AEAT/ENV/R/1260 Issue 1

Air Quality Monitoring in Northern Ireland, 2000-2001

A report produced for the Department of the Environment in Northern Ireland in partnership with the Chief Environmental Health Officers Group.

ENVIRONMENT AND HERITAGE SERVICE

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Investing for Health

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November 2002

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Contact Details for netcen:

A Loader
netcen
Culham Science Park
ABINGDON
OX14 3ED
Telephone 01235 463133
Facsimile 01235 463011
netcen is an operating division of AEA Technology plc
netcen is certificated to ISO 9001 and ISO 14001

Contact Details for Environment and Heritage Service:

Environment and Heritage Service
Air and Environmental Quality Unit
Calvert House
23 Castle Place
BELFAST
BT1 1FY
Telephone: 02890 254758
Facsimile: 02890 254793
Web site: www.ehsni.gov.uk

	Name	Signature	Date
Author	A Loader P Willis J Lampert		21/11/02
Reviewed by	K Stevenson		21/11/02
Approved by	P Willis		21/11/02

"Our aim is to protect and conserve the natural and built environment and to promote its appreciation for the benefits of present and future generations."

Foreword

The link between clean air and good health is well-known. High levels of air pollution can help to make people ill and it can contribute to the premature death of those already seriously ill. Clean air is therefore essential to the health and well-being of us all.

Implementing the Air Quality Strategy is a vital part of the Department of the Environment's commitment to improving air quality. Local air quality management is central to the Strategy. Legislation will soon be introduced to enable Government Departments, District Councils and stakeholders to deliver their contribution to meeting air quality targets and objectives. In meeting these targets and objectives, we will also be fulfilling our commitment to 'Investing for Health', to reduce the levels of respiratory and heart disease.

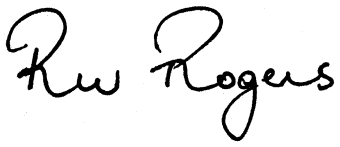
The Department has been most encouraged by the work already carried out by District Councils. All 26 Councils have completed the first stage of the review and assessment of air quality within their respective areas and are currently working to complete stage 2. Funding has been provided by the Department to assist Councils in this review and assessment process.

This Report provides a comprehensive view of air quality in Northern Ireland in 2000 and 2001. It has been drawn up in partnership with the Chief Environmental Health Officers Group (CEHOG). CEHOG has welcomed the publication of this report and is pleased to have been involved in this important partnership in collating and providing air quality monitoring data from District Council sites.

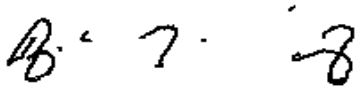
Since air quality is so important to our own health and our environment, we intend to publish annual Reports. We look forward to strengthening our close working relationship with CEHOG.

The Report will be an invaluable reference point. Readers will be able to assess compliance with air quality standards and air quality trends over time.

We commend this Report to you and would welcome any comments you may have.



Richard Rogers
Chief Executive Environment and Heritage Service



John Michael
Chairman of the Chief Environmental Health Officers Group

Executive Summary

This report presents a summary of air quality in Northern Ireland over the calendar years 2000 and 2001. It is intended to bring together in one report, results from all the District Councils and other organisations who carried out air quality measurements in Northern Ireland over this period, both as part of larger monitoring networks and for other purposes. It aims to provide information on the main pollutants of concern, details of the air quality monitoring undertaken in 2000 – 2001, and a summary of results for each pollutant.

On the basis of results from 2000 and 2001, the following pollutants appear not to present a problem with respect to meeting air quality objectives in Northern Ireland: carbon monoxide (CO), particulate matter (PM_{10}), benzene, 1,3-butadiene, lead and other metals. Occasional exceedences may occur in the case of ozone, particularly in rural locations. However, these are likely to be infrequent, and related to meteorological conditions; ozone is, in any case, a transboundary pollutant and difficult to control by local action.

The monitoring results indicate that the following pollutants may present a problem in meeting air quality objectives, in some parts of Northern Ireland:

- Sulphur dioxide: in residential areas where there is a high incidence of domestic solid fuel burning, there may be difficulty in meeting objectives relating to the 15-minute and 24-hour means.
- Benzo(a)pyrene and other polycyclic aromatic hydrocarbons (PAHs), again in solid-fuel burning residential areas.
- Possibly nitrogen dioxide (NO_2) at a few urban roadside locations.

Historically, there has been limited availability of natural gas in Northern Ireland, which has necessitated the widespread domestic use of solid fuels and oil. Inevitably, this has led to some residential areas having relatively high levels of pollutants associated with coal burning (sulphur dioxide, PAHs and in some cases smoke). Therefore, these remain the pollutants of concern for some parts of the region. However, as natural gas becomes more widely used in Northern Ireland, it is likely that ambient concentrations of these pollutants will decrease.

Carbon monoxide was monitored using automatic techniques at two sites (Belfast and Londonderry). Both met the EC 2nd Daughter Directive limit value and UK Air Quality Strategy (AQS) objective for this pollutant in 2000 and 2001.

Nitrogen dioxide was monitored using the automatic chemiluminescent technique at four sites: Belfast Centre, Londonderry and two in Newry. No sites exceeded the 1st Daughter Directive limit and AQS objective of 200 μg m^{-3} for the hourly mean, more than the permitted 18 times per year in 2000 or 2001. The annual mean was found to be below the limit value of 40 μg m^{-3} at all four sites.

Nitrogen dioxide was also monitored on a monthly basis using passive diffusion tube samplers at 128 sites in 2000 and 155 sites in 2001. The EC 1st Daughter Directive limit value and AQS objective for the annual mean (40 μg m^{-3}) was exceeded at four sites in 2000 (three Roadside and one Intermediate), and at six sites in 2001 (all Roadside). All these sites were either in urban centres close to busy main roads, or in smaller town centres at locations where traffic queues form. Annual average NO_2 concentrations for 2000 and 2001 were comparable to those reported by the NO_2 Network for Northern Ireland.

Sulphur Dioxide (SO_2) was monitored at five sites (central and eastern Belfast, Londonderry and two in Newry) using automatic techniques. All automatic sites except Belfast East met the 1st Daughter Directive limit values and AQS objectives. Belfast East exceeded the AQS objective for the 15-minute mean in both 2000 and 2001, and exceeded the EC 1st Daughter Directive limit value and AQS objective for the 24-hour mean in 2001. This site (and possibly similar locations) may have difficulty in meeting this EC limit value and these AQS objectives for sulphur dioxide by the required dates in 2004 and 2005.

A further 31 urban sites monitored sulphur dioxide using the non-automatic net acidity method. In 2000, one site in Dunmurry exceeded the 24-hour limit value for SO_2 (125 μg m^{-3}) on more than the permitted three days. In 2001, three sites in Belfast exceeded this limit value on more than three days. The 2001 exceedences were associated with episodes of high SO_2 during January and February 2001.

Particulate matter as PM_{10} was monitored at six sites (two in Belfast, one in Londonderry, two in Newry and one rural location, Lough Navar). All of these met the EC 1st Daughter Directive limits and Air Quality Strategy objectives relating to annual and daily averages, for PM_{10}.

Particulate matter was also measured using the older "black smoke" method, at 31 urban sites. The limits set for smoke by EC Directive 80/779/EEC (on sulphur dioxide and suspended particulates) remain in force until 2005, and require demonstration of compliance. No Northern Ireland sites have exceeded any of the limit values of Directive 80/779/EEC relating to smoke, since 1990. However, levels remain relatively high in residential areas where domestic solid fuel use is prevalent.

Ozone was monitored at four sites: three using automatic techniques (Belfast, Londonderry and Lough Navar) and one using diffusion tubes (in Fermanagh). In 2000, one of the automatic monitoring sites (at Londonderry) exceeded the target value of the latest EC Ozone Directive (2002/3/EC) and the AQS objective, on more than the permitted ten days.

Benzene and 1,3-butadiene were monitored at Belfast South until 2000, as part of a monitoring programme which concluded at the end of that year. Both pollutants were within AQS objectives in 2000.

Polycyclic aromatic hydrocarbons were monitored at two sites: Lisburn and Belfast. Annual mean benzo(a)pyrene concentrations for 2000 and 2001 were above the new AQS objective (currently applicable only to England, Scotland and Wales) of 0.25 ngm^{-3}. Those at Lisburn were very close to the proposed EC target value of 1.0 ngm^{-3} for this PAH. Benzo(a)pyrene concentrations at Lisburn were particularly high, with annual means of 0.93 ngm^{-3} in 2000, and 0.96 ngm^{-3} for 2001. These values are considerably higher than those measured at most urban sites in the UK, and closer to those typically found in industrial areas than in residential suburbs. The major source of PAH is the widespread use of domestic solid fuels in this area.

The metals lead, cadmium, arsenic, nickel and mercury were monitored at three industrial sites (Campsey, Whitehead and Belfast Harbour) over a twelve-month period, December 1999 to November 2000. Annual mean concentrations of lead were well within EC and AQS limits. Annual means of cadmium, arsenic, and nickel were well within *proposed* EC Directive target values (which have not yet been finalised). These metallic pollutants are unlikely to constitute a serious problem in Northern Ireland.

Trends in ambient concentrations were investigated for all pollutants where sufficient years' data were available, and in some cases significant downward trends were identified. However, by contrast, average pollutant concentrations in 2001 were, in many cases, slightly higher than those recorded in 2000. Such fluctuations are likely to be due to variations in factors such as meteorology; however they highlight the need for continued monitoring of air quality.

District Councils in Northern Ireland are currently engaged in the Local Air Quality Management Review and Assessment process. When complete, the results may highlight further areas of concern with respect to air quality. In addition, a substantial number of new automatic monitoring sites are being established throughout the region. These, too, will assist in identifying areas where action may be needed to improve air quality.

Contents

1 Introduction

1.1 BACKGROUND

This report on air quality monitoring in Northern Ireland has been produced for the Department of the Environment, by **netcen** (an operating division of AEA Technology Environment). It combines data from large-scale networks such as the Automatic Urban Network and Non-Automatic Networks, with data from the considerable number of other monitoring sites operated by Northern Ireland's District Councils. The former data are provided by **netcen**: the latter have been collected and compiled by the Pollution Control Group of the Chief Environmental Health Officers Group (CEHOG) for Northern Ireland. The period covered is calendar years 2000 and 2001. The report follows on from the series of six previous reports produced by CEHOG.

Long term, quality assured monitoring is an important feature of the assessment and control of air pollution. With appropriate analysis and interpretation, air quality monitoring data can be used for:

- Establishing a sound scientific basis for policy development;
- Determining compliance with air quality objectives and guidance;
- Assessing air quality trends;
- Assessing the effectiveness of control policies;
- Research needs;
- Public information; and
- National and local air quality management.

Much of Northern Ireland is rural, and in such areas air quality is usually good. However, urban localities experience generally higher levels of pollution. Historically, there has been limited availability of natural gas in Northern Ireland; as a result, domestic use of coal, solid fuels and oil has remained relatively widespread. Therefore, levels of pollutants associated with domestic solid fuel burning, such as sulphur dioxide (SO_2), and particulate matter (smoke and PM_{10}) can be particularly high in parts of Northern Ireland. Oxides of nitrogen (NO and NO_2) are also pollutants of concern in some urban areas; the dominant source of these pollutants is thought to be motor vehicles. This is an area over which District Councils currently have no regulatory control. The need for greater control over, or restrictions on emissions from vehicles will only become clear once District Councils complete their Review and Assessment of local air pollution.

1.2 OBJECTIVES

Air quality monitoring in Northern Ireland is carried out by various District Councils and other bodies. Techniques used range from simple passive samplers to sophisticated continuous analysers. Some monitoring sites are part of larger networks; others are not. This report aims to bring together all air quality monitoring data obtained for Northern Ireland in 2000 and 2001. It is intended to assist District Councils in their ongoing Review and Assessments of local air quality by:

- providing information on the main pollutants of concern,
- setting out details of the air quality monitoring undertaken in 2000 and 2001, and
- presenting a summary of results and trends from monitoring sites.

It is not intended that this report will make specific comment or recommendations on air quality monitoring in Northern Ireland. The need for additional monitoring within individual District Council areas should be identified as part of the ongoing Review and Assessment process (referred to later). This report is intended to be primarily an update on developments in the field of air quality and a summary of air quality data across Northern Ireland for 2000 and 2001.

2 Air Quality Developments in 2000 and 2001

2.1 THE EUROPEAN UNION

The European Council Directive 96/62/EC on Ambient Air Quality Assessment and Management, (The Framework Directive), establishes a framework under which the EU will agree air quality limit values for specified pollutants in a series of 'Daughter Directives'. These will supersede existing air quality legislation. It is envisaged that the structures established under the UK Air Quality Strategy and supporting legislation will provide the principal means of implementing the UK's commitments under this Directive. So far, three Daughter Directives have been agreed:

- The first Daughter Directive (1999/30/EEC), covering sulphur dioxide (SO_2), oxides of nitrogen, particulate matter as PM_{10}, and lead, came into force on 19 July 1999. This Directive contains limit values for these pollutants, aimed at protection of human health and of ecosystems. This Directive was transposed by The Air Quality Limit Values Regulations (Northern Ireland) 2002.
- The second Daughter Directive (2000/69/EC) covers carbon monoxide (CO) and benzene. It came into force on 13 December 2000. It is intended that this Directive will be transposed later this year by The Air Quality Limit Values (Amendment) Regulations (Northern Ireland) 2002.
- The third Daughter Directive (or EC Ozone Directive, 2002/3/EC) came into force in 2002 and is scheduled for transposition in 2003.

The remaining pollutants listed in the Framework Directive are polycyclic aromatic hydrocarbons (PAHs), and the metallic elements cadmium, arsenic, nickel and mercury. The European Commission is working on proposals for a fourth Air Quality Daughter Directive covering these. The aim is to set ambient air quality target values, from 2010, for arsenic, cadmium, nickel and polycyclic aromatic hydrocarbons (PAHs); some target values have been proposed but not yet agreed.

2.2 THE AIR QUALITY STRATEGY

The first Air Quality Strategy (AQS) was published in 1997, setting out policies for the management of ambient air quality and thus fulfilling the requirement of the Environment Act 1995 for a national air quality strategy. Pollutants originally covered by the strategy are: benzene, 1,3-butadiene, carbon monoxide, lead, oxides of nitrogen, particulate matter (as PM_{10}) and sulphur dioxide. The strategy sets out a strategic framework within which air quality policies will be taken forward in the short to medium term, and sets objectives to be met by 2005 for the air pollutants covered. The Strategy was subsequently reviewed, and a revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in January 2000. Air Quality Strategy objectives are discussed in the subsequent sections of this report which deal with the individual pollutants.

Following a recent consultation process on the revised Air Quality Strategy, it was announced by Defra, the Scottish Executive and the Welsh Assembly in 2002 that the AQS objectives for carbon monoxide and benzene are to be brought into line with those set by the 2nd Daughter Directive. In addition, further PM_{10} objectives have been set for 2010 and for the first time, an objective for polycyclic aromatic hydrocarbons (PAHs) has been added. These new Air Quality Strategy objectives at present only apply to England, Scotland and Wales. No policy decision has yet been taken on the inclusion of these objectives for Northern Ireland in the revised Air Quality Strategy addendum. Therefore, this report compares monitoring results only with the objectives currently applicable in Northern Ireland, except in the case of PAHs.

2.3 LOCAL AIR QUALITY MANAGEMENT REVIEW AND ASSESSMENT

Under the Environment Act 1995, Local Authorities in England, Scotland and Wales are required to carry out a Review and Assessment of their local air quality. The process involves a three stage phased approach.

Stage 1 is an initial screening of industrial, transport and other sources, such as domestic emissions, which have a significant impact within the local authority area and the identification of pollutants of concern locally. Every Authority must carry out Stage 1. If this indicates a possible exceedence of any Air Quality objective, the Authority should proceed to Stage 2.

Stage 2 is a more detailed screening assessment of all the pollutants identified as significant locally in the first stage; if this indicates that relevant objectives may not be met, it will be necessary to proceed to Stage 3.

Stage 3 is an accurate detailed review of pollutants, using monitoring and computer modelling techniques to predict the likelihood of exceeding the AQS objectives. An Air Quality Management Area (AQMA) must be declared after this stage if the review establishes that AQS objectives are likely to be exceeded after the relevant target date.

At the time of writing, almost all Local Authorities in England, Wales and Scotland have completed this process. The Review and Assessment process in Northern Ireland was to be given a statutory basis by the Local Air Quality Management Bill. This Bill was introduced in the Northern Ireland Assembly in June and was at Committee Stage in the legislative process when suspension of the Assembly occurred on 13 October. The provisions of the Bill are now contained in the draft Environment (Northern Ireland) Order, expected to receive Royal Assent by March 2003. In advance of the introduction of the legislative framework, District Councils in Northern Ireland have voluntarily completed Stage 1 reviews and assessments.

2.4 MONITORING

During 2000 and 2001, District Councils in Northern Ireland continued their own routine monitoring, and in many cases contributed to national networks including the Automatic Urban Network, the Nitrogen Dioxide Network and Smoke and Sulphur Dioxide Network. Information on these monitoring networks can be found on the Air Quality Archive, at www.airquality.co.uk .

The year 2000 saw the conclusion of a twelve-month investigation of ambient concentrations of heavy metals around industrial emission sources[1]. Concentrations of the metals lead, cadmium, arsenic, nickel and mercury in the particulate phase were monitored at three sites near industrial emission sources over a twelve-month period, December 1999 to November 2000. The sites were located at Campsey, Whitehead and Belfast Harbour.

A second monitoring site for polycyclic aromatic hydrocarbons (PAHs) was set up in 2000 at Clara Street, Belfast. Together with the existing site at Lisburn, these two sites contribute data to the Hazardous Air Pollutants (HAPS) network.

3 Carbon Monoxide

Carbon monoxide (CO) is a pollutant gas generated by combustion sources. At very high concentrations (such as may occur inside a building with a faulty heating appliance), it can be a dangerous asphyxiant. Whilst outdoor concentrations do not generally reach dangerous levels, they may still have adverse health effects for vulnerable people. CO is a component of vehicle emissions, and the highest outdoor concentrations occur near busy roads.

In this report, concentrations of carbon monoxide are expressed as milligrammes (i.e. 10^{-3} grammes) per cubic metre (mgm^{-3}). To convert to parts per million, if necessary, the following relationship should be used:

1 ppm = 1.16 mgm^{-3} for carbon monoxide at 293K (20°C) and 1013mb.

3.1 MONITORING OF CARBON MONOXIDE

CO is monitored at two sites in Northern Ireland. They are part of the Automatic Urban Network (AUN) and use the Non-Dispersive Infra Red (NDIR) continuous monitoring technique. The sites are listed in Table 3.1, and shown in Figure 3.1.

Table 3.1 CO Monitoring Sites

Site	Grid Reference	Classification	Network
Belfast Centre	J 339 744	Urban Centre	AUN
Londonderry	C 429 172	Urban Background	AUN

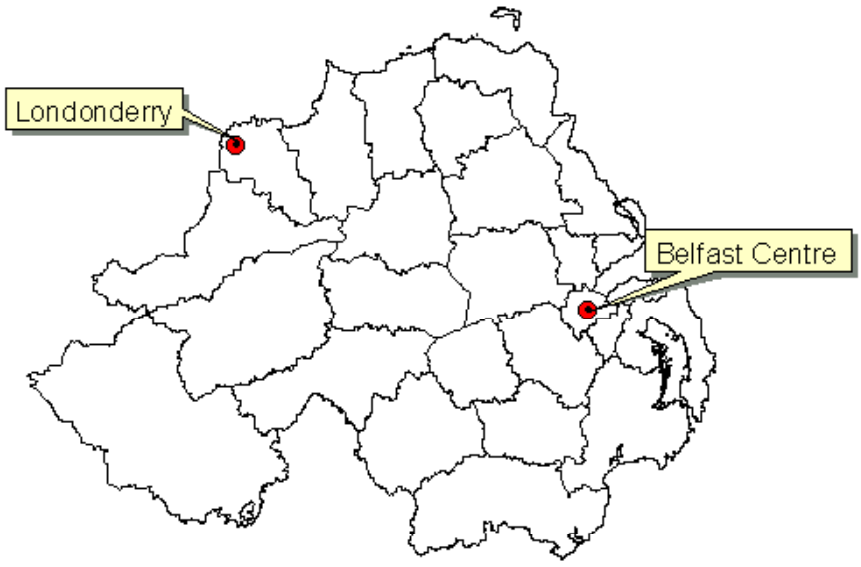


Figure 3.1 Carbon Monoxide Monitoring Sites

3.2 LIMIT VALUES AND OBJECTIVES FOR CARBON MONOXIDE

The World Health Organisation has established non-mandatory air quality guidelines for carbon monoxide. Within the European Community, CO is covered by EC Directive 2000/69/EC (the 2nd Daughter Directive). In the UK, the Air Quality Strategy contains an objective for CO, to be met by 31st December 2003.

Table 3.2 Limit Values and Objectives for Carbon Monoxide

Averaging period	EC Limit or AQS Objective	No. of Permitted exceedences	To be achieved by
WHO (non-mandatory)			
15-minute	100 mgm^{-3}	-	-
30-minute	60 mgm^{-3}	-	-
1-hour	30 mgm^{-3}	-	-
8-hour	10 mgm^{-3}	-	-
EC 2nd Daughter Directive (2000/69/EC)			
Max. Daily 8-hour Mean	10 mgm^{-3} (8.6 ppm)	-	1st January 2005
Air Quality Strategy (as currently adopted in Northern Ireland)			
Running 8-hour mean	11.6 mgm^{-3} (10 ppm)	-	31st December 2003

3.3 CARBON MONOXIDE RESULTS

The results from the CO measuring sites are shown in Table 3.3 below. Annual data capture is at least 75% except where indicated.

Table 3.3 Results from Automatic CO Monitoring Sites

Calendar Year	Annual Mean mg m^{-3}	Max 1 Hour Mean mg m^{-3}	Daily Max Running 8- Hour Mean mg m^{-3}	Number of Exceedences of EC Limit Value
Belfast Centre				
1992	0.8	21.0	11.9	5
1993	0.8	16.8	12.3	1
1994	0.8	18.9	15.5	2
1995	0.7	18.9	16.2	4
1996	0.6	12.5	9.4	0
1997	0.8	10.8	8.1	0
1998	0.5	6.0	4.1	0
1999	0.5	5.2	4.3	0
2000	0.5	5.2	3.5	0
2001 [a]	0.5	7.2	5.5	0
Londonderry				
1997 [b]	0.3	6.0	3.9	0
1998	0.5	9.5	4.9	0
1999	0.3	5.6	3.0	0
2000	0.3	3.9	2.3	0
2001	0.3	4.9	2.4	0

a) Limited data capture: Belfast Centre 2001 (60%)
b) Limited data capture Londonderry 1997 (60%)

Both sites currently meet the EC 2nd Daughter Directive limit value and the Air Quality Strategy objective for this pollutant, with maximum daily running 8-hour mean below 10 mg m^{-3} since 1996.

