Air Quality Review and Assessment - Stage 3 Domestic Fuel Combustion

Report to Fermanagh District Council

netcen/ED49225001/Issue 1
April 2003

Title	Air Quality Review and Assessment-Stage 3 for domestic Fuel Combustion
Customer	Fermanagh District Council
Customer reference	
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File reference	R:\Stage 3 R & A\Fermanagh\
Report number	AEAT/ENV/R/1514
Report status	Issue 1

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Executive Summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality which culminated in the Environment Act, 1995. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives[2] have been enacted through the Air Quality Regulations in 1997 and 2000. The Environment Act 1995 requires Local Authorities to undertake an air quality review. In areas where the air quality objective is not anticipated to be met, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

In Northern Ireland there are at present no equivalent Air Quality Regulations. However, there is a duty to meet the Air Quality limit values set within the European Commission Air Quality Framework Directive on which the UK National air quality objectives are based. Consequently, Councils in Northern Ireland have proceeded with the review and assessment process of air quality on a non-statutory basis.

The first step in this process is to undertake a review of current and potential future air quality. The number of reviews necessary depends on the likelihood of achieving the objectives.

This report on domestic fuel combustion forms part of the stage three air quality review for Fermanagh District Council. Only PM_{10} and sulphur dioxide are considered in this report. This is because PM_{10} and sulphur dioxide are the only AQS pollutants of concern when considering domestic fuel combustion. This report investigates current and potential future PM_{10} and sulphur dioxide levels through an examination of the location and size of domestic combustion sources, emissions modelling exercises and by reference to monitored air quality data.

As part of this report, detailed modelling of domestic fuel combustion using ADMS version 3.1 has been undertaken at the a 1x1km2 grid in Enniskillen, identified in the Stage 2 as needing further assessment.

The conclusions of the report are:

Particulates (PM_{10})

The modelling results suggest that it is likely that there will be an exceedence of the PM_{10} objectives in the modelled area. Due to the uncertainty associated with using a correction factor from a neighbouring LA it is suggested that Fermanagh do not proceed directly to declaring an AQMA at this time. Instead it suggested that monitoring be carried out in the north east area of the grid so that the concentrations can be closely observed. When monitoring data becomes available the results should be considered in combination with the modelled result. If the monitoring data confirms the likelihood of an exceedence then declaration of an AQMA should be considered.
Due to the uncertainty associated with modelling and using the bias adjustment of a neighbouring authority it would seem reasonable to adjust the model with a local bias factor before declaring an AQMA.
It is recommended that monitoring be undertaken in the grid and consideration is given to declaring an air quality management area (AQMA) for PM_{10} for domestic fuel burning.

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[1] Refers to standards recommended by the Expert Panel on Air Quality Standards. Recommended standards are set purely with regard to scientific and medical evidence on the effects of the particular pollutants on health, at levels at which risks to public health, including vulnerable groups, are very small or regarded as negligible.
[2] Refers to objectives in the Strategy for each of the eight pollutants. The objectives provide policy targets by outlining what should be achieved in the light of the air quality standards and other relevant factors and are expressed as a given ambient concentration to be achieved within a given timescale.

Sulphur dioxide
The modelling results suggest that it is unlikely that there will be an exceedence of the 15 minute mean SO_2 objective in the modelled area. This is the most stringent SO_2 objective and therefore if this is predicted to be met then it is likely that the hourly and daily SO_2 objectives will also be met. The model has been bias corrected for model bias. Ideally this would have been done using local monitoring data but as this was not available a model bias correction factor from Strabane has been used where the modelling monitoring relationship was tested. The bias corrected modelling shows that an exceedence of the Air Quality Standards for SO2 is unlikely. Therefore…
It is <u>not</u> recommended that Fermanagh District Council consider declaring an AQMA for sulphur dioxide from domestic fuel burning.

Maps reproduced within this document

Acronyms and definitions

ADMS	an atmospheric dispersion model
AQDD	Common Position on Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AUN	Automatic Urban Network
d.f.	degrees of freedom
DEFRA	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
GIS	Geographical Information System
LADS	Urban background model specifically developed for Stage 3 Review and Assessment work. This model allowed contributions of the urban background and domestic emissions to be calculated
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NETCEN	National Environmental Technology Centre
ppb	parts per billion
r	the correlation coefficient
roadside	1 to 5 m from the kerb

Contents

1 Introduction

1.1 PURPOSE OF THE STUDY

AEA Technology's National Environmental Technology Centre (NETCEN) was commissioned to complete the domestic fuel combustion section of the third stage review and assessment for Fermanagh District Council.

1.2 GENERAL APPROACH TAKEN

The approach taken in this study was to:

- Collect and interpret additional data to support the third stage assessment, including the detailed fuel use survey data for the location where exceedences were predicted;
- Use the monitoring data from the neighbouring council of Strabane. Strabane have undertaken a monitoring campaign to assess the ambient concentrations produced by domestic fuel combustion and to validate the output of their own modelling studies. The data will also be used to validate the output of the model for Fermanagh.
- Model the concentrations of PM_{10} and SO_2 in the selected grid square, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Present the concentrations as contour plots of concentrations and comment on the uncertainty in the predicted concentrations

1.3 VERSION OF THE LAQM TECHNICAL GUIDANCE USED IN THIS ASSESSMENT

This report has used the guidance in LAQM.TG (03), published in February 2003.

1.4 NUMBERING OF FIGURES AND TABLES

The numbering scheme is not sequential, and the figures and tables are numbered according to the chapter and section that they relate to.

1.5 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g\ m^{-3}$ (which is consistent with the presentation of the AQS objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is a Third Stage Air Quality review for Fermanagh District Council for PM_{10} and SO_2 from domestic fuel combustion. This chapter, Chapter 1 has summarised the need for the work and the approach to completing the study.

Chapter 2 of the report describes the most recent developments in the UK’s Air Quality Strategy (AQS). In addition, it discusses when implementation of an AQMA is required.

Chapter 3 contains details of the information used to conduct the stage 3 review and assessment for Fermanagh District Council.

Chapters 4, 5 and 6 describe the results of the assessment and discuss whether both the PM_{10} and sulphur dioxide objectives will be exceeded in Fermanagh in 2004/5. The results of the analysis are displayed as contour plots.

2 The updated Air Quality Strategy

2.1 THE NEED FOR AN AIR QUALITY STRATEGY

The Government published its proposals for review of the National Air Quality Strategy in early 1999 (DETR, 1999). These proposals included revised objectives for many of the regulated pollutants. A key factor in the proposals to revise the objectives was the agreement in June 1998 at the European Union Environment Council of a Common Position on Air Quality Daughter Directives (AQDD).

Following consultation on the Review of the National Air Quality Strategy, the Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

The Environment Act (1995) provides the legal framework for requiring LA's to review air quality and for implementation of an AQMA. The main constituents of this Act are summarised in Table 2.1 below.

Table 2.1 Major elements of the Environment Act 1995

Part IV Air Quality	Commentary
Section 80	Obliges the Secretary of State (SoS) to publish a National Air Quality Strategy as soon as possible.
Section 81	Obliges the Environment Agency to take account of the strategy.
Section 82	Requires local authorities, any unitary or Borough, to review air quality and to assess whether the air quality standards and objectives are being achieved. Areas where standards fall short must be identified.
Section 83	Requires a local authority, for any area where air quality standards are not being met, to issue an order designating it an air quality management area (AQMA).
Section 84	Imposes duties on a local authority with respect to AQMAs. The local authority must carry out further assessments and draw up an action plan specifying the measures to be carried out and the timescale to bring air quality in the area back within limits.
Section 85	Gives reserve powers to cause assessments to be made in any area and to give instructions to a local authority to take specified actions. Authorities have a duty to comply with these instructions.
Section 86	Provides for the role of County Councils to make recommendations to a district on the carrying out of an air quality assessment and the preparation of an action plan.
Section 87	Provides the SoS with wide ranging powers to make regulations concerning air quality. These include standards and objectives, the conferring of powers and duties, the prohibition and restriction of certain activities or vehicles, the obtaining of information, the levying of fines and penalties, the hearing of appeals and other criteria. The regulations must be approved by affirmative resolution of both Houses of Parliament.
Section 88	Provides powers to make guidance which local authorities must have regard to.

