The Scottish Government

Air Pollution in Scotland 2011

AEA

1

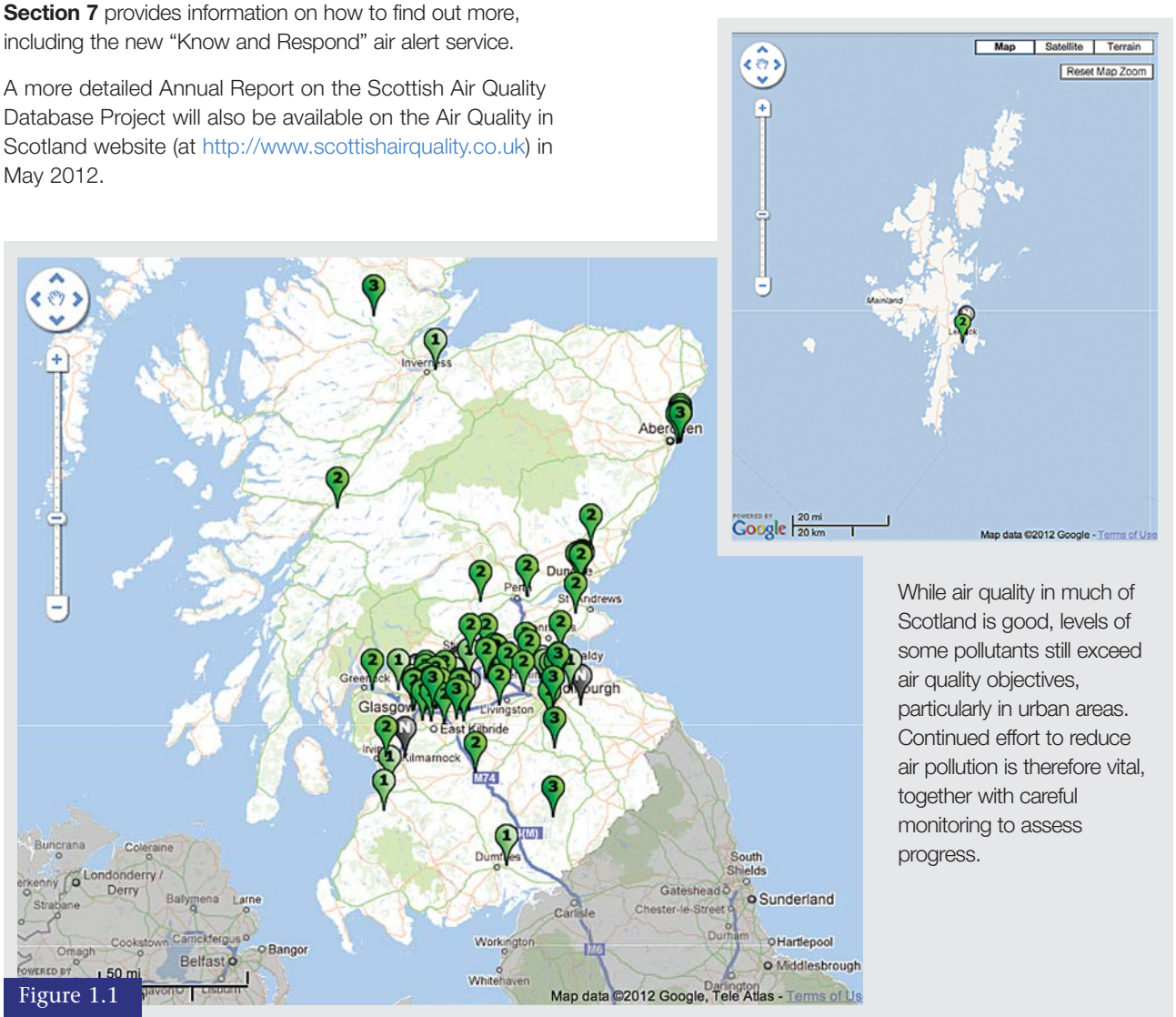
Introduction

This brochure has been produced on behalf of the Scottish Government, and is the fifth in an annual series. It aims to provide a summary of the air quality monitoring and associated work carried out by and on behalf of the Scottish Government and local authorities during 2011.

Section 2 of this brochure reviews the air quality legislation and policy applicable to Scotland. **Section 3** summarises the air quality monitoring carried out in Scotland, and presents an overview of the provisional data from 2011, including exceedances of air quality objectives. **Section 4** provides information on the recent update of the UK Air Quality Index. **Section 5** deals with trends in air pollution in Scotland, and **Section 6** covers spatial patterns of pollution. Finally, **Section 7** provides information on how to find out more, including the new "Know and Respond" air alert service.

A more detailed Annual Report on the Scottish Air Quality Database Project will also be available on the Air Quality in Scotland website (at http://www.scottishairquality.co.uk) in May 2012.

The total number of automatic air quality monitoring sites in the Scottish Air Quality Database during 2011 was 92. During the year, eight new sites started up, and three closed down, leaving 88 sites operating at the beginning of 2012. The locations of the monitoring sites are shown in Figure 1.1.



While air quality in much of Scotland is good, levels of some pollutants still exceed air quality objectives, particularly in urban areas. Continued effort to reduce air pollution is therefore vital, together with careful monitoring to assess progress.

Figure 1.1

Locations of Automatic Air Quality Monitoring Sites in Scotland (courtesy of Google™). (Please note, the colour of the dot showing each site just refers to the air pollution level at the site at the time the screenshot used to generate this map was taken).

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.

2.1 European Union Legislation

Much of the foundation of Scotland's air quality management has its roots within the Air Quality Directives adopted by all Member States of the European Union:

- The European Union's Directive 2008/50/EC on Ambient Air Quality and Cleaner Air For Europe (the Air Quality Directive); and
- Directive 2004/107/EC (the Fourth Daughter Directive) relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

The Scottish Government has duly transposed these Directives into Scotland's national law. A substantial review of the EU's air quality policy, including the Air Quality Directive, is under way, scheduled for completion in 2013.

2.2 The Air Quality Strategy

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (first published in 1997 and revised in 2000 and 2007), establishes a UK wide strategy for tackling air pollution. It is based on strong scientific evidence and a science-based understanding of the effects of air pollutants on health and the environment.