3.4 CARBON MONOXIDE TRENDS

Figure 3.2 illustrates the falling trend in maximum 8-hour running mean CO concentration for the two sites. Peak CO concentrations at Belfast Centre have decreased since the mid 1990s. However, both sites showed a slight increase in 2001 compared to the previous year.

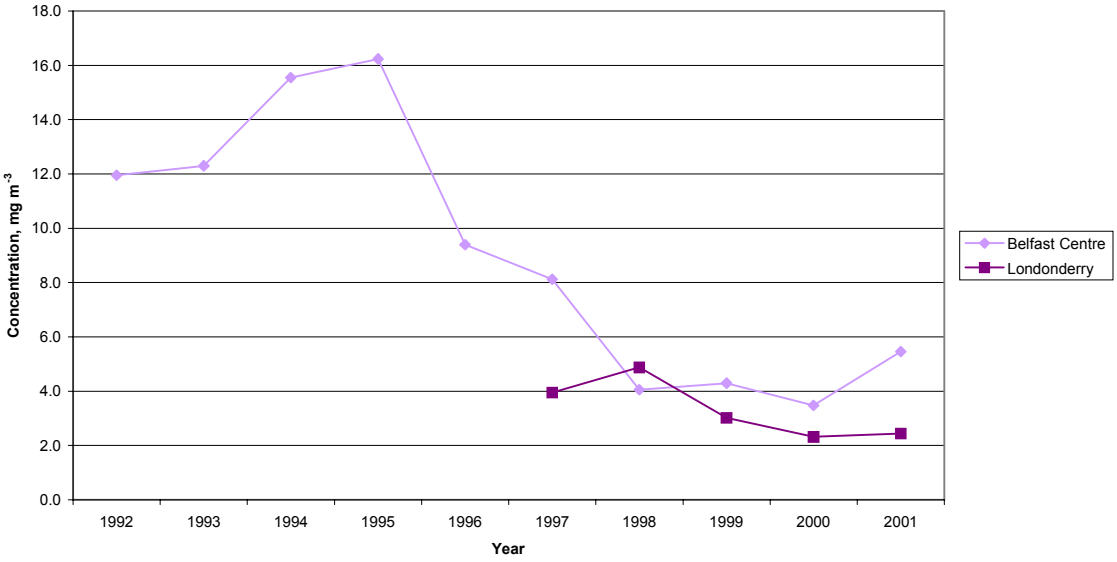


Figure 3.2 Maximum Running 8-hour Mean CO Concentration

Trends are often shown more clearly by statistics based on longer periods, such as the annual mean. Figure 3.3 shows how the annual mean CO concentrations at the same sites have decreased since the early and mid 1990s but remained stable in recent years. Based on a regression analysis (Theil's non-parametric regression analysis), there is a significant downward trend in the annual mean carbon monoxide at Belfast Centre but not at Londonderry. However, despite the overall downward trend at Belfast Centre, it should be noted that annual mean carbon monoxide appears to have remained stable for the past four years. Annual mean CO concentrations for 2001 showed slight increases on the 2000 values at both sites. Future years' monitoring will be important, to establish whether or not the downward trend resumes.

Figure 3.3 Annual Mean CO Concentrations at Automatic Monitoring Sites (data capture at least 75%)

Emission inventory data for the UK (although not for Northern Ireland alone) are available from the National Atmospheric Emissions Inventory (NAEI), on the World Wide Web at www.naei.org.uk. Total UK emissions of carbon monoxide have reduced by 37% between 1992 and 2000, and the downward emission trend shows no sign of flattening off in recent years. An emission inventory study of Greater Belfast[2], based on 1997 data, calculated that around 23% of Belfast's CO emissions arise from domestic combustion; a much larger proportion than in other UK cities (for example around 10% in Swansea and Port Talbot[3], and less than 2% in Merseyside, Bristol and Southampton[3]) However, Belfast's total CO emissions are still dominated by road traffic (75%), and total UK emissions from this source are decreasing.

4 Nitrogen Dioxide

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. This mixture of oxides of nitrogen is collectively termed NO_x. NO is subsequently oxidised to NO_2 in the atmosphere. NO_2 is an irritant to the respiratory system, and can affect human health. Ambient concentrations of NO_2 are likely to be highest in the most built-up areas, especially where traffic is congested, or buildings either side of the street create a "canyon" effect, impeding the dispersion of vehicle emissions.

In this report, concentrations of nitrogen dioxide are expressed as microgrammes (i.e. 10^{-6} grammes) per cubic metre ($\mu g\ m^{-3}$). To convert to parts per billion (ppb) if necessary, the following relationship should be used:

1 ppb = 1.91 $\mu g\ m^{-3}$ for nitrogen dioxide at 293K (20°C) and 1013mb.

4.1 MONITORING OF NITROGEN DIOXIDE

Monitoring of NO_2 is mainly carried out by two methods; automatic NOx analysers and NO_2 diffusion tubes. Automatic analysers are based on the chemiluminescent method, and provide continuous monitoring of NO, NO_2 and total NO_x. The results can be directly compared with air quality objectives based on short-term measurements such as the hourly mean. This technique is the reference method for the EC 1st Daughter Directive. However, this automatic equipment is expensive and is commonly supplemented by a low-cost indicative method, diffusion tubes. These are passive samplers, which work by absorbing the pollutant direct from the surrounding air and need no power supply. Tubes are exposed for periods of typically 4-5 weeks, providing an average result for the exposure period. Although diffusion tube data cannot be compared directly with air quality limit values based on short-term averages, the low cost of diffusion tubes means they can be used to give wide spatial coverage, and are useful for screening studies, identifying areas with high concentrations of NO_2, which can then be targeted for monitoring using more sophisticated techniques.

NO_2 is monitored using the automatic chemiluminescent technique at four sites in Northern Ireland, of which two belong to the Automatic Urban Network. The sites are listed in Table 4.1, and their locations are shown in Figure 4.1.

Table 4.1 Automatic NO_2 Monitoring Sites

Site	Grid Ref.	Classification	Method	Network
Belfast Centre	J 339744	Urban Centre	Chemiluminescent	AUN
Londonderry	C 429172	Urban Background	Chemiluminescent	AUN
Newry, Monaghan Row	J 078 268	Urban Background	Chemiluminescent	Newry & Mourne
Newry, Trevor Hill	J 088 266	Roadside	Chemiluminescent	Newry & Mourne

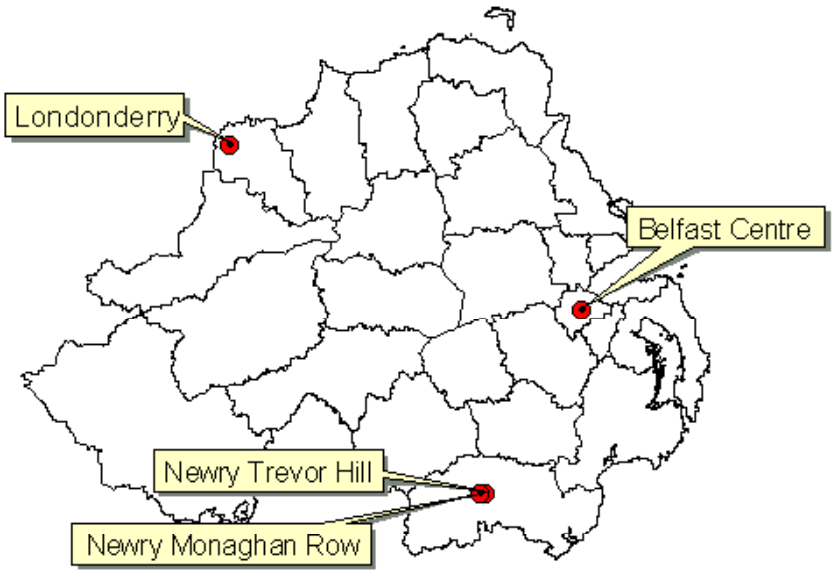


Figure 4.1 Automatic Nitrogen Dioxide Monitoring Sites

Many District Councils in Northern Ireland carry out diffusion tube monitoring of NO_2. Each District Council may operate several sites, which are in some cases part of the Nitrogen Dioxide Network. The total number of sites operated by each District Council, and the number belonging to the Nitrogen Dioxide Network, are listed in Table 4.2. As there are so many, full site details are provided in Appendix 1, Tables A1.1 (2000) and A1.2 (2001).

Table 4.2 Diffusion Tube NO_2 Monitoring Sites

District Council	Number of sites	Number belonging to NO_2 Network (as of 2001)
Antrim	5	0
Ards	4	4
Armagh	8	4
Ballymena	13	4
Ballymoney	8	4
Banbridge	5	0
Belfast	16	4
Carrickfergus	11	3
Castlereagh	6	3
Coleraine	4	0
Cookstown	5	0
Craigavon	4	4
Down	8	4
Dungannon	4	4
Fermanagh	5	0
Lisburn	8	4
Londonderry	11	4
Magherafelt	4	0
Newry & Mourne	4	4
Newtownabbey	9	4
North Down	8	4
Omagh	4	4

NO_2 diffusion tube monitoring sites in Northern Ireland are categorised as follows:

- **(A) Roadside;** 1-5m from the kerb of a busy road.
- **(B) Intermediate;** 20-30m from the same or equivalent busy road.
- **(C)Urban Background;** >50m from any busy road and typically in a residential area.
- **(D) Rural Background;** sites > 50m from any busy road, in a rural area.

Locations of the NO_2 diffusion tube monitoring sites in the Roadside category are shown in Figure 4.2, and NO_2 diffusion tube monitoring sites in other categories are shown in Figure 4.3. These Figures show the locations of sites operating in 2001.

District Councils that participate in the Nitrogen Dioxide Network submit monthly measurements from typically four locations within their area: two Roadside and two Urban Background. (Prior to 2001, the Network included Intermediate sites. However, as from January 2001, most participating District Councils now submit data from two Roadside and two Urban Background sites, instead of one Roadside, one Intermediate and two Urban Background as previously).

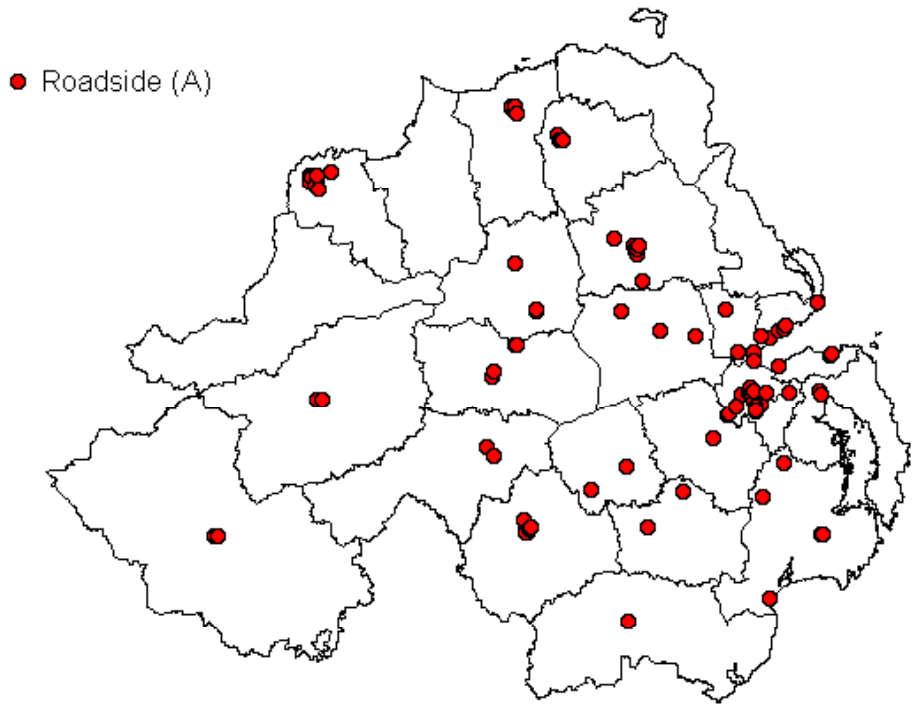


Figure 4.2 NO_2 Diffusion Tube Monitoring Sites 2001, Roadside

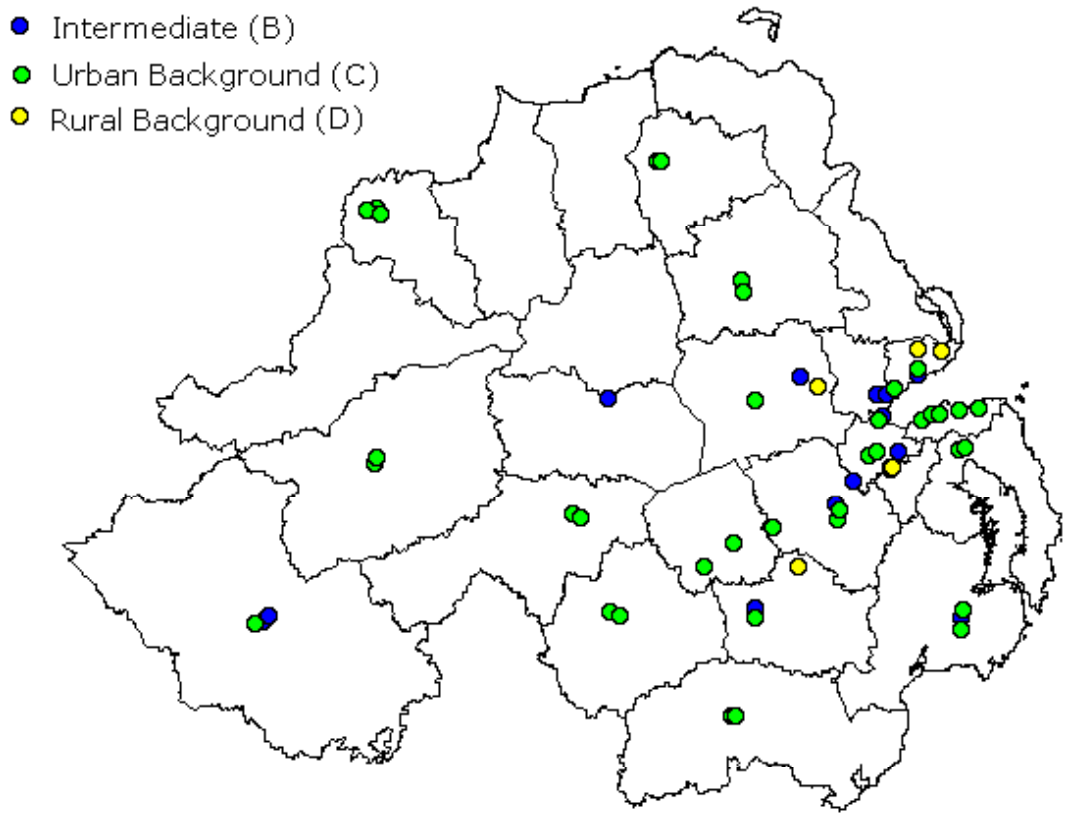


Figure 4.3 NO_2 Diffusion Tube Monitoring Sites 2001, Non Roadside

4.2 LIMIT VALUES AND OBJECTIVES FOR NITROGEN DIOXIDE

The World Health Organisation has set non-mandatory guide values for NO_2. Within Europe, NO_2 is covered by the 1st Daughter Directive, 1999/30/EC. In the UK, the Air Quality Strategy sets objectives for this pollutant, for protection of human health and ecosystems. Limit values and objectives for NO_2 are shown in Table 4.3.

Table 4.3 Limit Values and Objectives for Nitrogen Dioxide

Averaging period	EC Limit or AQS Objective	No. of Permitted exceedences	To be achieved by
WHO (non-mandatory)			
1 hour	200 μg m^{-3}	-	-
Annual Mean	40 μg m^{-3}	-	-
EC 1st Daughter Directive (1999/30/EC)			
1 hour	200 μg m^{-3}	18 per year	1st January 2010
Annual Mean	40 μg m^{-3}	-	1st January 2010
Annual Mean, for protection of vegetation	30 μg m^{-3} Total NOx	-	19th July 2001
Air Quality Strategy			
1 hour	200 μg m^{-3}	18 per year	31st December 2005
Annual Mean	40 μg m^{-3}	-	31st December 2005
Annual Mean, for protection of vegetation	30 μg m^{-3} Total NOx	-	31st December 2000

4.3 AUTOMATIC NITROGEN DIOXIDE RESULTS

Table 4.4 below shows NO_2 results from automatic monitoring sites in Northern Ireland, from 1992 onwards. The statistics shown are the maximum hourly mean, the annual mean, and the number of hourly means greater than 200 μg m^{-3} (the hourly EC limit value and AQS Objective). Annual data capture is at least 75% except where stated.

Table 4.4 NO_2 Results from Automatic Monitoring Sites

Year	Max Hourly Mean μg m^{-3}	Annual Mean μg m^{-3}	No. of hourly means > 200 μg m^{-3}	Annual Mean > 40 μg m^{-3} ?
Belfast Centre				
1992 [a]	248	**44**	3	**Yes**
1993	355	**42**	6	**Yes**
1994	191	40	0	No
1995	380	40	15	No
1996	250	38	3	No
1997	164	38	0	No
1998	162	34	0	No
1999	141	34	0	No
2000	124	31	0	No
2001	334	32	3	No
Londonderry				
1997 [b]	130	21	0	No
1998	94	13	0	No
1999	94	15	0	No
2000	73	15	0	No
2001	74	15	0	No
Newry - Monaghan Row				
2001	150	17	0	No
Newry – Trevor Hill (8 months data only)				
2001	154	34	0	No

a) Limited data capture: Belfast Centre 1992 (60%)
b) Limited data capture: Londonderry 1997 (25%)

No sites exceeded the 1st Daughter Directive limit and AQS objective of 200 μg m^{-3} for the hourly mean more than the permitted 18 times per calendar year. The annual mean has been below the limit value of 40 μg m^{-3} at all sites since 1994. These sites are mostly Urban Centre and Urban Background (Newry Trevor Hill is a Roadside site, but in a smaller town). Higher values may be expected at roadside and kerbside locations in urban centres, and exceedences of the annual mean limit in such locations cannot be ruled out.

The EC and AQS vegetation protection limit of 30 μg m^{-3} total NO_x is not applicable to any of the above sites, as they are all in built up areas.

4.4 DIFFUSION TUBE NITROGEN DIOXIDE RESULTS

Annual mean NO_2 concentrations, for 2000 and 2001, from *all* NO_2 diffusion tube sites in Northern Ireland, are provided in Appendix 1. (No annual mean is shown where the site was in operation for less than 6 months of the year). Table 4.5 provides a summary of average NO_2 concentrations, for 2000 and 2001, at the four site types. The average concentration for each site type is the arithmetic mean of all the individual site annual means.

Table 4.5 Average NO_2 Concentrations in Northern Ireland Measured by Diffusion Tubes

Site Type	Number of sites 2000	Average NO_2, 2000 $\mu g\ m^{-3}$	Number of sites 2001	Average NO_2, 2001 $\mu g\ m^{-3}$
A (Roadside)	58	**26**	96	**27**
B (Intermediate)	25	**18**	15	**16**
C (Urban Background)	39	**12**	39	**14**
D (Rural Background)	6	**9**	5	**10**

The averages in Table 4.5 are based upon *all* sites in Northern Ireland, whether or not they are part of the NO_2 Network. The annual averages were found to be in most cases comparable with the averages reported by the NO_2 Network for the Northern Ireland region, which are as follows:

2000: Roadside 29 $\mu g\ m^{-3}$, Intermediate 19 $\mu g\ m^{-3}$ and Urban Background 13 $\mu g\ m^{-3}$.
2001: Roadside 27 $\mu g\ m^{-3}$, Urban Background 14 $\mu g\ m^{-3}$.

During 2000, four sites had annual mean NO_2 concentrations greater than the EC Directive limit and AQS objective of 40 $\mu g\ m^{-3}$. These were as follows:

- Roadside (type A), Lisburn Road, Belfast – a main arterial route into the city centre.
- An Intermediate (type B) site, Molyneaux Street, central Belfast. This is close to major routes through the city, and near a motorway interchange. (However, it should be noted that the annual mean was based on only six months of data, January to June 2000).
- Roadside (type A), Dublin Road in Omagh. At this site, traffic on a main road into the town centre queues approaching traffic lights.
- Roadside (type A), Water Street, Newry. This site is on a main road in the city centre, where traffic queues form. Buildings on either side form a "canyon".

In 2001, the following six sites, all Roadside, exceeded the annual mean limit value of 40 $\mu g\ m^{-3}$.

- Great George's Street, central Belfast. This is near an exit from the M3 motorway and not far from the Molyneaux Street site mentioned above).
- Creggan Road, Londonderry; near the city centre, on a busy road with a steep incline.
- Strand Road, Londonderry; a dual carriageway 300m from the city centre,
- Glendermot Road, Londonderry; at a crossroads on a main arterial route into the city
- St Patrick's Terrace, Londonderry; also at a junction on a main arterial route into the city.
- Water Street in Newry, which is described above.

These findings indicate that exceedences of the annual mean limit for NO_2 may occur not only in large urban centres, but also at roadside locations in smaller towns and cities with frequent heavy or waiting traffic, or street "canyon" effects.

4.5 NITROGEN DIOXIDE TRENDS

Emission inventory data for the UK are available from the National Atmospheric Emissions Inventory (NAEI), on the World Wide Web at www.naei.org.uk. Total estimated UK emissions of NOx have shown a steady, approximately linear decrease between 1990 and 2000, of around 5.4% per year. This is due to reduced emissions from two major sources: power generation, and road vehicles (the latter partly as a result of the introduction of catalytic converters). In greater Belfast, road traffic is the dominant source of NOx, accounting for 60% of the city's total NOx emissions[2]; in this respect, Belfast might be expected to show a similar emission trend to the total UK. Hence, ambient NO_2 should show some downward trend.

4.5.1 Trends at Automatic Nitrogen Dioxide Sites

Figure 4.4 shows how annual mean NO_2 concentrations have changed at the automatic sites in Northern Ireland. Only two sites have been in operation long enough to assess trends: the Belfast Centre and Londonderry AUN sites. Regression analysis (Theil's non-parametric analysis) shows a significant downward trend (at the 95% confidence level) in annual mean NO_2 concentration at Belfast Centre, but not at Londonderry.