2.2 OVERVIEW OF THE PRINCIPLES AND MAIN ELEMENTS OF THE NATIONAL AIR QUALITY STRATEGY

The main elements of the AQS can be summarised as follows:

- The use of a health effects based approach using national air quality standards and objectives.
- The use of policies by which the objectives can be achieved and which include the input of important actors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with a target dates of 2003, 2004, 2005, 2008 and 2010 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the AQS will provide a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles which include:

- the provision of a statement of the Government's general aims regarding air quality;
- clear and measurable targets;
- a balance between local and national action and
- a transparent and flexible framework.

Co-operation and participation by different economic and governmental sectors is also encouraged within the context of existing and potential future international policy commitments.

2.2.1 National Air Quality Standards

At the centre of the AQS is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Most of the proposed standards have been based on the available information concerning the health effects resulting from different ambient concentrations of selected pollutants and are the consensus view of medical experts on the Expert Panel on Air Quality Standards (EPAQS). These standards and associated specific objectives to be achieved between 2003 and 2010 are shown in Table 2.2. The table shows the standards in ppb and $\mu g\ m^{-3}$ with the number of exceedences that are permitted (where applicable) and the equivalent percentile.

Specific objectives relate either to achieving the full standard or, where use has been made of a short averaging period, objectives are sometimes expressed in terms of percentile compliance. The use of percentiles means that a limited number of exceedences of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as November 5th. For example, if an objective is to be complied with at the 99.9th percentile, then 99.9% of measurements at each location must be at or below the level specified.

Table 2.2. Air Quality Objectives in the Air Quality Regulations (2000) for the purpose of Local Air Quality Management.

Pollutant	Concentration limits ($\mu g\ m^{-3}$)	(ppb)	Averaging period	Objective [number of permitted exceedences a year and equivalent percentile] ($\mu g\ m^{-3}$)	date for objective
Benzene	16.25	5	**running annual** mean	**16.25**	by 31.12.2003
	5		**Annual mean**	**5**	by 31.12.2010
1,3-butadiene	2.25	1	**running annual** mean	**2.25**	by 31.12.2003
CO	10,000	8,600	**running 8-hour** mean	**10,000**	by 31.12.2003
Pb	0.5	-	**annual** mean	**0.5**	by 31.12.2004
	0.25	-	**annual** mean	**0.25**	by 31.12.2008
NO_2 (see note)	200	105	**1 hour** mean	**200** [maximum of 18 exceedences a year or equivalent to the 99.8th percentile]	by 31.12.2005
	40	21	**annual** mean	**40**	by 31.12.2005
PM_{10} (**gravimetric**) (see note)	50	-	**24-hour** mean	**50** [maximum of 35 exceedences a year or ~ equivalent to the 90th percentile]	by 31.12.2004
	40	-	**annual** mean	**40**	by 31.12.2004
SO_2	266	100	**15 minute** mean	**266** [maximum of 35 exceedences a year or equivalent to the 99.9th percentile]	by 31.12.2005
	350	132	**1 hour** mean	**350** [maximum of 24 exceedences a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour** mean	**125** [maximum of 3 exceedences a year or equivalent to the 99th percentile]	by 31.12.2004

Notes
1. Conversions of ppb and ppm to ($\mu g\ m^{-3}$) correct at 20°C and 1013 mb.
2. The objectives for nitrogen dioxide are provisional.
3. PM_{10} measured using the European gravimetric transfer standard or equivalent. The Government and the devolved administrations see this new 24-hour mean objective for particles as a staging post rather than a final outcome. Work has been set in hand to assess the prospects of strengthening the new objective.

2.2.2 Relationship between the UK National Air Quality Standards and EU air quality Limit Values

As a member state of the EU, the UK must comply with European Union Directives.

There are three EU ambient air quality directives that the UK has transposed in to UK law. These are:

- **96/62/EC** Council Directive of 27 September 1996 on ambient air quality assessment and management. (the Ambient Air Framework Directive)

- **1999/30/EC** Council Directive of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, particulate matter and lead in ambient air. (the First Daughter Directive)

- **2000/69/EC** Directive of the European Parliament and the Council of 16 Nov 2000 relating to limit values for benzene and carbon monoxide in ambient air. (the Second Daughter Directive)

The first and second daughter directives contain air quality Limit Values for the pollutants that are listed in the framework directive. The United Kingdom (i.e. Great Britain and Northern Ireland) must comply with these Limit Values. The UK air quality strategy should allow the UK to comply with the EU Air Quality Daughter Directives, but the UK air quality strategy also includes some stricter national objectives for some pollutants, for example, sulphur dioxide.

The Government is ultimately responsibility for achieving the EU limit values. However, it is important that Local Air Quality Management is used as a tool to ensure that the necessary action is taken at local level to work towards achieving the EU limit values by the dates specified in those EU Directives.

2.2.3 Recent proposed changes to the UK National Air Quality Standards

DEFRA have recently issued a consultation document with proposed changes to the UK AQS for benzene, carbon monoxide and particulate matter (DEFRA, 2001). The proposed changes are:

For ***benzene***

- An objective derived from the long-term policy aim of **3.25 μg/m^3 as a running annual mean** recommended by UK EPAQS (Expert Panel on Air Quality Standards). The objective for benzene included in the 2000 Strategy is 16 μg/m^3 as a running annual mean to be achieved by 2003. This is derived from the EPAQS recommended standard. The UK adopted the second EU Air Quality Daughter Directive (which sets limit values for benzene and carbon monoxide) in 2000. This Daughter Directive sets a limit value for benzene of 5 μg/m^3 as an annual mean to be achieved by 2010.

For **p*articulates*** new provisional objectives of

- for **all parts of the UK**, except London and Scotland, a **24-hour mean of 50 μg/m^3 not to be exceeded more than 7 times per year** and an **annual mean of 20 μg/m^3**, both to be achieved by the end of 2010;
- for London, a 24-hour mean of 50 μg/m^3 not to be exceeded more than 10 times per year and an annual mean of 23 μg/m^3, both to be achieved by the end of 2010;
- for Scotland, a 24-hour mean of 50 μg/m^3 not to be exceeded more than 7 times per year and an annual mean of 18 μg/m^3, both to be achieved by the end of 2010.

2.2.4 Policies in place to allow these objectives to be achieved

The policy framework to allow these objectives to be achieved is one that that takes a local air quality management approach. This is superimposed upon existing national and international regulations in order to effectively tackle local air quality issues as well as issues relating to wider spatial scales. National and EC policies which already exist provide a good basis for progress towards the air quality objectives set for 2003 to 2010. For example, the Environmental Protection Act 1990 allows for the monitoring and control of emissions from industrial processes and various EC Directives have ensured that road transport emission and fuel standards are in place. These policies are being developed to include more stringent controls. Developments in the UK include the announcement by the Environment Agency in January 2000 on controls on emissions of SO_2 from coal and oil fired power stations. This system of controls means that by the end of 2005 coal and oil fired power stations will meet the air quality standards set out in the AQS.

Local air quality management provides a strategic role for local authorities in response to particular air quality problems experienced at a local level. This builds upon current air quality control responsibilities and places an emphasis on bringing together issues relating to transport, waste, energy and planning in an integrated way. This integrated approach involves a number of different aspects. It includes the development of an appropriate local framework that allows air quality issues to be considered alongside other issues relating to polluting activity. It should also enable co-operation with and participation by the general public in addition to other transport, industrial and governmental authorities.