The Air Quality Strategy (AQS) sets objectives for a series of pollutants to be met within the UK. The scientific basis, the objectives set and provisions contained within the Strategy are closely associated with the corresponding limit values set by European Air Quality Directives, as described above. The Strategy's provisions for some pollutants differ from those in the Directives: these differences relate to scientific evidence and expert opinion that is specific to the UK situation. However, all the AQS objectives are at least as stringent as the corresponding limit values applicable within the European Union. For some pollutants (such as PM_{10}), Scotland has adopted more stringent objectives than the rest of the UK.

The full revised AQS and its extended series of associated technical annexes can be seen at: http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116.

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. LAQM requires local authorities to review and assess a range of air pollutants against the AQS objectives, using a range of monitoring, modelling, observations and corresponding analyses. For locations where objectives are not met by the specified 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 and Technical Guidance on LAQM are available online, from http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116.

At the time of writing, 13 of Scotland's 32 local authorities have declared AQMAs. Since last year's edition, six additional AQMAs have been declared: East Dunbartonshire A809 (NO_2 and PM_{10}), Falkirk Banknock (PM_{10}), Fife Dunfermline Appin Crescent (NO_2), West Lothian Broxburn (PM_{10}), North Lanarkshire Croy (PM_{10}) and North Lanarkshire Moodiesburn. In addition, Glasgow's City Centre AQMA for NO_2 has had PM_{10} added to the declaration. There are now 30 AQMAs in Scotland, and a summary is presented in Table 2.1. All Authorities with AQMAs have either prepared, or are currently preparing, Air Quality Action Plans for their AQMAs.

Figure 2.1

A Local Authority Monitoring Site: West Lothian Whitburn

Table 2.1 **Air Quality Management Areas in Scotland**

Council	Pollutant	Main Source	Date Declared	AQMAs
Aberdeen	NO_2 & PM_{10}	Roads	July 2006 December 2008	3
Dundee City	NO_2	Roads	July 2006	1
East Dunbartonshire	NO_2 & PM_{10}	Roads	December 2005 December 2010	2
Edinburgh	NO_2	Roads	Dec 2000, 2006 March 2009	3
Falkirk	SO_2 (1) NO_2 (3) PM_{10} (1)	Industry (SO_2) Roads (NO_2) Industry and roads (PM_{10})	November 2005 March 2010 August 2011	5
Fife	NO_2 & PM_{10} (1) NO_2 (1)	Roads	October 2008 November 2011	2
Glasgow City	NO_2 & PM_{10} (1) NO_2 (2)	Roads	January 2002 July 2007	3
Midlothian	PM_{10}	Domestic	April 2008	1
North Lanarkshire	PM_{10}	Roads	December 2005 June 2008 2011	6
Perth & Kinross	NO_2 & PM_{10}	Roads	May 2006	1
Renfrewshire	NO_2	Roads	September 2005	1
South Lanarkshire	PM_{10}	Roads	November 2008	1
West Lothian	PM_{10}	Roads	March 2011	1

3

2011 Results from Monitoring Networks

3.1 Monitoring in Scotland

A wide range of air quality monitoring is carried out in Scotland. Some monitoring sites are run as part of UK-wide monitoring networks; others are operated by local authorities for LAQM purposes. The following AQS pollutants were monitored in Scotland during 2011:

- Benzene
- 1,3-butadiene
- Carbon monoxide (CO)
- Lead
- Oxides of nitrogen (NO_X), comprising nitric oxide (NO) and nitrogen dioxide (NO_2)
- Particles (as PM_{10}, $PM_{2.5}$ and black carbon).
- Sulphur dioxide (SO_2)
- Polycyclic Aromatic Hydrocarbons (PAH)
- Ozone (O_3)

The locations of automatic monitoring sites are shown in Figure 1.1 (in section 1). These provide high-resolution hourly information on a wide range of pollutants. Data from national network monitoring sites are updated hourly in near-real time on the Scottish Air Quality Database, whilst data from local authority operated monitoring sites are updated either hourly or daily, depending on the station configuration.

Scotland's automatic monitoring is supplemented by non-automatic monitoring techniques, for example the pumped-tube samplers used to monitor benzene, the high-volume samplers used to measure PAH, and the non-automatic techniques used to monitor metals including lead.

3.2 King's College Volatile Correction Model

Many monitoring sites use the Tapered Element Oscillating Microbalance (TEOM) to measure PM_{10}. The relatively high operating temperature of this instrument (necessary to prevent condensation on the filter) can result in the loss of volatile components of the particulate matter sampled, causing under-estimation of the PM_{10} concentration.

However, it is possible to correct for this, using the Volatile Correction Model (VCM) developed by King's College, London. The VCM uses data from Filter Dynamic Measurement Systems (FDMS) PM_{10} analysers in the region (which measure both the volatile and non-volatile fractions) to calculate an appropriate correction based on the location of the instrument and the period of the measurements. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent. To access the model and for more information, visit www.volatile-correction-model.info.

The VCM correction of PM_{10} data in this brochure is based on FDMS data from sites in the national Automatic Urban and Rural Network (AURN): at the time of writing (February 2012), the last three months' data remain provisional pending full ratification at the end of March. It is therefore possible that there could be some changes to the VCM-corrected data, once the ratification process is complete.

3.3 Key Results for 2011

This section provides a summary of results from both automatic and non-automatic monitoring in Scotland in 2011 including compliance with AQS objectives. Further information is provided on the Scottish Air Quality website at www.scottishairquality.co.uk. This will be supplemented by further information and data to be published in the full Annual Report later this year.

The automatic data for 2011 summarised here are not yet fully ratified; there may therefore be subsequent changes to the data which may affect the results presented here.

Benzene

This hydrocarbon is a constituent of vehicle exhaust emissions. Benzene was monitored using a non-automatic pumped-tube sampler at two sites (Glasgow Kerbside and Grangemouth), as part of the UK Non-Automatic Hydrocarbon Network. Both sites had annual mean concentrations well below the AQS objective for the running annual mean.

1,3-Butadiene

1,3-butadiene is also a constituent of vehicle exhaust. This pollutant was monitored at one rural site, Auchencorth Moss in Midlothian, as part of the UK Automatic Hydrocarbon Network. However, there was insufficient valid data for a running annual mean to be calculated. Previous year's annual means have indicated that the AQS objective is met.

