Report

Air Quality Review and Assessment

Stage 4 - Domestic Fuel Combustion

A report for Ballymena Borough Council

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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. The Environment (NI) Order came into operation in January 2003 and implements both the European Air Framework Directive 96/62EC and the UK Air Quality Strategy. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality objectives.

Under the Air Quality Strategy all Local Authorities are required to undertake an air quality review. In areas where air quality objectives are not anticipated to be met by the specified date, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

Local Air Quality Management Policy Guidance (LAQM.PGNI (03)) is designed to help relevant authorities with their Local Air Quality Management (LAQM) duties under Part III of the Environment (NI) Order 2002. The Environment (NI) Order 2002 provides the framework for LAQM across Northern Ireland. The Air Quality Objectives set out in the Air Quality Regulations (NI) 2003 provide the statutory basis for the system of LAQM.

Solid fuel burning for domestic heating is still relatively common in parts of Northern Ireland. Where solid fuel burning is predominant it may have the potential to cause exceedences of the objectives. Ballymena Borough Council identified "the risk of exceedence" at stage 2 assessment and proceeded to a third stage review and assessment. Detailed modelling using ADMS version 3.1 was undertaken in 6 one kilometre square grids. Following a third stage review and assessment, PM_{10} exceedance was concluded likely in Ballykeel and Dunclug areas and therefore Ballymena Borough Council proceeded to declare two AQMAs. These were declared for PM10 on 25th October 2004

This report forms a Stage 4 Air Quality Review for domestic emissions sources within Ballymena Borough Council. The report assesses current and potential future PM_{10} and SO_2 concentrations as a result of domestic fuel combustion emissions in two grids Ballykeel and Dunclug. This assessment has been undertaken by means of modelling. Monitoring is in place near Ballykeel's grid but a full dataset is not yet available. Concentrations arising from domestic fuel combustion have been assessed using **netcen**'s DISP model. It should be noted that the modelling methodology used in this Stage 4 assessment differs from that used in the Stage 3 assessment. Until model verification can be undertaken these model results are not finalised. This Stage 4 study represents a more accurate modelling exercise using more up to date information than the previous stage 3 modelling. The modelling remains subject to verification with local monitoring data.

The conclusions of the report are:

Particulate Matter (PM_{10} gravimetric)
Detailed modelling has shown that PM_{10} emissions arising from domestic fuel combustion in Ballymena Borough Council is predicted to cause an exceedence of the daily PM_{10} objective at relevant receptors within the assessed areas, specifically Ballykeel.

Sulphur dioxide (SO_2)
Detailed modelling has shown that SO_2 emissions arising from domestic fuel combustion in Ballymena Borough Council are not predicted to cause an exceedence of the air quality objectives at relevant receptors within the assessed areas.

The modelling has predicted an exceedance of the regulated objectives. The designation of an AQMA remains valid. This is subject to verification of the modelling using local monitoring data. Continuous monitoring of SO_2 and PM_{10} is already in place to capture these data for the purpose of verification.

The modelling has also predicted an exceedance of the provisional PM_{10} annual objective in 2010 in Ballykeel. This objective is not currently included in regulation.

It is recommended that the existing monitoring be continued in order to provide data to substantiate these conclusions. The next formal Review and assessment requirement is the production of a progress report in April 2005.

Maps reproduced within this document

Acronyms and definitions

AADTF	Annual Average Daily Traffic Flow
ADMS	Atmospheric Dispersion Modelling System
AQDD	Air Quality Daughter Directive
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
defra	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions (now defra)
DoE NI	Department of Environment Northern Ireland
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
GIS	Geographical Information System
LADS	model specifically developed for Review and Assessment by **netcen**.
NAEI	National Atmospheric Emissions Inventory
NAQS	National Air Quality Strategy (now the Air Quality Strategy)
ppb	parts per billion
roadside	1 to 5 m from the kerb
SD	standard deviation (of a range of data)
TEMPRO	software for forecasting traffic flow increases
$\mu g\ m^{-3}$	micrograms per cubic meter

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1 Introduction

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1.1 PURPOSE OF THE STUDY

netcen was commissioned to complete a Stage 4 review and assessment of for Ballymena Borough Council, covering domestic fuel combustion.

The assessment further assesses the ambient concentrations of PM_{10} and SO_2 within the areas of Ballymena Borough council that are predominantly solid fuel burning areas. Two AQMAs have already been designated for part of Ballymena Borough Council. These designations are verified using further detailed modelling. The modelling:

- Assesses the air quality in 2004, 2005 and 2010 (PM_{10} and SO_2) in Ballymena Borough Council as a result of local domestic fuel combustion
- Where exceedances are predicted, considers options for mitigation of these sources by modelling a scenario for emission reductions.
- Considers any actions that are likely to be required by Ballymena Borough Council under the Environment (NI) Order 2002, as a result of the findings of this report.

1.2 GENERAL APPROACH TAKEN

The general approach taken in this Stage 4 Assessment has been to:

- Analyse newly available domestic emission inventory information for surveyed properties;
- Compile an emission inventory for the whole area;
- Use monitoring data (where available) to assess the ambient concentrations in the area and, where appropriate, verify the output of the modelling studies;
- Model the concentrations of PM_{10} and SO_2 in the selected domestic fuel combustion areas including local background concentration using netcen's DISP model;
- Present the concentrations as contour plots, directly comparable to the relevant objectives, overlaid onto a map of local housing;

1.3 VERSION OF THE LAQM TECHNICAL GUIDANCE USED IN THIS ASSESSMENT

In preparing this report the latest version of the Government Guidance has been used LAQM.TG (03) in conjunction with the previous 'Pollutant Specific Guidance' (2000).