An important part of the Strategy is the requirement for local authorities to carry out air quality reviews and assessments of their area against which current and future compliance with air quality standards can be measured. Over the longer term, these will also enable the effects of policies to be studied and therefore help in the development of future policy. The Government has prepared guidance to help local authorities to use the most appropriate tools and methods for conducting a review and assessment of air quality in their Borough. This is part of a package of guidance being prepared to assist with the practicalities of implementing the AQS. Other guidance covers air quality and land use planning, air quality and traffic management and the development of local air quality action plans and strategies.

2.2.5 Timescales to achieve the objectives

In most local authorities in the UK, objectives will be met for most of the pollutants within the timescale of the objectives shown in Table 2.2. It is important to note that the objectives for NO_2 remain provisional. The Government has recognised the problems associated with achieving the standard for ozone and this will not therefore be a statutory requirement. Ozone is a secondary pollutant and transboundary in nature and it is recognised that local authorities themselves can exert little influence on concentrations when they are the result of regional primary emission patterns.

2.3 AIR QUALITY REVIEWS

A range of Technical Guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes the Technical Guidance LAQM.TG(03), and the previous version LAQM.TG4(00) May 2000, on 'Review and Assessment: Pollutant Specific Guidance'. This review and assessment has considered the procedures set out in the guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed therefore that reviews should be carried out in three stages. All three stages of review and assessment may be necessary and every authority is expected to undertake at least a first stage review and assessment of air quality in their authority area. The Stages are briefly described in the following table, Table 2.3.

Table 2.3 Brief details of Stages in the Air Quality Review and Assessment process

Stage	Objective	Approach	Outcome
First Stage Review and Assessment	• Identify all significant pollutant sources within or outside of the authority's area.	• Compile and collate a list of potentially significant pollution sources using the assessment criteria described in the Pollutant Specific Guidance	
	• Identify those pollutants where there is a **risk** of exceeding the air quality objectives, and for which further investigation is needed.	• Identify sources requiring further investigation.	• Decision about whether a Stage 2 Review and Assessment is needed for one or more pollutants. If not, no further review and assessment is necessary.
Second Stage Review and Assessment	• Further screening of significant sources to determine whether there is a significant risk of the air quality objectives being exceeded.	• Use of screening models or monitoring methods to assess whether there is a risk of exceeding the air quality objectives.	
	• Identify those pollutants where there is a **risk** of exceeding the objectives, and for which further investigation is needed.	• The assessment need only consider those locations where the highest likely concentrations are expected, and where public exposure is relevant.	• Decision about whether a Stage 3 Review and Assessment is needed for one or more pollutants. If, as a result of estimations of ground level concentrations at suitable receptors, a local authority judges that there is no significant risk of not achieving an air quality objective, it can be confident that an Air Quality Management Area (AQMA) will not be required. • However, if there is doubt that an air quality objective will be achieved a third stage review should be conducted.

Table 2.3 (contd.) Brief details of Stages in the Review and Assessment process

Stage	Objective	Approach	Outcome
Third Stage Review and Assessment	• Accurate and detailed assessment of both current and future air quality. Assess the **likelihood** of the air quality objectives being exceeded.	• Use of validated modelling and quality-assured monitoring methods to determine current and future pollutant concentrations.	
	• Identify the geographical boundary of any exceedences, and description of those areas, if any, proposed to be designated as an AQMA.	• The assessment will need to consider all locations where public exposure is relevant. For each pollutant of concern, it may be necessary to construct a detailed emissions inventory and model the extent, location and frequency of potential air quality exceedences.	• Determine the location of any necessary Air Quality Management Areas (AQMAs). Once an AQMA has been identified, there are further sets of requirements to be considered. • A further assessment of air quality in the AQMA is required within 12 months which will enable the degree to which air quality objectives will not be met and the sources of pollution that contribute to this to be determined. A local authority must also prepare a written action plan for achievement of the air quality objective. Both air quality reviews and action plans are to be made publicly available.

2.4 LOCATIONS THAT THE REVIEW AND ASSESSMENT MUST CONCENTRATE ON

For the purpose of review and assessment, the authority should focus their work on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 2.4 summarises the locations where the objectives should and should not apply.

Table 2.4 Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	• 1,3 Butadiene • Benzene • Lead • Nitrogen dioxide • Particulate Matter (PM_{10})	• All background locations where members of the public might be regularly exposed.	• Building facades of offices or other places of work where members of the public do not have regular access.
		• Building facades of residential properties, schools, hospitals, libraries etc.	• Gardens of residential properties.
			• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term
24 hour mean and 8-hour mean	• Carbon monoxide • Particulate Matter (PM_{10}) • Sulphur dioxide	• All locations where the annual mean objective would apply.	• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
		• Gardens of residential properties.	

Table 2.4 (contd.) Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives should apply at ...	Objectives should generally not apply at ...
1 hour mean	• Nitrogen dioxide • Sulphur dioxide	• All locations where the annual mean and 24 and 8-hour mean objectives apply.	• Kerbside sites where the public would not be expected to have regular access.
		• Kerbside sites (e.g. pavements of busy shopping streets).	
		• Those parts of car parks and railway stations etc. which are not fully enclosed.	
		• Any outdoor locations to which the public might reasonably expected to have access.	
15 minute mean	• Sulphur dioxide	• All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

It is unnecessary to consider exceedences of the objectives at any location where public exposure over the relevant averaging period would be unrealistic, and the locations should represent non-occupational exposure.

Key Points

- The Environment Act 1995 has required the development of a National Air Quality Strategy for the control of air quality.
- A central element in the Strategy is the use of air quality standards and associated objectives based on human health effects that have been included in the Air Quality Regulations.
- The Strategy uses a local air quality management approach in addition to existing national and international legislation. It promotes an integrated approach to air quality control by the various actors and agencies involved.
- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2010.
- A number of air quality reviews are required in order to assess compliance with air quality objectives. The number of reviews necessary depends on the likelihood of achieving the objectives.

3 Information used to support this assessment

This Chapter presents the information used to support this review and assessment.

3.1 MAPS

Fermanagh District Council provided a map of the kilometre grid square to be modelled.

3.2 METEOROLOGICAL DATA USED IN THE DISPERSION MODELLING

Hourly sequential data was obtained for 1999 from the Meteorological Office for the Aldergrove site for input into the ADMS dispersion model.

3.3 AMBIENT MONITORING

In the absence of local monitoring data is it possible to use monitoring data of a nearby authority. This is the approach taken here. As Fermanagh has no relevant monitoring data available, use will be made of monitoring data available from Strabane to validate the model. The increased uncertainties associated with this methodology will be considered when the modelling study is fully complete..

3.3.1 Particulates (PM_{10})

PM_{10} has been monitored at the neighbouring local authority of Strabane:

- By continuous monitoring since April 2002 at Springhill Park (OS Grid Reference 2351 3972) in the Head of the Town area.

The concentrations recorded by the continuous monitor are provided in Section 4.4.

3.3.2 Sulphur dioxide

Sulphur dioxide has been monitored by the neighbouring local authority of Strabane:

- By continuous monitoring since April 2002 at Springhill Park (OS Grid Reference 2351 3972) in the Head of the Town area.

The concentrations recorded by the continuous monitor are provided in Section 5.4

4 Review and Assessment for PM_{10} from domestic fuel combustion

4.1 INTRODUCTION

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. Particles are often classed as either primary (those emitted directly into the atmosphere) or secondary (those formed or modified in the atmosphere from condensation and growth). PM_{10} particles (the fraction of particulates in air of very small size, <10 µm aerodynamic diameter) can potentially pose significant health risks as they are small enough to penetrate deep into the lungs. Larger particles are not readily inhaled.