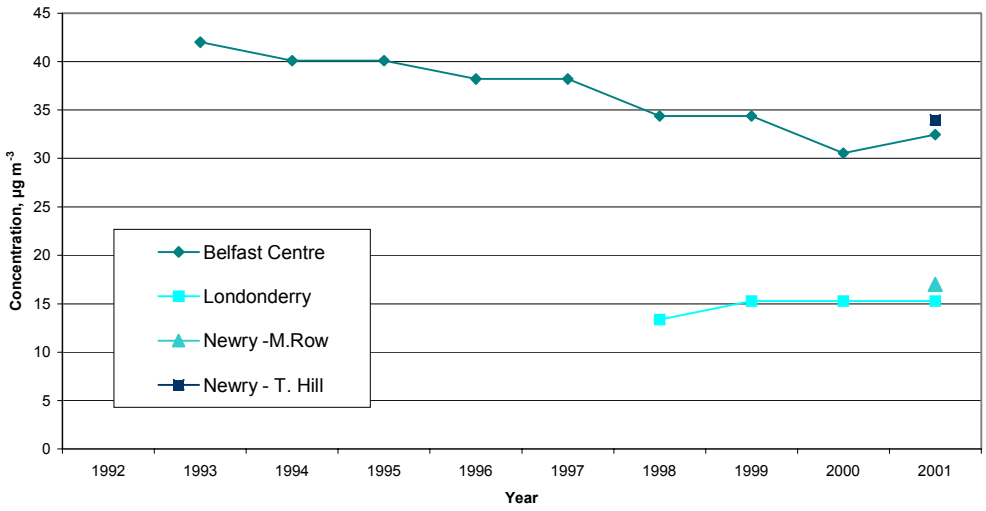


Figure 4.4 Annual Mean NO_2 Concentrations at Automatic Monitoring Sites (data capture at least 75%)

4.5.2 Trends at Diffusion Tube Nitrogen Dioxide Sites

A substantial proportion (40%) of the NO_2 diffusion tube sites operated by District Councils in Northern Ireland are also part of the NO_2 Network. One of the objectives of this Network is to investigate long-term trends in concentrations of this pollutant. The Network has been in operation for nine years, thus it is possible to identify trends.

Table 4.6 shows annual mean NO_2 concentrations for Northern Ireland, based on data from the NO_2 Network. These statistics are based upon the Network sites only, as very few of the non-Network sites had long-term datasets available.

Table 4.6 Average NO_2 Concentrations, NO_2 Network Diffusion Tube sites in Northern Ireland

Year	Average Roadside $\mu g\ m^{-3}$	Average Intermediate $\mu g\ m^{-3}$	Average Urban Background $\mu g\ m^{-3}$
1993	38	24	19
1994	40	25	19
1995	42	24	18
1996	40	21	18
1997	36	20	16
1998	36	20	13
1999	33	21	14
2000	29	19	13
2001	27	-	14

Average concentrations appear to have fallen slightly since the mid 1990s. Regression analysis shows that this downward trend in average NO_2 concentration is significant (with 95% confidence limit) for all three site categories.

5 Sulphur Dioxide

Sulphur dioxide (SO_2) is formed during the combustion of fuels containing sulphur. The most significant source of this pollutant is fossil fuelled power generation, although diesel engines and a number of chemical processes also produce SO_2. In Northern Ireland, domestic solid fuel and oil burning is a major source of SO_2. Sulphur dioxide is a respiratory irritant, and is toxic at high concentrations. It is also damaging to ecosystems and a major precursor in the formation of acid rain.

In this report, concentrations of sulphur dioxide are expressed as microgrammes per cubic metre ($\mu g\ m^{-3}$). To convert to parts per billion (ppb) if necessary, the following relationship should be used:

1 ppb = 2.66 $\mu g\ m^{-3}$ for sulphur dioxide at 293K (20°C) and 1013mb.

5.1 MONITORING OF SULPHUR DIOXIDE

Monitoring of SO_2 is carried out by three methods: continuous automatic analysers, the non-automatic Net Acidity method (using the 8-port sampler) and diffusion tubes.

Automatic analysers (based on the UV Fluorescence method, which is the reference method for the EC 1st Daughter Directive, 1999/30/EC) provide continuous monitoring of SO_2, and the data can be compared with air quality limit values and objectives based on short-term and longer averaging periods. Automatic SO_2 monitoring sites in Northern Ireland are listed in Table 5.1 and shown in Figure 5.1:

Table 5.1 Automatic SO_2 Monitoring Sites

Site	Grid Reference	Classification	Network
Belfast Centre (Lombard Street)	J 339744	Urban Centre	AUN
Belfast East (Templemore Ave)	J 357 740	Urban Background	AUN
Londonderry	C 429172	Urban Background	AUN
Newry, Monaghan Row	J 078 268	Urban Background	Newry & Mourne
Newry, Trevor Hill	J 088 266	Roadside	Newry & Mourne

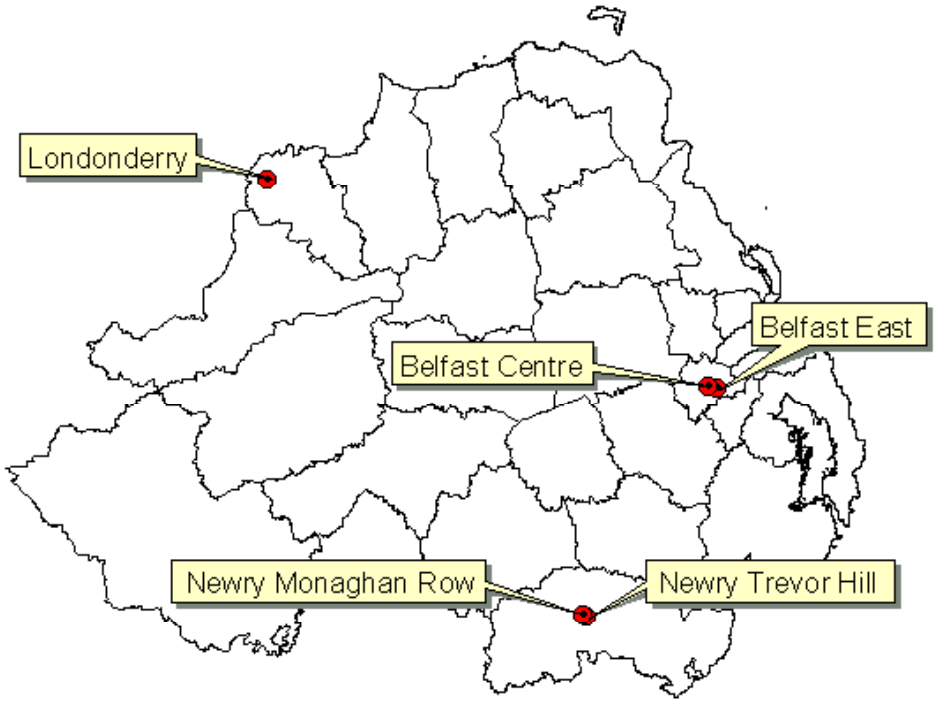


Figure 5.1 Automatic Sulphur Dioxide Monitoring Sites

A more widespread method of measuring SO_2 is by the 8-port sampler apparatus. This also measures suspended particulate matter as black smoke (see Section 6). This technique technically measures total net acidity rather than sulphur dioxide. However, it is widely used for low-cost indicative measurement of SO_2.

This non-automatic method samples on a 24-hour basis, so results are not suitable for comparison with air quality objectives based on shorter periods. However, it has been in widespread use since the early 1960's, so there is an extensive historical dataset which can be used to assess trends. During 2000 and 2001, there were 31 smoke and SO_2 monitoring sites operating in Northern Ireland, all but two belonging to the Smoke and SO_2 Network. A further three sites (Bentra, Cam Forest and Fermoyle which replaced the latter in 2001) were part of the Rural SO_2 Network, monitoring SO_2 only. These are shown in Table 5.2 and Figure 5.2.

Table 5.2 Non-Automatic Smoke and SO_2 Monitoring Sites

Site name	Grid Ref.	District Council	Network
ARMAGH 1	H 877 450	Armagh	Smoke & SO_2
KEADY 1	H 845 341	Armagh	Smoke & SO_2
BALLYMENA 3	D 103 029	Ballymena	Smoke & SO_2
BALLYMONEY 4	C 954 259	Ballymoney	Smoke & SO_2
BELFAST 12	J 324 737	Belfast CC	Smoke & SO_2
BELFAST 13	J 357 740	Belfast CC	Smoke & SO_2
BELFAST 33	J 346 755	Belfast CC	Smoke & SO_2
BELFAST 42	J 322 748	Belfast CC	Smoke & SO_2
BELFAST 44	J 338 740	Belfast CC	Smoke & SO_2
BELFAST 45	J 335 723	Belfast CC	Smoke & SO_2
BELFAST 46	J 803 334	Belfast CC	Smoke & SO_2
PORTADOWN 4	J 012 538	Craigavon	Smoke & SO_2
LONDONDERRY 11	C 431 170	Derry CC	Smoke & SO_2
LONDONDERRY 12	C 438 200	Derry CC	Smoke & SO_2
LONDONDERRY 14	C 443 174	Derry CC	Smoke & SO_2
DUNGANNON 1	H 802 629	Dungannon	Smoke & SO_2
LARNE 3	D 400 029	Larne	Smoke & SO_2
DUNMURRY 2	J 289 679	Lisburn CC	Smoke & SO_2
DUNMURRY 3	J 287 875	Lisburn CC	Smoke & SO_2
LISBURN 3	J 263 636	Lisburn CC	Smoke & SO_2
TWINBROOK 1	J 281 689	Lisburn CC	Smoke & SO_2
MAGHERAFELT 1	H 896 901	Magherafelt	Smoke & SO_2
NEWRY 3	J 078 268	Newry and Mourne	Smoke & SO_2
NEWTOWNABBEY 1	J 349 824	Newtownabbey	Smoke & SO_2
NEWTOWNABBEY 2	J 318 825	Newtownabbey	Smoke & SO_2
NEWTOWNABBEY 3	J 321 851	Newtownabbey	Smoke & SO_2
BANGOR (CO DOWN) 5	J 497 810	North Down	Smoke & SO_2
HOLYWOOD 1	J 397 784	North Down	Smoke & SO_2
STRABANE 2	H 351 972	Strabane	Smoke & SO_2
DOWNPATRICK	J 490 459	Down	Local Auth.
NEWTOWNARDS	J 480 736	Newtownards	Local Auth.
Bentra	J 458 923	Defra	Rural SO_2
Cam Forest (to 2001)	C766 221	Defra	Rural SO_2
Fermoyle(2001 onwd.)	C767 291	Defra	Rural SO_2

(Rural SO_2 sites monitor SO_2 only, not smoke.)

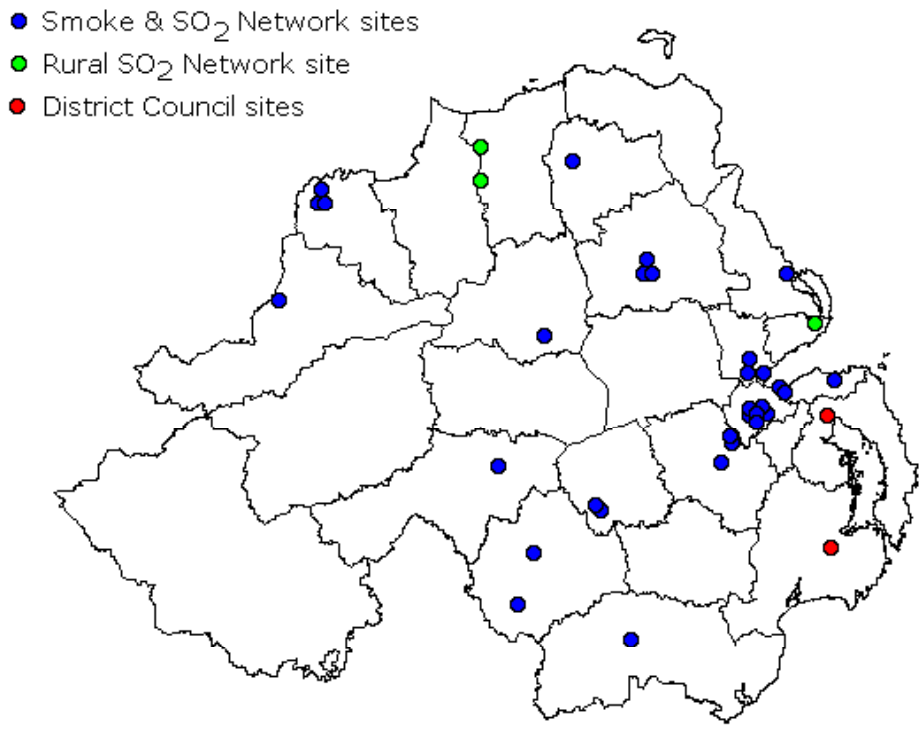


Figure 5.2 Smoke and Sulphur Dioxide Monitoring Sites

Diffusion tubes are also used to monitor SO_2. These passive samplers are similar to those used for NO_2 and described in Section 4. However, it should be noted that SO_2 diffusion tubes are considered less accurate than NO_2 diffusion tubes, and they are considered unsuitable for use for Review and Assessment purposes. Table 5.3 and Figure 5.3 show the SO_2 diffusion tube monitoring sites in use during 2000 and 2001. Site details are given in Appendix 1.

Table 5.3 Diffusion Tube SO_2 Monitoring Sites

District Council	Number of sites Active, 2000	Number of sites Active, 2001
Carrickfergus	2	2
Coleraine	3	3
Cookstown	2	2
Fermanagh	2	2
Lisburn	13	12
Newtownabbey	-	10 (from Dec 2001 only)

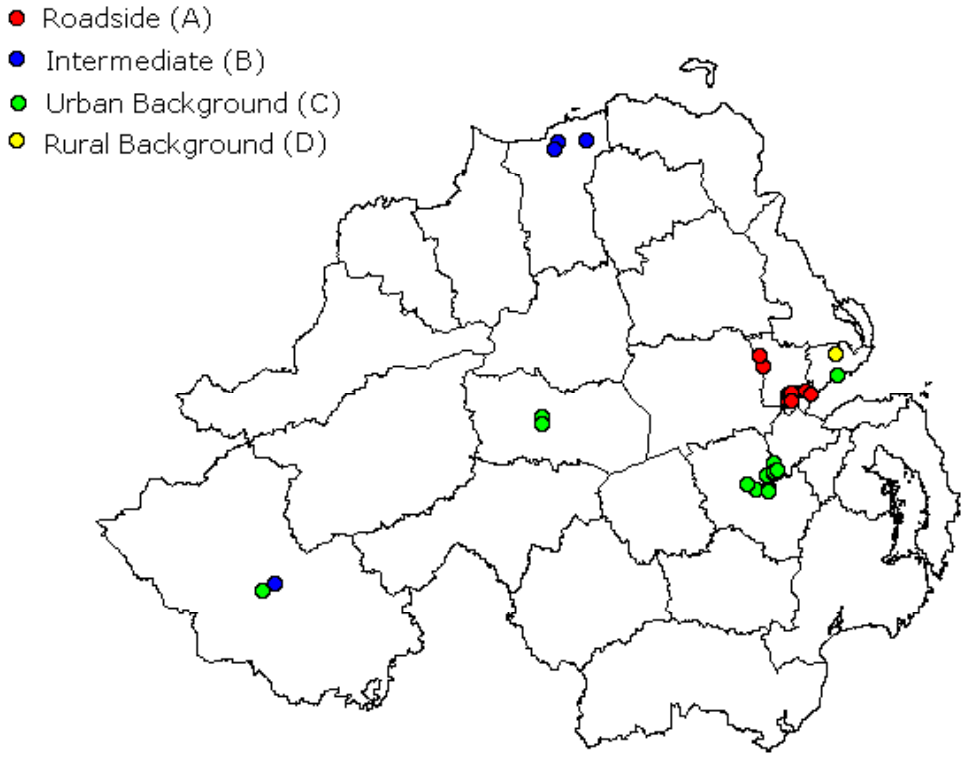


Figure 5.3 Sulphur Dioxide Diffusion Tube Monitoring Sites

5.2 LIMIT VALUES AND OBJECTIVES FOR SULPHUR DIOXIDE

Sulphur dioxide is covered by the following limit values and objectives as shown in Table 5.4. All these limits are for protection of human health except where stated.

Table 5.4 Limit Values and Objectives for Sulphur Dioxide

Averaging period	EC Limit or AQS Objective	No. of Permitted exceedences	To be achieved by
WHO (non-mandatory)			
10 minute	500 μg m^{-3}	-	-
24 hour	125 μg m^{-3}	-	-
Year	50 μg m^{-3}	-	-
EC 1st Daughter Directive (1999/30/EC)			
1 hour	350 μg m^{-3}	24 per year	1 January 2005
24 hour	125 μg m^{-3}	3 per year	1 January 2005
Calendar year and winter (1st October – 31st March), for protection of vegetation (relevant in rural areas)	20 μg m^{-3}	-	19 July 2001
Air Quality Strategy			
15 minute	266 μg m^{-3}	35 per year	31 December 2005
1 hour	350 μg m^{-3}	24 per year	31 December 2004
24 hour	125 μg m^{-3}	3 per year	31 December 2004
Calendar year and winter (1st October – 31st March), for protection of vegetation (relevant in rural areas)	20 μg m^{-3}	-	31 December 2000

Before the 1st Daughter Directive came into force, SO_2 was covered by EC Directive 80/779/EEC on Sulphur Dioxide and Suspended Particulates. This Directive has been superseded by the 1st Daughter Directive. Although the limits of this older Directive remain in force until they are fully repealed in 2005, they are less stringent than those in the later 1st Daughter Directive and have been fully met in Northern Ireland since the early 1990s. The current report therefore compares current SO_2 results with the limit values of the 1st Daughter Directive, rather than Directive 80/779/EEC.

5.3 AUTOMATIC SULPHUR DIOXIDE RESULTS

Table 5 shows results from the automatic SO_2 monitoring sites. Annual data capture is at least 75% except where stated. Figures in ***bold italics*** indicate more than the permitted number of exceedences of the relevant limit value.

Table 5.5 SO_2 Results from Automatic Monitoring Sites

	Max 15-minute mean, µg m^{-3}	No. of 15-minute means > 266 µg m^{-3}	Max 1-hr mean µg m^{-3}	No. of 1-hr means > 350 µg m^{-3}	Max 24-hr mean µg m^{-3}	No. of 24-hour means > 125 µg m^{-3}
Belfast Centre						
1992	1256	***316***	1024	***43***	306	***12***
1993	867	***436***	766	***53***	354	***13***
1994	1045	***388***	934	***52***	388	***8***
1995	1317	***346***	963	***54***	407	***9***
1996	944	***326***	739	***45***	301	***10***
1997	606	***141***	426	8	170	***4***
1998	471	***47***	394	3	136	2
1999	378	5	338	0	90	0
2000	436	16	322	0	67	0
2001	301	2	253	0	69	0
Belfast East						
1992	1649	***1176***	1447	***179***	489	***50***
1993	1266	***824***	1149	***125***	412	***35***
1994	1069	***453***	958	***59***	545	***18***
1995	1514	***579***	1402	***106***	705	***14***
1996	1176	***656***	1069	***108***	362	***22***
1997	774	***500***	636	***58***	245	***20***
1998	833	***199***	636	19	218	***9***
1999	601	***98***	487	5	152	***5***
2000	479	***38***	466	2	112	0
2001	450	***139***	399	13	226	***5***
Londonderry						
1997 [a]	197	0	149	0	51	0
1998	1088	31	734	3	130	1
1999	258	0	218	0	45	0
2000	649	19	383	1	74	0
2001	197	0	136	0	43	0
Newry, Monaghan Row *						
2001	505	1	138	0	37	0
Newry, Trevor Hill *						
2001	128	0	74	0	29	0

a) Limited data capture: Londonderry 1997 (26%)

** Data from these two Newry sites are awaiting full ratification.*

In most cases, the requirements of the 1st Daughter Directive and the objectives of the Air Quality Strategy are met at these sites. However, at Belfast East the objective for the 15-minute average is still consistently exceeded more than the permitted 35 times per year. Also, in 2001, the 24-hour limit value was exceeded more than the permitted three times. It would appear that the area

in the vicinity of this site (a residential suburb where domestic solid fuel use is prevalent) is likely to have difficulty in meeting the AQS objectives for sulphur dioxide. The same is likely to be true of similar locations.

5.4 NON-AUTOMATIC SULPHUR DIOXIDE RESULTS

A summary of results from all Smoke and SO_2 Network sites in Northern Ireland is provided in Appendix 2, for years 2000 and 2001. Relatively high concentrations of SO_2 have been measured in Northern Ireland, particularly Belfast, for many years. The limited availability of natural gas in previous years has led to greater domestic use of solid fuels and oil. This has led to higher concentrations of pollutants such as SO_2, particularly in residential areas.

Data from 8-port samplers (i.e. daily 24-hour averages) cannot be directly compared with air quality limits based on shorter averaging periods. Nor is it relevant to compare data from urban sites with the annual and winter mean limit values set for the protection of ecosystems. However, both the EC 1st Daughter Directive, and the Air Quality Strategy, set an objective of 125 $\mu g\ m^{-3}$ for the 24-hour mean, not to be exceeded more than 3 times per calendar year.

In 2000, the overall average SO_2 concentration for all Smoke and SO_2 sites in Northern Ireland was 27 $\mu g\ m^{-3}$; considerably higher than the annual mean of 15 $\mu g\ m^{-3}$ obtained for the whole UK. Only one Smoke and SO_2 site in Northern Ireland recorded more than three days when the 24-hour average for SO_2 was greater than the limit of 125 $\mu g\ m^{-3}$: DUNMURRY 2. However, DUNMURRY 2 was suspected to be directly affected by emissions from a nearby boiler chimney, and has since been replaced by DUNMURRY 3. The annual mean SO_2 concentration at DUNMURRY 2 was unusually high (82$\mu g\ m^{-3}$) for the same reason. At other sites, annual mean SO_2 concentrations ranged from 8$\mu g\ m^{-3}$ in Portadown, to 42$\mu g\ m^{-3}$ at BELFAST 33, a site in an industrial area of Belfast.

In 2001, the overall annual mean SO_2 for all sites in Northern Ireland was 20 $\mu g\ m^{-3}$. This value is lower than the previous year but still considerably higher than the annual mean for the whole UK, which was again 15 $\mu g\ m^{-3}$. Three Smoke and SO_2 sites in Northern Ireland exceeded the 24-hour limit value of 125 $\mu g\ m^{-3}$ on more than three days; BELFAST 13, BELFAST 33 and BELFAST 42. These exceedences related to episodes of high SO_2 during January and February 2001. Annual mean SO_2 concentrations for 2001 ranged from 3$\mu g\ m^{-3}$ at the small town of Keady near Armagh, to 43 μgm^{-3} at BELFAST 33.

Annual mean SO_2 concentrations at the two non-network sites, Downpatrick and Newtownards, were as follows: Downpatrick, 10.7 $\mu g\ m^{-3}$ in both 2000 and 2001: Newtownards, 8.6 $\mu g\ m^{-3}$ in 2000.

Annual and winter mean sulphur dioxide concentrations at the three Rural SO_2 Network sites (Bentra, Cam Forest and Fermoyle) were less than 5 $\mu g\ m^{-3}$: well within the limit of 20 $\mu g\ m^{-3}$ set for protection of vegetation in rural areas.