1.4 NUMBERING OF FIGURES AND TABLES

The numbering scheme is not sequential, 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 $\mu g\ m^{-3}$ and the PM_{10} levels are gravimetric equivalent (which is consistent with the presentation of the AQS objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is the completion of the Stage 4 review and assessment for domestic fuel combustion for Ballymena Borough Council.

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).

Chapter 3 gives a description of the two pollutants assessed in this report (PM_{10} and SO_2).

Chapter 4 describes the information and tools used to support this assessment

Chapter 5 describes the of domestic fuel combustion including the results of the modelling

Chapter 6 discusses the finding of this report.

Chapter 7 concludes the finding of this report and makes recommendations.

2 The Updated Air Quality Strategy

2.1 THE NEED FOR AN AIR QUALITY STRATEGY

After agreement, in June 1998 at the European Union Environment Council, of a Common Position on the First Air Quality Daughter Directive (AQDD), the UK government published its proposals for review of the National Air Quality Strategy. Subsequent to this review, the Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in January 2000.

The Environment (NI) Order 2002 came into operation in January 2003 and implements both the European Air Framework Directive 96/62/EC, Daughter Directives and the UK Air Quality Strategy.

The Environment (NI) Order 2002 provides the framework for LAs to review air quality in Northern Ireland and for implementation of any AQMAs. It is issued by the Department of the Environment in Northern Ireland under Article 16 of the Environment (NI) Order 2002. Under the Order, all Councils and other relevant authorities are required to have regard to published guidance when carrying out any of their duties under, or by virtue of, Part III of the Order. The published guidance is outlined in Table 2.1 below.

Table 2.1 Environment (NI) Order 2002 Key Guidance:

- The statutory background and the legislative framework within which relevant authorities have to work
- The principles behind reviews and assessments of air quality up to 2010 and the recommended steps that relevant authorities should take
- The timetable for reviews and assessments up to 2010
- How councils should handle the designation of AQMAs
- How relevant authorities should handle the drawing up and implementation of action plans
- Recommendations and suggestions on taking forward the development of local and regional air quality strategies
- Suggestions of how relevant authorities should consult and liase with others
- Local transport measures which Roads Service might wish to consider
- The general principles behind air quality and land use planning; and
- How enforcing authorities should use powers of entry under Article 19 of the Order

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

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

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

The UK Government intention is that the AQS provides 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 encouraged within the context of existing and potential future international policy commitments.

2.2.1 Air Quality Strategy

At the centre of the AQS is the use of 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 $\mu g\ m^{-3}$ with the number of exceedences that are permitted (where applicable).

Table 2.2. Objectives included in the Air Quality Regulations (NI) 2003 for the purpose of Local Air Quality Management.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 μgm^{-3} 3.25 μgm^{-3}	Running annual mean Running annual mean	31.12.2003 31.12.2010
1,3 Butadiene	2.25 μgm^{-3}	Running annual mean	31.12.2003
Carbon Monoxide	10.0 mgm^{-3}	Maximum daily running 8-hour mean	31.12.2003
Lead	0.5 μgm^{-3} 0.25 μgm^{-3}	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen Dioxide[1]	200 μgm^{-3} not to be exceeded more than 18 times a year 40 μgm^{-3}	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10})[2] **Gravimetric**[3]	50 μgm^{-3} not to be exceeded more than 35 times a year 40 μgm^{-3}	24 hour mean annual mean	31.12.2004 31.12.2004
Sulphur Dioxide	350 μgm^{-3} not to be exceeded more than 24 times per year 125 μgm^{-3} not to be exceeded more than 3 times per year 266 μgm^{-3} not to be exceeded more than 35 times per year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

Notes
1. The objectives for nitrogen dioxide are provisional.
2. Likely to be new particles objective for 2010, not in regulation at present, expected after the review of the EU's first Air Quality Daughter Directive (2005)
3. Measured using the European Gravimetric reference standard or equivalent.

2.2.2 Relationship between the UK 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 four EU ambient air quality directives that the UK has transposed into 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).

- **2002/03/EC** Directive of the European Parliament and the Council of 12 Feb 2002 relating to ozone in ambient air (the third Daughter Directive).

The first, second and third daughter directives contain air quality Limit Values for the pollutants that are listed in the framework directive. The United Kingdom must comply as a minimum with these Limit Values. The UK Air Quality Strategy must comply with the limit values set out in the EU Air Quality Daughter Directives but the UK Air Quality Strategy also includes stricter objectives for some pollutants, for example, sulphur dioxide.

The UK 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 the relevant EU Directives.

2.2.3 Policies in place to allow these objectives to be achieved

The policy framework to allow these objectives to be achieved is one 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 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 station emissions will result in ambient concentrations that meet the air quality standards set out in the AQS.

Northern Ireland now has in place the Air Quality Regulation (NI) 2002. The Government has recognised the problems associated with achieving the AQS standard for ozone, 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. For this reason ozone is specifically excluded from the LAQM regime.

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.

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 area. 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.