A major source of fine primary particles is combustion processes, in particular diesel combustion, where transport of hot exhaust vapour into a cooler tailpipe or stack can lead to spontaneous nucleation of "carbon" particles before emission. Secondary particles are typically formed when low volatility products are generated in the atmosphere, for example the oxidation of sulphur dioxide to sulphuric acid. The atmospheric lifetime of particulate matter is strongly related to particle size, but may be as long as 10 days for particles of about 1 µm in diameter.

Concern about the potential health impacts of PM_{10} has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring the smaller particle fraction, $PM_{2.5}$, which is capable of penetrating deepest into the lungs, or to even smaller size fractions or total particle numbers.

4.2 LATEST STANDARDS AND OBJECTIVES FOR PM10

The government and the devolved administrations have adopted two air quality objectives for fine particles (PM_{10}), which are the equivalent to the EU Stage 1 limit values in the first Air Quality Daughter Directive. The gravimetric objectives are:

- An annual mean of 40 $\mu g/m^3$.
- A 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 35 days per year.

The EU has also set indicative limit values for PM_{10} which are to be achieved by 1st January 2010. These stage 2 limit values are considerably more stringent and are:

- For England and Wales (except London), a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 days per year and an annual mean of 20 $\mu g/m^3$ to be achieved by the end of 2010;
- For London, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 10 days per year and an annual mean of 23$\mu g/m^3$ to be achieved by the end of 2010. An annual mean objective of 20$\mu g/m^3$ to be achieved by the end of 2015 has also been set.

The 24 hour objective is more stringent than the annual mean objective in 2004. However, the opposite is true in 2010, and the annual mean objective is more stringent than the 24 hour objective.

4.3 THE NATIONAL PERSPECTIVE

National UK emissions of primary PM_{10} have been estimated as totalling 213,000 tonnes in 1996. Of this total, around 24% was derived from road transport sources, 38% from industrial sources, 16% from power stations and 17% from domestic and other low-power combustion. It should be noted that, in general, the emissions estimates for PM_{10} are less accurate than those for the other pollutants with prescribed objectives, especially for sources other than road transport.

The Government established the Airborne Particles Expert Group (APEG) to advise on sources of PM_{10} in the UK and current and future ambient concentrations. Their conclusions were published in January 1999 (APEG, 1999). APEG concluded that a significant proportion of the current annual average PM_{10} is due to the secondary formation of particulate sulphates and nitrates, resulting from the oxidation of sulphur and nitrogen oxides. These are regional scale pollutants and the annual concentrations do not vary greatly over a scale of tens of kilometres. There are also natural or semi-natural sources such as wind-blown dust and sea salt particles. The impact of local urban sources is superimposed on this regional background. Such local sources are generally responsible for winter episodes of hourly mean concentrations of PM_{10} above 100 $\mu g\ m^{-3}$ associated with poor dispersion. However, it is clear that many of the sources of PM_{10} are outside the control of individual local authorities and the estimation of future concentrations of PM_{10} are in part dependent on predictions of the secondary particle component.

Further advice to local authorities on review and assessment of particles has now been published in the Technical Assistance with the Review and Assessment of PM_{10} concentrations in relation to the proposed EU Stage 1 Limit Values (Moorcroft *et al.*, 1999).

4.4 MONITORING DATA

PM_{10} concentrations have been continuously monitored in Strabane District at Springhill Park since April 2002 (OS Grid Reference 2351, 3972).

All the PM_{10} concentrations presented and used in this study are in gravimetric equivalents. A summary of the PM_{10} concentrations recorded by the continuous monitor is provided in Table 4.4 below.

QA/QC of continuous monitoring data
The data from the continuous monitor located at Springhill Park has been ratified by Netcen. The data conforms to the QA/QC standards used in the Defra network.

Summary statistics
Table 4.4 shows the daily average measured concentrations from the 26th April 2002 until the 28th January 2003. The average concentration (ratified) for the Springhill site exceeds the annual and 24 hour objective for PM_{10}.

Table 4.4 Summary of continuous PM_{10} ratified data from the 26th April 2002 to the 28th January 2003 inclusively. Concentrations are in gravimetric equivalents.

	Concentration, $\mu g\ m^{-3}$
	PM_{10}
Average over period	43
90 %ile of 24hour mean	73
Data capture	98%

4.5 COMPARISON OF MONITORING DATA WITH DERRY

The modelling carried out for this report has used 1999 meteorological data from Aldergrove. Therefore a comparison has been made between PM_{10} concentrations recorded by the continuous monitor in Derry in 1999 with that recorded between 26th April and the 28th January 2003 when the Springhill park site was in operation. Ideally a comparison would have been done with more monitoring sites but Derry was the only site for which data was available and for which was deemed suitable. The results are shown in Table 4.5 below. All results shown are in gravimetric equivalents.

Table 4.5 Comparison of PM_{10} concentrations in Springhill park with the Derry site.

Site	90th percentile daily mean (μg/m^3) in 1999	90th percentile daily mean (μg/m^3) from 26th April 2002 to 28th Jan 2003
Derry	39	37.7
Springhill Park	*	73

* It is estimated that in 1999, Springhill Park would have recorded a 90th percentile daily mean PM_{10} concentration of approximately 75.5 μg/m^3. This result has been used in the modelling to correct for bias.

5 Review and Assessment for SO_2 from domestic fuel combustion

5.1 INTRODUCTION

Sulphur dioxide is a corrosive acid gas which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses. SO_2 in ambient air is also associated with asthma and chronic bronchitis.

The principal source of this gas is power stations burning fossil fuels which contain sulphur. Episodes of high concentrations of SO_2 now only tend to occur in cities in which coal is still widely used for domestic heating, in industry and in power stations. As most power stations are now located away from urban areas, SO_2 emissions may affect air quality in both rural and urban areas. Since the decline in domestic coal burning in cities and in power stations overall, SO_2 emissions have diminished steadily and, in most European countries, they are no longer considered to pose a significant threat to health.

5.2 LATEST STANDARDS AND OBJECTIVES FOR SO_2

Two new objectives have been introduced for SO_2 in the AQS based on the limit values in the Air Quality Daughter Directive. Hence there are now three objectives:

- 266 $\mu g\ m^{-3}$ as a 15 minute mean (maximum of 35 exceedences a year or equivalent to the 99.9^{th} percentile) to be achieved by the 31^{st} December 2005
- 350 $\mu g\ m^{-3}$ as a 1 hour mean (maximum of 24 exceedences a year or equivalent to the 99.7^{th} percentile) to be achieved by the 31^{st} December 2004
- 125 $\mu g\ m^{-3}$ as a 24 hour mean (maximum of 3 exceedences a year or equivalent to the 99^{th} percentile) to be achieved by the 31^{st} December 2004

The 15 minute mean objective is the most stringent; the other two objectives will not be exceeded if this objective is not exceeded.

5.3 THE NATIONAL PERSPECTIVE

Sulphur dioxide is emitted in the combustion of coal and oil. Emissions today are dominated by fossil-fuelled power stations which in 1997 accounted for 62% of the national total emission. Emissions from road transport are a very small fraction of the national total: 2%.

Exceedences of the 15-minute air quality standard currently occur near industrial processes for which the stack heights were designed to meet previous air quality standards and downwind of large combustion plant such as power stations. Exceedences are also possible in areas where significant quantities of coal are used for space heating. These large combustion plant are currently regulated under BATNEEC and the EPA 1990, and will come under the provisions of the IPPC. The government considers that bearing in mind the envisaged change in fuel use, it does not expect exceedences of the 15-minute objective by 2005 from these sources.

5.4 MONITORING DATA

Sulphur dioxide concentrations have been continuously monitored at Springhill Park in Strabane since April 2002. The site is in a dense domestic fuel burning area. A summary of the concentrations recorded at the site are shown in Table 5.4 below. The data has been ratified by Netcen and conform to the Defra standards.

