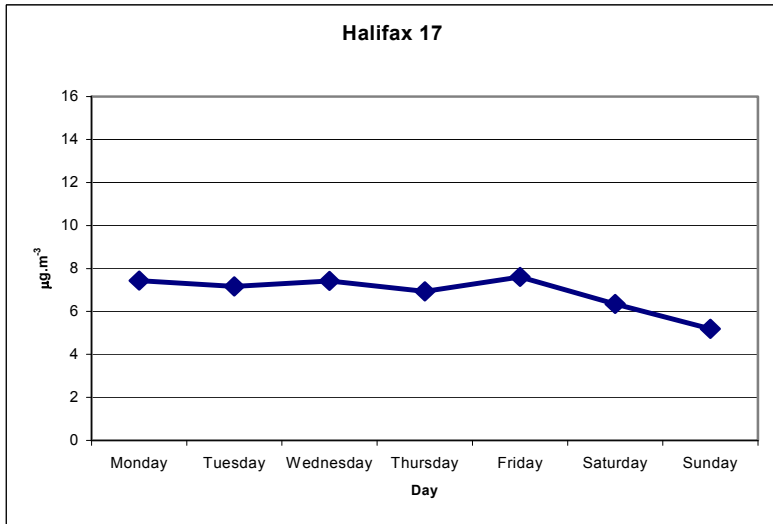
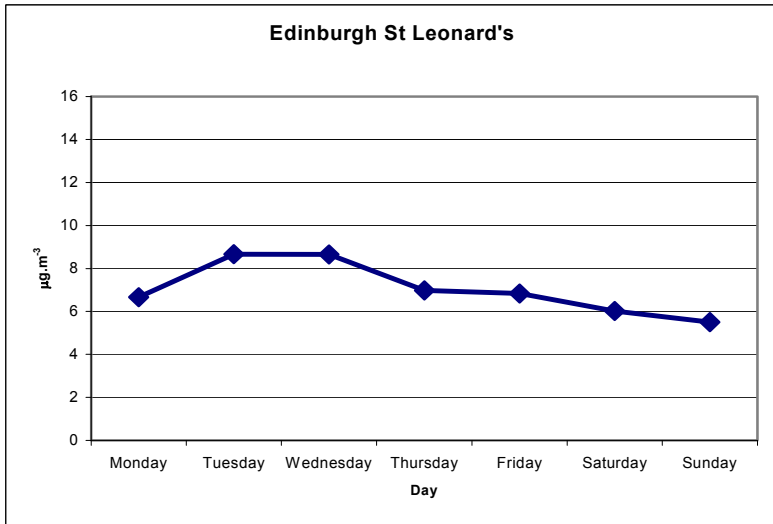