2.2.4 Timescales to achieve the objectives

Objectives are to be met within the timescales shown in Table 2.2. Note: the objectives for NO_2 remain provisional.

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 these guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet 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.

At present Councils in Northern Ireland are engaged in the 3 staged approach to review and assessment as set out in the original technical guidance. The Stages are briefly described in Table 2.3. The latest technical guidance LAQM.TG (03) is based on a revised '2 step' approach. The revised steps are briefly described in Table 2.4. In this process a Stage 1 equates to an 'updating and Screening assessment, and a stage 2 and 3 equates to a 'detailed assessment'.

The department recommends that councils should use the latest technical guidance LAQM.TG (03) to complete their first rounds of review and assessment. Where councils have commenced using the old technical guidance (LAQM. TG (00)) they may continue using the old guidance. However the methodology should be cross-referenced with the new guidance.

The latest technical guidance LAQM.TG (03) has been used as the guidance document for both the road emissions and domestic fuel combustion modelling methodology.

Table 2.3 Brief details of Stages in the Air Quality Review and Assessment process (LAQM.TG4 (00))

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 first 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.

Table 2.4 Brief details of Steps in the revised Air Quality Review and Assessment process (LAQM.TG (03))

Level of Assessment	Objective	Approach
Updating and Screening Assessment (USA)	• To identify those matters that have changed since the last review and assessment, which might lead to a risk of an air quality objective being exceeded.	• Use a checklist to identify significant changes that require further consideration. • Where such changes are identified, then apply simple screening tools to decide whether there is sufficient risk of an exceedence of an objective to justify a detailed assessment.
Detailed Assessment	• To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment of any necessary AQMAs.	• Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

2.4 LOCATIONS THAT THE REVIEW AND ASSESSMENT MUST CONCENTRATE ON

For the purpose of review and assessment, the authority should focus on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 2.5 summarises the locations where the objectives should and should not apply.

Table 2.5 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 2.5 (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, locations should represent non-occupational exposure.

AQS Key Points

- The Environment (NI) Order 2002 has implemented an 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 detail necessary depends on the likelihood of achieving the objectives

3 Pollutants Assessed

This chapter gives information about the two pollutants assessed in this report.

3.1 PM_{10}

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 particles in air size <10 µm aerodynamic equivalent 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, $PM_{2.5}$, and even smaller size fractions or total particle numbers.

3.1.1 Objectives for particulate matter

The Air Quality Strategy objectives to be achieved by 31st December 2004 are:

- An annual average concentration of 40 µg m^{-3} (gravimetric);
- A maximum 24-hourly mean concentration of 50 µg m^{-3} (gravimetric) not to be exceeded more than 35 times a year.

3.1.2 The National Perspective

National UK emissions of primary PM_{10} have been estimated as totalling 182,000 tonnes in 2001. Of this total, around 18% was derived from road transport sources, 11% from power stations and 21% from combustion in commercial and residential. 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)[5]. 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 µg 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.

3.2 SO_2

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 areas affected by heavy industry and in footprints of power stations. As power stations are now generally 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.

3.2.1 Objectives for sulphur dioxide

The Air Quality Strategy Objectives to be achieved are:

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

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

3.2.2 The National Perspective

Sulphur dioxide is emitted in the combustion of coal and oil. Emissions today are dominated by fossil fuelled power stations. Combustion in energy production accounted for 73% of the national total emission. Emissions from road transport are a very small fraction of the national total: less than 1% and combustion in Commercial, institutional and residential combustion accounted for 18% of the national total.

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 plants 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.

4 Information and tools used to support this assessment

This chapter presents the information and tools used to support the review and assessment of domestic fuel combustion sources.

4.1 DATA SOURCES

Ballymena Borough Council provided the information necessary for domestic fuel combustion modelling. The following data was provided:

- Fuel Use Survey 2003/4 (including type of fuel, consumption, address etc.),
- GIS shape files
- COMPASS data file for Ballymena Borough Council that contains geographical location information for all the properties.

4.2 EMISSION FACTORS

Emissions factors for household emissions where obtained from latest estimates within the National Atmospheric Emissions Inventory (NAEI). Domestic emissions factors have recently been revised within the NAEI and the emissions factors used are as detailed in table 4.1.

Table 4.1 Domestic Emissions Factors taken from the NAEI

	SO_2 kt/mt fuel burnt	*PM_{10} kt/mt fuel burnt*
Oil	0.58	2.31
Non smokeless coal	20.83	9.70
Smokeless coal	16.00	3.11
Turf/peat	20.83	9.70
Logs/sticks	0.11	7.90

4.3 BACKGROUND AIR QUALITY DATA

Background concentration of particulates (PM_{10}) and sulphur dioxide (SO_2) have been taken from the UK Air Quality Mapping work undertaken by netcen on behalf of defra and the Devolved Administrations, some of which is available through the air quality Archive (http://www.airquality.co.uk/archive/laqm/laqm.php). Data have been scaled to the year of interest where necessary following the recommended procedure in LAQM. TG (03). For PM_{10} data were scaled to match the most recent annual period of monitoring available. For SO_2 data were available for 2003, 2005 and 2010.

4.4 LOCAL AIR QUALITY MONITORING DATA

4.4.1 Extent of data available

Ballymena have recently installed continuous monitoring equipment for PM_{10} and SO_2 in the Ballykeel area, one of the areas of interest with respect to solid fuel combustion. This equipment has been in place since early 2005 and therefore there is not yet sufficient data from the site to use for model verification purposes.