Table 5.4 Summary of continuous SO2 data 26th April 2002 to the 28th January 2003

	SO_2 ($\mu g/m^3$)
Average	8
Maximum daily	29.3
Maximum hourly mean	90.4
99.9^{th} %ile 15 minute mean	74.5
Data capture	93.4%

The most stringent SO_2 objective is the 99.9 percentile 15 minute mean. If this objective is met then it is likely that all the other objectives will be met. The 99.9^{th} % percentile 15 minute mean concentration at the Strabane site is well below the objective of 266 $\mu g/m^3$ for sulphur dioxide during the period of monitoring.

5.5 COMPARISON OF MONITORING DATA WITH BELFAST EAST SITE.

The modelling carried out for this report has used 1999 meteorological data from Aldergrove. Therefore a comparison has been made between SO_2 concentrations recorded by the continuous monitor at Belfast East in 1999 with that recorded between 26^{th} April and the 28^{th} January 2003 when the Springhill park site was in operation. Ideally a comparison would have been done with more monitoring sites but Belfast East was the only site for which data was available and for which was deemed suitable. The results are shown in Table 5.5 below.

Table 5.5 Comparison of 99.9 percentile 15 minute mean SO_2 concentrations in Springhill park with the Belfast East site ($\mu g/m^3$).

Site	**1999**	**2000**	**2001**	**26^{th} April 2002 to 28^{th} Jan 2003**
Belfast East	338	274	373	162
Springhill Park	*	N/a	N/a	74.5

The Belfast East site recorded far higher 99.9 percentile 15 minute mean SO_2 concentrations in 1999, 2000 and 2001 than during April 2002 to January 2003 when the Springhill site has been in operation. Therefore it is likely that although the concentrations recorded by the monitor in Strabane are well below the SO_2 15 minute mean objective, that this period of monitoring is unrepresentative of the norm.

* It is estimated that in 1999, Springhill Park would have recorded a 99.9 percentile 15 minute mean SO_2 concentration of approximately 155 $\mu g/m^3$. This figure has been used to bias correct the modelled results.

6 Results of the fuel use survey

6.1 INTRODUCTION

Domestic fuel combustion releases particulates including PM_{10} and SO_2, (from the sulphur in fuel). To estimate emissions of PM_{10} and SO_2, a fuel use survey is needed.

A Fuel Use Survey was carried out by Wrean (the Western Regional Energy Agency and Network) on behalf of Fermanagh District Council. The survey covered the Devenish region and determined:

- the types of fuels used in the domestic sector,
- the quantities of fuels consumed,
- the seasonal use of heating fuels,
- the types of heating appliances used,
- the total number of persons who live in coal burning households.

There are 1100 dwellings in the 1 km grid square under review. Of these properties 211 householders, or nearly 20%, completed a fuel usage survey for their property. The main fuel usage was as detailed in table 6.1.

Table 6.1 Fuel survey results for main fuel usage of the 211 dwellings questioned in Devenish.

Fuel	Number of properties	% of those questioned
Oil	**135**	**64**
Solid Fuel	**61**	**29**
Economy	**15**	**7**

Based on these results it can be assumed that the proportion of main fuel usage is the same in the rest of the 1km grid and therefore the number of properties in the entire grid using each fuel type can be estimated.

Table 6.2 Fuel survey results for main fuel usage calculated up for all properties in the1km grid

Fuel	Total estimated number of properties
Oil	**704**
Solid Fuel (coal)	**293**
Solid Fuel (Solid Smokeless Fuel)	**26**
Economy	**77**

The results of the survey showed that overall oil was the most popular fuel in the grid (64% of all households). Solid Fuel accounted for 29% of all households and 7% used Economy 7 (i.e. electrical heating)as the main fuel.
The quantities that each household use have also been estimated. The total fuels use has been calculated for the grid from the survey result, see tables 6.3 and 6.4.

Table 6.3 Fuel survey results for oil as main fuel calculated up for all properties in the1km grid

Litres oil	
211365	litres oil used by 135 properties
1566	average litres used per property
1102229	**Total number of litres of oil used in the 1km grid**

Table 6.4 Fuel survey results for Solid fuel as main fuel calculated up for all properties in the1km grid

Solid Fuel	
153	Number of 50 kg bags used by 61 properties
3	Therefore average number of 50 kg bags used per property/week
800	Total number of 50 kg bags used in grid/week
40006 kgs	**Total weight of solid fuel in grid / wk**
1040149	Kgs in grid in Winter (26 weeks)
602439	Kgs in grid in Summer (26 weeks)
1642588	kg/yr solid fuel in grid in year
1511181	Coal (92%) in grid in year
131407	SSF (8%) in grid in year

To satisfactorily assess whether there might be exceedences of the objectives, we need to consider the strength of any emissions (in other words how much coal will be burnt) and when these emissions will occur (in other words, on which days and when during the day).
The seasonal change in coal use has been surveyed and the averages are that main fuel is used in winter for 10.6 hours but only 3.7 hours in summer. However to predict when the coal burning is likely to be most intense, we use an approach called a "degree day" approach. The word "degree" relates to the external temperature, measured in degrees. Using this approach, we use the outside temperature to estimate when people may start to burn coal, and, how much coal they might burn in a day based on how cold it is. This approach provides the best estimate of the likely concentrations and any exceedences of the relevant air quality objectives.

6.2 EMISSION FACTORS USED IN THE MODELLING

The PM_{10} emissions arising from domestic fuel combustion were taken from the UK emission factor database (www.naei.org.uk). This web site is managed by Netcen on behalf of Defra. The emission factor for sulphur dioxide from household coal which has been taken from a CRE study carried out for Belfast City Council. It was felt that this locally derived emission factor maybe more representative of fuel burnt in Northern Ireland.

Table 6.2 Emissions arising from domestic fuel combustion

Fuel type	**SO2**	**PM_{10}**	**Units**
Anthracite	13	3.59	kt/mt fuel burnt
Burning Oil	0.42	0.01	kt/mt fuel burnt
Coal	10*	10	kt/mt fuel burnt
SSF	16	5.6	kt/mt fuel burnt
Wood	0.03	7.9	kt/mt fuel burnt

Source: UK emission factor database (www.naei.org.uk)
SSF = solid smokeless fuel
* - emission factor taken from CRE, 1997.

The emission factors provided in the above table have been used to derive PM_{10} and SO_2 emissions for the area.

6.3 SPATIAL EMISSIONS INVENTORY

In the 1 km grid there are 1100 households. The emission factors shown in Table 6.3.2 above have been applied to the results of the fuel survey for the grid square to calculate PM_{10} and SO_2 emissions arising from the area as a result of domestic fuel combustion. The details of the modelling are explained in the next chapter.

7 Detailed modelling

7.1 METEOROLOGICAL DATA

Hourly sequential meteorological data for 1999 for Aldergrove was obtained from the Meteorological Office. The meteorological data provided information on wind speed and direction and the extent of cloud cover for each hour of 1999.

7.2 OVERVIEW OF THE MODELLING APPROACH

The dispersion model ADMS 3.1 has been used to predict the PM_{10} and SO_2 concentrations in Fermanagh district. ADMS is a PC-based model that includes an up-to-date representation of the atmospheric processes that contribute to pollutant dispersion and has been deemed suitable for use in the review and assessment process.

The emissions arising from each survey area have been modelled as a volume source. Emissions have been weighted with both seasonal and diurnal emission patterns. The seasonal emission pattern was obtained from the Building Research Establishment Domestic Energy Model (BREDEM, BRE, 1985). The pattern was derived using formulae that allow a degree day to be calculated. The degree day provides a method to weight emissions to the colder periods of the year. A seasonal profile was derived using the 1999 Aldergrove meteorological data.