5.5 DIFFUSION TUBE SULPHUR DIOXIDE RESULTS

As stated above, SO_2 diffusion tubes produce data of limited accuracy and are considered unsuitable for use for Review and Assessment purposes. However, some limited SO_2 diffusion tube data are available for years 2000–01. Where annual means are available, these are shown in Table 5.6. Annual mean SO_2 concentrations, as measured using diffusion tubes, ranged from 2 $\mu g\ m^{-3}$ to 15 $\mu g\ m^{-3}$. These values appear typically lower than those measured using other techniques.

Table 5.6 Annual Mean Sulphur Dioxide as Measured at Diffusion Tube Sites

Site	District Council	Annual Mean 2000 $\mu g\ m^{-3}$	Annual Mean 2001 $\mu g\ m^{-3}$
Town Hall, Carrickfergus	Carrickfergus	6.6	nm
Lough Road, Loughmourne	Carrickfergus	2.3	nm
30 Daneshill, Coleraine	Coleraine	nm	9.0
11 Laurel Avenue, Coleraine	Coleraine	nm	5.5
6/8 Ganimore Avenue, Portrush	Coleraine	nm	2.9
Queens Avenue, Cookstown	Cookstown	nm	15
Greenvale Drive, Cookstown	Cookstown	nm	14.7
Everglades, Tempo Road, Enniskillen	Fermanagh	2.5	2.1
Rossole Park, Enniskillen	Fermanagh	3.1	3.4

nm = not measured.

5.6 SULPHUR DIOXIDE TRENDS

For reasons outlined in Sections 1.1 and 5.4, widespread reliance on solid fuels and oil for domestic heating has continued throughout the 1970s, 1980s and 1990s. Domestic combustion accounts for an estimated 28% of total annual SO_2 emission in the Belfast area[2], compared with 4% of total annual SO_2 emission in the UK as a whole. Sulphur dioxide emissions and source distribution have therefore been different in Northern Ireland than in other parts of the UK for many years, and it cannot be assumed that UK trends in either emissions or ambient concentrations are necessarily representative of Northern Ireland. However, UK emission data from the NAEI shows two interesting features: (i) a decrease of almost 70% between 1990 and 2000, and (ii) a levelling-off of the downward trend in the most recent years 1999 and 2000.

5.6.1 Trends at Automatic Sulphur Dioxide Sites

Trends in SO_2 concentration, as monitored at the automatic sites, are illustrated by Figure 5.4. Regression analysis (Theil's non-parametric regression analysis) identified a significant downward trend (with 95% confidence limit) in the annual mean SO_2 concentrations at Belfast Centre and Belfast East, though not at Londonderry. It is interesting to note the apparent levelling-off of the downward trend in 2000-2001: it is possible that this may reflect a levelling-off in total emissions, similar to that evident in the UK data.

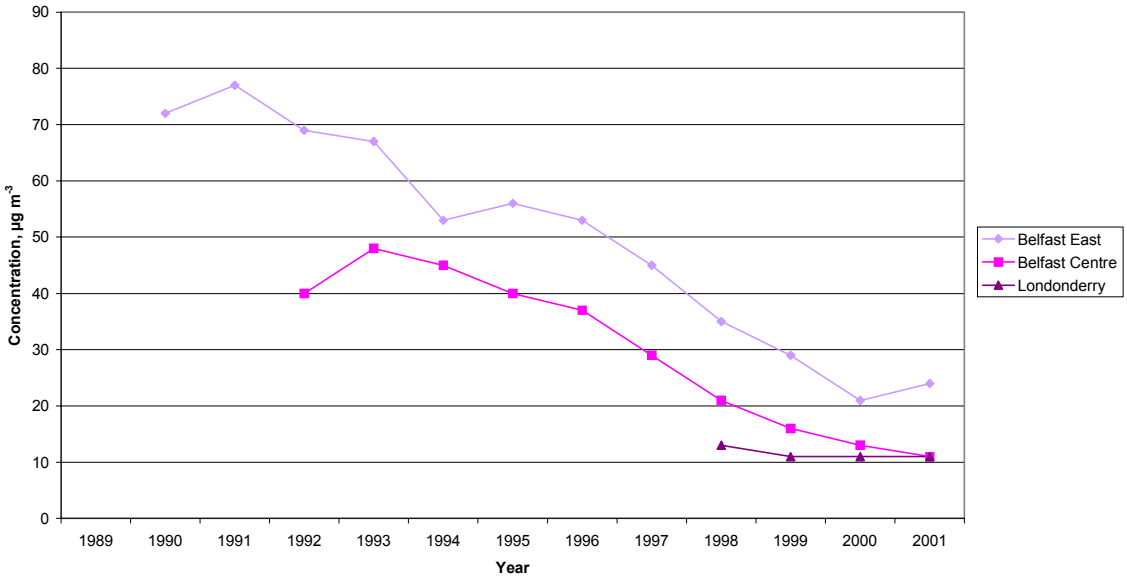


Figure 5.4 Annual Mean SO_2 concentration at Automatic Sites (data capture at least 75%)

5.6.2 Trends at Non-Automatic Sulphur Dioxide sites

Most of the non-automatic (8-port sampler) sites belong to the Smoke and SO_2 Network, and many have a long-running historical dataset. Thus, it is possible to identify how concentrations of sulphur dioxide, as measured by the net acidity technique, have decreased since the early 1960s. This trend is shown in Figure 5.5, a graph of the average SO_2 concentration at all Network sites in Northern Ireland since 1962. For historical reasons the annual averaging periods run April -March. The annual mean is based only upon sites with at least 75% data capture for the year, which in most years totalled between 14 and 27.

The annual average concentration of SO_2 has fallen, from over 80 μg m^{-3} in the 1960s to around 30 μg m^{-3} in 1980. From 1980 – 1987, average concentrations rose, before the downward trend continued again from the late 1980s. A possible explanation for the rise in the early 1980s is that it may have resulted from a rise in coal and oil burning, as the use of town gas was phased out. Town gas use decreased through the late 1970s and early 1980s, and the eventual shut-down of the supply began in 1984 and was completed in 1988.

Figure 5.5 also shows the trend in annual mean for three particular sites in Belfast: BELFAST 12 (at the Royal Victoria Hospital), BELFAST 13 (at Templemore Avenue, co-located with the Belfast East automatic monitoring site) and BELFAST 33 (Dufferin Road, an industrial area of the city centre). All of these have been in continuous operation since the early 1960s. These three individual sites show a similar pattern to the average, including the period during the early 1980s when the general downward trend appeared to be reversed.

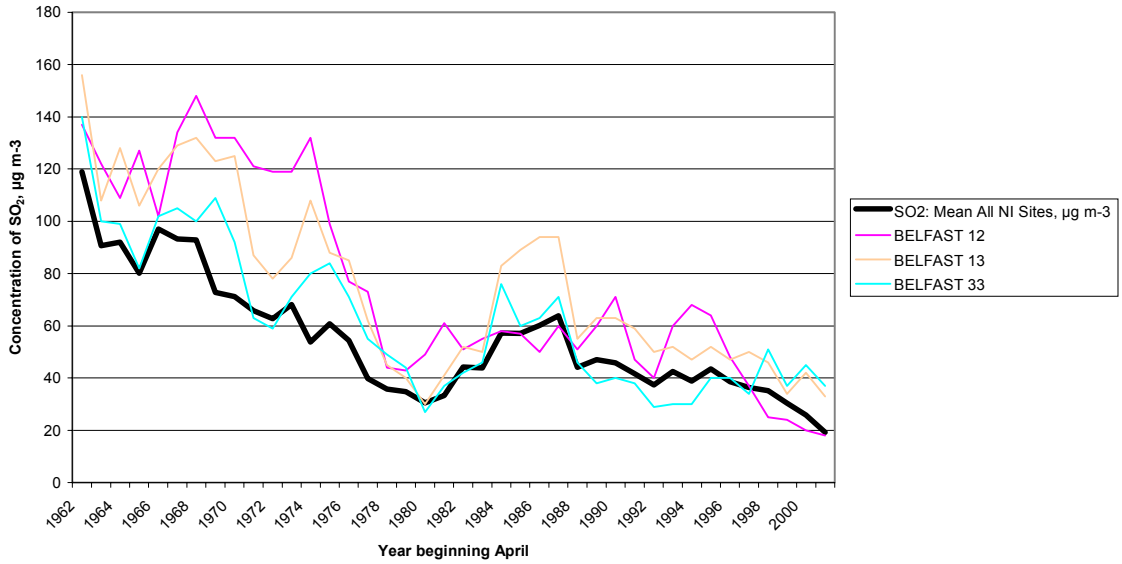


Figure 5.5 Annual Mean SO_2 Concentration at Smoke & SO_2 Sites in Northern Ireland. Network average and 3 long-running Belfast sites.

Although this network has provided a long-term historical dataset, it is also useful to examine trends for the most recent five years. Regression analysis for annual (pollution year) means 1997 to 2001 identified a downward trend, significant at the 95% confidence level, over this period. Therefore, it appears that on average, SO_2 concentrations in Northern Ireland, as measured by the non-automatic Smoke and SO_2 Network, are still decreasing. Further decrease is expected in the next few years, as natural gas becomes more readily available in the region.

The estimated total annual UK emission of SO_2 is available from the NAEI, for years 1970 onward. The correlation was investigated between this parameter and the average annual SO_2 in Northern Ireland, as measured by the Smoke and SO_2 Network. The correlation between the two parameters can be expressed in terms of the correlation coefficient R. The closer this value is to 1, the stronger the correlation between them. In this case, correlation coefficient R = 0.61; for the sample of 31 paired values (for years 1970-2000) the correlation *is* significant, at the 99% confidence level. However, this should be compared with the much stronger correlation (R = 0.94) between the NAEI estimate of total annual UK emission of SO_2, and UK annual mean SO_2 concentrations, as measured by the same network. This is consistent with Northern Ireland's SO_2 emissions over the past 31 years having followed a different trend to those of the whole UK.

6 Particulate Matter

Ambient suspended particulate matter consists of a "primary" component (ie. emitted directly into the atmosphere and therefore usually local to source), and a "secondary" component (formed in the atmosphere by chemical reactions, and therefore often a long-range pollutant). The primary component mostly consists of combustion related particles (emitted from sources such as vehicles, domestic and industrial coal and fuel oil burning), but includes other material such as entrained dust, and salt from sea spray. The secondary material consists mostly of sulphate and nitrate particles formed by oxidation of sulphur dioxide and oxides of nitrogen, and ammonium salts. Ambient particulate matter, when inhaled, can affect human health, particularly in sensitive individuals.

The two particulate metrics most widely used in the UK are PM_{10} and Black Smoke. The term "PM_{10}" refers to the mass fraction of particles collected by a sampler with a 50% cut-off at aerodynamic diameter 10 μm. PM_{10} is measured by automatic techniques, such as the Tapered Element Oscillating Microbalance (TEOM), gravimetric samplers and beta attenuation monitors. The term "black smoke" refers to any fine dark suspended particulate which can be measured by the smoke stain technique, not necessarily particulate resulting from combustion sources. Black smoke is defined by the ISO standard for the method (ISO 9835) as "strongly light absorbing particulate material suspended in the ambient atmosphere.... The major contributor to black smoke is soot particles; i.e. particles containing carbon in its elemental form". Concentrations of particulate matter are expressed as micrograms per cubic metre ($\mu g\ m^{-3}$).

6.1 MONITORING OF PARTICULATE MATTER

6.1.1 PM_{10} Monitoring

Particulate matter as PM_{10} is currently monitored at six sites in Northern Ireland using the techniques shown in Table 6.1 and Figure 6.1. The AUN sites at Belfast Centre and Londonderry, also the two Newry sites, use the Tapered Element Oscillating Microbalance (TEOM). A Beta Attenuation Monitor is located at Clara Street. Two gravimetric PM_{10} monitors (the KFG and Partisol) are also in use at Belfast Centre, as part of an investigation comparing PM_{10} monitoring techniques: however no ratified data are yet available from these.

The reference method for PM_{10} is the gravimetric technique, in which the ambient concentration of PM_{10} is calculated from the mass of particulate matter collected on a filter. The more widely-used TEOM has been found to underestimate relative to this reference method. Therefore, by convention PM_{10} concentrations measured using the TEOM (or using a Beta Attenuation Monitor, if it has a heated inlet) must be multiplied by a factor of 1.3 to convert to gravimetric equivalent, before comparison with EC Directive or AQS limit values. ***All TEOM measurements in this report have been converted to gravimetric equivalent.***

Table 6.1 Automatic PM_{10} Monitoring Sites, 2000 and 2001

Site	Grid Ref.	Classification	Technique	Network
Belfast Centre (Lombard Street)	J 339 744	Urban Centre	TEOM, KFG Gravimetric, Partisol Gravimetric	AUN
Belfast Clara Street	J 360 734	Suburban	Beta Attenuation Monitor	AUN
Londonderry	C 429 172	Urban Background	TEOM	AUN
Newry, Monaghan Row	J 078 268	Urban Background	TEOM	Newry & Mourne
Newry, Trevor Hill	J 088 266	Roadside	TEOM	Newry & Mourne
Lough Navar	H 065 545	Rural	TEOM	Rural

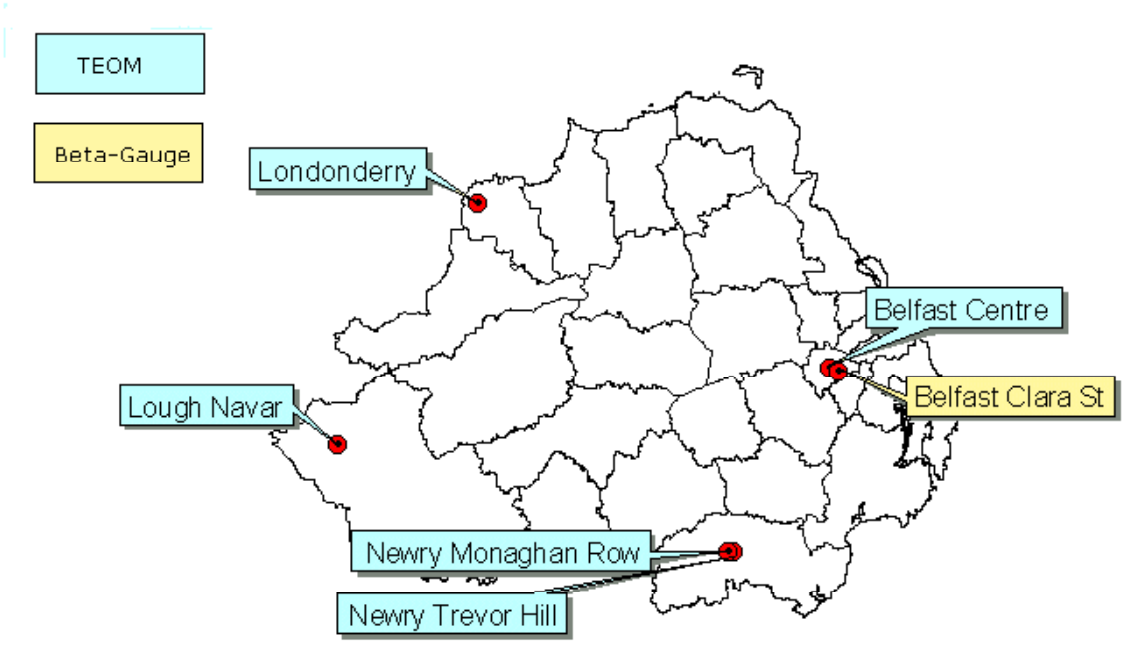


Figure 6.1 PM_{10} Monitoring Sites

In earlier years, PM_{10} monitoring has also been carried out at the Shambles Market, Armagh (1999) and Dungannon (1998) using a TEOM housed in a mobile monitoring station.

6.1.2 Smoke Monitoring

The principle of the smoke stain method involves drawing air at a constant, measured flowrate through a paper filter. Suspended particulate matter is collected on the filter, forming a dark stain. An instrument known as a reflectometer is used to measure the darkness of the stain, and this reflectometer measurement is then used to calculate the concentration of particulate matter in the sampled air from a standard calibration. The sampler inlet funnel has a 50% cut-off at around 4.5 μm; thus black smoke can be considered an approximation to dark PM_5.

During 2000-2001, there were 31 sites measuring particulate as black smoke, 29 of which were part of the Smoke and SO_2 Network. Black smoke is monitored using the same 8-port sampler apparatus as non-automatic SO_2: site details are therefore identical to those presented in Table 5.2 and Figure 5.2 (for SO_2) in Section 5.1. Many of these smoke monitoring sites have been in operation since the 1960s or 1970s: hence there is an extensive historical dataset for smoke.

6.2 LIMIT VALUES AND OBJECTIVES FOR SUSPENDED PARTICULATE MATTER

6.2.1 Limit Values and Objectives for PM_{10}

Particulate matter, when measured as PM_{10}, is covered by the EC 1st Daughter Directive (1999/30/EC), which contains a two-stage set of limit values. The UK Air Quality Strategy sets objectives for PM_{10} that are almost identical to the first stage limit values set by the EC Daughter Directive. These are outlined in Table 6.2.

Table 6.2 Limit Values and Objectives for Particulate Matter as PM_{10}

Averaging period	EC Limit or AQS Objective	Number of Permitted exceedences	To be achieved by
EC 1st Daughter Directive (1999/30/EC) Stage 1			
24 hour	50 μg m^{-3}	35 per year	1st January 2005
Annual Mean	40 μg m^{-3}	-	1st January 2005
EC 1st Daughter Directive (1999/30/EC) Stage 2 (to be confirmed)			
24 hour	50 μg m^{-3}	7 per year	1st January 2010
Annual Mean	20 μg m^{-3}	-	1st January 2010
Air Quality Strategy (as currently adopted in Northern Ireland)			
24 hour	50 μg m^{-3}	35 per year	31st December 2004
Annual Mean	40 μg m^{-3}	-	31st December 2004

All limit values refer to gravimetric equivalent measurements.

6.2.2 Limits and Guide Values for Black Smoke

Before the 1st Daughter Directive and Air Quality Strategy set objectives for PM_{10}, smoke was covered by EC Directive 80/779/EEC on sulphur dioxide and suspended particulates. This Directive has been superseded by the 1st Daughter Directive; however, the limits relating to smoke remain in force until 2005, and the new Daughter Directive deals only with PM_{10}. The current report therefore compares results with the smoke limits and guidelines of Directive 80/779/EEC. The limit values are presented in Table 6.3 below, along with the non-mandatory guide values.

Table 6.3 EC Directive 80/779/EEC Limit Values For Smoke (To be fully repealed in 2005)

Reference Period	Smoke μg m^{-3} BS	Limit Values for Sulphur Dioxide
YEAR (median of daily values)	68	if smoke ≤ 34:120 if smoke > 34: 80
WINTER (median of daily values October-March)	111	if smoke ≤ 51: 180 if smoke > 51: 130
YEAR (Peak) (98th Percentile of daily values)	213	if smoke ≤ 128: 350 if smoke > 128: 250
Guide Values (advisory only)		
Reference Period	**Smoke μg m^{-3} BS**	**Guide Values for Sulphur Dioxide**
YEAR (arithmetic mean of daily values)	34 to 51	40 to 60
24 HOURS (daily mean value)	85 to 128	100 to 150

NOTE: The Limit and Guide Values given above for smoke according to the BS calibration are calculated from the original OECD calibration figures given in the EC Directive using the relationship: BS concentration = OECD concentration multiplied by 0.85

6.3 PARTICULATE MATTER RESULTS

6.3.1 PM_{10} Results

Table 6.4 presents data from automatic PM_{10} monitoring sites. TEOM data have been converted to gravimetric equivalent by multiplying by the appropriate factor of 1.3. Figures in ***bold italics*** indicate more than the permitted number of exceedences of the relevant limit or objective.

Table 6.4 Results from Automatic PM_{10} Monitoring Sites

Calendar Year	Annual Mean $\mu g\ m^{-3}$	Max Daily Mean $\mu g\ m^{-3}$	Daily means > 50 $\mu g\ m^{-3}$
Belfast Centre (TEOM, converted to gravimetric equivalent)			
1992	35	322	***44***
1993	***41***	156	***86***
1994	34	248	***38***
1995	32	190	35
1996	31	145	***44***
1997	32	110	***41***
1998	27	87	20
1999	26	84	15
2000	25	69	8
2001	25	108	15
Belfast Clara Street (Beta Attenuation Monitor)			
1999	22	71	12
2000	16	69	2
2001	19	128	14
Londonderry (TEOM, converted to gravimetric equivalent)			
1997 [a]	28	90	13
1998	26	157	18
1999	25	111	11
2000	20	84	6
2001	23	130	15
Lough Navar (TEOM, converted to gravimetric equivalent)			
1996 [b]	13	27	0
1997	13	38	0
1998	12	44	0
1999	12	38	0
2000	12	35	0
2001	13	41	0
Newry, Monaghan Row (TEOM, converted to gravimetric equivalent)			
1998	24	90	*9*
1999	23	76	*8*
2000	22	114	*5*
2001	20	68	4
Newry , Trevor Hill (TEOM, converted to gravimetric equivalent)			
2001	34	86	26
Armagh (TEOM, converted to gravimetric equivalent)			
1999	25	64	8
Dungannon (TEOM, converted to gravimetric equivalent)			
1998	21	83	29

a) Limited data capture: Londonderry 1997(60%)
b) Limited data capture: Lough Navar 1996 (22%)

All the sites for which data are available currently meet the EC Directive Stage 1 limits and AQS Objectives. Only one site, Lough Navar, currently meets the EC Directive Stage 2 limit values: however, if confirmed, these need not be met until January 2010.

6.3.2 Black Smoke Results

A summary of smoke data for calendar years 2000 and 2001 for all Smoke and SO_2 Network sites in Northern Ireland is shown in Appendix 2.

Smoke in 2000: Annual mean smoke concentrations in Northern Ireland for calendar year 2000 ranged from 5μg m^{-3} to 17μg m^{-3} with one exception. An unusually high concentration of 27 μg m^{-3} was measured at STRABANE 2. This was investigated, and appears to be genuine; the site is located on a housing estate with considerable domestic coal and oil burning, and local topography may impede dispersion. The average for Northern Ireland was 11 μg m^{-3}, compared with the average for the UK as a whole of 7.4 μg m^{-3}. Maximum daily smoke concentrations at the majority of sites were less than 100 μg m^{-3}.

Smoke in 2001: Smoke concentrations in Northern Ireland were similar to those measured in the previous year, with all except one annual mean in the range of 5 μg m^{-3} to 17 μg m^{-3} . Again, the exception was STRABANE 2, with an annual mean smoke concentration of 34 μgm^{-3}, substantially higher than at any other site. The average for all Network sites in Northern Ireland was again 11 μg m^{-3}; slightly higher than the UK average of 8.2 μg m^{-3}.