Figure 10 Daily Average Concentrations For Urban Centre Sites





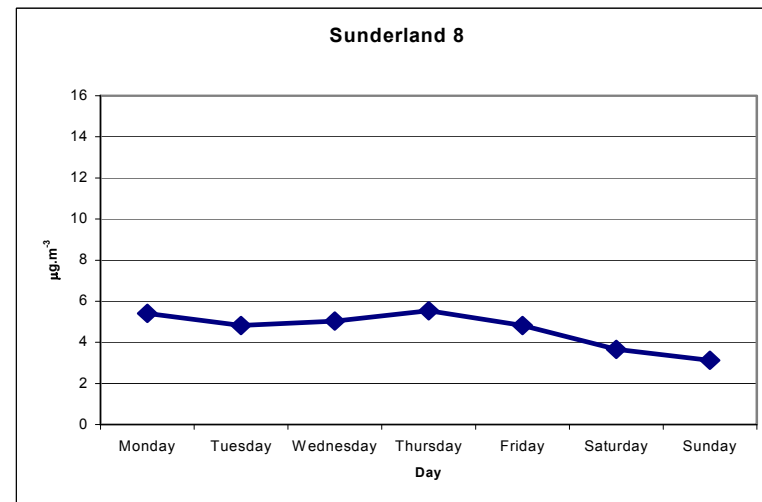
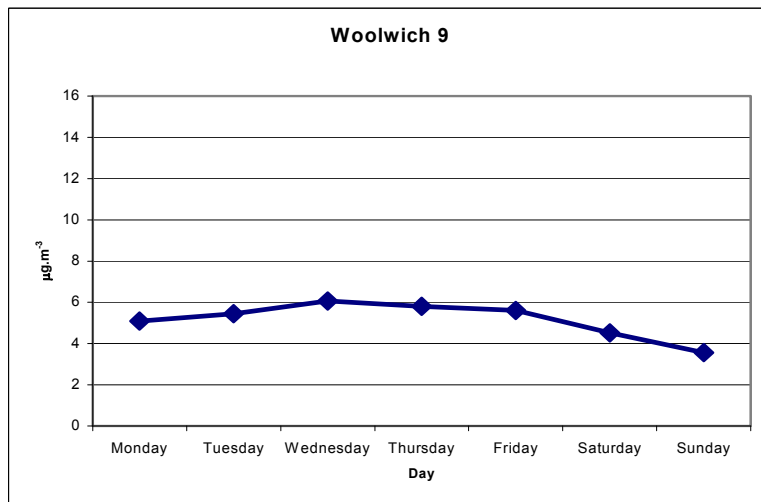
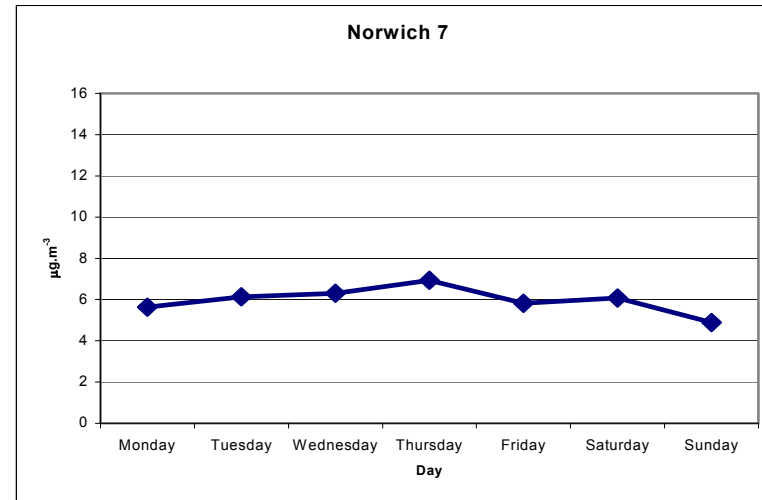
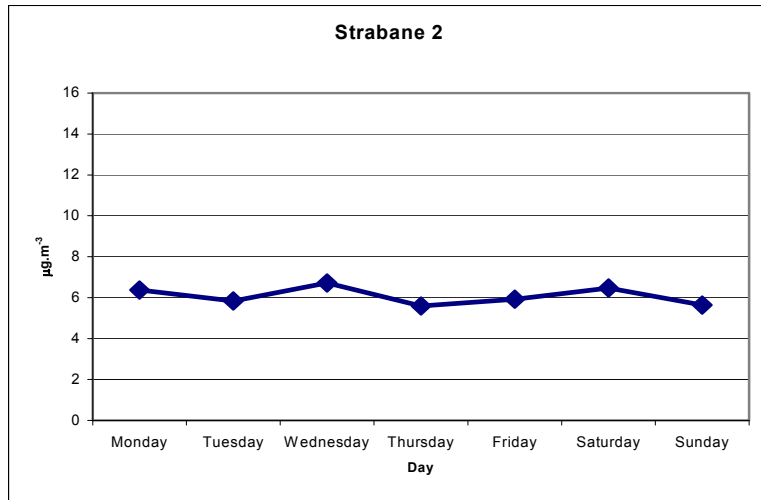