Carbon Monoxide

Carbon monoxide (CO) is a product of incomplete combustion, with vehicle exhaust emissions being an important source. It was monitored at five sites in Scotland in 2011; Edinburgh St Leonards, Glasgow Centre, Glasgow Byres Road, Glasgow Anderston and North Lanarkshire Croy. Outdoor concentrations of CO were well within the AQS objective, as they have been for many years.

Lead

This toxic metallic pollutant is emitted from some industrial processes (although emissions are now strictly controlled). Lead is monitored at two non-automatic sites in Scotland: the full dataset for 2011 is not yet available, but previous years' data from both sites have established that ambient concentrations are well within the AQS objective, so no exceedances are expected.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is emitted from most combustion processes, including power generation, domestic heating and vehicle engines. This pollutant was monitored at 71 automatic sites in Scotland during 2011. Thirteen of these achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean, either because of instrument faults, or because the site started up or closed down part way through the year.

Eighteen sites had annual mean NO_2 concentrations greater than the AQS objective of 40 μgm^{-3} (although eight did not meet the AQS data capture target of 90%, and six of these eight had less than 75% data capture). The highest annual mean concentrations were measured at Glasgow Kerbside and Dundee Lochee Road: both sites are close to busy roads.

Figure 3.1 shows annual mean NO_2 concentrations at each site (with at least 75% data capture), based on provisional data. Dundee Lochee Road is not shown in Figure 3.1 because its data capture was less than 75%.

Seven sites exceeded the AQS objective of 200 μgm^{-3} on more than the 18 permitted occasions: these were Dundee Lochee Road, Dundee Seagate, Edinburgh St John's Road, Glasgow Battlefield Road, Glasgow Burgher Street, Glasgow Kerbside and Stirling Craig's Roundabout. Four were sites which had also exceeded the annual mean objective – Dundee Lochee Road, Dundee Seagate, Edinburgh St John's Road and Glasgow Kerbside.

Sulphur Dioxide

Sulphur dioxide (SO_2) is emitted when fuels containing small amounts of sulphur (such as oil and coal) are burned. This pollutant was monitored at 14 sites in 2011. Two of these (Grangemouth and Grangemouth Moray) recorded more than the permitted 35 exceedances of the AQS objective for the 15-minute mean (266 μgm^{-3}) during 2011. All other sites in Scotland met this AQS objective, and those applying to the 1-hour and 24-hour mean.

Particulate Matter as PM_{10}

Particulate matter arises from many sources. It can be directly emitted from combustion processes, or formed from chemical reactions involving other pollutants. Natural sources, e.g. wind-blown dust and sea salt, also contribute. PM_{10} (particulate matter of size 10 microns or less) was monitored at 75 Scottish sites in 2011. No sites exceeded the UK AQS objective of 40 μgm^{-3} for the annual mean. However, Scotland has adopted a more stringent annual mean objective of 18 μgm^{-3}. This objective was exceeded at 24 sites in 2011 (based on VCM-corrected data where TEOMs were used). Three of these annual means were based on less than 75% data capture.

The UK AQS objective for the 24-hour mean PM_{10} concentration is 50 μgm^{-3}, not to be exceeded on more than 35 days per calendar year. All sites in Scotland met this objective. The more stringent Scottish objective requires the daily mean PM_{10} concentration not to exceed 50 μgm^{-3} on more than seven days per year. Nine sites

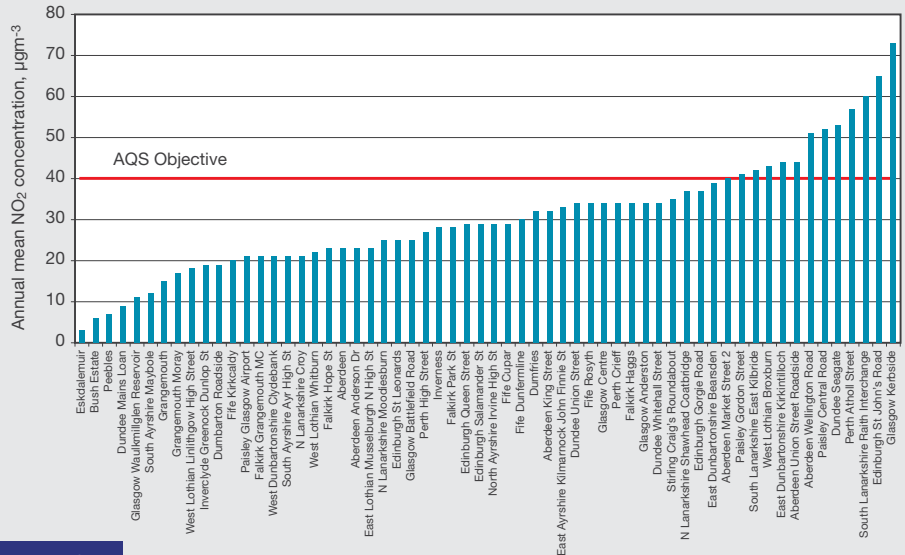


Figure 3.1

Annual Mean NO_2 concentrations (minimum 75% data capture for inclusion).

recorded more than the seven permitted exceedances (Figure 3.2).

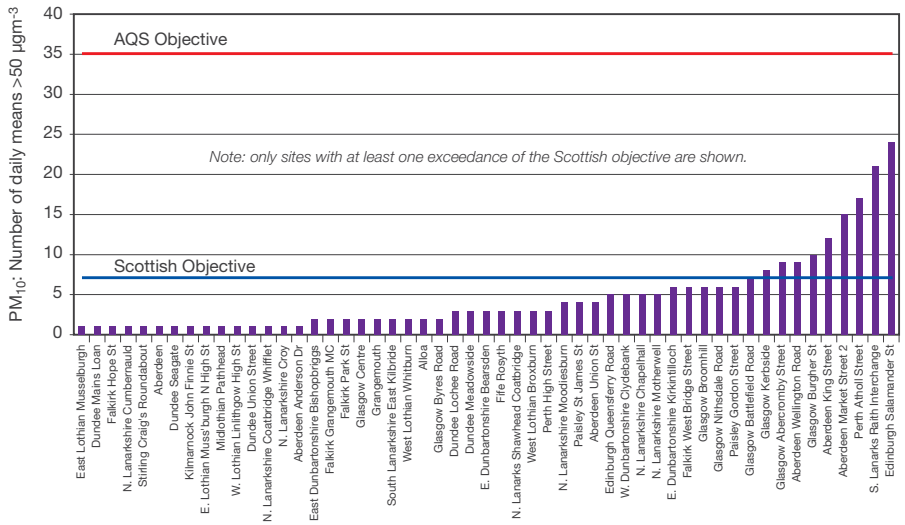


Figure 3.2

Exceedances of Daily Mean Objectives for PM_{10} (Graph shows only sites with at least one exceedance of the Scottish objective).