Maximum daily smoke concentrations exceeded 100 μg m^{-3} at a large proportion of sites in 2001, with one site (BALLYMENA 3) recording a maximum daily value of 303 μg m^{-3}. However, such high values only occur during short-term "episodes" of particularly high pollution and are rare: the 98th percentile of daily values was below 100 μg m^{-3} at all but one site. Two such episodes occurred in Northern Ireland during 2001: one during 18th-19th January 2001 and (in some areas) another around 11th-16th December 2001. The former also affected northern parts of England, the latter also affected Scotland.

The two non-network sites, Downpatrick and Newtownards, recorded annual mean smoke concentrations of 4.5 μg m^{-3} and 10.8 μg m^{-3} respectively in 2001.

Smoke concentrations, historically, have been higher in Northern Ireland than in most other parts of England, Wales and Scotland. This is because the limited availability of natural gas for domestic heating has necessitated greater use of coal and oil for this purpose.

All the sites in Northern Ireland meet the limit values of 80/779/EEC for smoke. The last occasion on which any of the limit values for smoke were exceeded in Northern Ireland was in 1990. During 2000 and 2001, the annual arithmetic mean was well below the lower guide value of 34 μg m^{-3} at all sites in Northern Ireland with the exception of STRABANE 2. However, the maximum daily mean exceeded both the upper and lower 24-hour guide values at many sites in the UK, including several in Northern Ireland.

6.4 PARTICULATE MATTER TRENDS

In the Belfast area, the contribution to primary PM_{10} emissions from domestic contribution is around 26%[2], a substantially higher proportion than in most UK cities. Therefore, trends in PM_{10} and black smoke emissions for Northern Ireland will not necessarily be the same as for other regions. However, NAEI data show a substantial decrease (of around 45%) in total UK PM_{10} emissions between 1990 and 2000, so it is not unreasonable to expect a decreasing trend for Northern Ireland.

6.4.1 PM_{10} Trends

Figure 6.2 shows annual mean PM_{10} concentrations for sites in Northern Ireland.

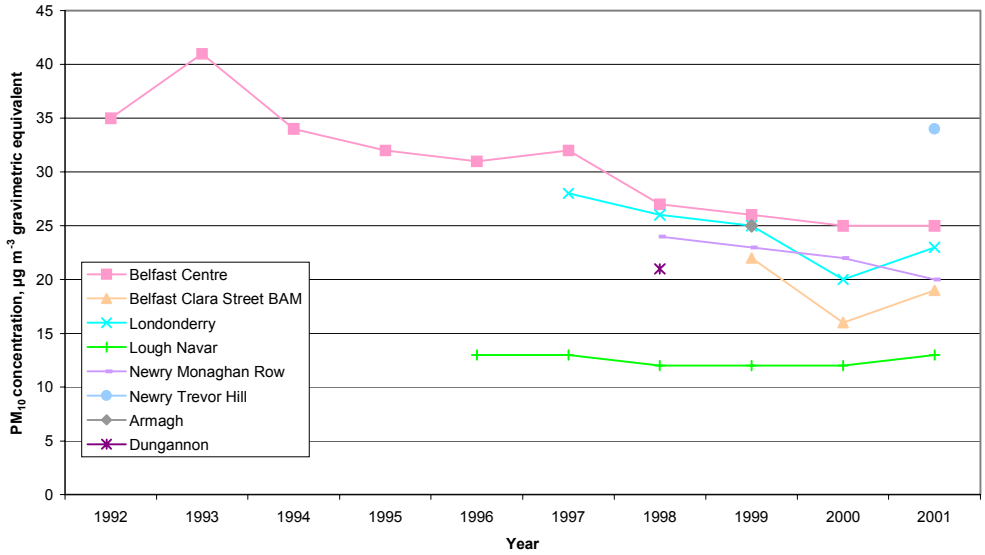


Figure 6.2 Annual Mean PM_{10}Concentrations at Automatic Monitoring Sites, Converted to Gravimetric Equivalent where applicable. (Data capture at least 75%).

The longest running site is Belfast Centre, which has been in operation since 1992. The annual mean PM_{10} concentration at this site has shown a steady decrease over this period. The urban sites at Londonderry and Monaghan Row, Newry have operated for shorter periods, but also appear to show decreasing annual mean PM_{10} concentrations. At the rural Lough Navar site, annual mean PM_{10} concentrations have remained stable and below 15 μg m^{-3}. Regression analysis (Theil's non-parametric regression analysis) identified a significant downward trend (with 95% confidence limit) in the annual mean PM_{10} concentrations at Belfast Centre and Londonderry, although not at Belfast Clara Street and Lough Navar. (At the two Newry sites, there is not enough data to assess trends). Three sites show a slight increase in 2001 relative to 2000: future years' monitoring will be important to establish whether the downward trend resumes.

6.4.2 Black Smoke Trends

The long-running historical dataset for the Smoke and SO_2 Network gives an indication of how concentrations of fine suspended primary particulate, as measured by this technique, have decreased since the early 1960s. This trend is shown in Figure 6.3, a graph of the average smoke concentration at all Network sites in Northern Ireland since 1962. For historical reasons the annual averaging periods run April -March. The annual mean is based only upon sites with at least 75% data capture for the year, which in most years totalled between 14 and 24. The annual average concentration of smoke has fallen, from over 100 μg m^{-3} in the early 1960s to less than 10 μg m^{-3} in 2001.

Figure 6.3 also shows the trend in annual mean for three particular sites in Belfast: BELFAST 12 (at the Royal Victoria Hospital), BELFAST 13 (the suburban Templemore Avenue) and BELFAST 33 (the industrial, city centre Dufferin Road), all of which have been in continuous operation since the early 1960s. These three individual sites show a similar pattern.

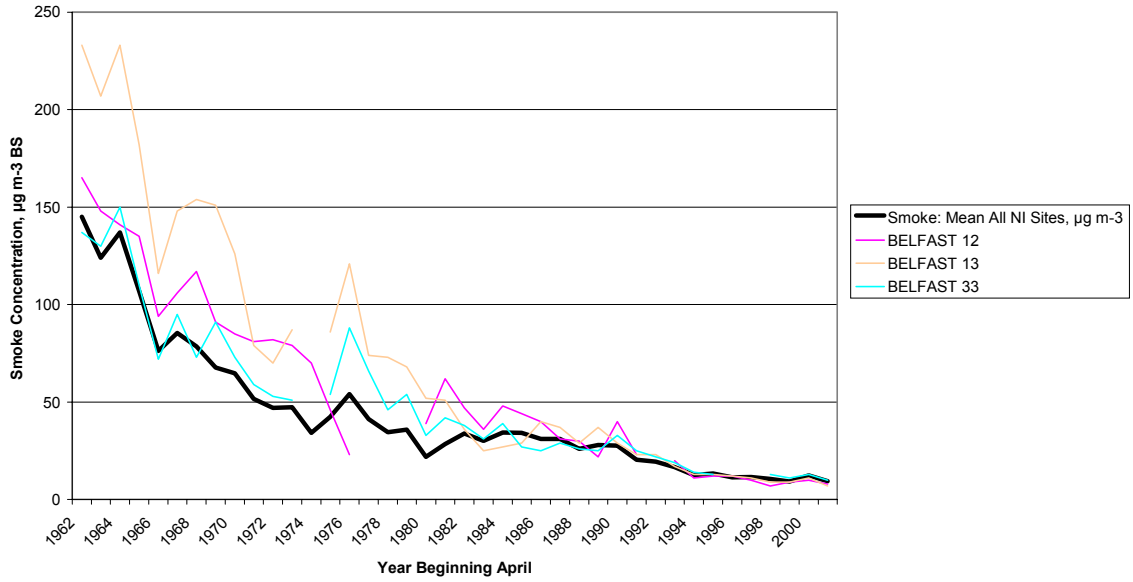


Figure 6.3 Trends in Black Smoke Concentration, Northern Ireland. Network average and 3 long-running Belfast sites.

As well as the long-term trends it is also interesting to investigate the trend over the past five years. Regression analysis of the average annual mean smoke concentration based on all sites in Northern Ireland shows that there is a small downward trend for the period 1997 – 2001, which is not significant at the 95% confidence limit. However, further decrease in smoke concentration in Northern Ireland is expected in the next few years, as natural gas becomes more readily available in the region, and domestic solid fuel use declines.

Estimated annual total UK emission data for black smoke are available from the NAEI, for years 1970 to 2000. The correlation was investigated between the total annual UK emission of black smoke, and the average annual smoke concentration in Northern Ireland, as measured by the Smoke and SO_2 Network. The correlation between the two parameters can be expressed in terms of the correlation coefficient R; the closer this value is to 1, the stronger the correlation between them. In this case, the correlation was found to be strong: R = 0.93. For the sample of 31 paired values (for years 1970-2000) this is significant at the 99% confidence level. The correlation is almost as strong as that found between total annual UK emission of smoke, and the average UK annual smoke concentration as measured by the Smoke and SO_2 Network (R = 0.96). This is consistent with black smoke emission trends for Northern Ireland over the past 31 years being similar to those calculated for the whole UK. This is in contrast to the findings for SO_2 (Section 5.6.2).

7 Ozone

Ozone (O_3) is a form of oxygen, with three atoms per molecule (unlike normal oxygen, O_2, which has two). In the upper atmosphere it is beneficial, forming the "ozone layer" which protects living things from harmful UV radiation. However, at ground level it is a pollutant, having an irritant effect on the respiratory system.

Ground level ozone is not emitted directly from source, but formed by chemical reactions involving the action of sunlight, where NO_2 and volatile organic compounds (VOCs) are present. These reactions may happen over several hours, so the highest ozone concentrations may occur a long distance downwind of the sources of the primary pollutants. Also, O_3 may persist for several days. Ozone pollution can therefore be a transboundary problem, and difficult to control by local action.

O_3 concentrations are usually therefore lowest in towns, and highest in the rural areas downwind of them. Because ozone formation requires sunlight, concentrations are highest in the summer, and during daylight hours.

In this report, concentrations of ozone are expressed as microgrammes per cubic metre (μg m^{-3}). To convert to parts per billion (ppb) if necessary, the following relationship should be used:

1 ppb = 2.0 μg m^{-3} for ozone at 293K (20°C) and 1013mb.

7.1 MONITORING OF OZONE

Monitoring of O_3 in Northern Ireland is carried out largely using continuous automatic analysers. Diffusion tubes are also available for this pollutant, but are used routinely at only one site, which is operated by Fermanagh District Council. Monitoring of ozone is carried out at the sites shown in Table 7.1 below, and in Figure 7.1.

Table 7.1 Automatic O_3 Monitoring Sites

Site	Method	Grid Ref.	Classification	Network
Belfast Centre	Automatic	J 339 744	Urban Centre	AUN
Londonderry	Automatic	C 429 172	Urban Background	AUN
Lough Navar	Automatic	H 065 545	Rural	Rural
Fermanagh	Diff. tube	H 232 429	Urban Background	District Council

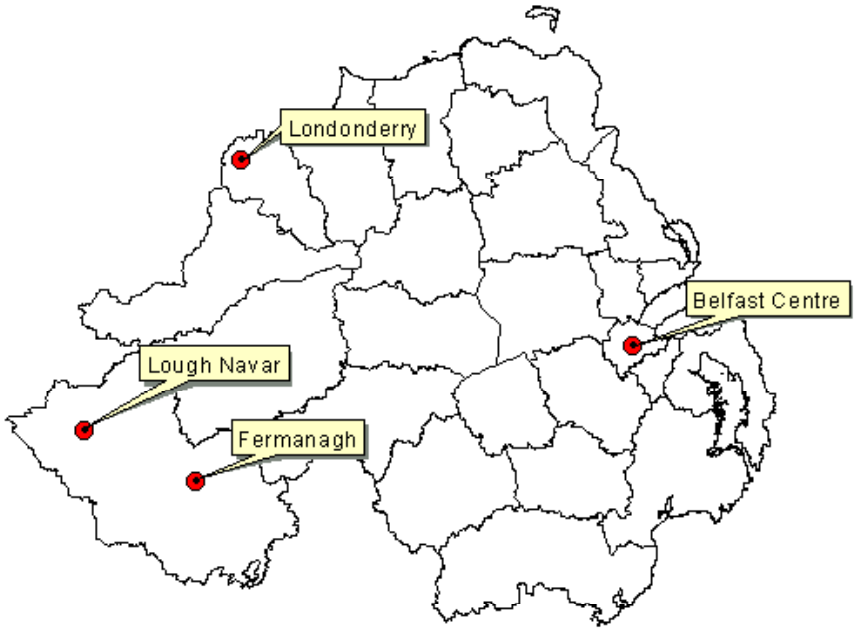


Figure 7.1 Ozone Monitoring Sites

7.2 LIMIT VALUES AND OBJECTIVES FOR OZONE

Ozone is covered by the target values and objectives in Table 7.2. EC Directive 92/72/EC on air pollution by ozone will be superseded by a third Daughter Directive, 2002/3/EC. This Directive, which sets "target values" rather than limits, has not yet been transposed into Northern Ireland's legislation. However, as this transposition is scheduled for 2003, this report compares ozone measurements with the 3rd Daughter Directive rather than the older Directive. The AQS objective is more stringent than the EC target value for protection of human health.

Table 7.2 Target Values and Objectives for Ozone

Averaging period	Target or Objective	Number of Permitted exceedences	To be achieved by
WHO (non-mandatory guide)			
Day	O_3 concentrations not to exceed 120 μg m^{-3} for more than eight hours per day.		
EC Ozone Directive (2002/3/EC)			
Max. daily 8-hour mean. Compliance assessment to be based on the average number of days exceedence over 3 consecutive years.	120 μg m^{-3}	25 days per calendar year	3-year period beginning 2010.
AOT40[a], calculated from 1h values May- July. *For protection of vegetation.*	18,000 μg m^{-3} h	-	Averaged over 5 years, beginning 2010
Air Quality Strategy [b]			
Max. daily running 8-hour mean	100 μg m^{-3}	10 days per year	31 December 2005

a) AOT 40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.

b) Not included in the Air Quality Regulations.

7.3 OZONE RESULTS

Table 7.3 shows the annual maximum daily 8-hour running mean ozone concentration for each site, and also the number of days per year on which this parameter exceeded 100 μg m^{-3}. Years in which the AQS objective was exceeded on more than 10 days are highlighted in ***bold italics.*** Annual mean ozone concentrations are also included in Table 7.3: although no limit values apply to this statistic, the annual mean may show long-term trends more clearly than short-term statistics. Annual data capture is at least 75% except where indicated.

Table 7.3 O_3 Results from Automatic Monitoring Sites

	Calendar Year	Max Daily 8 Hour Mean μg m^{-3}	Days with max. daily 8hr mean > 100 μg m^{-3}	Annual Mean μg m^{-3}
Belfast Centre				
	1992	108	2	36
	1993	88	0	32
	1994	106	2	36
	1995	136	5	38
	1996	130	5	34
	1997	124	6	34
	1998	112	3	42
	1999	126	7	44
	2000	130	2	42
	2001	130	2	38
Londonderry				
	1997 [a]	152	6	44
	1998	108	2	52
	1999	154	4	52
	2000	120	***11***	54
	2001	104	2	46
Lough Navar				
	1987 [b]	156	8	44
	1988	144	***11***	50
	1989	196	***15***	46
	1990	170	***21***	52
	1991	158	***14***	46
	1992	160	***19***	52
	1993	112	***5***	48
	1994	132	7	52
	1995	148	***20***	48
	1996	118	6	46
	1997	140	5	42
	1998	112	3	46
	1999	118	6	50
	2000	124	7	48
	2001	130	9	46

a) Limited data capture: Londonderry 1997 (59%)
b) Limited data capture: Lough Navar 1987 (66%)

The 2001 annual mean ozone concentration at the Fermanagh diffusion tube site was 83 μg m^{-3}. This is very high compared with the automatic analyser results.

Table 7.3 shows that:

- In earlier years, peak concentrations of ozone were typically higher at the rural Lough Navar site than at the two urban sites. However, since the mid 1990s all three sites have had similar maximum daily 8-hour running mean.
- In recent years, the AQS objective for ozone has been met at most sites. The exceptions are Lough Navar, 1995 and Londonderry, 2000.

Ozone data from the rural Lough Navar site, for the five years 1997 to 2001, was compared with the EC 3rd Daughter Directive target value for protection of vegetation (based on the AOT40 statistic). This site currently meets the target value.

7.4 OZONE TRENDS

Figure 7.2 shows a timeseries plot of the annual maximum daily 8-hour running mean for ozone. There appear to be no clear trends, although at Lough Navar this statistic appears slightly lower in recent years than in the late 1980s and early 1990s. If ozone concentrations remain at their current levels, occasional exceedences of the AQS objective may continue to occur at rural locations.

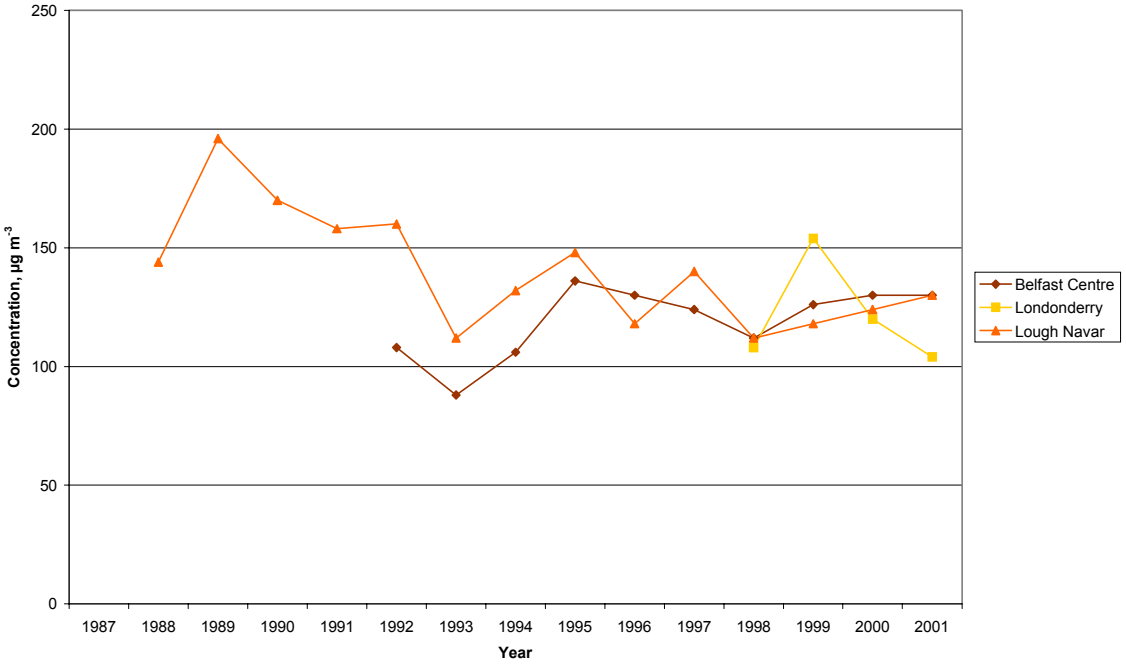


Figure 7.2 Maximum Daily 8-hour Running Mean Ozone Concentration, μg m^{-3}

Trends are sometimes more clearly identifiable in statistics based on longer sampling periods, such as the annual mean. Figure 7.3 shows a similar plot for the annual mean. Regression analysis (Theil's non-parametric analysis) of the annual mean showed no statistically significant trends in the case of Londonderry or Lough Navar. However, in the case of Belfast Centre there was a positive trend in the annual mean ozone concentration from 1992 to 2001, significant at the 95% confidence level. Average ozone levels at Belfast Centre therefore appear to be increasing. However, it is possible that this is caused by decreasing concentrations of other pollutants (such as oxides of nitrogen), which "scavenge" ozone from the air, keeping levels low in urban areas.

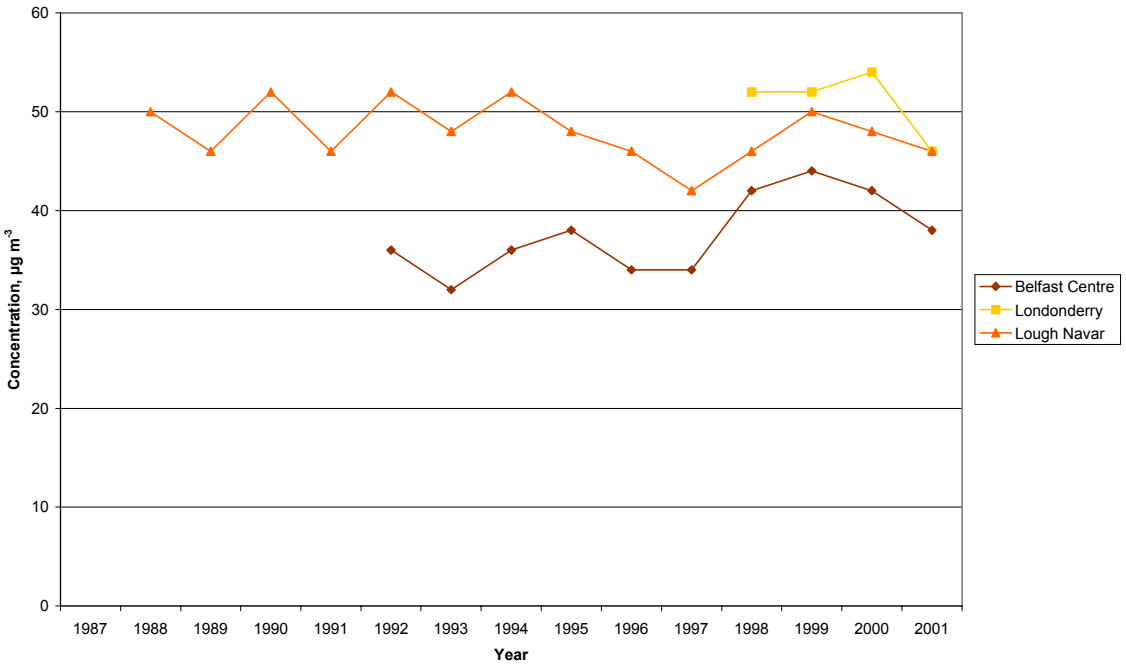


Figure 7.3 Annual Mean Ozone Concentrations (data capture at least 75%)

8 Hydrocarbons

There are many hydrocarbon compounds which have the potential to be pollutants when released into the atmosphere. Some occur naturally, others are man-made.

(i) Benzene and 1,3-butadiene

A range of hydrocarbons are found in vehicle fuel, and occur in vehicle emissions. In most urban areas, vehicle emissions constitute a major source of hydrocarbons, including benzene and 1,3-butadiene. Also, there is the potential that they may be released to the air from facilities where fuels are stored or handled.

Benzene is of most concern, as it is a known human carcinogen; long-term exposure can cause leukaemia. It is found in petrol and other liquid fuels, in small concentrations. In urban areas, the major source is vehicle emissions.

1,3-butadiene is also found in vehicle emissions: although not actually present in petrol or diesel, it is formed as these fuels undergo combustion. 1,3-butadiene is a suspected human carcinogen and therefore an air quality objective has been set for it.