Figure 11 Daily Average Concentrations For Urban Background Sites

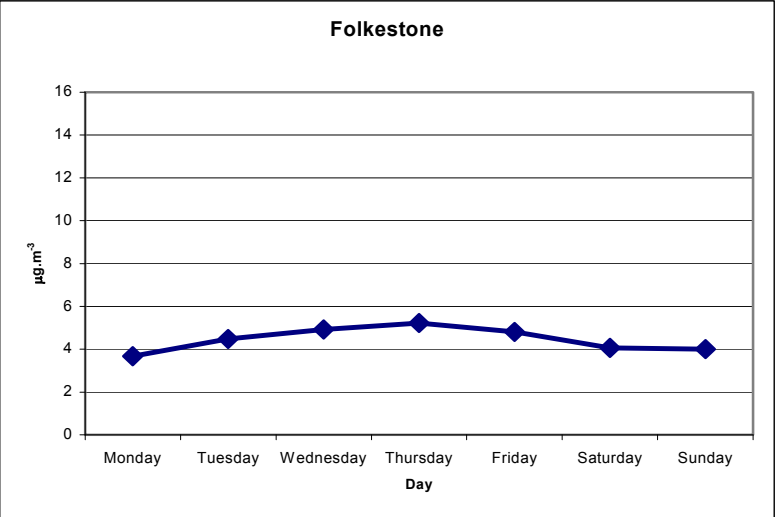
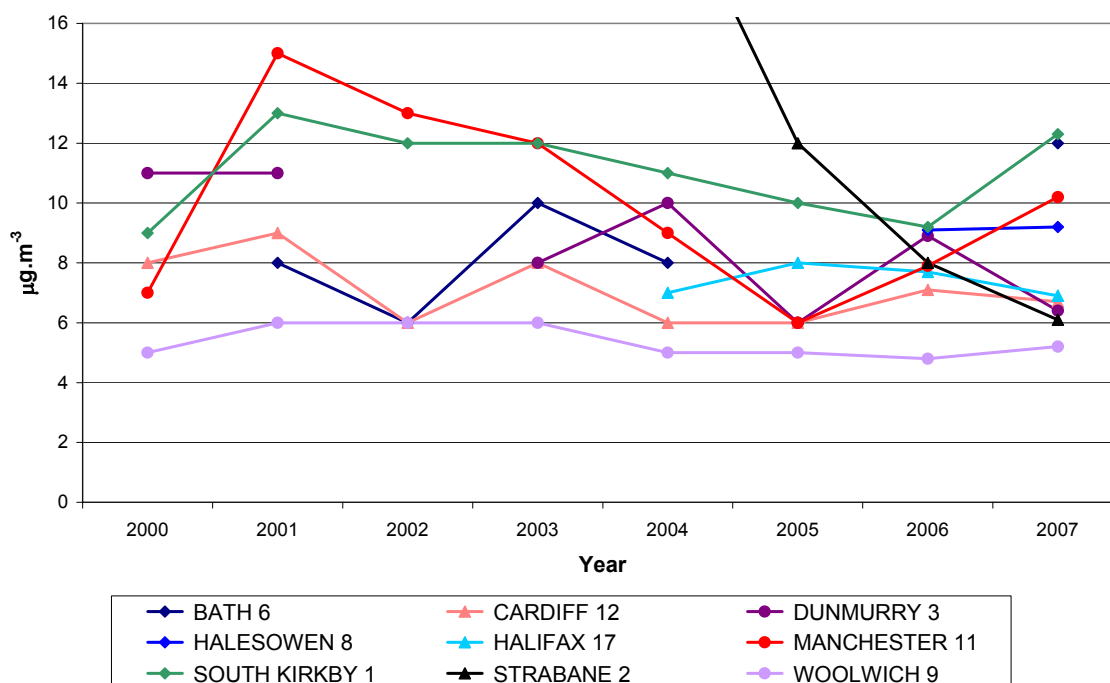


Figure 12 Daily Average Concentrations For Suburban Sites

5.4 Trends since 2000

Figure 13 shows the trend in Black Smoke concentration from 2000 to 2007 for those sites operating over most of that period.



2004 Strabane 2 concentration = 21 $\mu\text{g.m}^{-3}$

Manchester 11 is an affiliated site and has not undergone the same QA/QC procedures as the other sites.