Particulate Matter as $PM_{2.5}$

The finer particulate fraction $PM_{2.5}$ was monitored at seven sites in Scotland during 2011. The Scottish AQS objective of 12 µgm^{-3} was exceeded at one of these sites: Glasgow Kerbside.

Only the sites in urban background areas are used for monitoring under the EU Air Quality Directive. The Directive sets an exposure reduction target for $PM_{2.5}$, based on the Average Exposure Indicator (AEI). This statistic is the three calendar year running annual mean, averaged over all urban background measurement stations. The "baseline" period is the three years 2009-2011. The reduction required by 2020 depends on the "baseline" AEI. Over the "baseline" period, the mean $PM_{2.5}$ concentration at Scotland's urban background sites was 9.1 µgm^{-3}. Based on this value (which remains provisional until the 2011 dataset is finalised) it is likely that the reduction required in Scotland by 2020 will be 10%. For more information on the Air Quality Directive's provisions regarding $PM_{2.5}$, please see the 2009 report in this series[1].

Polycyclic Aromatic Hydrocarbons

This group of pollutants (referred to as PAHs) is monitored at four sites in Scotland. The full 2011 dataset is not yet available and will be reported in the full Annual Report later this year. In 2010, one site (Kinlochleven) exceeded the AQS objective for benzo (a) pyrene.

Ozone

Ozone is a secondary pollutant – 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 makes it difficult to control by local action. Ozone is monitored at 11 sites in Scotland: of these, three (Bush Estate, Lerwick and Strath Vaich) exceeded the AQS objective of 100 µgm^{-3} on more than the permitted ten days in 2011. All these sites are in rural or remote areas, which often have the highest ozone concentrations.

The AQS objective for ozone is currently not included in regulations, in recognition of the fact that it is transboundary in nature, and that local authorities have very little control over ozone concentrations in their areas.

3.4 Summary

Provisional results from Scotland's network of air quality monitoring stations in 2011 show that measured concentrations of benzene and carbon monoxide continue to meet the applicable AQS objectives.

However, some pollutants at some sites did not meet the AQS objectives. Two sites in industrial areas such as Grangemouth failed to meet the objective for 15-minute mean SO_2. The objective for ozone – which is difficult for local authorities to control – was exceeded at three sites in rural areas. The pollutants for which exceedances were most widespread were NO_2 and PM_{10}. These pollutants are associated with vehicle emissions, and exceedances were particularly prevalent close to busy roads.

1 Scottish Government "Air Pollution in Scotland 2009" [online]. Available at http://www.scottishairquality.co.uk/documents/reports2/281100426_Scottish_Newsletter_2009-vFF4_screenopt.pdf. [Accessed 29 Feb 2012].

4

Update of the Daily Air Quality Index

For over 12 years, a Daily Air Quality Index (DAQI) has been used in the UK to communicate information about current and forecast concentrations of pollution to the public. The index uses a scale of 1-10, divided into four bands (Low, Moderate, High and Very High) to provide a simple indication of pollution levels, similar to the sun index or pollen index. Low air pollution is between 1 and 3, Moderate is between 4 and 6, High is between 7 and 9, and Very High is 10 on the scale. The scale is colour-coded as illustrated in Figure 4.1.

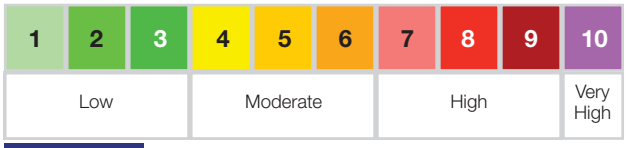


Figure 4.1

Daily Air Quality Index

In 2011, the Committee on the Medical Effects of Air Pollutants (COMEAP) reviewed the (DAQI)[2]. They made recommendations on how the Index (and the information provided to accompany it) should be updated. The main ones were as follows:

- The ten-point scale and four bands should be kept.
- Some of the thresholds between the bands should be lowered, in line with current scientific understanding of the effects of pollutants.
- Carbon monoxide should no longer be included, as outdoor concentrations are now very low.
- Very fine particulate matter (measured as $PM_{2.5}$) should be added to the index, as EU Directives require it to be monitored.
- "Trigger" levels should be set, to provide advanced warning of likely periods of raised pollution levels.

Table 4.1 Daily Air Quality Index – Thresholds of Bands

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	$PM_{2.5}$ Particles	PM_{10} Particles
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour running mean	24 hour running mean
		µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3} (Grav. Equiv.)
Low						
	1	0-33	0-66	0-88	0-11	0-16
	2	34-65	67-133	89-176	12-23	17-33
	3	66-99	134-199	177-265	24-34	34-49
Moderate						
	4	100-120	200-267	266-354	35-41	50-58
	5	121-140	268-334	355-442	42-46	59-66
	6	141-159	335-399	443-531	47-52	67-74
High						
	7	160-187	400-467	532-708	53-58	75-83
	8	188-213	468-534	709-886	59-64	84-91
	9	214-239	535-599	887-1063	65-69	92-99
Very High						
	10	240 or more	600 or more	1064 or more	70 or more	100 or more

[2] COMEAP (2011) "Review of the Air Quality Index" (online). Available at http://www.comeap.org.uk/images/stories/Documents/Reports/comeap%20review%20of%20the%20uk%20air%20quality%20index.pdf. (Accessed 22 Feb 2012).

