Air Pollution in Scotland 2008

A report to the Scottish Government

AEA

The Scottish Government

1. Introduction

This annual newsletter is the second in a series on air quality in Scotland. Produced by AEA on behalf of The Scottish Government, it is intended to provide a summary of air quality monitoring carried out on behalf of Government and Local Authorities in Scotland during 2008.

Section 2 of the Newsletter reviews the continuing developments in air quality legislation and policy affecting Scotland. Section 3 summarises the main national air quality monitoring programmes, together with locations of monitoring sites. Section 4 provides information on a recent study to investigate the air quality impact of biomass boiler installations. In Section 5, we review long-term trends in air quality, followed by spatial patterns of pollution in Section 6. Finally, for readers wanting to find out more, additional web-based and published sources of information on Scotland's air quality issues are summarised in Section 7. A more detailed Annual Report on the Scottish Air Quality Database Project will also be available on the Air Quality in Scotland website in April 2009.

At present, the Scottish Air Quality Database contains data from approximately 60 monitoring stations in total. Site numbers have increased by 10 since 2007. As this body of data accumulates it will provide a valuable resource for assessment of air quality trends and spatial distribution, as well as for the general public, health professionals, academics and other interested parties.

The latest UK Air Quality Strategy reports indicate that current average levels of man-made particulate pollution in the UK are estimated to reduce life expectancy by up to eight months. Hence, continued effort to reduce air pollution is therefore important, together with comprehensive monitoring to assess progress towards strategy and health objectives.

2. Legislation and policy

The management of air quality is based on a series of statutory measures and policy programmes originating from Europe, the UK and within Scotland. Together, these form the basis of a strong framework for managing air quality over the coming years.

2.1 The European Union Process

Much of the foundation for managing air quality in Scotland can be traced back to the objectives and provisions contained within the series of Air Quality Directives adopted by all Member States of the European Union.

One of the most recent developments in European policy will affect the way that we manage fine particulate matter in the air, known as PM. Currently, PM is most commonly monitored as PM_{10} (fine particles with an aerodynamic diameter less than or equal to a nominal 10 micrometer). However, evidence from a number of epidemiological studies and directly from the World Health Organisation (WHO) suggests that major health impacts of PM are strongly associated with the fraction below 2.5 microns in size (known as $PM_{2.5}$). As a result of this, a new Air Quality Directive* has recently been published which incorporates - for the first time – a range of requirements and provisions related specifically to $PM_{2.5}$. These include:

1. **Average Exposure Indicator:** The Average Exposure Indicator (AEI) is based on measurements in urban background locations in zones and agglomerations throughout the territory of a Member State. It is assessed as a three-calendar year running annual mean concentration averaged over all measurement stations for 2009, 2010 and 2011. The required reduction by 2020 is based on the level of the 3-year AEI as follows:

* Directive 2008/50/EC of the European Parliament and the Council of 21 May 2008 on ambient air quality and cleaner air for Europe: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

Initial Concentration, µg m^{-3}	Reduction target in the new European Air Quality Directive, percent
<8.5 – 8.5	0%
>8.5 - <13	10%
13 - <18	15%
18 - <22	20%
≥22	All appropriate measures to achieve 18µg m^{-3}

2. **Exposure Concentration Obligation:** this requires a reduction of the AEI to 20µgm^{-3} by 2015

3. **Target Value:** this is to be met by 1 Jan 2010 is 25µg m^{-3}

4. **Limit Value:** the Stage 1 limit value for all stations is 25µg m^{-3}, to be met by 1 Jan 2015. The Stage 2 limit value is 20µg m^{-3} for all stations to be met by 1 Jan 2020.

To meet the requirements of the new Directive, the UK National Network for monitoring PM – the Automatic Urban and Rural Monitoring Network (AURN) – is currently being re-configured to incorporate monitoring of $PM_{2.5}$ at a number of monitoring sites. This additional monitoring, which is required for the monitoring year 2009 in order to contribute to the AEI, will include $PM_{2.5}$ monitoring at 5 urban locations and one rural location in Scotland.

2.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, first published in 1997, establishes a strong and coherent framework for tackling air pollution. It was based on strong scientific evidence and a science-based understanding of the effects of air pollutants on health and the environment. The Strategy sets objectives for a series of pollutants to be met within all UK countries. The scientific basis, the objectives set and provisions contained within the Strategy are closely associated with the corresponding standards set within European Air Quality Directives, as described above. However, provisions and corresponding objectives for some pollutants differ from those in the Air Quality Directives; these differences relate to scientific evidence and expert opinion that is specific to the UK situation.

A major revision of the Strategy was published in July 2007. This includes a detailed update of the effectiveness of current provisions and objectives, as well as a series of newly proposed regulatory measures and objectives to be adopted. The key outcomes from the Strategy revision are that all current objectives for pollutants will be maintained. Additional objectives for $PM_{2.5}$ to protect human health, and for ozone to protect ecosystems, have been adopted (Table 1). Both of these new objectives are generally in line with corresponding standards set in the new Air Quality Directive. In addition, a series of policy measures have been considered for adoption following detailed cost-benefit analysis. The full revised Air Quality Strategy and associated technical annexes can be seen at: www.scotland.gov.uk/Topics/Environment/Pollution/16215/6116

The Air Quality (Scotland) Regulations 2000 and the Air Quality (Scotland) Amendment Regulations 2002 prescribe the air quality objectives to be considered for review and assessment purposes. The Air Quality Standards (Scotland) Regulations 2007, which came into operation on March 29th of that year, cover EU Limit Values. Other relevant legislation includes The Road Traffic (Vehicle Emissions) (Fixed Penalty) (Scotland) Regulations 2003, which enable local authorities to check vehicles at roadside to ensure that emissions limits are not exceeded; and The Sulphur Content of Liquid Fuels (Scotland) Regulations 2000 which limit the permissible sulphur content of liquid fuel oils such as those used for domestic heating, and thus helps to reduce emissions of sulphur dioxide.

Table 1: New objectives to be adopted within the Air Quality Strategy for England, Scotland, Wales and Northern Ireland from 2007.