Figure 13 Trends in Black Smoke concentration from 2000 to 2007

The drop in the Strabane 2 Black Smoke concentration since 2004 is attributable to the installation of oil fired central heating (generally replacing coal burning) in the estate of houses that surround the monitoring site on three sides. Central heating replacement started in 2003.

Apart from Strabane 2 there are no significant trends in this recent data, given the relatively large measurement uncertainty.

There is no evidence of discontinuity in the data as a result of the handover of Network operation in 2006.

5.5 Comparisons with other pollutants

To assess the relationship between Black Smoke measurements and other pollutant concentrations, linear regressions were calculated between Black Smoke data and data for PM_{10} , total NO_x (expressed as NO_2) and particle number concentrations. The results can be seen in Tables 8, 9 and 10.

Black smoke = Particulate Site * M + C

Black Smoke Site	Particulate Site	Instrument	Instrument Annual Mean, $\mu\text{g.m}^{-3}$	M	C	R ²
South Kirkby 1	South Kirkby 1	TEOM	19.8	0.8917	- 5.4741	0.6308
Woolwich 9	Woolwich – Bexley 6	TEOM	30.1	0.2365	-1.8642	0.5537
Dunmurry 3	Dunmurry 3	TEOM	18.1	0.691	- 6.1772	0.5118
Marylebone Road	Marylebone Road	TEOM	44.7	0.9984	- 4.7889	0.5059
North Kensington	North Kensington	TEOM	25.5	0.5784	- 5.9534	0.4759
Nottingham Centre	Nottingham Centre	TEOM	22.3	0.3832	+ 1.444	0.473
Stoke Centre	Stoke Centre	TEOM	23.1	0.4027	+ 0.3873	0.4579
Manchester Piccadilly	Manchester Piccadilly	TEOM	24.4	0.3477	+ 2.4098	0.444
Belfast Centre	Belfast Centre	TEOM	18.8	0.4019	+ 0.8765	0.4353
Norwich 7	Norwich Centre	TEOM	21.8	0.4095	- 2.9906	0.3805
Cardiff 12	Cardiff Centre	TEOM	22.3	0.2628	+ 0.7748	0.3062
Folkestone	Folkestone	TEOM	23.0	0.3128	- 2.7097	0.304
Birmingham Tyburn ¹	Birmingham Tyburn	TEOM	29.5	0.4393	- 0.3376	0.2707
Edinburgh St Leonard's	Edinburgh St Leonard's	TEOM	18.8	0.3966	+ 0.2723	0.2484
Strabane 2	Strabane 2	MetOne BAM	16.5	0.2806	+ 1.4365	0.241
Bradford Centre	Bradford Centre	TEOM	23.9	0.1838	+ 2.0446	0.1963
Glasgow Centre	Glasgow Centre	TEOM	20.3	0.1283	+ 2.3041	0.1686

1 Limited data set for Birmingham Tyburn due to no black smoke measurements being made between 26/04/07 and 01/11/07

Table 8 Relationship between Black Smoke and PM₁₀ concentrations

Black smoke = NO_x site * M + C

Black smoke Site	NO _x Site	NO _x Annual Mean $\mu\text{g.m}^{-3}$	M	C	R ²
Birmingham Tyburn ¹	Birmingham Tyburn	86	0.1266x	+ 1.4374	0.9174
North Kensington	North Kensington	65	0.1196x	+ 0.84	0.8532
Norwich 7	Norwich Centre	37	0.1204x	+ 1.5091	0.8175
Marylebone Road	Marylebone Road	264	0.1309x	+ 4.4482	0.8151
Folkestone	Folkestone	38	0.0987x	+ 0.7554	0.7592
Cardiff 12	Cardiff centre	50	0.1602x	- 1.3393	0.7551
Stoke on Trent	Stoke on Trent	50	0.1664x	+ 1.3465	0.6533
Manchester Piccadilly	Manchester Piccadilly	83	0.1337x	+ 0.0141	0.6323
Nottingham Centre	Nottingham Centre	61	0.1445x	+ 1.098	0.6211
Edinburgh St Leonard's	Edinburgh St Leonard's	41	0.1516x	+ 0.8442	0.6203
Bath 6	Bath Roadside	177	0.0631	+ 0.8848	0.5982
Belfast Centre	Belfast Centre	23	0.1652	+ 0.5928	0.5759
Sunderland 8	Sunderland Silksworth	22.8*	0.1652	+ 0.5928	0.5759
Dunmurry 3	Lisburn Hospital	56	0.1602x -	+0.8542	0.4789
Woolwich 9	Woolwich – Bexley 6	37	0.1032x	+ 1.6817	0.478
Glasgow Centre	Glasgow Centre	57	0.043x	+ 2.5048	0.4636
Bradford Centre	Bradford Centre	30	0.1546x	+ 1.8409	0.4467