Table 4.2 Air Pollution Bandings and Health Impacts

Air Pollution Banding	Value	Accompanying health messages for at-risk groups and the general population	
		At-risk individuals*	General Population
Low	**1-3**	**Enjoy** your usual outdoor activities.	**Enjoy** your usual outdoor activities.
Moderate	**4-6**	Adults and children with lung problems, and adults with heart problems, **who experience symptoms**, should **consider reducing** strenuous physical activity, particularly outdoors.	**Enjoy** your usual outdoor activities.
High	**7-9**	Adults and children with lung problems, and adults with heart problems, should **reduce** strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also **reduce** physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should **consider reducing** activity, particularly outdoors.
Very High	**10**	Adults and children with lung problems, adults with heart problems, and older people, should **avoid** strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	**Reduce** physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

*Adults and children with heart or lung problems are at greater risk of symptoms. Follow your doctor's usual advice about exercising and managing your condition. It is possible that very sensitive individuals may experience health effects even on Low air pollution days. Anyone experiencing symptoms should follow the guidance provided at "Additional information on the short-term effects of air pollution" below.

These recommendations have now been implemented, apart from those for ozone which were considered too stringent. The DAQI covers the five pollutants that are most likely to affect health on a day-to-day basis:

- Ozone
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Fine particulate matter (as PM_{10})
- Very fine particulate matter (as $PM_{2.5}$).

The new thresholds between the bands are as shown in Table 4.1.

The DAQI should be used as follows:

1. Determine whether you (or your children) are likely to be at risk from air pollution. Information on groups who may be affected is available online (see the link to the website, below). Your doctor may also be able to give you advice.
2. If you may be at risk, and are planning strenuous activity outdoors, check the air pollution forecast.
3. Use the health messages corresponding to the highest forecast level of pollution as a guide. These are shown in Table 4.2.

The additional information on the short-term effects of air pollution can be found online at http://www.scottishairquality.co.uk/about.php?n_action=standards&t=5#additional

5

Changes over Time: Oxides of Nitrogen

This section summarises how air pollutant concentrations have changed over time in Scotland. This year, the brochure focuses on one specific group of pollutants – oxides of nitrogen (NO_X), which consists of nitric oxide (NO) and nitrogen dioxide (NO_2). Within Scotland (and throughout the UK) the most widely exceeded AQS objective applies to annual mean nitrogen dioxide (NO_2) concentration. It is therefore important to understand how ambient concentrations of this pollutant are varying with time. Temporal variation 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 emitted from source (combustion processes including vehicle engines, industry and domestic fuel use). At roadside locations, direct emissions of NO_2 are also important; the effect of these is discussed in more detail later in this section. (Changes in other pollutants over time will be dealt with in the main report, to be produced later this year.)

Recent years have seen a substantial increase in the number of automatic air quality monitoring sites in Scotland. This has helped improve our understanding of the pollution climate across the country. However, it potentially complicates the investigation of temporal variation in air quality: if such investigations are based on all available data, discontinuities and false trends may be introduced because of changes in the number of monitoring sites, and their distribution. Therefore, in this brochure, investigation of changes over time has been based upon subsets of long-running sites rather than all the sites in the network. This should lead to a more robust assessment.

Figure 5.1 and Figure 5.2 show time series graphs of annual mean concentrations of NO_X and NO_2 respectively, for urban background sites. There are currently 11 such sites in operation: however, only a few have been in operation for long enough to assess trends. Therefore, Figures 5.1 and 5.2 show annual mean concentrations for the following:

- Glasgow City Chambers – the longest-running site, which started up in 1987 and closed in 2011
- Edinburgh Centre, from 1993-2003
- The mean of a subset of three sites in operation from 2004 onwards: Aberdeen, Edinburgh St Leonards and Grangemouth.
- The mean of a subset of five sites in operation from 2007 onwards: this comprises the above sites plus Fort William and Glasgow Anderston.

Please note that Figure 5.1 and Figure 5.2 are shown on different scales. Minimum annual data capture for inclusion is 70%. Glasgow Centre is not included, despite being a long-running site. This is because a diesel generator was operated close to the site during an annual Christmas Market in 2009 and 2010: this is believed to account for unusually high annual mean NO_X results at Glasgow Centre for these years.

In Figure 5.1, the results of the longest-running sites (Glasgow City Chambers and Edinburgh Centre) show a reduction in NO_X concentrations during the late 1980s and 1990s. This may reflect reductions in emissions from combustion sources, achieved by UK and EU policies. However, in later years there is no clear downward slope. The annual means based on subsets of sites do not show a clear decrease in recent years.

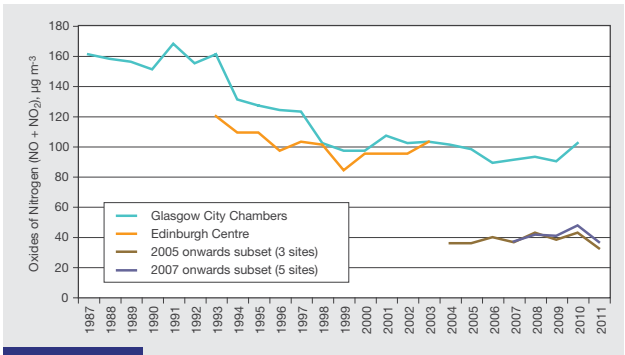


Figure 5.1

Time Series Graph: Annual Mean NO_X at Urban Background Sites, 1987-2011

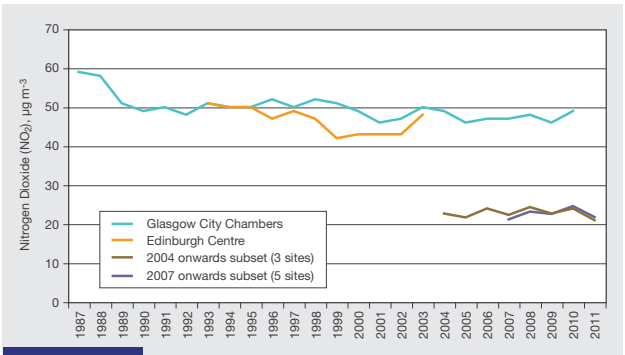


Figure 5.2

Time Series Graph: Annual Mean NO_2 at Urban Background Sites, 1987-2011

In Figure 5.2, longest-running sites (Glasgow City Chambers and Edinburgh Centre) show some indication of a slight long-term decrease in NO_2 concentration. However, the downward slope is much less pronounced than for NO_X. The annual means based on the subsets of sites in operation from 2004 and from 2007 do not show any clear trends.