In this report, concentrations of benzene and 1,3-butadiene are expressed as microgrammes per cubic metre (μg m^{-3}). To convert to parts per billion (ppb) if necessary, the following relationships should be used:

1 ppb = 3.25 μg m^{-3} for benzene at 293K (20°C) and 1013mb.

1 ppb = 2.25 μg m^{-3} for 1,3-butadiene at 293K (20°C) and 1013mb.

(ii) Polycyclic Aromatic Hydrocarbons

Another class of organic pollutants is the polycyclic aromatic hydrocarbons, (PAHs). These include the following compounds: Acenapthene, Acenapthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(ah)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Napthalene, Phenanthrene, Pyrene. They are all, to varying degrees, toxic or carcinogenic, and are therefore classified as Hazardous Air Pollutants. Concentrations of these hazardous compounds in ambient air are usually very small, and are reported as nanogrammes (i.e. 10^{-9} grammes) per cubic metre (ngm^{-3}).

The largest source of PAHs in the UK at present is road transport, which in 2000 contributed 53% to the total UK emissions. Non-ferrous metal processes such as aluminium smelting can also be a significant source, although there are no aluminium smelting plant in Northern Ireland at present. However, there is one significant source particularly relevant to parts of Northern Ireland: domestic solid fuel combustion. For this reason, it is important to continue monitoring PAH in areas where domestic solid fuel use is widespread.

PAHs can be adsorbed onto the surface of fine particulate: therefore they are monitored in the particulate phase, by sampling the PM_{10} fraction and analysing for the compounds of concern.

8.1 MONITORING OF HYDROCARBONS

A range of 27 hydrocarbons including benzene and 1,3-butadiene were monitored at the Belfast South site from 1993 to 2000. This site ceased operation at the end of 2000; there are plans to replace it with an instrument monitoring a more limited range of compounds. A range of polycyclic aromatic hydrocarbons (PAHs) in the particulate phase are monitored at two sites in Northern Ireland as part of Defra's Hazardous Air Pollutants (HAPS) Network. These are Belfast (at Clara

Street) and Lisburn (at Dunmurry High School). The sites are shown in Table 8.1 below, and site locations are shown in Figure 8.1.

"BTEX" diffusion tubes are also available for monitoring benzene, toluene, ethylbenzene and xylenes, but these were not used at any sites in Northern Ireland during 2000 – 2001.

Table 8.1 Hydrocarbon Monitoring Sites

Site	Grid Ref.	Classification	Pollutants	Network
Belfast South (until 2000 only)	J 333 726	Urban Background	27 species inc. benzene and 1,3-butadiene	Hydrocarbon
Lisburn (Dunmurry High School)	J 287 675	Urban Background	Range of PAH	Hazardous Air Pollutants
Belfast (Clara Street)	J 360 734	Suburban	Range of PAH	Hazardous Air Pollutants

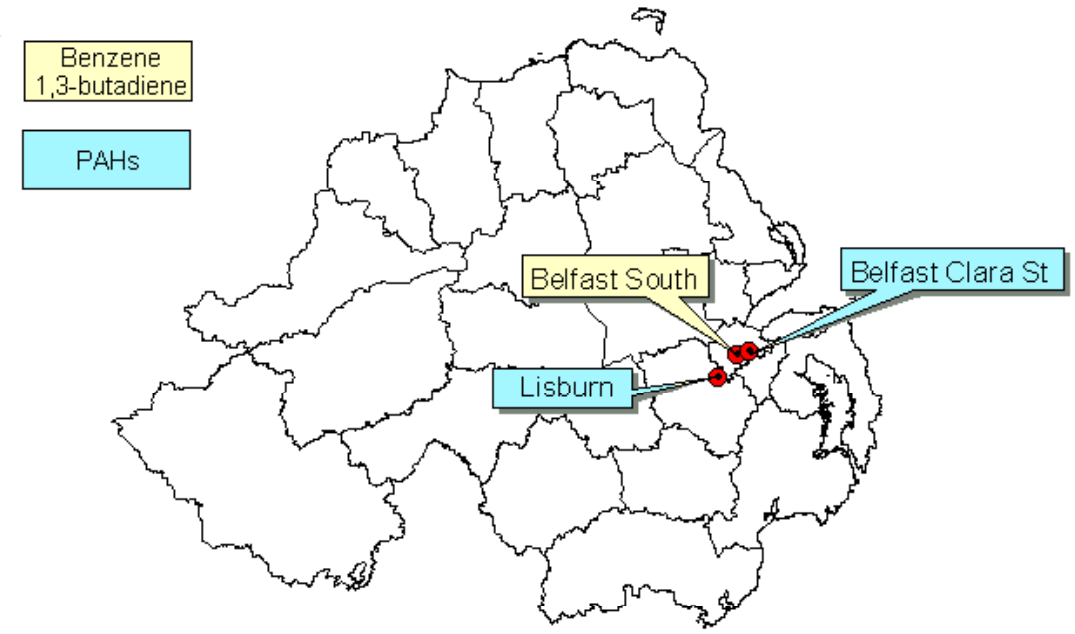


Figure 8.1 Hydrocarbon Monitoring Sites

8.2 LIMIT VALUES AND OBJECTIVES FOR HYDROCARBONS

Within the European Community, benzene is covered by EC Directive 2000/69/EC (the 2nd Daughter Directive). The Air Quality Strategy initially covered benzene and 1,3-butadiene; in 2002, in England, Scotland and Wales, an objective was added for PAHs. Northern Ireland's policy on an objective for PAH has still to be determined. However, the objective is discussed in this section because of its relevance to domestic solid fuel use. EC limits and AQS objectives for these three hydrocarbon pollutants are summarised in Table 8.2:

Table 8.2 Limit Values and Objectives for Hydrocarbons

Averaging period	EC Limit or AQS Objective	To be achieved by
EC 2nd Daughter Directive (2000/69/EC)		
BENZENE: Calendar Year Mean	5 μg m^{-3}	1st January 2010
Air Quality Strategy (as currently adopted in Northern Ireland)		
BENZENE: Running annual mean	16.25 μg m^{-3}	31st December 2003
1,3 BUTADIENE: Running annual mean	2.25 μg m^{-3}	31st December 2003
Air Quality Strategy for PAH (Not at present adopted in Northern Ireland)		
PAHs * *(using B(a)P as an indicator)* Calendar year mean	0.25 ng m^{-3}	31st December 2010

** Footnote to Table 8.2: No policy decision has yet been taken on the inclusion of the PAH objective for Northern Ireland.*

PAHs are to be covered by a fourth Daughter Directive, currently at the draft stage. This specifies a range of PAHs to be monitored, but proposes a target value for just one PAH compound, benzo(a)pyrene, which will be used as a marker of carcinogenic risk from PAHs in ambient air. The proposed target value for benzo(a)pyrene is **1 ngm^{-3} for the annual mean total benzo(a)pyrene in the PM_{10} particulate fraction**, to be met by 1st January 2010. However, this limit has not yet been finalised and may change.

8.3 HYDROCARBON RESULTS

8.3.1 Benzene and 1,3 Butadiene

Table 8.3 shows calendar year annual mean, maximum running annual mean and maximum hourly concentrations of benzene and 1,3-butadiene at Belfast South.

Table 8.3 Concentrations of benzene and 1,3-butadiene at Belfast South

Benzene	1993	1994	1995	1996	1997	1998	1999	2000	2001
Annual Mean (µgm^{-3})									
Max. Running Annual Mean (µgm^{-3})	-	4.6	3.6	3.3	3.3	2.9	2.3	2.3	nm
Maximum Hour (µgm^{-3})	47.1	85.5	110.5	76.7	68.6	55.3	44.2	25.4	nm
1,3-butadiene	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Annual Mean (µgm^{-3})	-	0.5	0.5	0.5	0.5	0.2	0.2	0.2	nm
Max. Running Annual Mean (µgm^{-3})	-	0.5	0.5	0.5	0.5	0.5	0.2	0.2	nm
Maximum Hour (µgm^{-3})	-	12.4	14.6	10.6	7.7	6.1	9.9	4.5	nm

a) Very limited data capture for benzene, 1993 (27%).

nm = no measurement.

Annual mean benzene concentration has been below 5 μg m^{-3} since 1994: hence the EC 2nd Daughter Directive limit value for this pollutant is currently met at this site. Also, the maximum running annual means for this site show that neither benzene nor 1,3-butadiene has exceeded the applicable Air Quality Strategy objective (16.25 μg m^{-3} and 2.25 μg m^{-3} for benzene and 1,3-butadiene respectively) during the period 1994 – 2000. The Air Quality Strategy objectives for benzene and 1,3-butadiene have therefore been met at this site throughout its operational period.

8.3.2 Polycyclic Aromatic Hydrocarbons

Annual mean benzo(a)pyrene concentrations at Lisburn were 0.93 ngm^{-3} in 2000, and 0.96 ngm^{-3} for 2001. Annual mean benzo(a)pyrene concentration at Belfast Clara Street was 0.37 ngm^{-3} in 2001. Both sites are therefore within the proposed EC target value of 1.0 ngm^{-3} for this PAH (although in the case of Lisburn by a very small margin). The new AQS objective of 0.25 ngm^{-3} for benzo(a)pyrene does not apply to Northern Ireland at the present time. However, both sites currently exceed this value; in the case of Lisburn, the exceedence is substantial.

To put these values into context, they should be compared with results from other sites in the HAPS Network in England, Wales and Scotland – see Table 8.4 and Figure 8.2. The two sites in Northern Ireland are shown in ***bold italics***.

Table 8.4 Annual Mean Benzo(a)pyrene Concentrations at all HAPS Network Sites

Site	Type	Annual Mean 2000 ng m^{-3}	Annual Mean 2001 ng m^{-3}
Ashington	Urban	0.17	0.20
Belfast	***Urban***	***-***	***0.37***
Birmingham	Urban	-	0.16
Bolsover	Urban	0.25	0.28
Glasgow	Urban	0.12	0.12
Hazelrigg	Semi-Rural	0.06	0.08
High Muffles	Rural	0.04	0.05
Holyhead	Urban	0.11	0.15
Kinlochleven *	Urban	2.28	0.34
Leeds	Urban	-	0.16
Lisburn	Urban	***0.93***	***0.96***
London 2a	Urban	0.14	0.14
Manchester	Urban	0.24	0.34
Middlesbrough	Urban	0.28	0.37
Newcastle	Urban	-	0.11
Newport	Urban	0.35	0.36
Port Talbot	Urban	0.59	0.40
Scunthorpe	Urban	1.18	0.34
Stoke Ferry	Rural	0.09	0.09

**Kinlochleven site (Scotland) was near an aluminium smelter, which closed in July 2000.*

Annual mean benzo(a)pyrene concentration for 2000-2001 at rural sites (Hazelrigg, High Muffles, Stoke Ferry), ranged from 0.04 to 0.09 ngm^{-3}, well within the Air Quality Strategy's new 2010 objective of 0.25 ngm^{-3}. Urban sites typically had higher annual mean benzo(a)pyrene concentrations for 2000 and 2001 ranging from 0.11 to 2.28 ngm^{-3}: nine of the 19 sites exceeded the AQS objective of 0.25 ngm^{-3} in 2000 or 2001. Typically, the highest values were measured at sites near industrial areas, such as Kinlochleven, Scunthorpe, Middlesbrough, and Port Talbot.

Only three sites approached or exceeded the proposed EC limit value for benzo(a)pyrene of 1.0 ngm^{-3} : Kinlochleven (2000 annual mean 2.28 ng m^{-3}), Lisburn (annual means 0.93 ng m^{-3} and 0.96 ng m^{-3} in 2000 and 2001 respectively) and Scunthorpe (2000 annual mean 1.18 ng^{-3}). Kinlochleven was near an aluminium smelter, which closed in June 2000 (hence the much lower 2001 annual mean). The Scunthorpe site is near a major steel works and a coal tar processing plant. The Lisburn site, by contrast, is in a non-industrial residential area. In the case of Lisburn, it is likely that domestic fuel burning is the dominant source of PAHs.

As there are only two years data for PAHs in Northern Ireland, it is not possible to assess trends. A study[4] carried out by **netcen** for Defra has predicted that the continued high use of solid fuels in Northern Ireland for domestic purposes may result in some urban areas exceeding the AQS objective of 0.25 ngm^{-3} for benzo(a)pyrene in 2010. However, no exceedences of the proposed EC target value of 1.0ngm^{-3} were predicted.

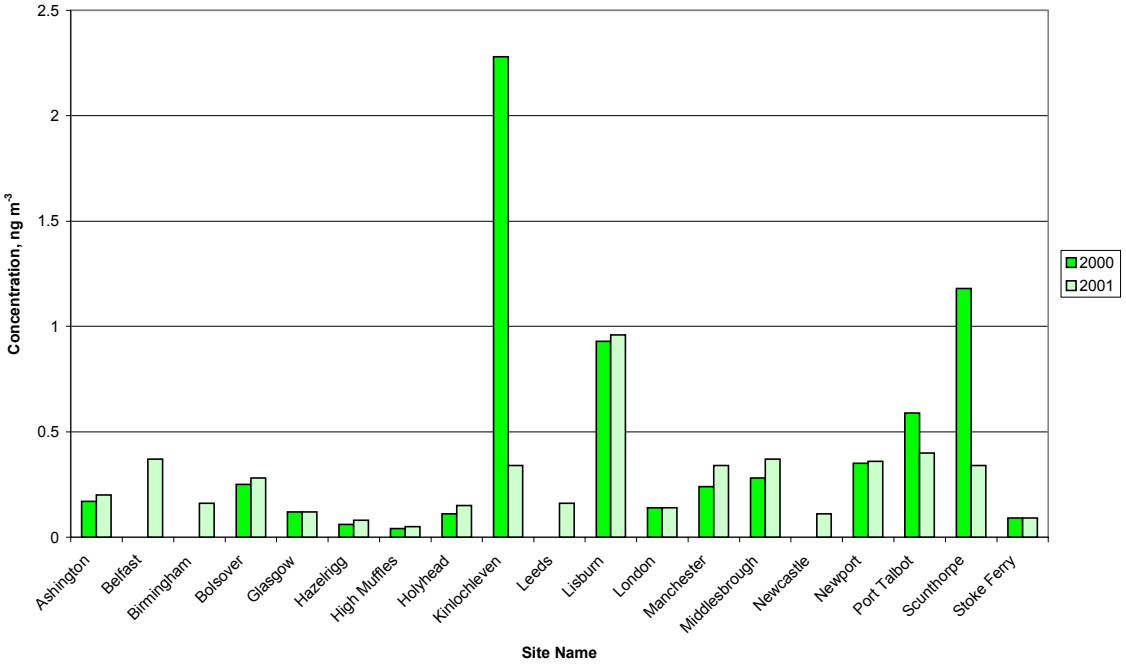


Figure 8.2 Annual Mean Benzo(a)pyrene Concentrations at HAPS Network sites, ng m^{-3} 2000 & 2001

8.4 HYDROCARBON TRENDS

Figure 8.3 shows annual mean benzene and 1,3-butadiene concentrations at the Belfast South hydrocarbon monitoring site. Average benzene concentrations at the site have clearly decreased over the 8 years of monitoring. A regression analysis (Theil's non-parametric analysis) confirms that the downward trend in the annual mean is statistically significant at the 95% confidence level.

For 1,3-butadiene, by contrast, regression analysis confirms there is no statistically significant trend in the annual mean. However, levels are low and do not appear to be rising.

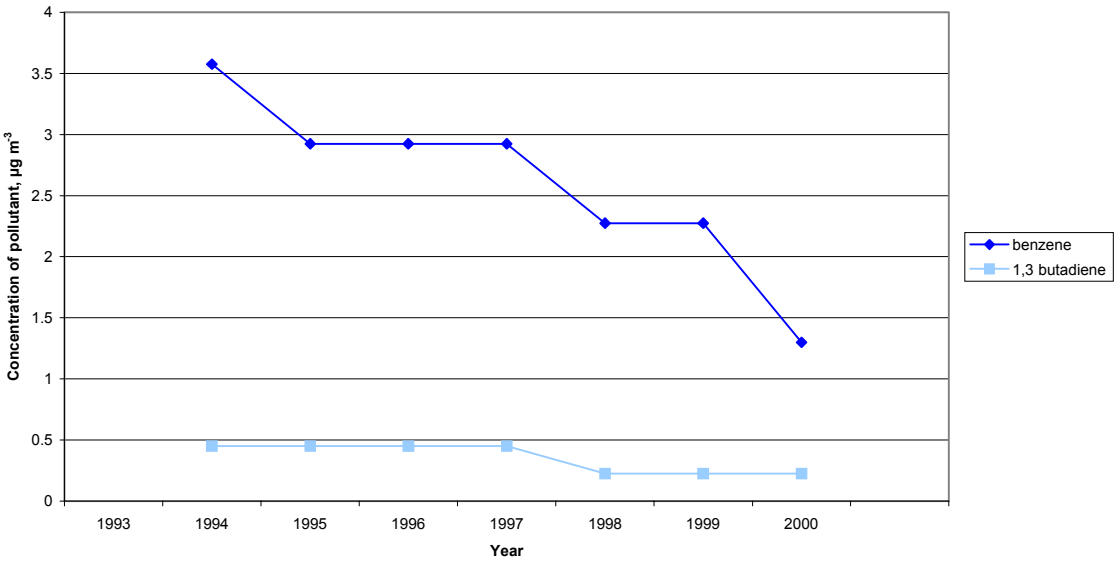


Figure 8.3 Annual Mean Concentrations of Benzene and 1,3, Butadiene at Belfast South (data capture at least 75%)

9 Metals

The metallic elements lead (Pb), cadmium (Cd), arsenic (As), nickel (Ni) and mercury (Hg) have the potential to cause adverse health effects in humans. Cadmium, arsenic, and nickel occur as pollutant emissions from coal burning, heavy fuel oil burning, waste incineration and some industrial processes. Mercury is emitted from waste incineration, industrial processes using mercury cells, some non-ferrous metal processes and coal combustion. The major source of ambient lead is vehicles using lead-containing fuel. Emissions of cadmium, arsenic, nickel and mercury in the UK have all fallen by more than 80% since 1970, as a result of reduced coal and oil combustion, and better emission controls on industrial processes and waste incineration plant. Emissions of lead have been reduced by 93% since 1970, by a substantial reduction of the permitted lead content of petrol in 1986, followed by the phasing out of leaded petrol in 1999.

Concentrations of these metallic elements in ambient air are expressed in microgrammes (i.e. 10^{-6} grammes) per cubic metre (μg m^{-3}) or nanogrammes (i.e. 10^{-9} grammes) per cubic metre (ngm^{-3}).

9.1 MONITORING OF METALS

The metals lead (Pb), cadmium (Cd), arsenic (As), nickel (Ni), and mercury (Hg) were monitored at three sites in Northern Ireland over a twelve month period, December 1999 to November 2000. This monitoring was carried out by Casella Stanger on behalf of the Department of Environment, Transport and the Regions (now Defra), as part of a study investigating ambient concentrations of these metals around industrial emission sources. The three sites were all located near to power stations or large industrial plant. Table 9.1 shows the locations of these monitoring sites. At these sites, particulate phase ambient concentrations were measured using gravimetric PM_{10} measurement apparatus. The duration of each sample period was one week. One site, Whitehead, also monitored the metal vanadium.

Table 9.1 Metals Monitoring Sites

Site	Grid reference	Description	Technique
Donnybrewer Road, **Campsey**	C 486 208	1km to the NE of Coolkeeragh Power station (oil fired)	Gravimetric PM_{10}
Bentra Road, **Whitehead**	J 450 911	1km to NE of Kilroot Power Station (oil fired)	Gravimetric PM_{10}
Victoria Park, **Belfast**	J 364 754	800m from Belfast Harbour Estate (mixed industrial area)	Gravimetric PM_{10}

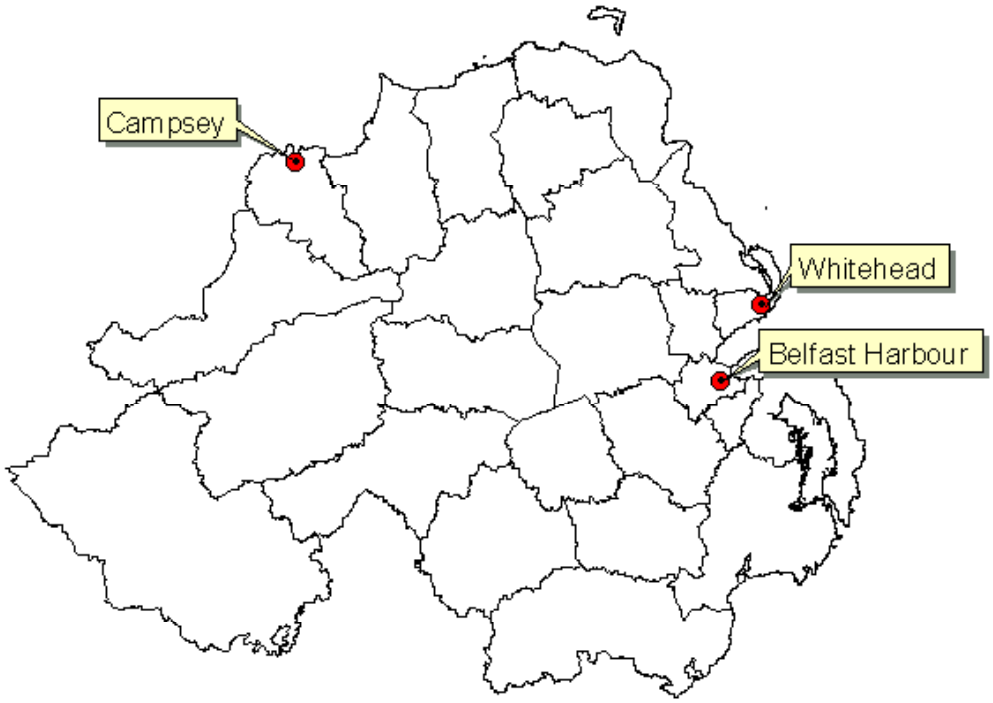


Figure 9.1 Monitoring Sites for Particulate Phase Metals, 2001

9.2 LIMIT VALUES AND OBJECTIVES FOR METALS

9.2.1 Lead

The 1st Daughter Directive, (1999/30/EC) and the Air Quality Strategy contain limit values and objectives for annual mean lead. These are shown in Table 9.2.

Table 9.2 Limit Values and Objectives for Lead

Averaging period	EC Limit or AQS Objective	To be achieved by
EC 1st Daughter Directive (1999/30/EC)		
Calendar Year Mean	0.5 μg m^{-3} (= 500 ng m^{-3})	1st January 2005, or 1st January 2010 in the immediate vicinity of industrial sources.
Air Quality Strategy		
Calendar Year Mean (1)	0.5 μg m^{-3} (= 500 ng m^{-3})	31st December 2004
Calendar Year Mean (2)	0.25 μg m^{-3} (= 250 ng m^{-3})	31st December 2008

At present, lead is the only metallic pollutant to be covered by the Air Quality Strategy.