1 Limited data set for Birmingham Tyburn due to no black smoke measurements being made between 26/04/07 and 01/11/07

Table 9 Relationship between Black Smoke and total oxides of nitrogen concentrations

Black smoke = Particulate Number Site * M + C

Black smoke Site	Particle Number Site	Particle Number Mean Particles.cm ⁻³	M	C	R ²
North Kensington	North Kensington	20106	0.0008x	- 7.0966	0.4992
Marylebone Road	Marylebone Road	78774	0.0004x	+ 4.9087	0.662

Table 10 Relationship between Black Smoke and particle number concentrations

It can be seen that in general the best correlation is between Black Smoke concentration and total NO_x. Some comparative time series plots are given in Figures 14 and 15.

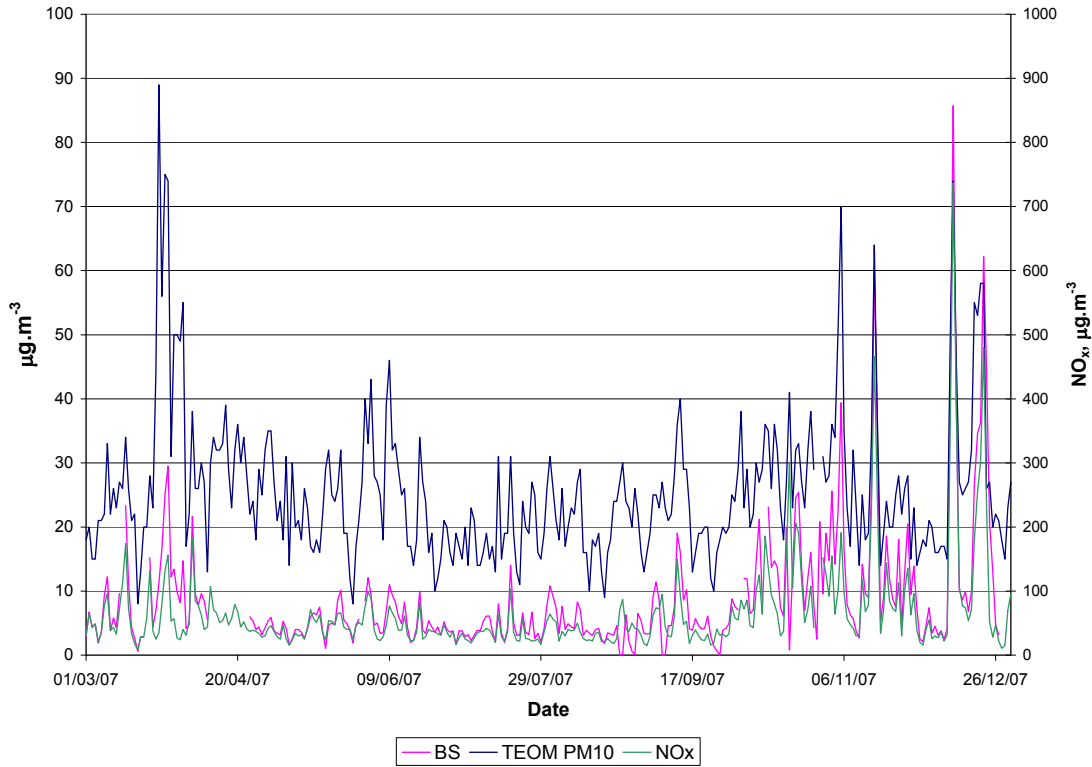


Figure 14 Black Smoke, TEOM and NO_x concentrations measured at North Kensington in 2007