Pollutant	Applies	Objective	Measure	Date to be achieved	European obligation	Date to be achieved
Particles ($PM_{2.5}$) Exposure Reduction	Scotland	12 μg m $^{-3}$	Annual Mean	2020	Limit value 25 μg m^{-3}	2015
	UK urban areas	Target of 15% reduction in concentrations at urban background		Between 2010 and 2020	Target up to 20% reduction at urban background	Between 2010 and 2020
Ozone: vegetation and ecosystems	UK	Target value of 18,000μgm^{-3}.hr based on AOT40* to be calculated from hourly values,May to July	Average over 5 years	1 January 2010	Target value of 18,000 μg m^{-3} based on AOT40*	1 January 2010

*. *AOT40 is a measure of accumulated ozone dose exceeding a 40ppb – 80*μg m $^{-3}$ *threshold; it provides a useful measure of the exposure of crops and ecosystems to this pollutant.*

2.3 Local Air Quality Management

Local Air Quality Management (LAQM) provides the framework within which air quality is managed by Local Authorities in Scotland. It requires Local Authorities to review and assess a range of air pollutants against the objectives set out within the Air Quality Strategy, using a range of monitoring, modelling, observations and corresponding analyses. For locations where objectives are not expected to be met by the relevant target date, Local Authorities are required to:

- Declare an Air Quality Management Area (AQMA), and
- Develop an Action Plan to address the problem.

The Scottish Government Policy Guidance on LAQM - PG(S)(09) - has recently been revised and republished at www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116. The new LAQM Technical Guidance - LAQM TG (09) - and associated practice guidance notes are also available at the same web location.

At the time of preparing this Newsletter, 12 of Scotland's 32 Local Authorities have declared Air Quality Management Areas This is three more (in Fife, Midlothian and South Lanarkshire) than in 2007. Of these 12, three have declared an AQMA for PM_{10} alone, five for NO_2 and PM_{10} together, three for NO_2 only, and one for SO_2. Table 2 shows the locations of these AQMAs, and what pollutants they cover. The Authorities with AQMAs have either prepared, or are currently preparing, Air Quality Action Plans for their AQMAs.

Table 2: Air Quality Managements Areas (AQMAs) declared by Local Authorities in Scotland

Council	Pollutant	Source	Date Declared	AQMAs
Aberdeen	NO_2 & PM_{10}	Roads	July 2006	3
Edinburgh	NO_2	Roads	December 2000, 2006	3
Glasgow City	NO_2 & PM_{10}	Roads	January 2002, July 2007	3
Dundee City	NO_2	Roads	July 2006	1
East Dunbartonshire	NO_2 & PM_{10}	Roads	December 2005	1
Falkirk	SO_2	Industry	November 2005	1
Fife	NO_2 & PM_{10}	Roads	October 2008	1
Midlothian	PM_{10}	Domestic	April 2008	1
North Lanarkshire	PM_{10}	Roads	December 2005	3
Perth	NO_2 & PM_{10}	Roads	May 2006	1
Renfrewshire	NO_2	Roads	September 2005	1
South Lanarkshire	PM_{10}	Roads	November 2008	1

3. Networks and data

A wide range of air quality monitoring activities is carried out in Scotland. Some monitoring sites are run as part of UK-wide monitoring networks; others are operated by Local Authorities in order to meet local objectives. The following Air Quality Strategy pollutants were monitored in Scotland during 2008:

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO_x) and Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Particles (as PM_{10} and $PM_{2.5}$)
- Ozone
- Benzene
- 1,3-Butadiene
- Polycyclic Aromatic Hydrocarbons (PAH)
- Lead

The locations of the automatic monitoring sites are shown in Figure 1; they provide high-resolution hourly information on a wide range of pollutants. Data for the Local Authority monitoring sites are updated daily on the Scottish Air Quality Database, whilst corresponding measurements for National Network sites are updated hourly. This rapid data throughput provides rapid communication of data to the public. Examples of monitoring sites operated by Local Authorities are shown in Figure 2, one urban site at Falkirk Park St and a rural site at Waulkmillglen Reservoir near Glasgow.

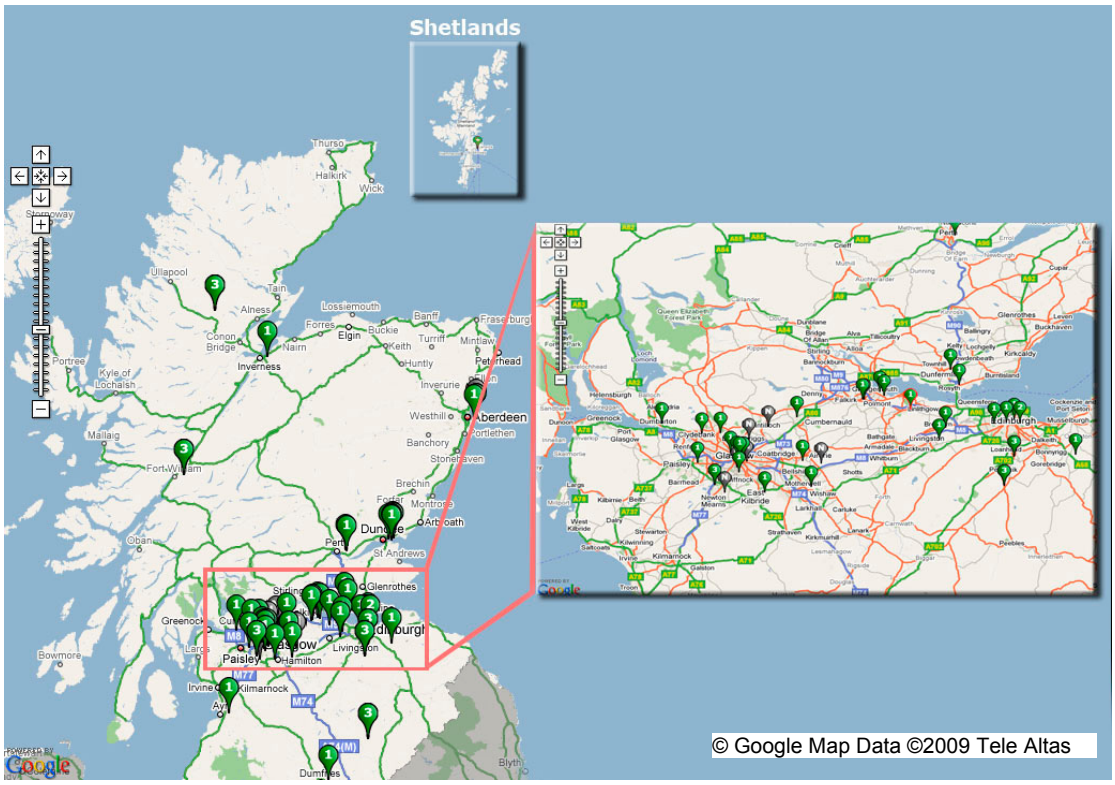

Figure 1 Automatic monitoring stations in Scotland

Note - Numbers on site locators indicate air quality banding of site concentrations at the time when these maps were produced.

Scotland's automatic sites are supplemented by a large number of non-automatic monitoring sites, which use less expensive techniques to provide additional information on air quality. The majority of these utilise diffusion tubes: low cost single-use samplers that absorb specific pollutant directly from the air and need no power supply. These measure average concentrations over a specified sampling period (typically one month) instead of instantaneous concentrations, but still provide invaluable data for screening purposes,

'hot-spot' identification, local impact assessment and mapping overall levels of pollution across the country as a whole.