Figure 5.3 and Figure 5.4 show time series graphs of annual mean NO_X and NO_2 concentrations respectively, for Scotland's roadside and kerbside sites. The same approach has been used as in Figure 5.1 and Figure 5.2, i.e. the graphs each show the annual mean for long-running sites and subsets of sites:

- Glasgow Kerbside, the longest-running traffic-related air quality monitoring site in Scotland.
- The mean of three sites in operation since 2002: Dumfries, Glasgow Kerbside and Inverness.
- The mean of 10 sites in operation since 2007 (Aberdeen Anderson Drive, Aberdeen Union Street, Dumfries, Dundee Lochee Road, Dundee Union Street, Dundee Seagate, Dundee Whitehall Road, East Dunbartonshire Bearsden, East Dunbartonshire Bishopbriggs and East Dunbartonshire Kirkintilloch). Minimum data capture 50%.
- The mean of 26 sites in operation since 2005. These include the above sites, plus Edinburgh Gorgie Road, Edinburgh Queen Street, Edinburgh Roseburn, Edinburgh St John's Road, Falkirk Hope Street, Falkirk Park Street, Fife Cupar, Fife Dunfermline, Glasgow Battlefield Road, Glasgow Byres Road, Glasgow Kerbside, Inverness, Paisley Central Road, Perth Atholl Street, Perth High Street, and West Dunbartonshire Clydebank. Minimum data capture 50%.

Please note that Figure 5.3 and Figure 5.4 are shown on different scales.

There appear to be no clear upward or downward trends in either NO_X or NO_2 at traffic-related sites. 2011 appears to have been a relatively low year.

The Air Quality Expert Group (AQEG) highlighted in 2007 that NO_2 concentrations in the UK as a whole, which had been decreasing, had levelled off in recent years. AQEG believe this may be due to[3]:

- Increased market penetration of diesel cars, and the retrofitting of pollution control devices (such as catalytically regenerative traps) to buses: this has had the effect of increasing the *proportion* of total NO_X emitted as NO_2.
- Increasing background concentration of O_3, which promotes the oxidation of emitted NO to NO_2.

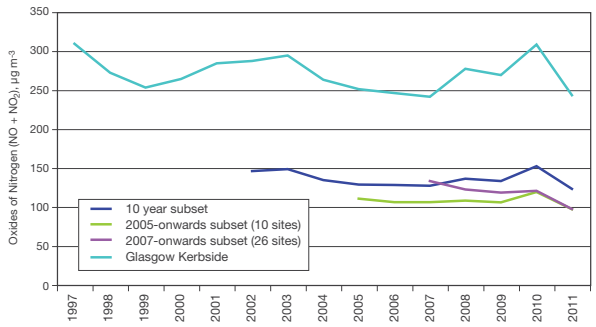


Figure 5.3

Time Series Graph: Annual Mean NO_X at Kerbside and Roadside Sites, 1997-2011

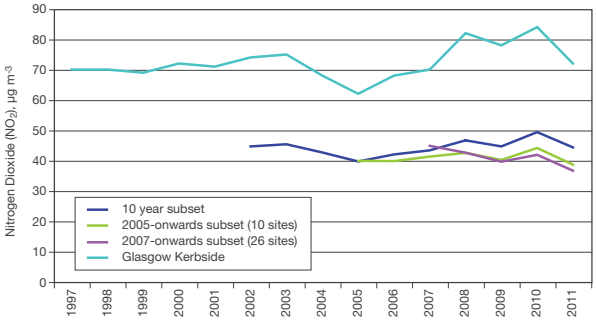


Figure 5.4

Time Series Graph: Annual Mean NO_2 at Kerbside and Roadside Sites, 1997-2011

[3] Air Quality Expert Group (2007) "Trends in primary nitrogen dioxide in the UK" [online]. Available at http://archive.defra.gov.uk/environment/quality/air/airquality/publications/primaryno2-trends/documents/primary-no-trends.pdf. [Accessed 24 Jan 2012].

6

Maps of Air Quality

As part of the Scottish Air Quality Database project, AEA calculates maps of modelled pollutant concentrations on a 1 x 1 km square grid basis. These pollution maps combine measurements from Scottish air quality monitoring sites, emissions data from the National Atmospheric Emissions Inventory (NAEI), and Scottish meteorology data (from RAF Leuchars) to provide estimated pollutant concentrations for the whole of Scotland. Roadside and background concentrations are modelled.

This section discusses some of the maps of pollutant concentrations produced for the Scottish Government. The full range of maps, together with a technical report describing the method[4], will be published on the "Maps" page of the Scottish Air Quality website at http://www.scottishairquality.co.uk/maps.php.

In this year's brochure, we have focused on oxides of nitrogen and PM_{10}. The other pollutants will be discussed in the main report, to be produced later in 2012. Only the background maps are discussed here: the roadside maps can be viewed on the Scottish Air Quality website, and will be included in the main report to be produced later this year.

6.1 Oxides of Nitrogen: Maps for 2010

The 2010 annual mean concentration of total NO_X and of NO_2 were modelled for Scotland at roadside and background locations. The emissions factors used to produce these maps have been updated, in the light of a report[5] published in 2011. This report investigated the reasons why ambient NO_2 concentrations have decreased less than would be expected on the basis of estimated emissions. The report concluded that several factors were involved, including:

- An increase in the proportion of NO_X emitted as NO_2.
- Older vehicles may emit more NO_2 than was previously thought.
- An increased proportion of diesel vehicles.
- Selective catalytic reduction (SCR) NO_X-reduction systems, used on HGVs, are ineffective under slow urban driving conditions.

The emission factors have been updated accordingly and used to produce the 2010 maps. More details will be provided when the maps are published online.

Figure 6.1 shows modelled annual mean background concentrations of NO_X and NO_2 for the whole of Scotland, and for the central area of the country where most of the urban areas are located. Throughout much of Scotland, modelled concentrations of both NO_X and NO_2 concentrations were low (less than 10 µg m^{-3}). Higher concentrations are evident within built-up areas due to combustion-derived NO_X emissions, mainly from road transport. The outlines of the major cities, and the main road links between them, are clearly visible.

Areas coloured yellow, orange or red indicate background concentrations greater than 40 µg m^{-3}. In the case of nitrogen dioxide, this is the case only for a small area in central Glasgow, and a small area on the coastline at Aberdeen. This is consistent with the monitoring results: all the sites that exceeded the AQS objective of 40 µg m^{-3} in 2010 and 2011 were roadside or kerbside.