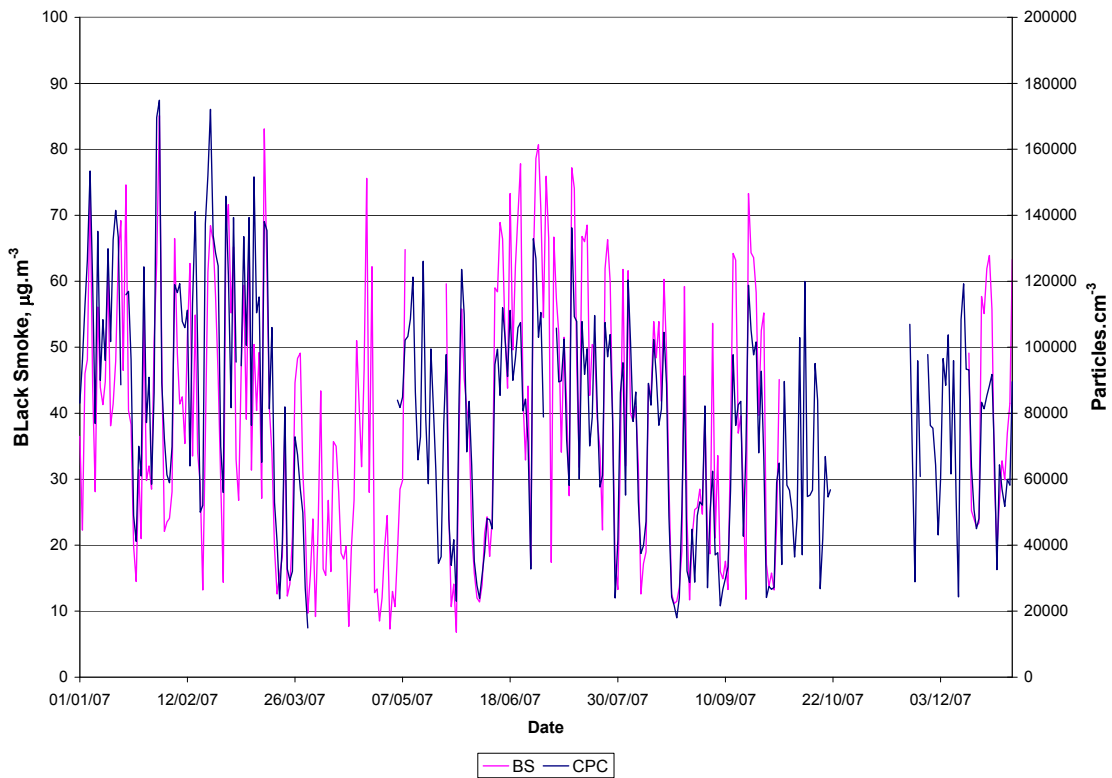


Figure 15 Black Smoke And particle number concentrations measured at Marylebone Road in 2007

5.6 Affiliate Sites

Three further Councils, Gloucester, Knottingley and Manchester, have submitted their data for inclusion in this report, but this data has not undergone any QA/QC by NPL. These sites have been listed as affiliate sites.

5.6.1 Time Series

Figure 16 shows the Black Smoke concentrations measured by the individual affiliate Councils for 2007.