Air quality data for Scotland are stored in a database that is available at www.scottishairquality.co.uk. The measurement data in the database for 2008, site numbers and areas covered are summarised in Table 3.

Figure 2 Falkirk Park Street and (left) and Glasgow Waulkmilkglen Reservoir (right) automatic monitoring stations

In addition, monitoring of a range of important pollutants for which no specific UK Objective has been set is also undertaken within National networks in Scotland. These include Heavy Metals (urban and rural), Ammonia, Black Smoke and Acid Deposition.

Table 3. Summary of Air Quality monitoring data available in the Scottish Air Quality Database www.scottishairquality.co.uk

Pollutant	Major sources	Sites with Data in the AQ Database	Areas covered
Nitrogen Dioxide (NO_2)	Road transport and industry	53 (Auto)	Mostly urban
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	10 (Auto)	Urban & rural
Particles (PM_{10}, $_{2.5}$)	Road transport, industry, construction, soil and natural sources	54 (Auto PM10) 3 (Auto PM2.5)	Mostly urban
Sulphur dioxide (SO_2)	Industry and fuel combustion	11 (Auto)	Mostly urban
Carbon Monoxide	Road transport	5 (Auto)	Urban
PAH	Industry, transport, solvent use and some natural sources	4 (Non-auto)	Urban & rural
Acid Deposition	Fuel burning, agricultural and other emissions	11 (Non-auto)	Rural
Benzene	Vehicles and industry	2 (Auto)	Urban and Rural
1,3 butadiene	Mostly industrial	2 (Auto)	Urban and rural

Since 2007, the number of monitoring sites for NO_2 has increased by 10, PM_{10} by 26 and sulphur dioxide by three. Only for carbon monoxide has the number of monitoring sites decreased (by 6). This is because of the low concentrations measured and, hence, the reduced requirement for monitoring in the national network and elsewhere.

3.1 Automatic Monitoring - key results for 2008

Please note that Automatic data for 2008 are not yet fully ratified; there may therefore be changes to the final data, which could affect the data summary given in this section.

This section summarises some of the key results of air quality monitoring in Scotland 2008, including compliance with Air Quality Strategy Objectives. Further information is provided on the Scottish Air Quality website at www.scottishairquality.co.uk.

Carbon monoxide is monitored using automatic techniques at five sites: three in Glasgow, one in Edinburgh and one in North Lanarkshire. All achieved the Air Quality Strategy (AQS) Objective for this pollutant.

Nitrogen dioxide data from 53 sites utilising automatic monitoring are available for 2008. Fourteen roadside or kerbside automatic sites exceeded the AQS Objective for the annual mean (40μg m^{-3}). These were Aberdeen Market Street, Aberdeen Union Street, Dundee Lochee Road, Dundee Seagate, Dundee Union St, Dundee Whitehall Street, East Dunbartonshire Bearsden, Edinburgh St John's Road, Fife Cupar, Glasgow Byres Road, Glasgow City Chambers, Glasgow Kerbside, Paisley Central Road and Perth Atholl Street, all of which are close to busy roads. Seven of these sites also exceeded the AQS Objective of 200μg m^{-3} for the hourly mean more than the permitted 18 times.

Sulphur dioxide data from 11 sites utilising automatic monitoring are available for 2008. At the Falkirk Grangemouth Municipal Chambers site, the AQS Objective for the 15-minute average was exceeded more than the permitted 35 times. All other sites in Scotland met the requirements of the AQS for 15-minute, 1-hour and 24-hour mean SO_2 in 2008.

Particulate matter – PM_{10} data from a total of 45 sites utilising automatic monitoring are available for 2008. Of these sites, 33 used TEOM analysers for all of 2008, 10 used TEOM FDMS analysers and a further 2 changed from TEOM to TEOM FDMS part-way through the year. In this section, we have used a conversion factor of 1.3 to convert measurements made with TEOM analysers into gravimetric equivalent results. As in 2007, most monitoring stations met the UK AQS Objective of 40µg m^{-3} (gravimetric equivalent) for the annual mean PM_{10}, although an exceedence was observed at Aberdeen Market Street. Aberdeen Market Street and Glasgow Kerbside also exceeded the UK AQS Objective of 50µg m^{-3} (gravimetric equivalent) for the 24-hour mean on more than the permitted 35 occasions. However, based on 2008 data, the 18µg m^{-3} annual mean objective for 2010 could be exceeded at many more monitoring sites in Scotland. This Objective was exceeded at 23 sites and equalled at a further seven sites in 2008. Data from the non-automatic Partisol samplers have been subject to detailed investigation and the final data from these samplers will be reported separately.

Particulate matter – $PM_{2.5}$ Measurement of $PM_{2.5}$ in Scotland has only recently commenced. For 2008, data are available for the rural site at Auchencorth Moss and from October at Edinburgh St Leonard's and from December at Grangemonth. A programme to initiate $PM_{2.5}$ measurements at several AURN sites in Scotland is currently underway. $PM_{2.5}$ data from the non-automatic Partisol samplers have been subject to detailed investigation and the final data from these samplers will be reported separately.

Ozone data from 10 sites utilising automatic monitoring are available for 2008. Ozone (O_3) is a secondary pollutant that is formed by reactions involving other pollutant gases, in the presence of sunlight, and over several hours. Once formed, it may persist for several days and be transported over long distances. This means that Local Authorities have little control over ozone levels in their area; accordingly, this pollutant is not included as part of Local Authority Local Air Quality Management assessment. In 2008, the AQS Objective of 100μg m^{-3} for the maximum daily 8-hour running mean was exceeded on more than the permitted ten days at eight out of the ten measurement sites in Scotland.

Benzene and 1,3-Butadiene are monitored at the rural Auchencorth Moss site and at Glasgow Kerbside. Both sites continue to meet the AQS objectives for these pollutants.

Summary: Data are available from at least 10 more monitoring sites in Scotland in 2008 compared to 2007. However, the general picture of air pollutant concentrations throughout the country is similar. Provisional results from Scotland's network of automatic air quality monitoring stations in 2008 show that the Air Quality Strategy Objectives for the following pollutants have been met by the due dates –

- Carbon monoxide
- Benzene
- 1,3-Butadiene

However, in 2008, there remain a number of sites close to busy roads in urban areas that did not meet AQS Objectives for nitrogen dioxide and/or particulate matter as PM_{10}. Moreover several sites, mostly in rural areas but also at Aberdeen and Edinburgh St Leonard's, did not meet the AQS Objective for ozone. At the Falkirk Grangemouth Municipal Chambers site, the AQS Objective for the 15-minute average was exceeded on more than the permitted 35 occasions. As a result of these measurements, a number of Air Quality Management Areas have been declared or are in the process of being declared throughout Scotland.