6.2 PM_{10}: Maps for 2010

The 2010 annual mean concentrations of PM_{10} (as gravimetric equivalent) were modelled for Scotland at background and roadside locations (Figure 6.2). Again, only the background maps are discussed here: the roadside maps will be published on the Scottish Air Quality website.

Throughout much of Scotland, the 2010 ambient PM_{10} concentrations were low. Typically PM_{10} concentrations were less than 10 µg m^{-3}, and therefore well below the Scottish objective of 18 µg m^{-3}. As in previous years, the spatial variation of PM_{10} reflects the location of built-up areas, major road links, and the contribution of combustion derived PM_{10} emissions to ambient concentrations. For example, the A74 heading southwards from Glasgow towards the border is clearly visible in Figure 6.2.

Road transport is not the sole source of ambient PM_{10}. Other components include:

a) secondary inorganic aerosols (e.g., sulphate, nitrate, ammonium)

b) secondary organic aerosols

c) long range transport primary component

d) sea salt contributions, and

e) iron and calcium associated dusts.

[4] Lingard J.J.N., and Kent A.J.: Scottish air quality modelling for 2008 and projected concentrations for 2010, 2015 and 2010: annual mean PM_{10}, NO_X and NO_2. AEAT/ENV/R3030 Issue 1. http://www.scottishairquality.co.uk/documents/reports2/296100915_ScottishAQmapping2008_Issue1.pdf (Accessed 29 Feb 2012).

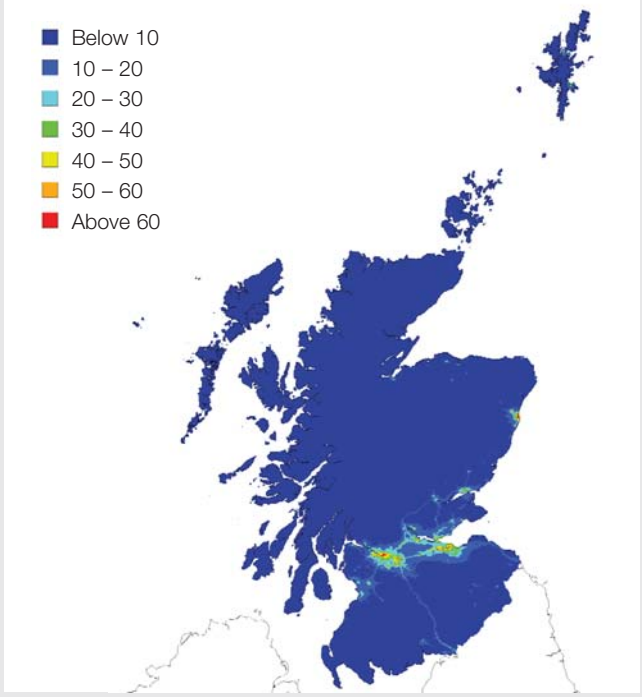
[5] Carslaw D., Beevers S. Westmoreland E., Williams M., Tate J., Murrells T., Stedman J., Li Y., Grice S., Kent A., Tsagatakis I. (2011). "Trends in NO_X and NO_2 emissions and ambient measurements in the UK. Version: 18th July 2011". [online]. Available at http://uk-air.defra.gov.uk/reports/cat05/1108251149_110718_AQ0724_Final_report.pdf (Accessed 22 Feb 2012).

These natural and secondary components contribute to the total PM_{10} mass particularly in background areas where there are few combustion sources. Wind-blown sea salt and dusts, e.g. soil, are believed to be the source of the relatively higher PM_{10} concentrations along the east coast and in Shetland.

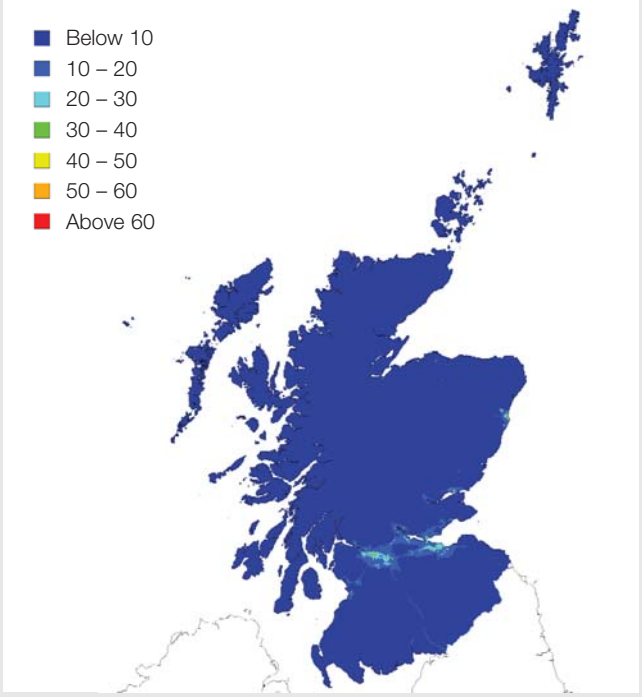
Figure 6.2 includes an enlarged image of the central belt of Scotland. The influence of road traffic emissions is clearly visible. The triangle of roads formed by the M8, M9 and A80 linking Glasgow, western Edinburgh and Falkirk can be clearly seen.

The modelled annual mean PM_{10} concentration exceeded the Scottish PM_{10} objective by 2 µg m^{-3} in two locations. These are shown as red in the maps. The first of these is in the area located on the western outskirts of Edinburgh, around the junction of the M9, M8 and A8. This location is also close to Edinburgh airport and contains various industrial sources which were believed to contribute to the elevated modelled PM_{10} concentrations in this area. The second location is in the Chapelhall area of North Lanarkshire, close to the junction of the A8 and M8 and other major roads. In addition there are various industrial sources in the vicinity.