7.3 ESTIMATED BACKGROUND CONCENTRATIONS

The modelled concentrations have been added to estimated background concentrations (taken from the NAEI web site). The maximum background concentrations the Fermanagh region have been used as conservative estimates and therefore the background concentrations that have been used are:

PM_{10}
14.9 □g/m^3 maximum as an annual average in Fermanagh District Council in 2004 (average 12.6□g/m^3). Multiplied by 1.68 gives the 90th percentile (as advised in LAQM TG4(00) and therefore a 90th percentile equivalent of 25□g/m^3.

SO_2
8.3□g/m^3 as an annual average maximum in the area in 2001 which is therefore predicted to be 75% of that value in 2004/2005. Hence a predicted estimate of 6.2□g/m^3 in 2004/2005. To be relevant to the 15minute mean this is doubled and therefore the background for 15 minute means is 12.4□g/m^3.

7.3.1 Model bias

The modelling has produced an estimate of the concentrations from domestic fuel combustion. This estimate needs to be compared to the concentrations accurately recorded by a continuous monitor. Any difference between the modelled and the monitored concentrations is called the model bias. In this case the model bias has been calculated at Springhill Park, Strabane.
The monitoring site at Springhill Park has been used as a reference site: e.g. model concentrations have been adjusted by taking the ratio between the modelled concentration in Strabane and the monitored concentration in Strabane and applying the bias between the two to the Fermanagh model. Therefore correcting Fermanagh model for model bias using the model bias established when modelling Strabane in the same way. The purpose of this adjustment was to ensure that the modelled concentrations are agreeing with measured values.

7.3.2 Model verification

The calculations have not taken account of:

- uncertainties in the fuel use survey;
- uncertainties in how the burning of domestic fuel might change in future years;
- Uncertainty resulting from year to year variations in atmospheric conditions;
- Model errors at the receptor sites;
- Model errors at the reference site;
- Uncertainty in the location of the monitor with respect to local sources
- Monitoring over a short time period
- Uncertainty in emission factors

Pollutant emissions are expected to decrease generally due to national measures (which will affect the background concentrations). However, for SO_2 in particular the background contribution is small. Concentration plots are therefore only shown for 1999 as this is the year for which modelling has been carried out and it is assumed that the results of the survey are applicable to both 1999 and 2004/5.

7.4 RESULTS OF MODELLING

7.4.1 SO_2

Figure 7.1a shows modelled SO_2 concentrations in the 1 km grid square in Enniskillen. in 1999, **uncorrected** for model bias. The model predicts that the 99.9 percentile of the 15 minute mean SO_2 concentration **will not be exceeded** in the grid. The highest concentrations are predicted in the north east area. This is due to a higher concentration of housing in this area.

Figure 7.1b shows modelled SO_2 concentrations in the 1 km grid square in Enniskillen. in 1999, **corrected** for model bias using the bias adjustment factors used by Strabane. The model predicts that the 99.9 percentile of the 15 minute mean SO_2 concentration **will not be exceeded** in the grid. The highest concentrations are predicted in the north east area. This is due to a higher concentration of housing in this area.

Due to the uncertainty in the domestic fuel burning in future years and the minute contribution of background SO_2, no attempt has been made at predicting concentrations in 2004/5. In this study, emissions from domestic fuel combustion in 2004/2005 are assumed to remain unchanged over those calculated from the fuel use survey.

Table 5.5 showed the variation in SO_2 concentrations between 1999 and 2002 in Belfast East. This has highlighted the fact that the SO_2 concentrations recorded by the continuous monitor in Springhill Park in Strabane between April 2002 and January 2003 might not be representative of 1999, which is the year that the time varying emissions factors have been calculated for.

7.4.2 PM_{10}

Figure 7.2a shows modelled PM_{10} concentrations in the 1 km grid square in Enniskillen. in 1999, **uncorrected** for model bias. The model predicts that the 90.41^{th} percentile of 24 hour PM_{10} concentrations **will not be exceeded** in the grid. The highest concentrations are predicted in the north east area. This is due to a higher concentration of housing in this area.

Figure 7.2b shows modelled PM_{10} concentrations in the 1 km grid square in Enniskillen. in 1999, **corrected** for model bias using the bias adjustment factors used by Strabane. The model predicts that the 90.41^{th} percentile of 24 hour PM_{10} concentrations **will be exceeded** in the grid. The highest concentrations are predicted in the north east area. This is due to a higher concentration of housing in this area.

Figure 7.1a. A contour plot of SO_2 concentrations predicted by the modelling relevant to the 15 minute mean objective, without a correction for model/monitor bias.

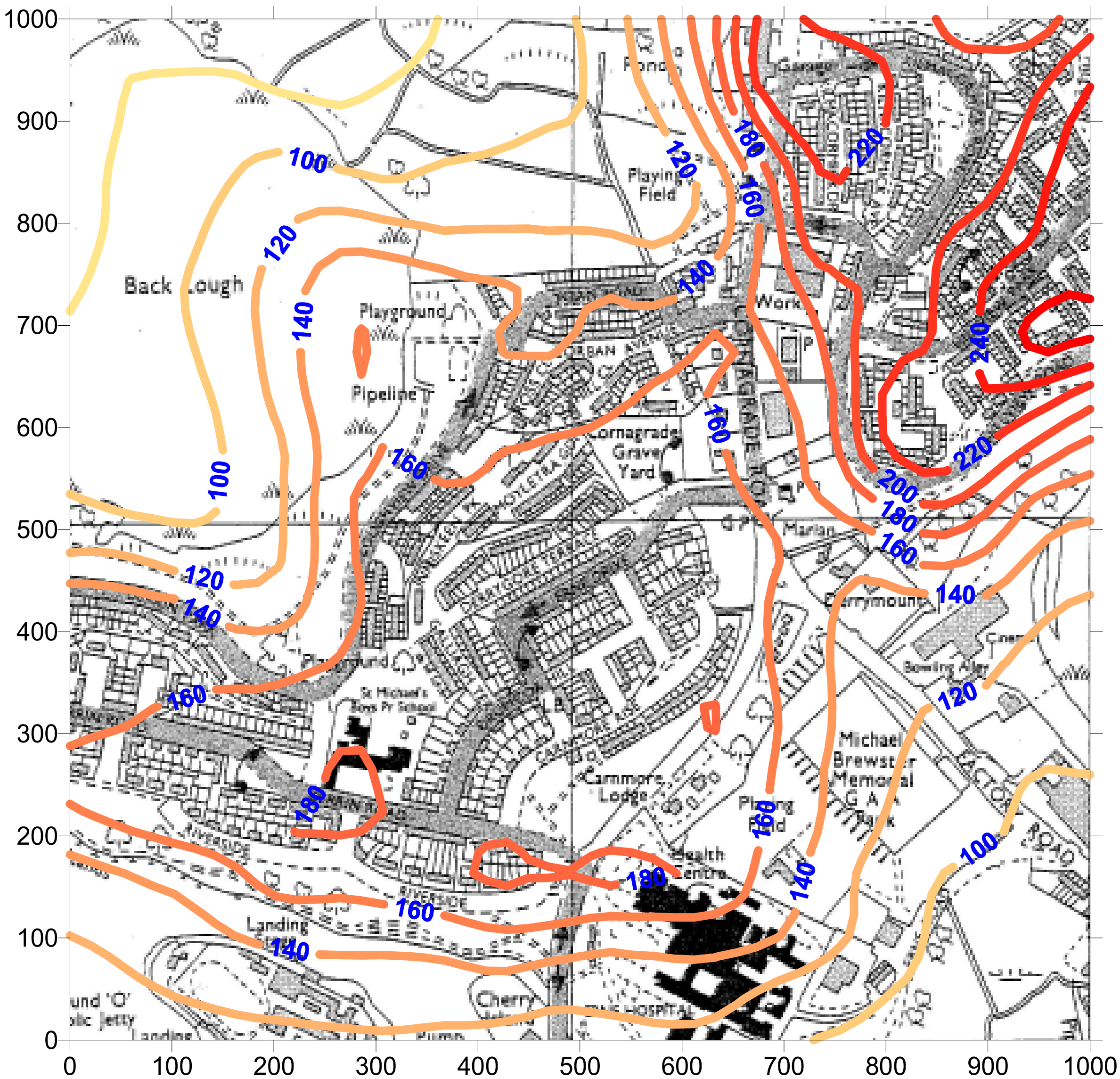


Figure 7.1b. A contour plot of SO_2 concentrations predicted by the modelling relevant to the 15 minute mean objective, with correction for model/monitor bias.