3.2 Non-Automatic Monitoring in 2007

Sampler-based pollution monitoring can provide a powerful and cost-effective way of determining overall pollution levels over large areas. Scotland's automatic monitoring sites are therefore supplemented by more than 800 Local Authority-operated sites using non-automatic sampling methods. The most widely used of these techniques is passive sampling, using diffusion tubes.

The main programmes of sampler-based monitoring in Scotland are as follows:

1) Diffusion tubes

These measure periodic - typically monthly - concentrations of nitrogen dioxide (NO_2). Diffusion tubes are easy to use and relatively inexpensive, so they can be deployed in large numbers over a wide area, giving good spatial coverage. They may also be used to complement detailed measurements made at automatic monitoring sites, or in circumstances where hourly measurements from automatic analysers are not required.

Although there is no longer a national monitoring network based upon NO_2 diffusion tubes, these samplers are still widely used by Local authorities for the purpose of Local Air Quality Management (LAQM). NO_2 is monitored at several hundred locations in Scotland in this way. Moreover, Scottish Government continues to provide a central web-based NO_2 diffusion tube data collation facility, together with QA/QC support for NO_2 diffusion tube monitoring.

The majority of Scotland's diffusion tube sites monitor NO_2. As well as this pollutant, however, diffusion tubes are also used in the region to provide indicative monitoring of ozone, sulphur dioxide and a range of hydrocarbons including benzene.

2) Non-automatic Hydrocarbon Monitoring

Pumped tube samplers for benzene (C_6H_6) and 1,3-butadiene are operated as part of the UK network (run by National Physical Laboratory) in Edinburgh and Grangemouth. Running annual mean concentrations for benzene and 1,3-butadiene in 2008 remain below the relevant UK Air Quality Strategy Objectives.

4. Air quality impacts of biomass boilers

During 2007/8, The Scottish Government commissioned AEA to undertake a study of the potential impact of PM_{10} & $PM_{2.5}$ emissions from wood burning biomass boilers. The report of this study is available at: www.scotland.gov.uk/Publications/2008/11/05160512/0.

The Scottish Government encourages the adoption of biomass combustion in order to reduce emissions of greenhouse gases, mitigate against climate change effects and improve energy security and rural development. In addition, as part of the Renewable Energy Framework, The Scottish Government is committed to the growth of the biomass market, particularly in areas not connected to the gas grid network. However, combustion of biomass, along with many other industrial, commercial and transport activities, can lead to emissions of air pollutant species that are potentially harmful to human health.

The study focused on the cities of Dundee and Edinburgh as, within these cities, the PM_{10} Objectives for Scotland are already closely approached or exceeded. A key component of this study was the inclusion of specific detailed measurements of particle emissions from a range of typical small-scale biomass boilers installed and operational in urban areas throughout Scotland. In total, six boilers were tested to determine emissions of PM_{10} and $PM_{2.5}$ particle size fractions. Based on these measurements, together with a review of the available literature, two emission factors of 20g/GJ and 60g/GJ were selected as representative of the range of boilers tested. However, it is recognised that this was a relatively small sample and restricted to a specific boiler capacity range; as a result, extrapolation of the results to other cities with potentially different biomass boiler installations should be undertaken with caution.

In the study, the maximum local contribution to annual mean particulate matter concentrations from each individual plant operating at capacity was limited to less than 1μg m^{-3}. It was assumed that this would be achieved by use of an appropriate chimney height. However, other measures, such as, additional emission abatement control systems, fuel type and boiler selection could be used to achieve the same outcome.

Information from Dundee City Council and The City of Edinburgh Council was used to prepare scenarios for possible biomass implementation in 2010 and 2020.

Air quality modelling, using recognised and validated air quality models, was then undertaken for each scenario in each city using the two emission factors derived from the emission monitoring programme. The modelling of particulate concentrations for 2010 showed that the potential impact of the current proposed biomass installations for both Dundee and Edinburgh for both the 20g/GJ and the 60g/GJ emission factor cases is likely to be less than 0.1μg m^{-3}, except in the immediate vicinity of the proposed installations. The modelled PM_{10} concentration arising from all other sources in 2010 is in the range 14 to 20μg m^{-3} in these city centre areas and hence, the resulting proportional biomass contribution is in the range 0.5 –0.7%.

The model for 2020, using the 20g/GJ emission factor, shows that the effect of biomass combustion is likely to increase annual mean PM_{10} concentrations across much of the city centres for both Dundee and Edinburgh by 0.2-0.5μgm^{-3}. For an emission factor of 60g/GJ, the model shows increases in particulate concentrations of 0.5-1.0μgm^{-3} across large parts of both cities. The modelled PM_{10} concentration arising from all other sources in 2020 is in the range 14 to 20μg m^{-3} in these city centre areas; the resulting proportional biomass contribution is therefore n the range 1 – 7%.

The Scottish Air Quality Objective for annual mean $PM_{2.5}$ is not predicted to be exceeded at any background locations for any scenario in either Dundee or Edinburgh. The UK has also set a $PM_{2.5}$ exposure reduction target of 15% by 2020 in urban background areas. The 'business as usual' scenario without biomass installations indicates this target will not be achieved. The combined impact of large-scale uptake of biomass installations, under the conditions assumed in this study, could increase the difficulty in achieving this target.

Additional controls on emissions from individual boilers could, however, be explored to minimise this impact.

The modelling study demonstrates that biomass boilers will not be the major source of PM_{10} or $PM_{2.5}$ in urban areas. However, in areas that are already close to PM_{10} Air Quality Objectives the additional contribution of biomass may lead to an exceedence at some city background locations. Note that this conclusion applies to urban background concentrations, and that higher particle concentrations may be seen in areas close to other specific sources.

As part of the study, screening tools have been developed to assist Local Authorities to assess the impact of both individual and multiple boiler applications – the spreadsheet version of this tool is available at http://www.airquality.co.uk/archive/laqm/tools.php .

The new LAQM Policy Guidance issued by the Scottish Government also provides guidance to Local Authorities on dealing with biomass planning applications.

The Clean Air Act regulates emissions from commercial and domestic premises in Smoke Control Areas. However, this legislation was developed in the 1960s, and was primarily aimed at coal combustion; as a result, is not wholly appropriate for the current pollution situation and control of fine particulate emissions. Of specific concern is the fact that most existing boilers in urban areas are now gas fuelled; their emissions are therefore significantly lower than the Act's requirements. Although biomass boilers may meet Clean Air Act standards, in many circumstances they still have the potential to produce PM_{10} emissions that are worse than the current gas equivalent. The Scottish Government, working with the other UK administrations as appropriate, intends to review the Clean Air Act to address this situation.