The instrumentation employed uses UV fluorescence for the measurement of SO_2 and the TEOM technique for PM_{10}. These methods are appropriate for Stage 4 Assessment under LAQM (LAQM TG (03)). All TEOM data are quoted as gravimetric equivalent in accordance with the guidance. Appendix 1 provides more details about the local air quality monitoring programme.

When a dataset is available, it is intended that it will be used for verification and adjustment of the modelled output. In the meantime verification has been undertaken using the bias adjustment at Carrickfergus where the same modelling exercise is being undertaken with the same methodology. There are full datasets available for PM_{10} and SO_2 at a location within the modelled area in Carrickfergus. **netcen** has undertaken calibration and ratification and the data are suitable for use in review and assessment.

4.5 MAPS

Ballymena Borough Council provided Ordnance Survey maps for the council in the form of DXF file tiles.

4.6 MET DATA USED IN THE DISPERSION MODELLING

Hourly sequential data was obtained for 1st October 2003 to 30th September 2004 for the Aldergrove site, to match the monitoring period, for input into the dispersion model. This Met station is located a few miles from Ballymena Borough Council (see figure 4.1). Further details are given in Appendix 2.

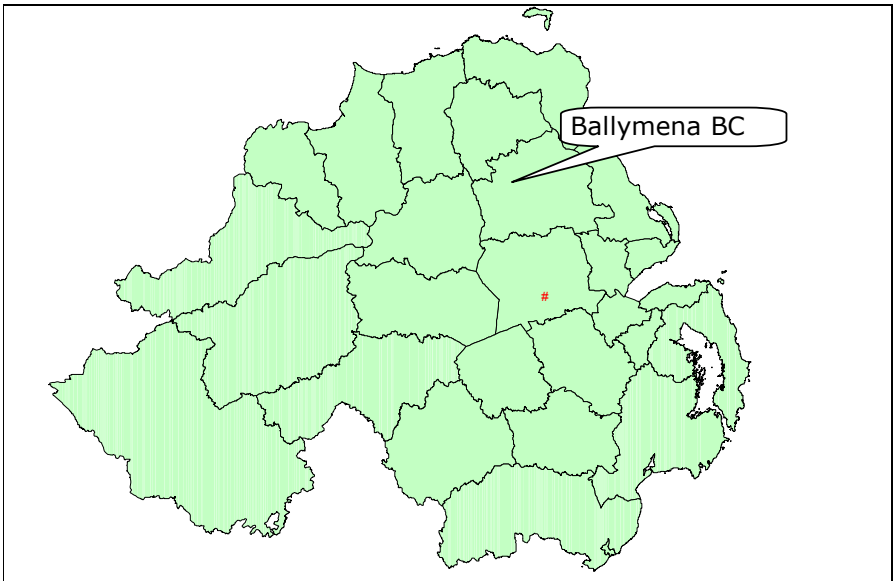

Figure 4.1 Location of Aldergrove Meteorological Station

4.7 OVERVIEW OF THE MODELLING APPROACH

In order to assess domestic fuel combustion emissions of SO_2 and PM_{10}, **netcen**'s DISP model has been used.

Concentrations of SO_2 and PM_{10} from domestic fuel combustion emissions have been assessed using a high-resolution approach, with concentrations being modelled at 50 m intervals across the grids. This high spatial resolution is recommended in Technical Guidance LAQM.TG (03). Domestic fuel combustion has been carried out using DISP to predict PM_{10} and SO_2 concentrations arising from domestic fuel burning in the area. It has been specially developed for Review and

Assessments by **netcen**. The model uses ADMS-3.1 to provide dispersion kernels over a grid. The model has been run for the relevant objective years.

4.7.1 Model verification and adjustment

Existing monitoring data from Carrickfergus and local modelling in Carrickfergus has been used to calculate a model bias factor, applied at Ballymena. The monitoring data has been ratified by **netcen**. The purpose of model verification and subsequent adjustment is, as specified in technical guidance, to ensure that the modelled concentrations reflect the monitored concentrations. Further details of model verification and adjustments are given in Appendix 3.

4.7.2 Model uncertainties

The modelling approach has not taken account of:

- Uncertainties in domestic fuel use survey data;
- Uncertainties in how the burning of domestic fuel might change in future years;
- Uncertainty resulting from year to year variations in atmospheric conditions;
- Uncertainty in emission factors
- Uncertainty in monitoring data

The above uncertainties are dealt with as fully as possible but it is important to remember that the modelling depends highly on the accuracy of the fuel use survey, which is a sample survey. It is assumed that the fuel use survey and predictions are representative. Predicted future background concentrations have been calculated and applied where possible and appropriate.

The dispersion modelling is based upon the meteorology and emissions for the period 1st October 2003 to 30th September 2004, as this was the period for which fully calibrated and ratified monitoring data was available. Clearly meteorological conditions will vary from year to year but overall would be expected to be broadly representative of local conditions for the year of the objectives.

Emissions Factors are average emission factors and do not take into account, for example, natural variation in coal and its sulphur content variability.

4.7.3 Relationship between annual means and short term concentrations

The DISP model calculates the annual mean contribution of domestic fuel combustion emissions for SO_2 and the annual and the daily mean contribution of domestic fuel combustion emissions for PM_{10}. In order to predict SO_2 short term AQ objectives, we have followed recommendations in LAQM.TG (03) and used information available from Pye and Vincent (2003).