9.2.2 Other Metals

The metals As, Cd, Hg and Ni in ambient air are to be covered by a fourth Daughter Directive, currently at the draft stage. This Directive proposes "target values" (rather than limits) for As, Cd and Ni, which are shown in Table 9.3; however, it should be noted that these have not been finalised and may change.

Table 9.3 *Proposed* EC Directive Target Values for As, Cd and Ni.

Element	Averaging period	Target Value
As	Calendar year	6 ng m^{-3}
Cd	Calendar year	5 ng m^{-3}
Ni	Calendar year	20 ng m^{-3}

For As, Cd and Ni the target values apply to the total As, Cd or Ni concentration in the PM_{10} fraction. No target value has been set for Hg.

9.3 METALS RESULTS

Table 9.4 shows the metals monitoring results for all three sites in Northern Ireland, from the study[1] carried out over the 12 months December 1999 to November 2000.

Annual mean Pb concentrations at all three sites were well within the EC Directive limit value 0.5 μg m^{-3} (500 ng m^{-3}). They were also well within the lower AQS objective of 0.25 μg m^{-3} (250 ng m^{-3}): thus all three sites already meet the AQS objective for this metal, set for the end of 2008.

Annual means of As, Cd and Ni were well within the proposed EC Directive target values at all three sites.

Table 9.4 Results of Metals Monitoring Study

	Annual mean ng m^{-3}	Min. weekly ng m^{-3}	Max weekly ng m^{-3}	Limit of detection ng m^{-3}
Lead				
Campsey	3	1	10	1
Whitehead	4	1	10	1
Belfast	12	3	40	1
Arsenic				
Campsey	0.72	0.06	14.92	0.06
Whitehead	0.47	0.06	1.48	0.06
Belfast	1.01	0.24	2.26	0.06
Cadmium				
Campsey	0.13	0.14	0.77	0.14
Whitehead	0.14	0.14	1.59	0.14
Belfast	0.14	0.14	0.45	0.14
Mercury				
Campsey	0.06	0.06	0.44	0.06
Whitehead	0.047	0.06	0.23	0.06
Belfast	0.08	0.06	0.63	0.06
Nickel				
Campsey	2.05	0.29	8.27	0.29
Whitehead	1.25	0.29	5.96	0.29
Belfast	3.59	0.29	11.38	0.29
Vanadium				
Whitehead	2.6	0.44	5.37	0.44

On the basis of this one-year study, it was concluded that levels of metallic pollutants at these three sites in Northern Ireland were low. As the duration of this study was just one year, it is not possible to assess trends. Overall UK trends for all these metals are decreasing.

10 Conclusions

1. Carbon Monoxide is measured at two sites: Belfast Centre and Londonderry. Both currently meet the EC limit value and the Air Quality Strategy objective for CO. There is a significant downward trend in the annual mean CO at Belfast Centre but not at Londonderry.

2. Nitrogen Dioxide is monitored at four automatic sites, and over 150 diffusion tube sites. The four automatic sites meet the EC limit values and the Air Quality Strategy objectives for NO_2. A small number of diffusion tube sites (four in 2000, six in 2001) had annual mean NO_2 concentrations greater than the EC Directive and AQS objective of 40 μg m^{-3}. In all but one case, these were Type A (Roadside) sites.

3. Two automatic sites (Belfast Centre and Londonderry) have sufficient NO_2 data to assess trends: there is a significant downward trend in annual mean NO_2 concentration at Belfast Centre only. Diffusion tube data show a significant downward trend for Roadside, Intermediate and Urban Background site types, for the period 1993 to 2001.

4. Sulphur Dioxide is monitored at five automatic sites, and 34 non-automatic sites. The requirements of the 1st Daughter Directive and the objectives of the Air Quality Strategy are met at all automatic sites, *except* Belfast East. This site exceeded the AQS objective for the 15-minute mean on more than 35 permitted occasions in 2000 and 2001, and the EC limit value and AQS objective for the 24-hour mean on more than three occasions in 2001.

5. Significant downward trends in annual mean SO_2 concentration were identified at Belfast Centre and Belfast East, but not Londonderry.

6. In calendar year 2001, three non-automatic SO_2 (8-port sampler) sites in Belfast exceeded the EC limit value and AQS objective for the 24-hour mean on more than the permitted three occasions. The historical dataset from this network show a clear decrease in annual mean SO_2 concentrations since the 1960s, which is also evident in recent years' data.

7. Particulate matter as PM_{10} is measured at six automatic monitoring sites in Northern Ireland. All these sites meet the EC Directive limits and Air Quality Strategy objectives for this pollutant. There is a significant downward trend in annual mean PM_{10} concentrations at Belfast Centre and Londonderry, although not at Belfast East and Lough Navar. (At the two Newry sites, there is as yet insufficient data to assess trends).

8. Particulate matter as black smoke is measured at 31 sites, of which 29 are part of a long-running network. The historical dataset from this network show a clear and consistent decrease in annual mean smoke concentrations from the 1960s to the mid 1990s; however the downward trend has levelled off in the past five years.

9. Ozone is measured at three automatic sites in Northern Ireland: the AUN sites Belfast Centre and Londonderry and the rural site Lough Navar. In recent years, the new EC Directive target and the more stringent AQS objective, for ozone have been met at these sites, except for Lough Navar in 1995 and Londonderry in 2000. Ozone concentrations at Belfast Centre show an increasing trend; this may be due to decreasing concentrations of other pollutants which can act as "scavengers" of ozone, keeping levels low in urban areas.

10. Hydrocarbons were measured from 1993 to 2000 at the Belfast South site. Concentrations of both benzene and 1,3-butadiene were within the limits set by the Air Quality Strategy at this site throughout its operational period. Annual mean benzene showed a significant downward trend over this period; annual mean 1,3, butadiene showed no significant trend.

11. Polycyclic aromatic hydrocarbons (PAHs) have been measured since 2000 at Lisburn, and since 2001 at Belfast Clara Street, as part of the Hazardous Air Pollutants (HAPs) Network. At Lisburn, annual mean concentrations of benzo(a)pyrene in 2000 and 2001 were substantially

above the new AQS objective of 0.25 ngm^{-3} (which at the present time does not apply to Northern Ireland) and very close to the *proposed* EC limit value of 1.0 ngm^{-3}. Lower concentrations of benzo(a)pyrene (2001 annual mean 0.37 ngm^{-3}) were measured at Belfast Clara Street. Benzo(a)pyrene concentrations at Lisburn in particular were high compared with most other urban sites in the UK. This is believed to be due to the widespread domestic use of solid fuels in this area. A study by **netcen** has predicted that continued use of such fuels may cause parts of Northern Ireland to fail to meet the AQS objective in 2010.

12. A one-year study, carried out on behalf of Defra, monitored ambient levels of the metallic elements lead, arsenic, cadmium, mercury and nickel at three sites near to industrial sources. Annual mean concentrations of lead were well within applicable air quality limits and guidelines. Annual mean concentrations of arsenic, cadmium and nickel were well within *proposed* EC target values.

11 Acknowledgements

Netcen would like to thank the District Councils and other organisations who carried out the air quality measurements detailed in this report, and CEHOG for collating their data.

12 References

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Appendices

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Appendix 1
Diffusion Tube Site Details and Data

CONTENTS

Table A1.1 NO_2 Diffusion Tube Data for 2000 (page 1 of 2)

Local Authority	Location of Sampler	Irish Grid E	Irish Grid N	Site Classification	Part of NO_2 Network?	NO_2 Network number if applicable	NO_2 Network classification	Annual mean 2000 ($\mu g\ m^{-3}$)
Antrim	Main Street, Templepatrick	3225	3856	A	NO			33.0
Antrim	Background - Templepatrick	3232	3857	D	NO			
Antrim	Moneyrod Road, Randalstown	3075	3905	D	NO			8.6
Ards	8 Court Street, Newtownards	3485	3735	A	YES	1N	R	29.0
Ards	Council Offices, 2 Church Street, Newtownards	3485	3740	B	YES	2N	I	11.0
Ards	7 Ashgrove, Newtownards	3485	3745	C	YES	3N	B	9.0
Ards	19 Islandmore Avenue, Newtownards	3495	3750	C	YES	6N	B	9.0
Armagh	25 Railway Street, Armagh	2875	3458	A	YES	1N	R	36.3
Armagh	Bridge House, Barrack Street, Armagh	2879	3450	A	YES	5N	R	17.2
Armagh	St Patrick's Fold, Scotch Street, Armagh	2877	3451	A	YES			19.9
Armagh	Tourist Information Office, English Street, Armagh	2876	3455	A	YES			26.9
Armagh	Portadown Road, Armagh	2887	3459	A	NO			29.8
Armagh	Lower Irish Street, Armagh	2873	3477	A	NO			29.2
Armagh	7 Desart Lane, Armagh	2856	3457	C	YES	3N	B	14.9
Armagh	17 Folly Lane, Armagh	2882	3458	C	YES	4N	B	19.1
Ballymena	29 Galgorm Road, Ballymena	3103	4032	A	YES	2N	R	26.7
Ballymena	Ballymoney Street, Ballymena	3108	4035	A	NO	5N	R	26.2
Ballymena	Queen Street, Ballymena	3108	4022	A	NO			24.4
Ballymena	9 Princes Street, Ballymena	3103	4033	B	YES	3N	I	21.6
Ballymena	Greenvale Street, Ballymena	3108	4035	B	NO			17.8
Ballymena	Patrick Place, Ballymena			B	NO			14.9
Ballymena	Leighmore Avenue, Ballymena	3102	4025	C	YES	1N	B	9.4
Ballymena	8 Ballyloughan Avenue, Ballymena	3096	4044	C	YES	4N	B	11.3
Ballymoney	19 Linenhall Street, Ballymoney	2948	4259	A	YES	1N	R	18.5
Ballymoney	6 Church Street, Ballymoney	2948	4258	A	NO			20.8
Ballymoney	31 Charles Street, Ballymoney	2946	4261	A	NO			19.1
Ballymoney	Opposite 51 Queen Street, Ballymoney	2952	4258	A	NO			19.9
Ballymoney	14/16 Ozone Avenue, Ballymoney	2954	4257	B	YES	2N	I	17.2
Ballymoney	Opposite 16 Armour Avenue, Ballymoney	2954	4257	C	YES	3N	B	10.1
Ballymoney	2/4 Semicock Avenue, Ballymoney	2948	4259	C	YES	4N	B	13.4
Banbridge	Dromore Street, Banbridge	3128	3462	A	NO			22.9
Banbridge	10 Reilly Court, Banbridge	3122	3461	B	NO			15.3
Banbridge	17 Springfields, Banbridge	3121	3444	C	NO			11.5
Banbridge	9 Fortfield, Dromore	3199	3535	D	NO			11.5
Belfast	Belfast City Hall, Donegal Square South	3338	3739	A	Yes	1N	R	38.2
Belfast	Black's Road, Belfast	3297	3695	A	Yes			36.3
Belfast	228 Antrim Road	3334	3757	A	Yes			11.5
Belfast	181 Lisburn Road	3327	3723	A	Yes			43.9
Belfast	5-11 Cromac Street	3341	3753	A	Yes			36.3
Belfast	301 Ormeau Road	3345	3722	A	Yes			36.3
Belfast	400 Ormeau Road	3350	3710	A	Yes			32.5
Belfast	59 Saintfield Road	3353	3698	A	Yes			34.4
Belfast	Belfast City Hall, Donegal Square East	3339	3739	B	Yes	2N	I	34.0
Belfast	9 Molyneaux Street	3339	3752	B	Yes			43.9
Belfast	St. Patrick's School	3340	3752	B	Yes			24.8
Belfast	Royal Victoria Hospital, 12 Grosvenor Road Belfast	3324	3735	C	Yes	3N	B	24.0
Belfast	Primary School, North Road	3375	3743	C	Yes	4N	B	19.1
Carrickfergus	59 Shore Road, Greenisland	3379	3849	A	YES	1N	R	16.2
Carrickfergus	27 Upper Road, Greenisland	3362	3857	A				14.7
Carrickfergus	Islandmagee Road, Whitehead	3476	3923	A				8.8
Carrickfergus	Railway Station, Fergus Avenue, Carrickfergus	3412	3878	B	YES	2N	I	11.3
Carrickfergus	32 Mullaghmore Park, Greenisland	3369	3856	C	YES	3N	B	6.5
Carrickfergus	College North Road, Carrickfergus	3411	3889	C	YES	4N	B	10.5
Carrickfergus	28 Bentra Road, Whitehead	3454	3919	D				5.7
Carrickfergus	Lough Road, Loughmourne	3412	3921	D				
Castlereagh	Council Offices, 368 Cregagh Road, BT6 9EZ	3362	3713	A	YES	1N	R	18.0
Castlereagh	3 Downshire Road, Cregagh, Belfast, BT6 9 EZ	3360	3713	B	YES	2N	I	14.0
Castlereagh	Lamp post, 17/19 Everton Drive, Castlereagh	3361	3711	C	YES	5N	B	13.0
Castlereagh	74 Downshire Park East	3365	3714	D	YES	6N	B	11.0
Coleraine	Lower Union Street, Coleraine	2848	4328	A	NO			
Coleraine	Upper Union Street, Coleraine	2852	4328	A	NO			
Coleraine	Lodge Road, Roundabout, Coleraine	2859	4314	A	NO			
Coleraine	Bridge Street, Coleraine	2847	4325	A	NO			
Coleraine	Lansdowne Crescent Car Park, Portrush	2856	4412	A	YES			3.6
Coleraine	Main Street, Portrush	2858	4408	A	YES			9.0
Coleraine	Dunluce Centre, Dunluce Avenue, Portrush	2860	4401	B	YES			4.6
Coleraine	Kelly's Caravan Site, Dunluce Road, Portrush	2871	4398	C	YES			3.1

Table A1.1 NO_2 Diffusion Tube Data for 2000 –*continued;* (page 2 of 2)

Local Authority	Location of Sampler	Irish Grid E	Irish Grid N	Site Classification	Part of NO_2 Network?	NO_2 Network number if applicable	NO_2 Network classification	Annual mean 2000 ($\mu g\ m^{-3}$)
Cookstown	Westland Road, Cookstown	2803	3784	A				20.6
Cookstown	Chapel Street, Cookstown	2811	3777	A				27.7
Cookstown	Parochial House, Cookstown			C				13.8
Cookstown	Rathmore, Cookstown	2809	3774	C				16.4
Cookstown	Westland Rd OPH			C				14.9
Craigavon	Town Hall, Union Street, Lurgan	3083	3583	A	YES	5N	R	18.0
Craigavon	17 Derrylodge Manor, Lurgan	3076	3592	B	YES	6N	I	26.0
Craigavon	36 Ardboe Drive, Lurgan	3081	3578	C	YES	7N	B	12.0
Craigavon	21 Ballyhannon Road, Portadown	3031	3533	C	YES	8N	B	10.0
Derry	No 3 Creggan Road, Londonderry	2429	4172	A	YES	8N	R	
Derry	St Columbs Park, Limavady Road, Londonderry	2445	4173	B	YES	7N	I	
Derry	3 Silverbirch Crescent, Londonderry	2453	4166	C	YES	5N/11N	B	
Derry	29 Argyle Street, Londonderry	2432	4179	C	YES	6N	B	
Down	9 Irish Street, Downpatrick, BT30 6BN	3487	3446	A	YES	1N	R	29.4
Down	High Street, Ballynahinch	3366	3523	A	NO	8N	R	25.2
Down	Link Road, Downpatrick	3488	3448	A	NO			11.5
Down	2 Belfast Road, Saintfield	3406	3591	A	NO			20.6
Down	4 main Street, Newcastle	3378	3316	A	NO			14.5
Down	5 Market Lane, Downpatrick, BT30 6TH	3486	3445	B	YES	2N	I	11.7
Down	11 Orchard Way, Strangford Road, Downpatrick, BT30	3489	3459	C	YES	4N	B	6.5
Down	7 St Patrick's Drive, Downpatrick, BT30 6NR	3486	3422	C	YES	3N	B	8.8
Dungannon	Market Square, Dungannon	2798	3625	A	YES	1N	R	20.0
Dungannon	Thomas Street, Dungannon	2797	3626	B	YES	2N	I	18.0
Dungannon	4 Ardgammon, Dungannon	2796	3630	B	YES	3N	B	11.0
Dungannon	11 Bushvale, Dungannon	2811	3623	C	YES	4N	B	12.0
Fermanagh	Belmore Street, Enniskillen	2239	3440	A	NO			22.5
Fermanagh	Lower Celtic Park, Enniskillen	2244	3435	B	NO			8.2
Fermanagh	Everglades, Tempo Road, Enniskillen	2256	3447	B	NO			4.6
Fermanagh	Rossole Park, Enniskillen	2230	3432	C	NO			5.7
Lisburn	Northern Bank, 62 Bow Street, Lisburn, BT28 1BN	3265	3644	A	YES	1N	R	27.0
Lisburn	18 Kingsway, Dunmurry	3295	3689	A	YES	7N	R	
Lisburn	2 Llewellyn Avenue, Lisburn	3273	3648	B	YES	5N	I	17.0
Lisburn	10 Beechlawn Park, Dunmurry	3296	3691	B	NO			
Lisburn	75 Edgewater, Lisburn	3272	3637	C	YES	6N	B	11.0
Lisburn	22 Ventnor Park, Lambeg	3269	3620	C	YES	3N	B	10.0
Lisburn	38 Ballynahinch Road, Lisburn	3274	3636	C	YES	4N	B	
Lisburn	Dunmurry High School, River Road, Dunmurry	3287	3675	C	NO			
Magherafelt	Queen Street, Magherafelt	2896	3905	A	NO			36.3
Magherafelt	Church Street, Magherafelt	2897	3909	A	NO			28.7
Magherafelt	Main Street, Magherafelt	2853	4004	A	NO			22.9
Newry and Mourne	20a Water Street, Newry	3087	3266	A	YES	6N	R	43.0
Newry and Mourne	Monaghan Row, Newry	3078	3268	C	YES	3N	I	16.0
Newry and Mourne	Edward St, Newry	3084	3268	C	YES	7N	B	16.0
Newry and Mourne	19 Balmoral Park, Newry	3084	3268	C	YES	9N	B	14.0
Newtownabbey	Opposite 229 Jordanstown Road, Newtownabbey	3347	3804	A	NO			26.9
Newtownabbey	49 Main Street, Ballyclare	3288	3911	A	YES	1N?		39.0
Newtownabbey	McMillan House, 323 Antrim Road, Glengormley	3313	3825	A	NO			35.0
Newtownabbey	Doagh Road, Abbots Cross, Newtownabbey	3346	3824	A	NO			30.0
Newtownabbey	Safeway Pole, lane off Main St., Ballyclare	3129	3591	B	YES	5N	I	26.0
Newtownabbey	Church/Lenamore Avenue, Jordanstown	3357	3844	B	NO			18.0
Newtownabbey	1251 Doagh Road, Newtownabbey	3335	3845	B	NO			20.1
Newtownabbey	19a Newtown Gardens, Newtownabbey	3288	3911	C	YES	4N	B	25.0
Newtownabbey	202 Carnmoney Road, Glengormley	3121	3833	C	YES	3N	B	18.9
North Down	52 Bingham Street, Bangor	3507	3819	A	YES	7N, 1N?	R	17.0
North Down	132 Main Street, Bangor	3504	3815	A	YES	2N	I	19.0
North Down	68 Groomsport Road, Bangor	3520	3819	C	YES	4N	B	8.0
North Down	1 Rathmore Road, Bangor	3483	3815	C	YES	5N	B	7.0
Omagh	Adjacent to 41 Dublin Road, Omagh	2456	3724	A	YES	1N	R	53.0
Omagh	9 Dergmoney Place, Omagh	2458	3722	B	YES	2N	I	19.0
Omagh	2 Ardmore Heights, Omagh	2442	3722	C	YES	5N	B	10.0
Omagh	16 Gortmore Gdns, Omagh	2444	3733	C	YES	6N	B	

All grid references are to nearest 100m.
Site classifications:

A = kerbside, 1-5m from the kerb of a busy road

B = intermediate site, 20-30m from the same or an equivalent road

C = urban background site, greater than 50m from any busy road

D = rural background site

E = special site; monitoring air pollution from some industrial process, etc.
Annual means shown only where there are at least 6 months' valid data.