When considering planning applications for biomass boilers, local authorities should - as a first step - apply the new screening tools to assess the possible impact. If this assessment indicates that any individual boiler, or group of boilers in a specific area, has the potential to contribute to an exceedence of the PM_{10} objectives, the local authority should give careful consideration as to whether the application should be approved.

Further advice on (i) when air quality is capable of being considered as a material planning consideration and (ii) on measures to reduce emissions from biomass boilers is also provided in the Policy Guidance PS(S)(09).

Fig 3 Biomass- logs for firewood in the snow

5. Air quality trends

In general, recent years have seen a marked improvement in Scotland's air quality. In particular, levels of pollutants associated with motor vehicle and industrial emissions have declined significantly over the past decade.

Here we examine how overall pollution levels in Scotland have changed over the last 20 years. To an extent, these analyses are affected by changes in monitoring site numbers. Since these were relatively low for background monitoring sites up until 2000, and for roadside/kerbside sites up until 2002, trends in the earlier years should be regarded with caution. Recent research has indicated that - for reasonably robust annual mean trends analysis - at least four monitoring sites with good annual data capture should be available.

For the purpose of this analysis, we will concentrate on those pollutants identified as currently not meeting Air Quality Strategy Objectives in Scotland- namely nitrogen dioxide, particulate matter as PM_{10} and ozone. We will examine the trends in annual mean statistics which reflect the effects on health of long-term exposure to elevated levels of pollution.

5.1 Nitrogen Dioxide (and Oxides of Nitrogen)

Within Scotland (and elsewhere across the UK) the largest numbers of Air Quality Management Areas are currently declared based on exceedences of the annual mean NO_2 objective of 40 $\mu g/m^3$. This is also reflected in the number of monitoring stations recording an exceedence of this objective (see earlier in Section 3 of this report). It is therefore important to understand how trends in this pollutant are changing over time, and whether concentrations are improving or deteriorating.

Trends in NO_2 cannot be considered without also taking into account the variations in total NO_x concentrations, since a large proportion of NO_2 is formed from the oxidation of NO to NO_2 subsequent to its emission from the motor vehicle tailpipe or chimney stack. At roadside locations, direct emissions of NO_2 are also important; the effect of these is discussed in more detail overleaf.

Figure 4 below presents the annual mean variation in measured NO_x concentrations at roadside/kerbside and urban background monitoring stations since reliable measurements began in Scotland in 1987. Despite the limitations in the number of monitoring stations in the early years, it is clear that there has been a smooth and clear long-term improvement in NO_x concentrations due to the progressive reductions in emissions from combustion sources delivered by UK and EC policies.

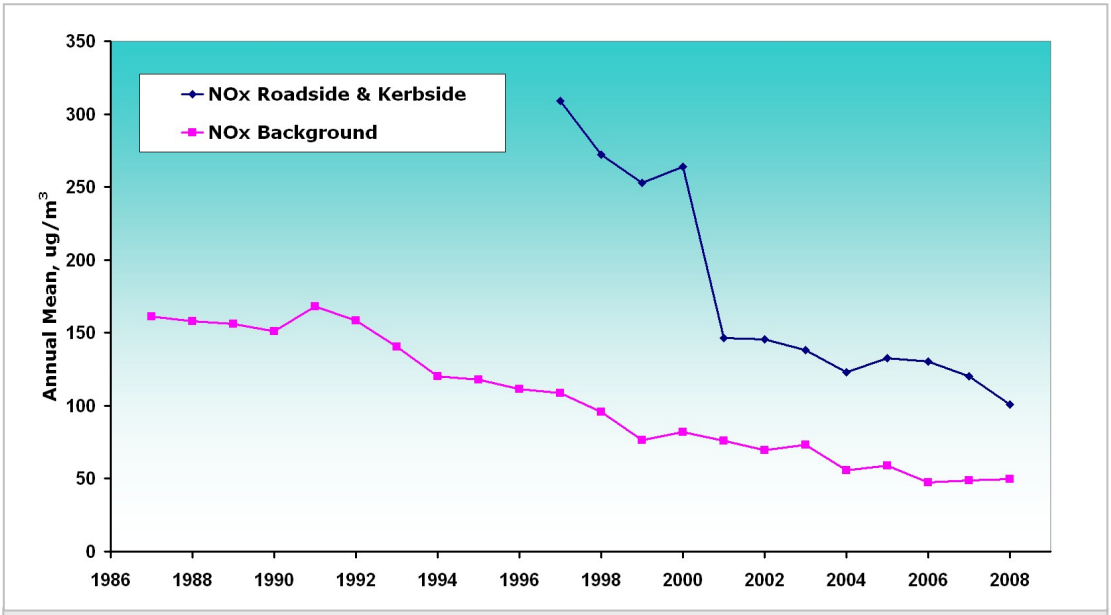

Figure 4 – Trends in NO_x annual means at urban background and roadside sites in Scotland: 1987 - 2008.

Figure 5 below shows the corresponding trends for NO_2, which also indicate a long-term decline in concentrations of this pollutant. In this case, however, the progression is clearly less smooth; this is principally due to the dependence of NO_2 concentrations on atmospheric ozone chemistry and – hence - the predominant weather conditions from year-to-year. Provisionally, 2008 does provide some encouragement in that average roadside concentrations of NO_2 in Scotland were below 40 $\mu g/m^3$ for the first time. This is despite evidence of a levelling-off in the reduction in concentrations in recent years, which UK experts (AQEG 2007) believe may be due to an increase in the proportion of NO_2 emitted directly to the atmosphere due to:

a) The increased market penetration of diesel cars and the retrofitting of pollution control devices, such as catalytically regenerative traps to buses, and
b) Increasing background O_3.