4.7.3.1 Relationship between annual mean and short term sulphur dioxide concentrations

Pye and Vincent (2003) published a report "*Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland*". This report includes a relationship between annual mean and short-term sulphur dioxide concentrations in Northern Ireland. When the annual mean concentrations for all years (between 1990 to 2002) and for each site (Belfast Centre, Belfast East and Derry) are plotted against each of the short-term average concentrations, strong associations are observed. Table 4.1 shows the regression equations that can be applied to annual mean concentrations to produce the respective short-term mean sulphur dioxide concentrations.

Table 4.1: Regression equations used to predict SO_2 concentrations over short term averaging times (from Pye and Vincent, 2003)

Short term mean (Y) Averaging period	Regression equation	R^2
15 minute (99.9 %ile)	Y = 15.6 × Annual mean concentration – 23.6	0.91
Hourly (99.73 %ile)	Y = 11.9 × Annual mean concentration – 18.7	0.87
Daily (99.18 %ile)	Y = 5.87 × Annual mean concentration – 17.8	0.95

5 Review and Assessment of PM_{10} and SO_2 from Domestic Fuel Combustion

5.1 DOMESTIC FUEL COMBUSTION

Solid fuel burning for domestic heating is still relatively common in parts of Northern Ireland. Where solid fuel burning is predominant it may have the potential to cause exceedences of the objectives. According to the guidance, "the risk of exceedence within an area can be considered significant where the density of coal burning (or solid smokeless fuel burning) houses exceeds 300 properties per $1km^2$". In such cases the guidance recommends an authority proceed to a second or third stage review and assessment.

In the first stage of Review and Assessment, Ballymena Borough Council identified six areas as having a high proportion of solid fuel use. These six areas were identified for further assessment.

Detailed modelling using ADMS version 3.1 was been undertaken in the six one kilometre square grids identified:

- Cullybackey
- Ahoghill
- Dunclug
- Ballymena Town Centre
- Ballykeel
- Ballee

The model results were bias corrected using data from Rosebrook Avenue in Carrickfergus, as no continuous monitoring of SO_2 and PM_{10} was available at a relevant location in the Ballymena area.

The conclusions of the stage 3 report were:

Particulate Matter (PM_{10})
The modelling shows that an exceedence of the daily mean PM_{10} objective is likely within Dunclug and Ballykeel under certain meteorological conditions conducive to poor dispersion. On the basis that an exceedence is likely under specific meteorological conditions an Air Quality Management Area (AMQA) should be declared and a further assessment undertaken.

Sulphur dioxide (SO_2)
Emissions arising from domestic fuel combustion in Ballymena Borough Council are not predicted to cause an exceedence of the SO_2 air quality objectives. However the monitor currently within the modelled area should be relocated to a more relevant location within the grid, in terms of highest predicted concentrations and relevant receptors. This would enable a greater degree of confidence when this data is subsequently used for model verification.

5.1.1 Modelled area

There are two areas in Ballymena considered to be at risk of exceeding the objectives, Dunclug and Ballykeel.

5.2 DOMESTIC MODELLING

Fuel use survey data supplied by Ballymena Borough Council has been used within **netcen**'s DISP model to determine whether domestic fuel combustion is likely to cause exceedences of the SO_2 and PM_{10} objectives. The DISP model calculates the annual contribution to SO_2. For PM_{10} it calculates the daily contribution for each day of the annual period and then the 90.4th percentile can be extracted.

Conversion factors from Pye and Vincent (2003) have been used to calculate the 99.9 percentile of 15 minute means for $_{SO2}$. Pye and Vincent (2003) published a report "*Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland*". This report includes a relationship between annual mean and short-term sulphur dioxide concentrations in Northern Ireland (see 4.7.3). Table 5.1 shows the regression equation to the annual mean concentrations to estimate the 15 minute mean sulphur dioxide concentrations.

Table 5.1: Regression equations used to predict $_{SO2}$ concentrations over short term averaging times (from Pye and Vincent, 2003)

Short term mean (Y) Averaging period	Regression equation	R^2
15 minute (99.9 %ile)	Y = 15.6 × Annual mean concentration – 23.6	0.91

5.2.1 Emissions rates

The PM_{10} and SO_2 emission rate for each dwelling surveyed has been calculated using information from the fuel use survey (fuel use type and quantity). Using the emissions factors in table 5.2, an annual emission rate for each surveyed dwelling was calculated. The emission for the surveyed properties in each area was then averaged and this average was applied to the properties that had not been surveyed.

Table 5.2 Domestic Emissions Factors taken from the NAEI

	SO_2 kt/mt fuel burnt	*PM_{10} kt/mt fuel burnt*
Oil	0.58	2.31
Solid Fuel	20.83	9.70
Non smokeless coal	20.83	9.70
Smokeless coal	16.00	3.11
Turf/peat	20.83	9.70
Logs/sticks	0.11	7.90

5.2.2 Point source characteristics

The assumptions in the modelling exercise are that each property has the following point source characteristics:

- Chimney height 10m.
- Chimney diameter of 0.2m
- Exit velocity of 4 m/s and temperature of 60 °C.
- Surface Roughness 0.5m
- Meteorological data from Aldergrove October 2003 – September 2004
- Concentrations calculated to a resolution of 20m
- Building Wake effects for representative building 10m high * 20m * 20m

5.2.3 2003 Background concentrations PM_{10}

Background PM_{10} concentrations for 2003 have been extracted from the UK national background maps.