Table A1.2 NO_2 Diffusion Tube Data for 2001 (page 1 of 3)

Local Authority	Location of Sampler	Irish Grid E	Irish Grid N	Site Classification	Part of NO_2 Network?	NO_2 Network number if applicable	NO_2 Network classification	Annual mean 2001 ($\mu g\ m^{-3}$)
Antrim	Main Street, Templepatrick	3225	3856	A	NO			31.6
Antrim	Moneyrod Road, Randalstown	3075	3905	A	NO			17.0
Antrim	Fountain Street, Antrim	3153	3865	A	NO			24.1
Antrim	At Donegore Bridge, Antrim	3202	3874	B	NO			19.7
Antrim	Background - Templepatrick	3232	3857	D	NO			10.9
Ards	8 Court Street, Newtownards	3485	3735	A	YES	IN	R	30.0
Ards	Rear of Town Hall opposite 18 Frances Street, Ne	3481	3741	A	YES	7N	R	26.0
Ards	7 Ashgrove, Newtownards	3485	3745	C	YES	3N	B	9.0
Ards	19 Islandmore Avenue, Newtownards	3495	3750	C	YES	6N	B	10.0
Armagh	25 Railway Street, Armagh	2875	3458	A	YES	1N	R	37.0
Armagh	Bridge House, Barrack Street, Armagh	2879	3450	A	YES	5N?	R	40.0
Armagh	St Patrick's Fold, Scotch Street, Armagh	2877	3450	A	YES			24.3
Armagh	19 Victoria Street, Armagh	2882	3455	A	NO			35.5
Armagh	Portadown Road, Armagh	2887	3459	A	NO			35.7
Armagh	Lower Irish Street, Armagh	2873	3477	A	NO			33.6
Armagh	7 Desart Lane, Armagh	2865	3457	C	YES	3N	B	16.0
Armagh	17 Folly Lane, Armagh	2882	3448	C	YES	4N	B	20.0
Ballymena	29 Galgorm Road, Ballymena	3103	4032	A	YES	2N	R	27.9
Ballymena	Ballymoney Street, Ballymena	3102	4035	A	YES	5N	R	20.8
Ballymena	Queen Street, Ballymena	3108	4022	A	NO			26.0
Ballymena	Broughshane Street, Ballymena	3110	4039	A	NO			22.3
Ballymena	Lisnevenagh Road, Ballymena	3119	3970	A	NO			18.3
Ballymena	Main Street, Cullybackey	3058	4057	A	NO			17.4
Ballymena	Cullybackey Road, Ballymena	3103	4034	A	NO			21.4
Ballymena	North Road, Ballymena	3106	4030	A	NO			25.0
Ballymena	Ballymoney Road, Ballymena	3099	4044	A	NO			23.2
Ballymena	George Street, Ballymena	3106	4032	A	NO			39.7
Ballymena	Wellington Street, Ballymena	3108	4033	A	NO			20.1
Ballymena	Leighmore avenue, Ballymena	3102	4025	C	YES	1N	B	12.0
Ballymena	8 Ballyloughan Avenue, Ballymena	3095	4044	C	YES	4N	B	15.3
Ballymoney	19 Linenhall Street, Ballymoney	2948	4259	A	YES	1N	R	21.4
Ballymoney	Adjacent 8 Ballybogey Road, Ballymoney	2942	4269	A	YES	5N	R	11.1
Ballymoney	6 Church Street, Ballymoney	2948	4258	A	NO			13.8
Ballymoney	31 Charles Street, Ballymoney	2946	4261	A	NO			20.1
Ballymoney	Opposite 51 Queen Street, Ballymoney	2952	4258	A	NO			20.8
Ballymoney	14/16 Ozone Avenue, Ballymoney	2954	4257	B	YES	2N	I	17.0
Ballymoney	Opposite 16 Armour Avenue, Ballymoney	2954	4257	C	YES	3N	B	16.8
Ballymoney	2/4 Semicock Avenue, Ballymoney	2948	4259	C	YES	4N	B	13.2
Banbridge	Dromore Street, Banbridge	3128	3462	A	NO			24.8
Banbridge	Fortfield Dromore (side of dual carriageway)	3199	3536	A				32.5
Banbridge	10 Reilly Court, Banbridge	3122	3461	B	NO			
Banbridge	17 Springfield's, Banbridge	3121	3444	C	NO			13.4
Banbridge	9 Fortfield, Dromore	3199	3535	D	NO			17.2

Table A1.2 NO_2 Diffusion Tube Data for 2001 – *continued;* (page 2 of 3)

Local Authority	Location of Sampler	Irish Grid E	Irish Grid N	Site Classification	Part of NO_2 Network?	NO_2 Network number if applicable	NO_2 Network classification	Annual mean 2001 ($\mu g\ m^{-3}$)
Belfast	Belfast City Hall, Donegal Square South	3338	3739	A	Yes	1N	R	36.3
Belfast	Milner Street	3324	3734	A	Yes	5N?	R	28.7
Belfast	Black's Road	3297	3695	A	Yes			34.4
Belfast	Cromac Street (A)	3341	3735	A	Yes			28.7
Belfast	Bridge End	3346	3743	A	Yes			34.4
Belfast	Upper Newtownards Road	3372	3740	A	Yes			38.2
Belfast	Cromac Street (B)	3342	3737	A	Yes			36.3
Belfast	301 Ormeau Road	3345	3722	A	Yes			38.2
Belfast	400 Ormeau Road	3350	3709	A	Yes			30.6
Belfast	Saintfield Road	3353	3698	A	Yes			36.3
Belfast	Great George's Street	3339	3750	A	Yes			45.8
Belfast	Ormeau Road, Galwally	3350	3702	A	Yes			32.5
Belfast	Stockman's Lane	3312	3710	A	Yes			34.4
Belfast	Primary School, North Road	3375	3741	B	Yes	4N	B	21.0
Belfast	Royal Victoria Hospital, 12 Grosvenor Road Belfas	3324	3735	C	Yes	3N	B	26.7
Belfast	Lombard Street	3339	3743	C	Yes			32.5
Carrickfergus	59 Shore Road, Greenisland	3379	3849	A	YES	1N	R	16.6
Carrickfergus	27 Upper Road, Greenisland	3362	3857	A				14.7
Carrickfergus	Islandmagee Road, Whitehead	3476	3923	A				8.6
Carrickfergus	42 Albert Road Carrickfergus	3413	3876	A				14.3
Carrickfergus	Model PS 4 Belfast Road Carrickfergus	3408	3871	A				21.8
Carrickfergus	93 Belfast Road Carrickfergus	3399	3867	A				16.8
Carrickfergus	Railway Station, Fergus Avenue, Carrickfergus	3412	3878	B	YES	2N	I	10.7
Carrickfergus	32 Mullaghmore Park, Greenisland	3369	3856	C	YES	3N	B	6.9
Carrickfergus	College North Road, Carrickfergus	3411	3889	C	YES	4N?	B	9.7
Carrickfergus	28 Bentra Road, Whitehead	3454	3919	D				6.3
Carrickfergus	Lough Road, Loughmourne	3412	3921	D				5.9
Castlereagh	Council Offices, 368 Cregagh Road, BT6 9EZ	3362	3713	A	YES	1N	R	16.0
Castlereagh	985 Upper Newtownards Road, Dundonald	3420	3740	A	NO			
Castlereagh	2 Newtownards Road	3352	3701	A	NO			
Castlereagh	3 Downshire Road, Cregagh, Belfast, BT6 9 EZ	3360	3713	B	YES	2N	I	
Castlereagh	Lamp Post, 17/19 Everton Drive, Castlereagh	3361	3711	C	YES			
Castlereagh	74 Downshire Park East	3365	3714	D	YES	6N	B	10.0
Coleraine	Lower Union Street, Coleraine	2848	4328	A	NO			39.7
Coleraine	Upper Union Street, Coleraine	2852	4328	A	NO			27.9
Coleraine	Lodge Road, Roundabout, Coleraine	2859	4314	A	NO			25.8
Coleraine	Bridge Street, Coleraine	2847	4325	A	NO			35.3
Cookstown	High Street, Moneymore	2857	3834	A	NO			28.7
Cookstown	Magherafelt Road, Moneymore	2860	3837	A	NO			23.7
Cookstown	William Street, Cookstown	2810	3784	A	NO			26.9
Cookstown	Drum Road, Cookstown	2806	3770	A	NO			24.4
Cookstown	Smith Court, Moneymore	2858	3835	B	NO			17.2
Craigavon	Castle Hardware, 7 Market Street, Portadown	3011	3537	A	YES	9N	R	24.0
Craigavon	Town Hall, Union Street, Lurgan	3083	3583	A	YES	5N	R	17.0
Craigavon	36 Ardboe Drive, Lurgan	3081	3578	C	YES	7N	B	13.0
Craigavon	27 Ballyhannon Road, Portadown	3031	3533	C	YES	8N	B	12.0
Derry	No 3 Creggan Road, Londonderry	2429	4172	A	YES	8N	R	62.0
Derry	3 Glendermot Road, Londonderry	2443	4168	A	YES	9N	R	48.0
Derry	7 Harberton Park, Londonderry	2451	4156	A	NO			23.9
Derry	3 Simpson Brae, Londonderry	2442	4164	A	NO			31.1
Derry	132a Strand Road, Londonderry	2436	4183	A	NO			47.2
Derry	2 Farren Park, Londonderry	2448	4188	A	NO			26.7
Derry	19 St Patricks Terrace, Londonderry	2435	4189	A	NO			42.4
Derry	34 Northland Terrace, Londonderry	2432	4188	A	NO			30.9
Derry	1 Temple Road, Londonderry	2476	4195	A	NO			19.3
Derry	St Columbs Park, Limavady Road, Londonderry	2445	4173	C	YES	7N	I	
Derry	Brooke Park, Infirmary Road, Londonderry	2429	4172	C	YES	10N	B	24.0

Table A1.2 NO_2 Diffusion Tube Data for 2001 – *continued;* (page 3 of 3)

Local Authority	Location of Sampler	Irish Grid E	Irish Grid N	Site Classification	Part of NO_2 Network?	NO_2 Network number if applicable	NO_2 Network classification	Annual mean 2001 ($\mu g\ m^{-3}$)
Derry	3 Silverbirch Crescent, Londonderry	2453	4166	C	YES	11N	B	
Down	9 Irish Street, Downpatrick, BT30 6BN	3487	3446	A	YES	1N	R	26.9
Down	High Street, Ballynahinch	3366	3523	A	NO		R	22.0
Down	Link Road, Downpatrick	3488	3448	A	NO			10.9
Down	2 Belfast Road, Saintfield	3406	3591	A	NO			20.8
Down	4 Main Street, Newcastle	3378	3316	A	NO			15.5
Down	5 Market Lane, Downpatrick, BT30 6TH	3486	3445	B	NO	2N	I	9.7
Down	11 Orchard Way, Strangford Road, Downpatrick, I	3489	3459	C	YES	4N	B	5.3
Down	7 St Patrick's Drive, Downpatrick, BT30 6NR	3486	3422	C	YES	3N	B	7.1
Dungannon	Market Square, Dungannon	2798	3625	A	YES	1N	R	17.2
Dungannon	Howard Primary School, Moy Road, Dungannon	2812	3607	A	YES	5N	R	17.2
Dungannon	4 Ardgammon, Dungannon	2796	3630	C	YES	3N	B	11.5
Dungannon	11 Bushvale, Dungannon	2811	3623	C	YES	4N	B	11.5
Fermanagh	Town Hall, Enniskillen BT74 7BA	2235	3441	A	NO			
Fermanagh	Belmore Street, Enniskillen	2239	3440	A	NO			20.4
Fermanagh	Lower Celtic Park, Enniskillen	2244	3435	B	NO			6.9
Fermanagh	Everglades, Tempo Road, Enniskillen	2256	3447	B	NO			5.0
Fermanagh	Rossole Park, Enniskillen	2230	3432	C	NO			5.5
Lisburn	Northern Bank, 62 Bow Street, Lisburn, BT28 1BN	3265	3644	A	YES	1N	R	24.0
Lisburn	18 Kingsway, Dunmurry	3295	3689	A	YES	7N	R	17.0
Lisburn	10 Beechlawn Park, Dunmurry	3296	3691	B	NO			
Lisburn	Antrim Road, Lisburn	3263	3646	B	YES			
Lisburn	75 Edgewater, Lisburn	3272	3637	C	YES	6N	B	9.0
Lisburn	22 Ventnor Park, Lambeg	3269	3620	C	YES	3N	B	10.0
Lisburn	Dunmurry High School, River Road, Dunmurry	3287	675	C	NO			
Lisburn	Main Street, Moira	3151	3606	C	YES			
Magherafelt	Queen Street, Magherafelt	2896	3905	A	NO			36.3
Magherafelt	Church Street, Magherafelt	2897	3909	A	NO			28.7
Magherafelt	Church Street, Magherafelt, Wesleyan Mews	2899	3907	A	NO			17.2
Magherafelt	Main Street, Magherafelt	2853	4004	A	NO			30.6
Newry & Mourne	20a Water Street, Newry	3087	3266	A	YES	6N	R	42.0
Newry & Mourne	St Colmans Parochial Hall, Trevor Hill, Newry	3088	3266	A	YES	10N	R	36.3
Newry & Mourne	Monaghan Row, Newry	3078	3268	C	YES	11N	B	15.3
Newry & Mourne	19 Balmoral Park, Newry	3084	3268	C	YES	9N	B	13.4
Newtownabbey	49 Main Street, Ballyclare	3288	3911	A	YES			32.9
Newtownabbey	McMillan House, 323 Antrim Road, Glengormley	3313	3825	A	NO			34.0
Newtownabbey	Doagh Road, Abbots Cross, Newtownabbey	3346	3824	A	NO			23.9
Newtownabbey	168 Shore Road, Jordanstown	3347	3804	A	NO			29.0
Newtownabbey	168 Shore Rd, Whiteabbey	3347	3804	B	YES	10N	R	29.0
Newtownabbey	Church/Lenamore Avenue, Jordanstown	3357	3844	B	NO			19.1
Newtownabbey	1251 Doagh Road, Newtownabbey	3335	3845	B	NO			23.9
Newtownabbey	19a Newtown Gardens, Newtownabbey	3343	3800	C	YES	4N	B	21.0
Newtownabbey	202 Carnmoney Road, Glengormley	3121	3833	C	YES			17.2
North Down	52 Bingham Street, Bangor	3507	3819	A	YES	7N	R	16.0
North Down	132 Main Street, Bangor	3504	3815	A	YES	6N	R	16.0
North Down	Marine Parade, Holywood	3400	3793	A	YES			
North Down	68 Groomsport Road, Bangor	3520	3819	C	YES	4N	B	10.0
North Down	1 Rathmore Road, Bangor	3483	3815	C	YES	8N	B	11.0
North Down	Station Road, Cultra	3416	3800	C	YES			
North Down	Bangor Road, Seahill	3433	3808	C	YES			
North Down	Bangor Road, Ballyrobert	3450	3808	C	YES			
Omagh	41 Dublin Road, Omagh, BT78 5EP	2456	3724	A	YES	1N	R	
Omagh	Hoggs Head, 1 O'Connell Place, Omagh	2445	3725	A	YES	7N	R	
Omagh	2 Ardmore Heights, Omagh	2442	3722	C	YES	5N	B	
Omagh	16 Gortmore Gdns, Omagh	2444	3733	C	YES	6N	B	

All grid references are to nearest 100m.

Site classifications:

A = kerbside, 1-5m from the kerb of a busy road

B = intermediate site, 20-30m from the same or an equivalent road

C = urban background site, greater than 50m from any busy road

D = rural background site

E = special site; monitoring air pollution from some industrial process, etc.
Annual means shown only where there are at least 6 months' valid data.

Table A1.3 SO_2 Diffusion Tube Monitoring Sites

Site	District Council	Easting	Northing
Town Hall, Carrickfergus	Carrickfergus	3415	3876
Lough Road, Loughmourne	Carrickfergus	3412	3921
Castleton Park, Portstewart	Coleraine *	2382	4820
Lyttlesdale, Garvagh	Coleraine *	2859	4338
Drumkil Gdns., Kilrea	Coleraine *	2930	4326
30 Daneshill, Coleraine	Coleraine	2838	4358
11 Laurel Avenue, Coleraine	Coleraine	2832	4344
6/8 Ganimore Avenue, Portrush	Coleraine	2897	4364
Queens Avenue, Cookstown	Cookstown	2806	3789
Greenvale Drive, Cookstown	Cookstown	2806	3775
Tempo Road, Enniskillen	Fermanagh	2256	3447
Rossole Park, Enniskillen	Fermanagh	2230	3431
Barleyhill, Dunmurry	Lisburn +	3272	3644
Ballyknockan Park, Knockmore	Lisburn +	3248	3639
22 Ventnor Park, Lisburn	Lisburn +	3269	3670
22 Lawnbrook Drive, Low Road, Lisburn	Lisburn +	3228	3653
75 Edgewater, Lisburn	Lisburn +	3272	3637
36 Credenhill Park, Dunmurry	Lisburn +	3285	3696
2 Beattie Park North, Dunmurry	Lisburn +	3295	3675
25a Lilac Walk, Seymour Hill, Dunmurry	Lisburn +	3292	3678
8 Pine Cross, Seymour Hill, Dunmurry	Lisburn +	3286	3672
4 Hornbeam Road, Seymour Hill, Dunmurry	Lisburn +	3286	3674
66 Larch Grove, Seymour Hill, Dunmurry	Lisburn +	3293	3678
36/38 Elm Corner, Seymour Hill, Dunmurry	Lisburn +	3291	3678
Anderson Park, Doagh, Ballyclare	Newtownabbey	3263	3895
Ravelston, Carnmoney	Newtownabbey	3328	3841
2 Mountainvale Crescent, Glengormley	Newtownabbey	3313	3823
15 Carwood Avenue, Glengormley	Newtownabbey	3313	3835
57 Burnthill Crescent, Carnmoney	Newtownabbey	3317	3834
13 Waverley Road, Newtownabbey	Newtownabbey	3322	3842
9 Mountpleasant Road, Jordanstown	Newtownabbey	3353	3845
7 Glenbroome Park, Jordanstown	Newtownabbey	3361	3835
15/16 Burnside Park, Ballyclare	Newtownabbey	3256	3918
22 Osterley Park, Newtownabbey	Newtownabbey	3324	3825

Grid references are in 8-figure format, to nearest 100m

- * =2000 only, + = 2001 only.
- All Newtownabbey sites began Dec 2001.

Appendix 2
Data from Smoke and SO_2 Sites

CONTENTS

The following two tables contain smoke and SO_2 data from Smoke and SO_2 Network sites in Northern Ireland. These pollutants are monitored simultaneously on a daily basis, using the 8-port sampler apparatus. All the sites shown are part of the Smoke and SO_2 Network. Grid references are in 8-figure format, to the nearest 100m. There are a further two sites of this type which are not part of the Network: annual mean smoke and SO_2 concentrations for these are presented in the main report.

Table A2.1 Summary of Smoke and SO_2 Results for Northern Ireland, Calendar Year 2000. All concentrations in μg m^{-3}.

Code	Site Name	Authority	Irish Grid Ref. To 100m East	Irish Grid Ref. To 100m North	Summary of Smoke Data 2000 Data Capt. %	Arith. Mean	Median	98th%ile	Max. Day	Summary of SO_2 Data 2000 Data Capt. %	Arith. Mean	Median	98th%ile	Max. Day
	NORTHERN IRELAND													
69701	ARMAGH 1	Armagh	2877	3450	84	7	4	27	67	84	11	13	21	28
160003	BALLYMENA 3	Ballymena	3103	4029	92	7	5	45	118	90	30	24	74	89
161504	BALLYMONEY 4	Ballymoney	2954	4259	5	15	10	44	49	4				0
270012	BELFAST 12	Belfast	3324	3737	99	9	6	37	50	99	19	18	47	55
270013	BELFAST 13	Belfast	3357	3740	100	9	8	33	48	100	40	38	83	166
270033	BELFAST 33	Belfast	3346	3755	100	12	9	40	68	100	42	38	85	115
270042	BELFAST 42	Belfast	3322	3748	100	10	8	36	88	100	42	38	81	172
270044	BELFAST 44	Belfast	3338	3740	100	9	7	28	68	100	39	38	81	153
270045	BELFAST 45	Belfast	3335	3723	100	8	7	31	51	100	37	32	77	128
270046	BELFAST 46	Belfast	3803	3334	100	6	4	19	79	100	31	26	64	140
2551504	PORTADOWN 4	Craigavon	3012	3538	64	6	4	21	25	64	8	6	18	24
2190011	LONDONDERRY 11	Derry	2431	4170	17	17	13	56	72	17	35	32	50	55
2190012	LONDONDERRY 12	Derry	2438	4200	67	5	4	15	39	86	36	38	51	58
2190014	LONDONDERRY 14	Derry	2443	4174	70	6	4	19	41	90	36	33	66	120
1025001	DUNGANNON 1	Dungannon	2802	3629	46	5	4	12	40	40	16	14	35	35
1757703	LARNE 3	Larne	3400	4029	96	11	9	34	59	96	17	18	25	25
1032502	DUNMURRY 2	Lisburn	3289	3679	90	8	6	34	76	86	82	74	188	250
1032503	DUNMURRY 3	Lisburn	3287	3875	79	11	7	47	81	74	19	18	49	55
1845003	LISBURN 3	Lisburn	3263	3636	90	11	7	62	118	87	17	14	49	70
2233501	MAGHERAFELT 1	Magherafelt	2896	3901	98	11	8	42	62	98	12	13	20	33
2410003	NEWRY 3	Newry and Mourne	3078	3268	96	10	6	62	142	96	10	6	30	33
2412501	NEWTOWNABBEY 1	Newtownabbey	3349	3824	88	14	9	46	70	88	13	12	24	42
2412502	NEWTOWNABBEY 2	Newtownabbey	3318	3825	99	15	11	50	96	99	12	13	25	38
3111502	STRABANE 2	Strabane	2351	3972	88	27	23	76	129	87	12	13	21	28

Table A2.2 Summary of Smoke and SO_2 Results for Northern Ireland, Calendar Year 2001. All concentrations in μg m^{-3}.

Code	Site name	Authority	Irish Grid Ref to 100m East	Irish Grid Ref to 100m North	Summary of Smoke Data 2001 Data Capt. %	Arith. Mean	Median	98th %ile	Max. Day	Summary of SO_2 Data 2001 Data Capt. %	Arith. Mean	Median	98th %ile	Max. Day
	NORTHERN IRELAND													
69701	ARMAGH 1	Armagh	2877	3450	61	9	7	38	55	60	16	14	25	28
1637001	KEADY 1	Armagh	2845	3341	73	8	7	27	71	71	3	0	12	19
160003	BALLYMENA 3	Ballymena	3103	4029	70	8	4	40	64	69	28	30	60	78
161504	BALLYMONEY 4	Ballymoney	2954	4259	100	17	11	70	303	100	13	13	20	40
270012	BELFAST 12	Belfast	3324	3737	96	10	6	62	113	96	18	13	63	87
270013	BELFAST 13	Belfast	3357	3740	100	10	7	43	112	100	38	38	96	160
270033	BELFAST 33	Belfast	3346	3755	98	13	9	49	124	98	43	38	120	160
270042	BELFAST 42	Belfast	3322	3748	100	10	7	43	92	100	41	38	102	160
270044	BELFAST 44	Belfast	3338	3740	98	6	4	19	55	98	33	32	58	141
270045	BELFAST 45	Belfast	3335	3723	100	9	7	33	113	100	36	32	70	134
270046	BELFAST 46	Belfast	3803	3334	100	6	4	23	43	100	29	26	58	134
2551504	PORTADOWN 4	Craigavon	3012	3538	86	8	5	37	67	79	9	6	24	24
2190012	LONDONDERRY 12	Derry	2438	4200	34	8	5	34	42	31	26	25	71	118
2190014	LONDONDERRY 14	Derry	2443	4174	32	9	6	29	58	29	18	13	47	67
1025001	DUNGANNON 1	Dungannon	2802	3629	60	5	4	11	13	59	15	13	30	49
1757703	LARNE 3	Larne	3400	4029	96	9	6	34	79	96	18	19	25	32
1032502	DUNMURRY 2	Lisburn	3289	3679	10	15	13	44	49	10	27	27	50	58
1032503	DUNMURRY 3	Lisburn	3287	3875	80	11	6	61	185	79	20	20	50	58
1845003	LISBURN 3	Lisburn	3263	3636	93	16	8	87	221	93	17	13	41	63
3325001	TWINBROOK 1	Lisburn	3281	3689	94	11	6	49	209	92	20	20	50	74
2233501	MAGHERAFELT 1	Magherafelt	2896	3901	94	9	5	56	76	96	13	13	26	32
2410003	NEWRY 3	Newry and Mourne	3078	3268	83	11	5	74	164	85	8	6	20	25
2412501	NEWTOWNABBEY 1	Newtownabbey	3349	3824	94	9	5	40	68	94	13	12	25	49
2412502	NEWTOWNABBEY 2	Newtownabbey	3318	3825	96	10	6	45	91	96	15	13	25	44
2412503	NEWTOWNABBEY 3	Newtownabbey	3321	3851	5	8	5	23	25	5	7	6	13	13
165005	BANGOR (CO DOWN) 5	North Down	3497	3810	59	16	8	77	158	59	11	12	23	48
1517501	HOLYWOOD 1	North Down	3397	3784	59	6	4	23	30	59	11	12	19	25
3111502	STRABANE 2	Strabane	2351	3972	89	34	26	114	249	89	12	13	26	67