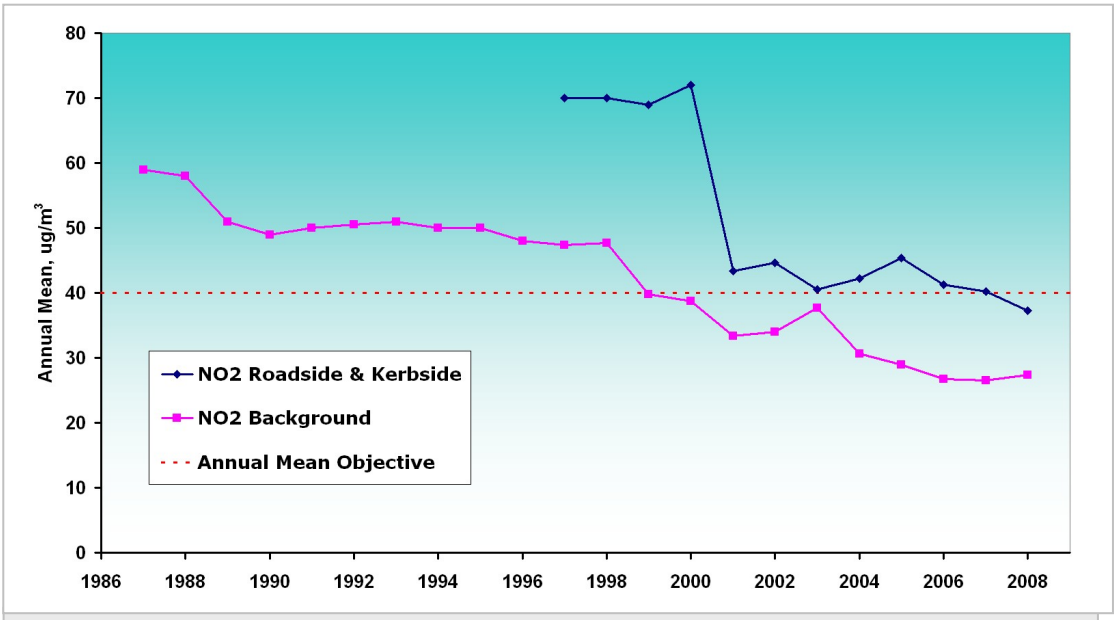

Figure 5 – Trends in NO_2 annual means at urban background and roadside sites in Scotland: 1987 - 2008.

5.2 Ozone

Figure 6 illustrates the increase in background ozone over time; this is small but detectable at rural and remote locations in Scotland, but dramatic and relatively clear at urban background locations.

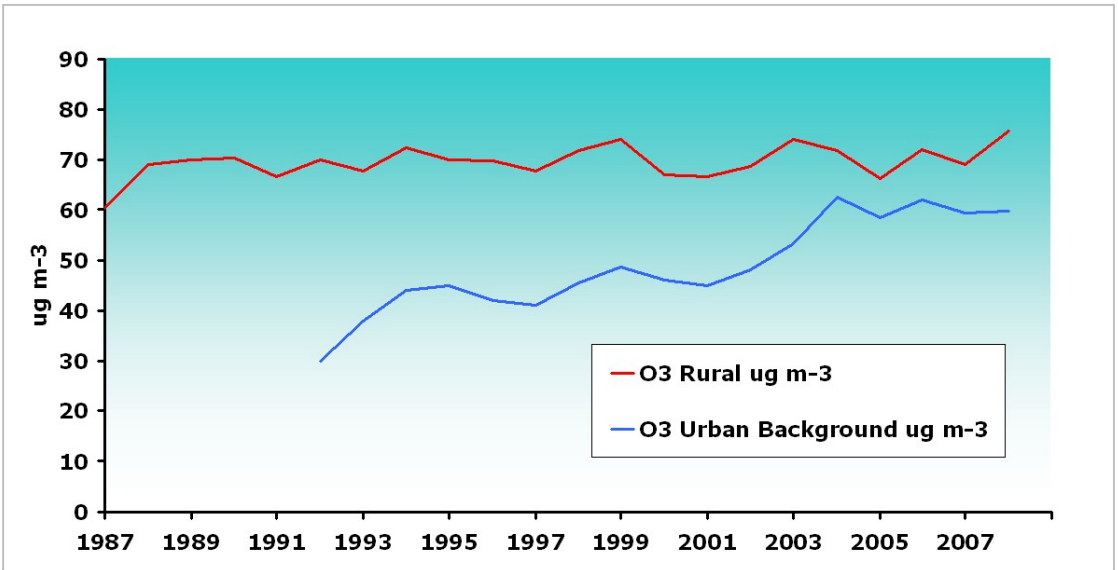

Figure 6: Trends in Ozone at Rural and Urban Background Sites in Scotland: 1987 - 2008.

5.3 Particulate Matter (PM10)

Finally, we examine the trends in PM_{10} particulate matter across Scotland in Figure 7 below. These are of great interest since:

a) Scotland has adopted a more stringent annual mean PM_{10} objective than the rest of the UK for 2010, at 18 $\mu g/m^3$.
b) Scientists do not believe that there is actually a safe level of this pollutant in terms of human health effects.

This figure demonstrates that there has been a general decline in urban background PM_{10} concentrations since 1992, but that - for the last few years - concentrations have hovered around the 18 $\mu g/m^3$ annual mean objective level. Once again there is encouragement in that the provisional 2008 figures show that, for the first time, average background PM_{10} concentrations across Scotland are below the 18 $\mu g/m^3$ objective.

For roadside sites the trend is less clear, mainly due to a large increase in the number of monitoring sites operational from 2005 onwards. This indicator appears to show a decreasing trend from 1997 to 2004, and then a step change up to a slightly higher concentration in 2005 and 2006 followed by decreases again in 2007 and 2008: however, this observation should be interpreted with caution: it may well due to the establishment of several new roadside PM_{10} sites in 2005, at locations where particulate concentration are likely to be high.

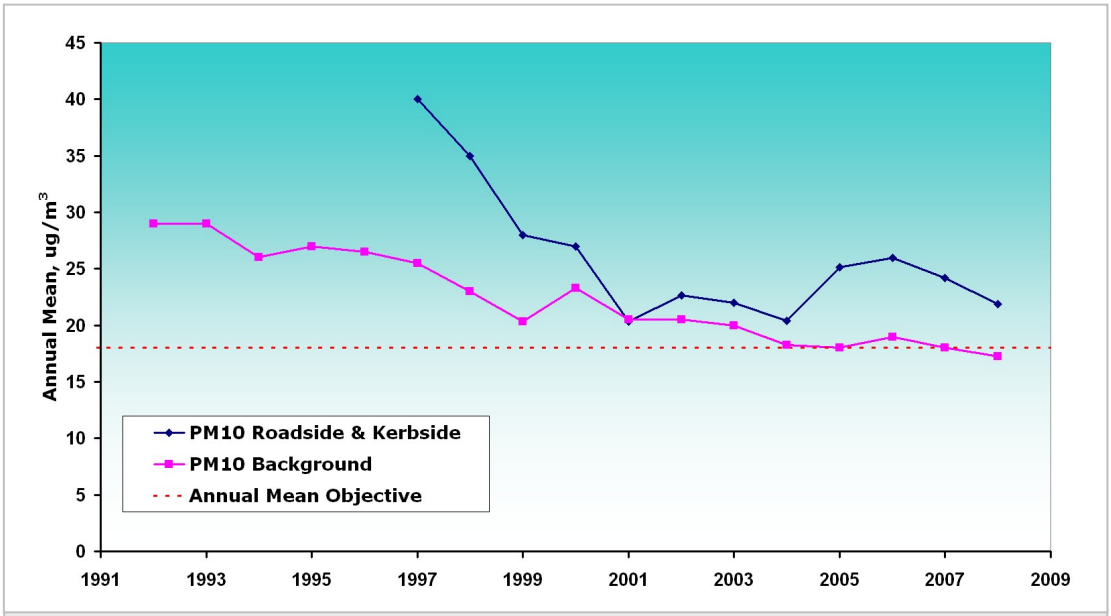

Figure 7 Annual Mean PM_{10} Concentrations in Scotland at urban background and roadside/kerbside locations from 1992 to 2008.