	Dunclug	*Ballykeel*
Total Annual Mean Background 2003	14.98	20.65

5.2.4 PM_{10} Source Apportionment

The domestic contribution to the background, from sources that have been modelled explicitly, has been removed. The remaining background can then be apportioned into the other sources contributing to ambient concentrations.

To remove all of the domestic component would underestimate concentrations. Although we are modelling the domestic component in this specific area there will be some domestic contribution from outside the modelled area. Therefore in order to avoid underestimating the background we are only stripping out the immediate localised proportion of the domestic. In order to calculate this an equation from the UK National background mapping methodologies has been used

Domestic $_{PM10}$ Contribution to remove =

Total $_{PM10}$ emissions in modelled areas (g s-1) * 0.903299 * 2.8914

Table 5.4 Source Apportionment of Background $_{PM10}$ concentrations in 2003 from national mapping (µg m^{-3})

	Dunclug	*Ballykeel*
Primary		
Road transport – exhaust	0.39	0.46
Road transport – brake and tyre wear	0.16	0.17
Domestic	2.88	8.45
Other	7.64	7.62
Secondary	3.91	3.95
Total Annual Mean Background 2003	**14.98**	**20.65**
Contribution to background from sources modelled explicitly (domestic)	**0.47**	**0.83**
Total Annual Mean Background 2003 excluding domestic*	**13.75**	**18.49**
Scaling from 2003 to monitoring period**	**10.37**	**13.94**
Conversion from Annual to 90th %ile daily***	**17.4**	**23.4**

*Not all domestic component of $_{PM10}$ removed as would remove domestic emissions from outside modelled area thus underestimating concentrations. An equation used to calculate the proportion of the background $_{PM10}$ component to be removed. Stedman et al

** Monitoring period – 1st October 2003 to 30th September 2004 based on AURN data from Belfast Clara St and Derry:

$PM10_{background\ (monitoring\ period)} = PM10_{background\ (2003)} \times m_{onitoring\ period\ :\ 2003}$

$PM10_{background\ (monitoring\ period)} = 0.754232$

*** To make the PM_{10} background relevant to the 90th percentile of daily mean concentrations, PSG (LAQM TG (00)) recommends that the background be multiplied by 1.68

This therefore excludes the contribution to background from explicitly modelled sources, i.e. domestic combustion, which is 2.16µg m^{-3} in Ballykeel and 1.23µg m^{-3} in Dunclug.

The background for the monitoring period (1st October 2003 to 30th September 2004) is scaled from 2003 by the ratio 0.75 based on AURN monitoring data from Belfast Clara St. and Derry.

5.2.5 2010 Background concentrations PM_{10}

Background PM_{10} concentrations for 2010 have been extracted from the UK national background maps. The contribution to the background, from sources that have been modelled explicitly, has been removed.

Table 5.5 Background PM_{10} concentrations 2010 from national mapping and excludes sources modelled explicitly (µg m^{-3})

	Dunclug	*Ballykeel*
Total Annual Mean Background 2010	12.22	12.26
Contribution to background from sources modelled explicitly (domestic)	0.47	0.83
Total Annual Mean Background 2010 excluding domestic*	10.99	10.10
Conversion from Annual to 90th %ile daily***	18.5	17.0

*Not all domestic component of $_{PM10}$ removed as would remove domestic emissions from outside modelled area thus underestimating concentrations. An equation used to calculate the proportion of the background $_{PM10}$ component to be removed. Stedman et al

*** To make the PM_{10} background relevant to the 90th percentile of daily mean concentrations, PSG (LAQM TG (00)) recommends that the background be multiplied by 1.68

5.2.6 Background concentrations SO_2

Background SO_2 concentrations for 2003 have been extracted from the UK national background maps. The background concentrations vary in the grid squares next to this grid in the national mapping. Therefore as a conservative approach the average background of the 9 grids has been used.

Dunclug

0.49	0.95	0.74
2.03	3.24	3.32
3.22	5.58	4.13

Ballykeel

7.06	5.31	3.19
3.12	6.14	1.22
1.94	1.41	0.32

The contribution to the background, from sources that have been modelled explicitly (domestic), has not been removed, as the background domestic component is negligible and unlikely to have a significant impact on overall modelled concentrations. Likewise the source apportionment of the background has not been undertaken as the contributions to ambient are small in relation to the objective values.

The Background used is therefore 2.63 µg m^3 in Dunclug and 3.30 in Ballykeel. A single plot is presented for each area that is representative of both 2005 and 2010, assuming no change in fuel use.

5.3 MODEL RESULTS

The model results form **netcen**'s DISP model is presented below.

Where plots are presented as 2004, the actual modelled period is modelled 1st October 2003 to 30th September 2004. This is considered representative of 2004. Modelling using the period for which monitoring is available reduces the uncertainty of correcting to the actual 2004 period.