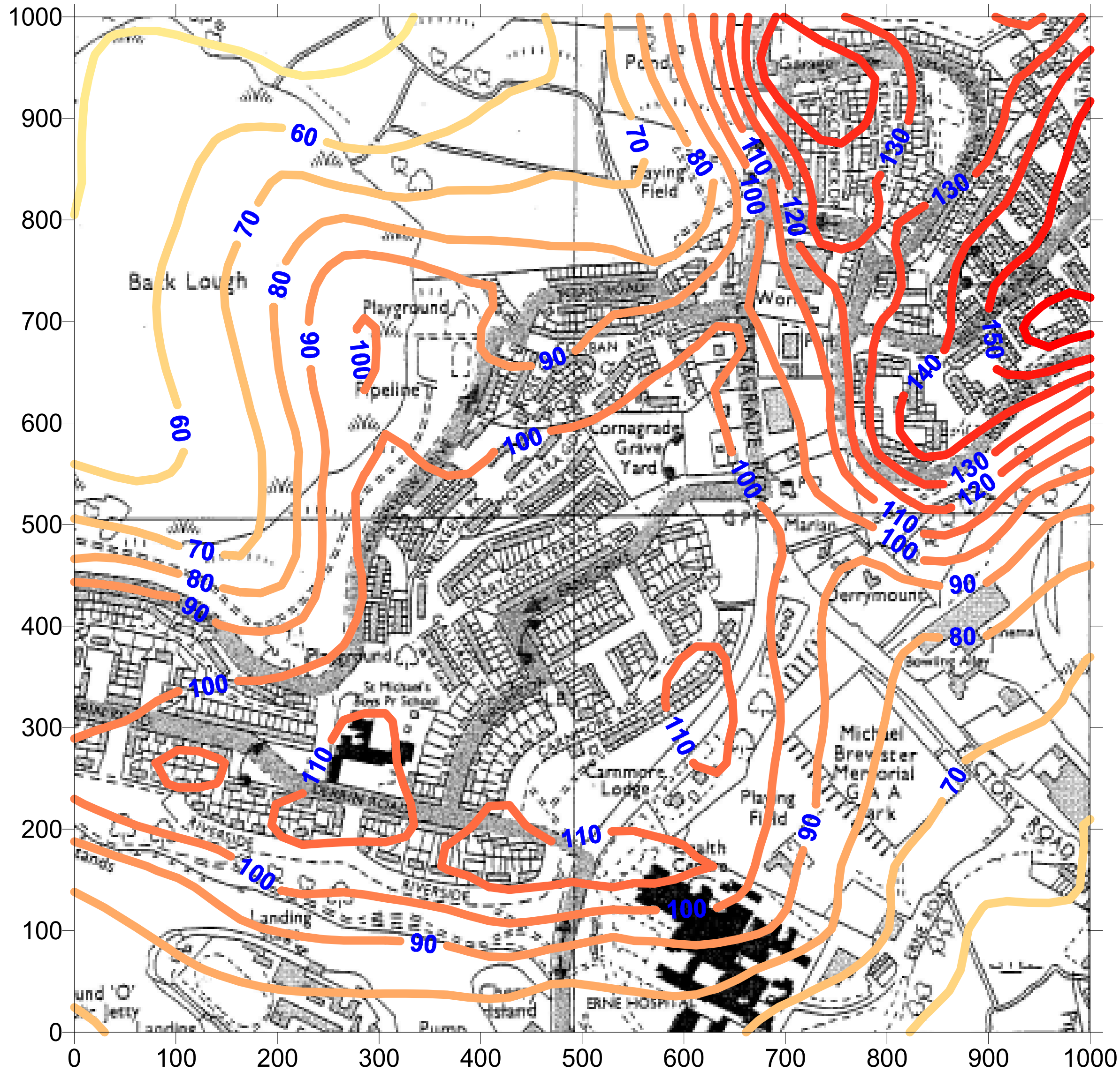


Figure 7.2a. A contour plot of PM_{10} concentrations predicted by the modelling relevant to the 24 hour objective, without a correction for model/monitor bias