5. Maps of air quality

As part of the overall Air Quality Database project, AEA provides mapped concentrations of pollutants on a 1x1km square grid basis. These pollution maps combine measurement data with the spatially disaggregated emissions information from the National Atmospheric Emissions Inventory (NAEI) to provide estimated pollutant concentrations for the whole of Scotland.

The methodology for producing the Scottish maps is based on that used for producing air pollution maps for the whole of the UK.

In 2008, the focus of AEA's mapping work has been on incorporating data from the Scottish Government Gravimetric Partisol sampling programme into the mapping process to:

1. Produce updated PM_{10} and $PM_{2.5}$ maps for Scotland and
2. Compare these with corresponding maps for the UK as a whole.

For the Scottish Government measurement programme, measurements of PM_{10} and $PM_{2.5}$ were undertaken at five existing AURN sites (Inverness, Fort William, Bush Estate, Eskdalemuir and Dumfries) for one-year at each location. These measurements have considerably increased the range and coverage of particulate data available for Scotland.

The sampling equipment and procedures used for the additional Scottish Government measurements were identical to those used for measurements in the AURN. However, during the course of the measurement programme, evidence emerged of issues with the data determined with these samplers in the UK. This has been the subject of detailed investigations, which have been fully reported. Now that these investigations are complete, the Scottish data have been revisited to provide a reliable dataset which is consistent with similar measurements made throughout the UK.

These new data have now been incorporated into updated PM_{10} and $PM_{2.5}$ maps for Scotland. In addition, the maps now utilise a dispersion kernel derived with Scottish meteorological data obtained from RAF Leuchars.

In conformance with the International Standard for Gravimetric PM_{10} measurements, the data were collected on quartz filters. However, in the UK Particulate sampler equivalence programme, gravimetric samplers were referenced to emfab* filters, as permitted by the new international standard for $PM_{2.5}$ measurement. As the UK is proceeding with gravimetric PM_{10} and $PM_{2.5}$ measurements based on the emfab filters, the quartz-based data have been reduced by $2.5 \mu gm^{-3}$ in the mapping exercise, in order to achieve consistency with the emfab based measurements in the future. The background and roadside maps thus produced are presented in Figure 8 and Figure 9 for PM_{10} and $PM_{2.5}$ respectively.

The Scottish Government will be asking a small number of local authorities to use the Scottish background maps to evaluate the impact of any reduction in PM_{10} on their ability to meet national air quality objectives.

For the purposes of the EU Air Quality Directive, Scotland has been split into two agglomerations (urban areas with population greater than 250,000) –

1. Edinburgh Urban Area
2. Glasgow Urban Area a

And four zones –

1. Scottish Borders,
2. Central Scotland
3. North East Scotland
4. Highlands.

** Emfab filters consist of pure borosilicate glass microfibers, reinforced with woven glass cloth and bonded with PTFE. These filters feature low air resistance for use in critical aerosol sampling tests that demand filter purity and non-hygroscopic properties, such as ambient air monitoring for particulate matter.*

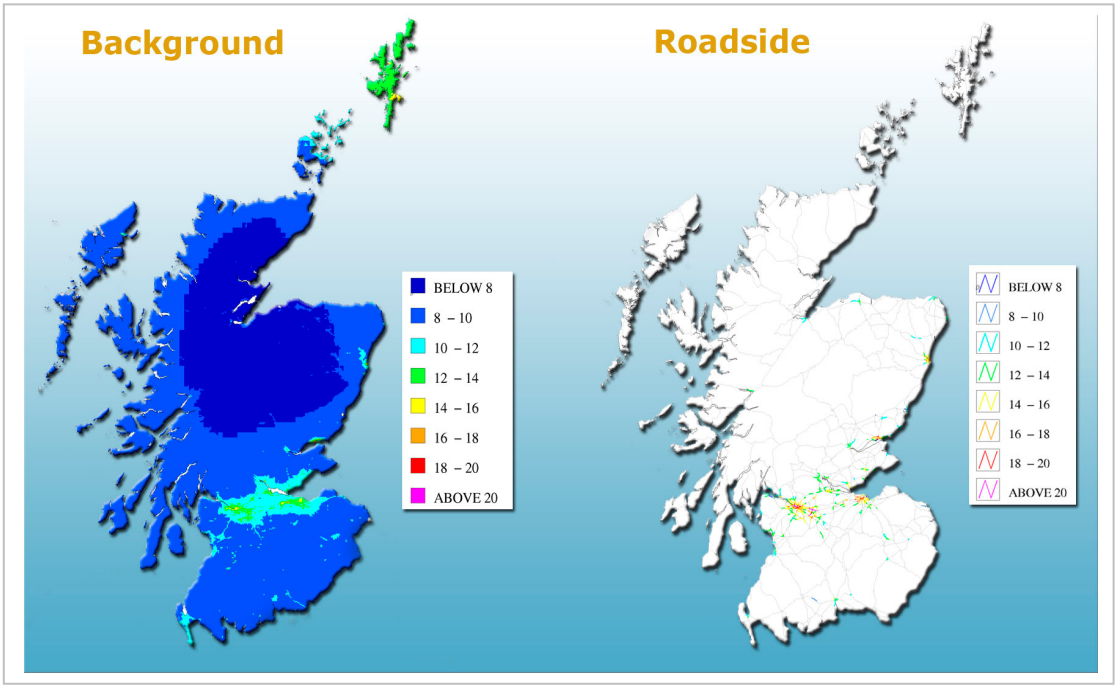

Figure 8 – Gravimetric PM_{10} maps for 2007 μgm^{-3} (Scotland-specific model)