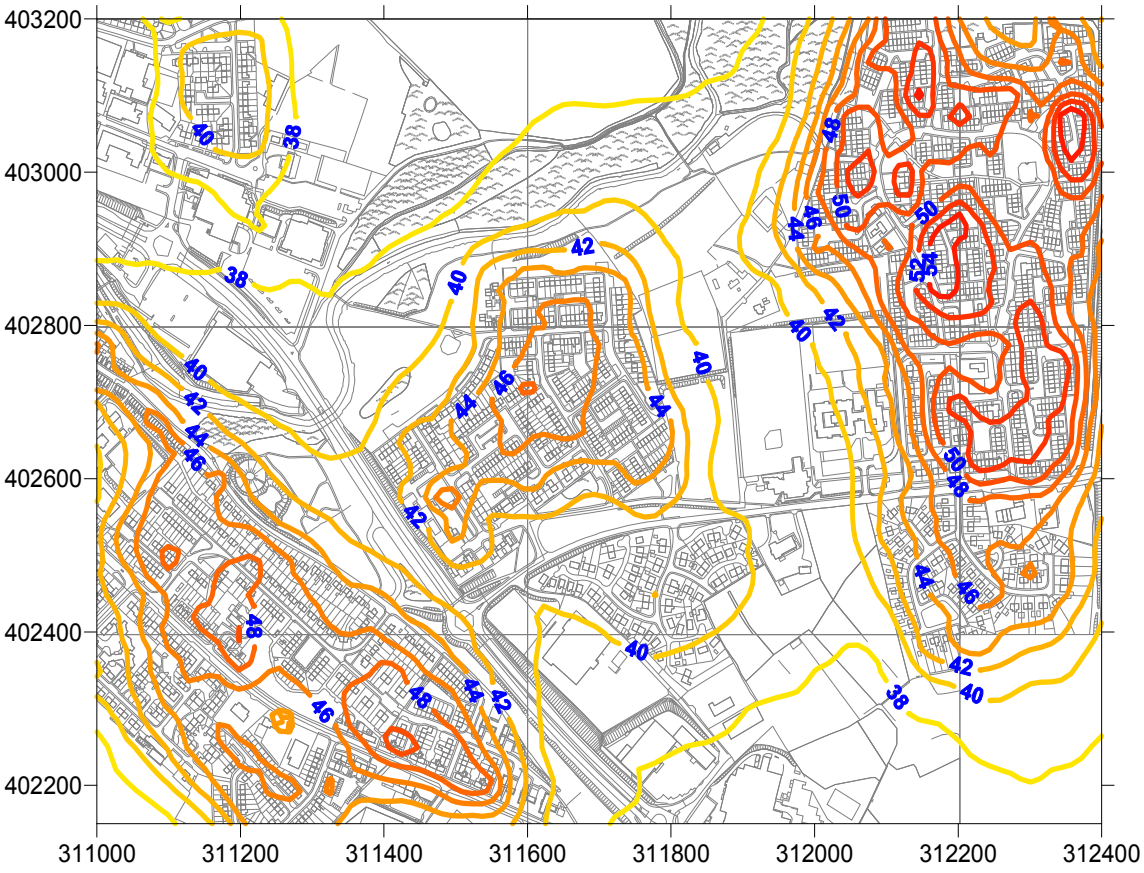

Figure 5.6 Ballykeel modelled 2004 90.4 %ile daily mean PM_{10} concentrations*(μg m^3)
***Correction applied for monitoring data using Carrickfergus modelling**