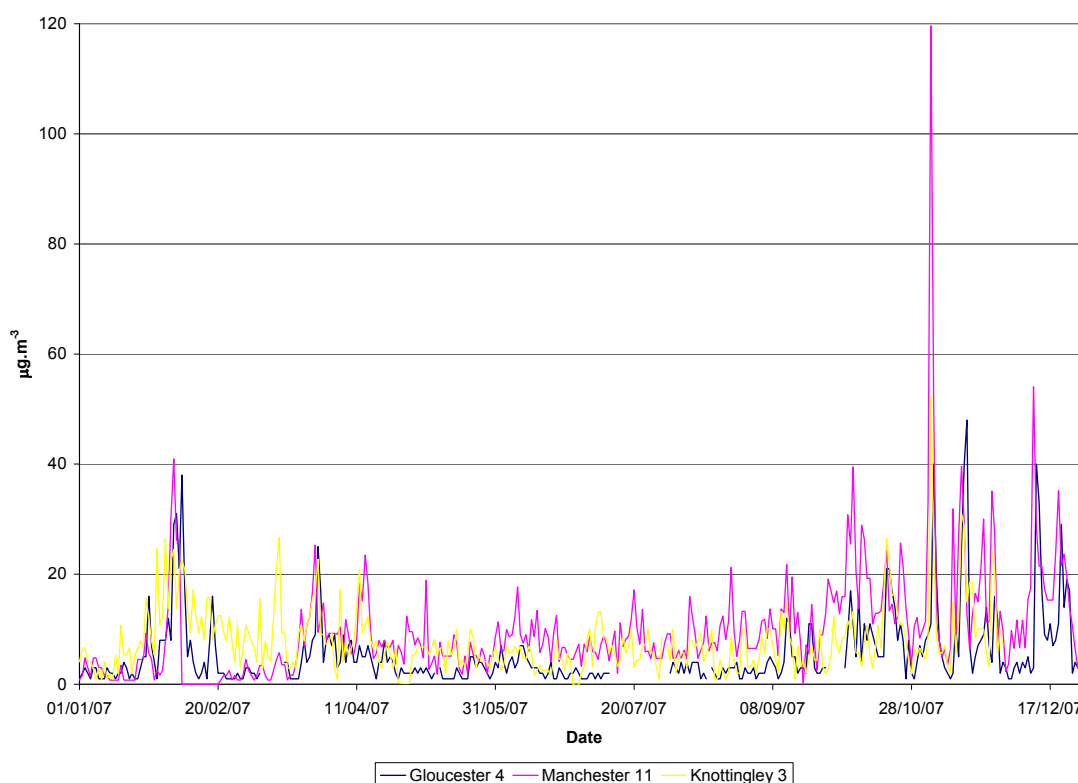


Figure 16 Black Smoke concentrations measured by affiliate Councils for 2007

5.6.2 Annual averages and data capture

Table 11 gives the annual mean measurement for Black Smoke in 2007 for each site.

Site	Black Smoke Concentration, $\mu\text{g.m}^{-3}$	Data Capture %
Gloucester 4	5.5	90
Knottingley 3	7.8*	100*
Manchester 11	10.2	96

* Measurements from 1st January 2007 to 30th November 2007 only due to site closure.

Table 11 Annual mean Black Smoke concentration measured by individual Councils for 2007

6.0 Planned major changes to the Network in 2008

After the intercomparison of black carbon measuring methods carried out at Marylebone Road by Kings College^[3] and the work carried out by Paul Quincey at NPL on the relationship between Black Smoke Index and Black Carbon concentration^[4], in 2007 Defra decided to purchase real-time aethalometers to replace the manual 8-port black smoke samplers. Aethalometer installation will start in March 2008, with installations at the Marylebone Road, North Kensington, Birmingham Tyburn, Halifax 17 and Edinburgh St Leonard's sites. At these sites aethalometers will be colocated with the 8-port sampler for 6 months for intercomparison purposes, while at the other sites there will be a direct replacement of the 8-port sampler, with no parallel running. It is expected that all the installations will be completed by June 2008.

References

- 1 NPL DQL Report: AS (RES) 008, UK Black Smoke Network Audit Report For 2007, January 2008.
- 2 NPL Report AS 2, 2006 Annual Report for the UK Black Smoke Network, April 2007.
3. Marylebone Road Aethalometer Trial Report, available at:

http://www.airquality.co.uk/archive/reports/cat13/0711261353_Marylebone_Road_Aethalometer_Trial.pdf
4. Paul Quincey, 2007, A relationship between Black Smoke Index and Black Carbon concentration, Atmospheric Environment 41, 7964 – 7968.