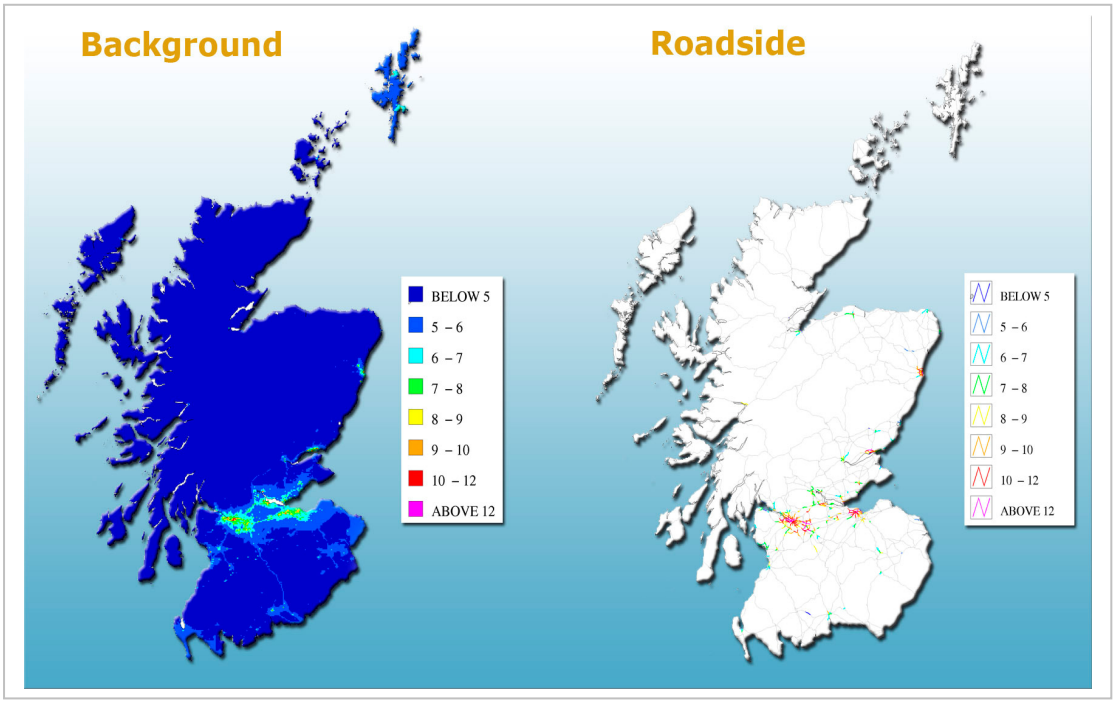

Figure 9 – Gravimetric $PM_{2.5}$ maps for 2007 μgm^{-3} (Scotland-specific model)

Whilst the concept of zones and agglomerations has no specific relevance in terms of the Air Quality Strategy and the Air Quality Objectives for Scotland, it nevertheless provides a coherent and useful framework for discussing the results.

The model outputs have been compared against the Air Quality Objectives for Scotland to determine the extent of exposure to specific concentrations. At background locations, the area and population exposed are assessed. At roadside locations, the number of road links and the length of road exposed are assessed.

The model can only determine annual mean concentrations. Hence, to compare the model output with Objectives based on numbers of exceedences of daily values, it is first necessary to calculate an annual average equivalent to the set number of exceedences. This is achieved by analysis of the available monitoring data.

The calculated annual mean equivalent of the UK wide daily objective of 35 exceedences of 50µgm^{-3} was found to be 31.5µgm^{-3}. By contrast, the calculated annual mean equivalent of the Scotland daily objective of 7 permissible exceedences of 50µgm^{-3} was found to be 22µgm^{-3}. This is based on the relationship between daily 98th percentile and annual mean concentrations across the whole of the UK from 1992 to 2007. Note that this relationship exhibits a lower correlation (0.72) than the 90th percentile (0.90) used to derive the annual mean equivalent for the UK daily objective.

No exceedences of the annual mean PM_{10} objective of 18µgm^{-3} at background locations were identified by the Scotland-specific model. However, the model identified 67 road links exceeding this objective across Scotland, 60% of which (41 road links) were located in Glasgow Urban Area. These 67 road links represent a length of road measuring 82.6km.

No roadside exceedences of this objective were identified by the model in the Highland or Scottish Borders zones. There were no exceedences of 22µgm^{-3} (equivalent to 7 exceedences of the daily Air Quality Objective for PM_{10}) at background locations but for roadside locations there were 5 roads modelled to exceed this, representing almost 10 km, most of which were in the Glasgow Urban Area.

For $PM_{2.5,}$ the Scotland-specific model did not identify any exceedences of the annual mean $PM_{2.5}$ Objective of 12µgm^{-3} at background locations, but did identify a small number of roadside exceedences. These roadside exceedences include 7 road links in total (4 in Glasgow Urban Area and 3 in Central Scotland zone) which represent 12.6km in length. There were no modelled exceedences of 25µgm^{-3} identified at either background or roadside locations

The corrected Scottish Partisol data (and corrected UK Partisol data) have also been incorporated into the process for preparing updated UK-wide particulate matter maps for 2007. The detailed report on the Scottish pollution mapping for 2007 shows that there are only minor differences between the Scotland-specific and UK-wide maps.

1) The Air Quality Scotland Website

The national air quality website, 'Air Quality Scotland' at www.scottishairquality.co.uk - has been created to provide a 'one stop shop' resource for information covering all aspects of air pollution in Scotland.

The site is funded by the Scottish Government. It was designed from the outset to be:

- Accurate and reliable
- Comprehensive
- User-friendly
- Easily navigable
- As interactive as possible
- Able to meet the needs of the general public as well as technical, local government and regulatory user communities.

Recent development work in 2008/9 has focussed on improving the direct user interface to monitoring results through the use of Google™ technology. This has resulted in substantial improvements to web usability, navigability functionality, ease of access and content.

The Air Quality Scotland website provides comprehensive information on:

- Latest up-to-date air quality levels across Scotland, through a variety of interfaces including the latest Google-based data visualisation technologies
- Reports and analysis of trends and historical data
- Information on both national air quality policy and the work of Scotland's Local Authorities
- Descriptions of what causes air pollution, how it is measured, and relevant health, amenity and ecosystem impacts

2) Current and forecast air quality (national and local)

In addition to the Air Quality Scotland website, this information is rapidly available from:

- Teletext page 156
- The Air Pollution Information Service on Freephone 0800 556677
- The UK Air Quality Archive on www.airquality.co.uk

3) General information on Air Quality

- The Scottish Government's Air Quality Management Internet Pages at http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561
- The UK Air Quality Information Archive on www.airquality.co.uk
- The National Atmospheric Emissions Inventory on www.naei.org.uk
- Defra air quality information www.defra.gov.uk/environment/airquality/index.htm

4) Local Air Quality Issues

For further information on air quality issues in your area, please contact the Environmental Health Department at your Local Authority office. Further information on Local Air Quality Management, including AQMAs and progress reports, may also be found at:

- http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561
- http://www.scottishairquality.co.uk/laqm.php
- http://www.laqmsupport.org.uk (the Local Authority support site)

This report has been produced by AEA on behalf of the Scottish Government. Its principal authors are Scott Hamilton, Ken Stevenson, Paul Willis, Andrew Kent and Jon Bower

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