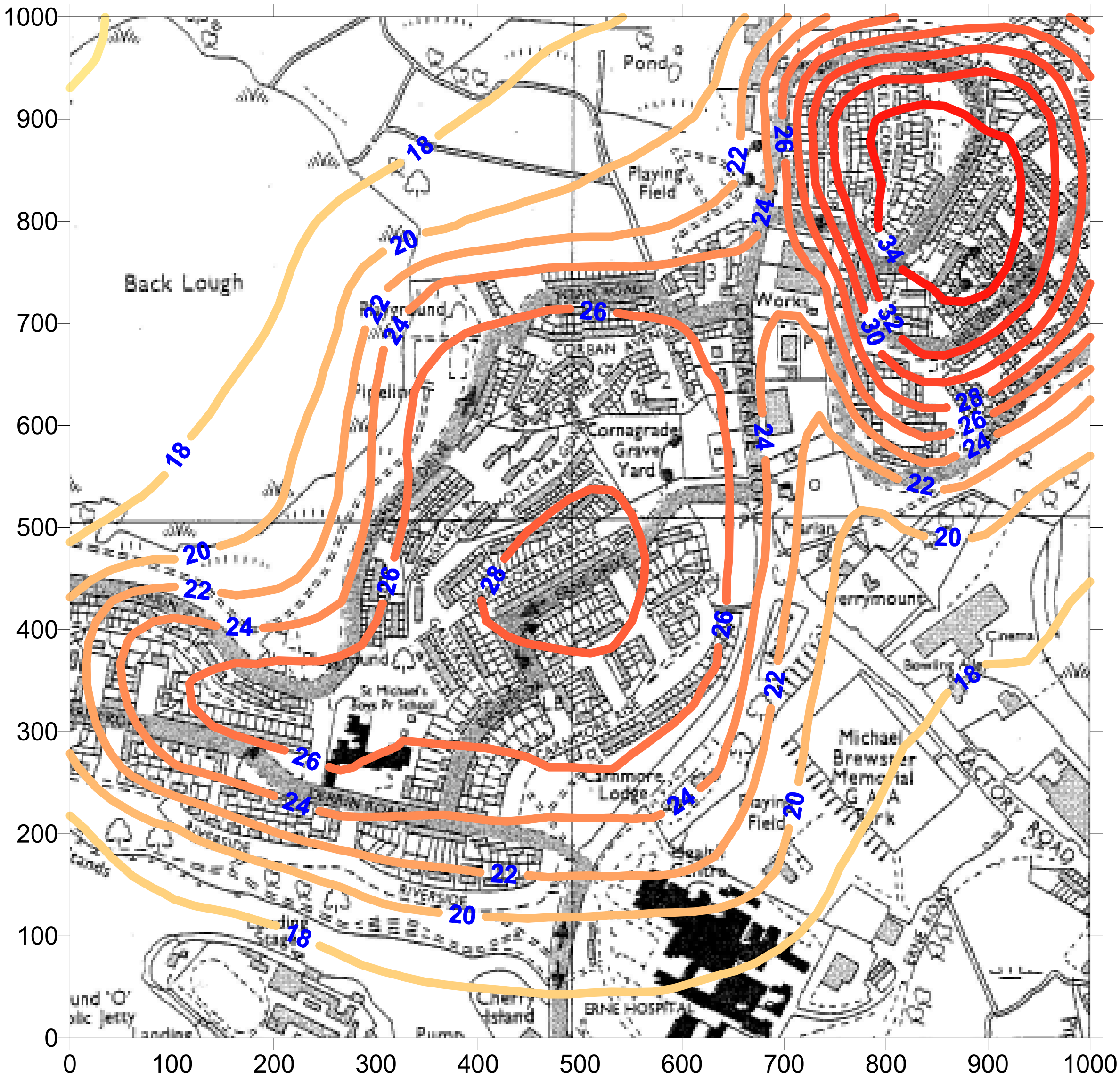
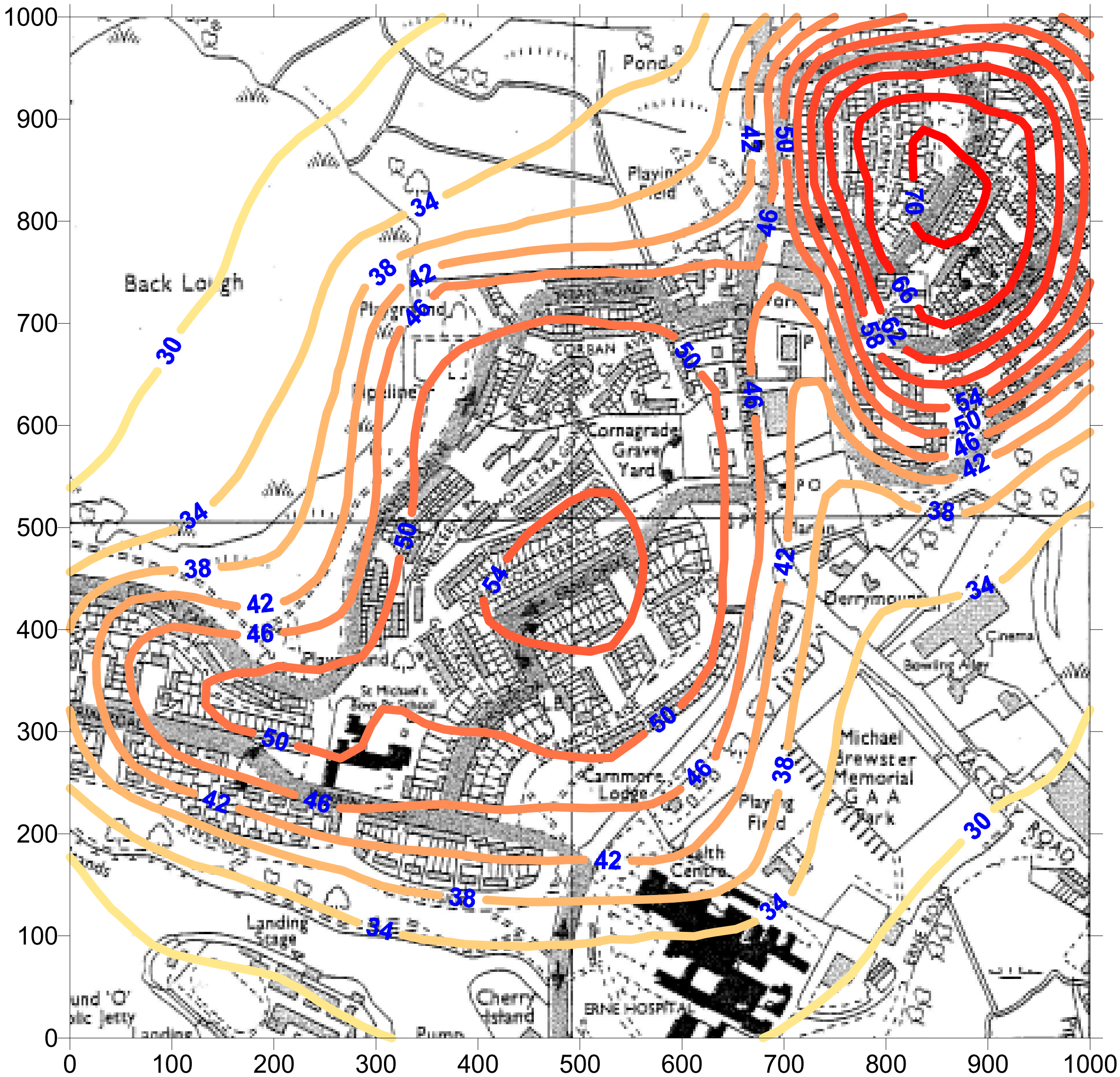


Figure 7.2b. A contour plot of PM_{10} concentrations predicted by the modelling relevant to the 24 hour objective, with correction for model/monitor bias



7.5 SUMMARY OF THE LIKELIHOOD OF EXCEEDING THE OBJECTIVES FOR SO_2

Detailed modelling using ADMS version 3.1 has been undertaken at a 1 km grid square in Enniskillen where large amounts of domestic fuel burning is common. The modelling predicts that exceedences of the SO_2 objectives are unlikely. Strabane's bias has been used to correct the model in this case as the best available information. However for an increased certainty the model would be corrected using monitoring data from Fermanagh.

A comparison of the monitoring data recorded at Belfast East during April 2002 to January 2003 (when the continuous monitor at Springhill Park was in operation) with data recorded during 1999, 2000 and 2001 showed that during the time that the Strabane site has been in operation, far lower values have been recorded than in previous years. Therefore the data recorded so far at Springhill Park may not be representative of future concentrations.

7.6 SUMMARY OF THE LIKELIHOOD OF EXCEEDING THE OBJECTIVES FOR PM_{10}

Detailed modelling using ADMS version 3.1 has been undertaken at a 1 km grid square in Enniskillen where large amounts of domestic fuel burning is common.
The modelling (corrected for model bias) has predicted that an exceedence of the PM_{10} objectives is likely. As the model correction has been made using a bias from the neighbouring Local Authority, Strabane, there is a much higher degree of uncertainty associated with this result than if Fermanagh had had there own data. Therefore it is recommended that Fermanagh carry out monitoring in the area of predicted highest PM_{10} concentrations and then reconsider the modelling with the monitoring data to support it.

7.7 RECOMMENDATIONS

It is recommended that consideration is given to declaring an air quality management area (AQMA) for PM_{10}. It is not recommended that an AQMA is declared for sulphur dioxide.

It is advisable that monitoring is carried out so that the concentrations of PM_{10} can continue to be closely observed. Local monitoring data for PM_{10} would enable a local bias adjustment factor to be used and therefore increase the certainty of the modelled result. As the predicted PM_{10} concentrations are close to the objective this is advisable.
As the modelled concentrations for SO2 are well within the objective it is not deemed necessary to monitor, notwithstanding that, local monitoring data would still be preferable to using the bias adjustment factor of a neighbouring authority should there be an opportunity for SO2 monitoring.

8 Conclusions

8.1.1 SO_2

The modelling predicts that exceedences of the SO_2 objectives are unlikely. Strabane's bias has been used to correct the model in this case as the best available information. However for an increased certainty the model would ideally be corrected using monitoring data from Fermanagh.

8.1.2 PM_{10}

The modelling predicts that exceedences of the PM_{10} objectives are likely. Monitoring is recommended for PM_{10} from domestic fuel combustion and that when such data is available that the model result is reconsidered and if the model result is confirmed it may be necessary to declare an AQMA. Due to the uncertainty associated with modelling and using the bias adjustment of a neighbouring authority it would seem reasonable to adjust the model with a local bias factor before declaring an AQMA.

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