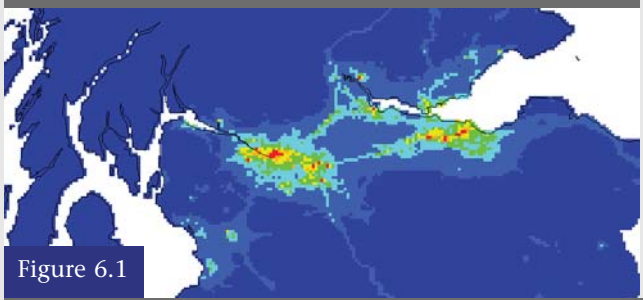
NO_X – All Scotland



NO_2 – All Scotland



NO_X – Central areas



NO_2 – Central areas

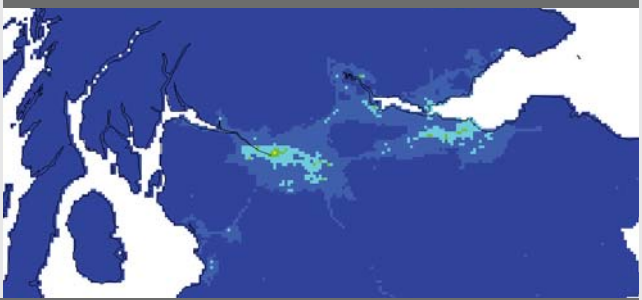


Figure 6.1

2010 background annual mean NO_X and NO_2 concentration in Scotland (Scotland-specific model, µg m^{-3}).

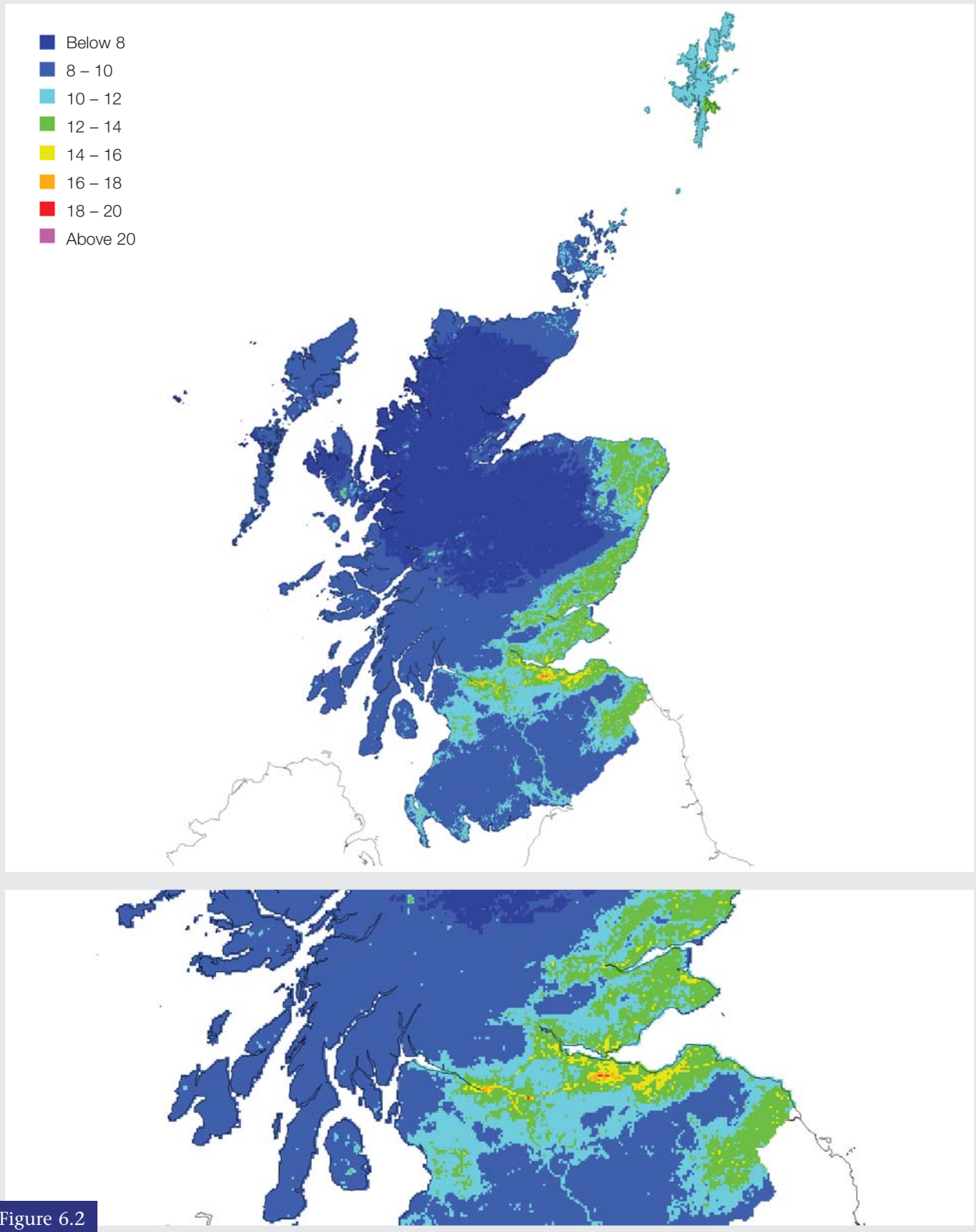


Figure 6.2

2010 background annual mean PM_{10} concentration in Scotland (Scotland-specific model, µg m^{-3}).

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More Information

Know and Respond – Scotland

In January 2012, the new Know and Respond air pollution alert service was launched in Scotland. This free service, funded by the Scottish Government, provides alert messages, via text or e-mail, when poor air quality is forecast for the day ahead. It is aimed at people with health problems that may make them sensitive to air pollution. Scotland is the first country within the UK to provide this service on a national basis.

To find out more about Know and Respond, or to register yourself (or someone you look after), please see the Know and Respond web pages at http://www.scottishairquality.co.uk/know-and-respond/.

Where to find out more about Air Quality in Scotland:

More information on air quality in Scotland can be found on the Scottish Air Quality web pages at http://www.scottishairquality.co.uk

The Scottish Government's Environment web pages at http://www.scotland.gov.uk/Topics/Environment and the Scotland's Environment web pages at http://www.environment.scotland.gov.uk/ provide information on a range of environmental issues including air quality and climate change.

National and local air quality forecasts are available from:

- The Air Pollution Information Service on freephone 0800 556677
- The Defra UK Air Information Resource (UK-AIR) at http://uk-air.defra.gov.uk/

For information on air quality issues in your local area, please contact the Environmental Health Department of your local authority.

The Scottish Government

AEA

This report has been produced by AEA on behalf of the Scottish Government.

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