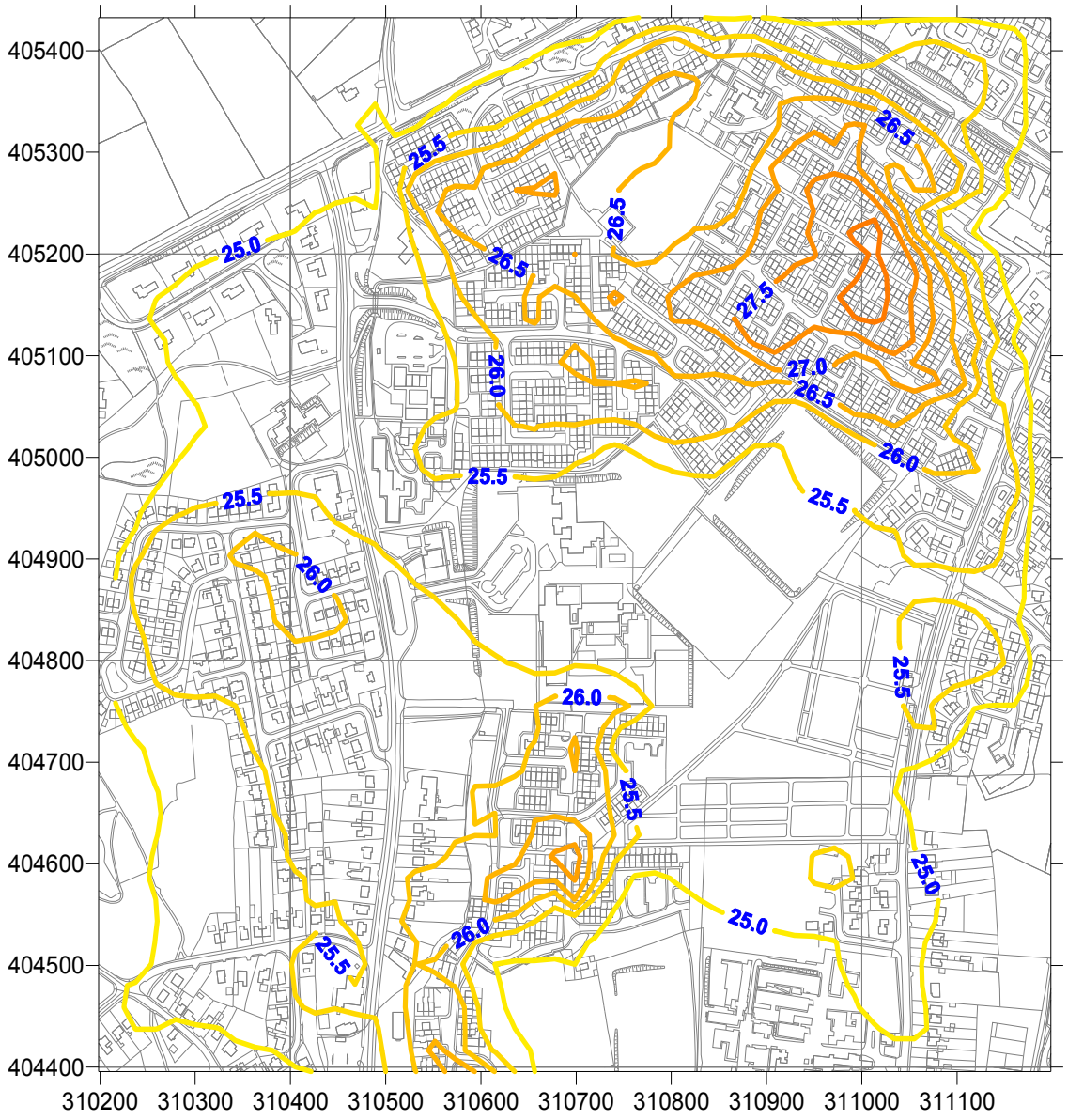

Figure 5.7 Dunclug modelled 2004 90.4 percentile daily mean PM_{10} concentrations* (μg m^3)
***Correction applied for monitoring data using Carrickfergus modelling**

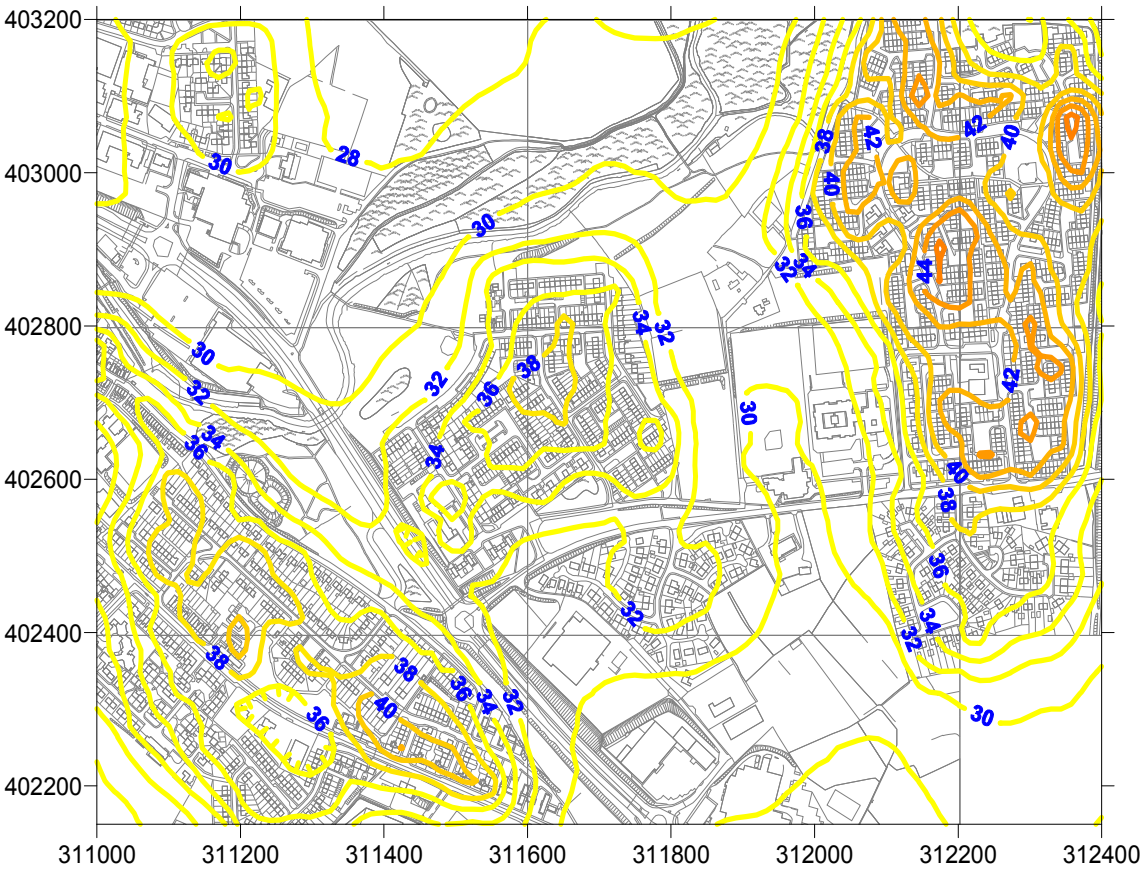

Figure 5.8 Ballykeel modelled 2010 90.4 %ile daily mean PM_{10} concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

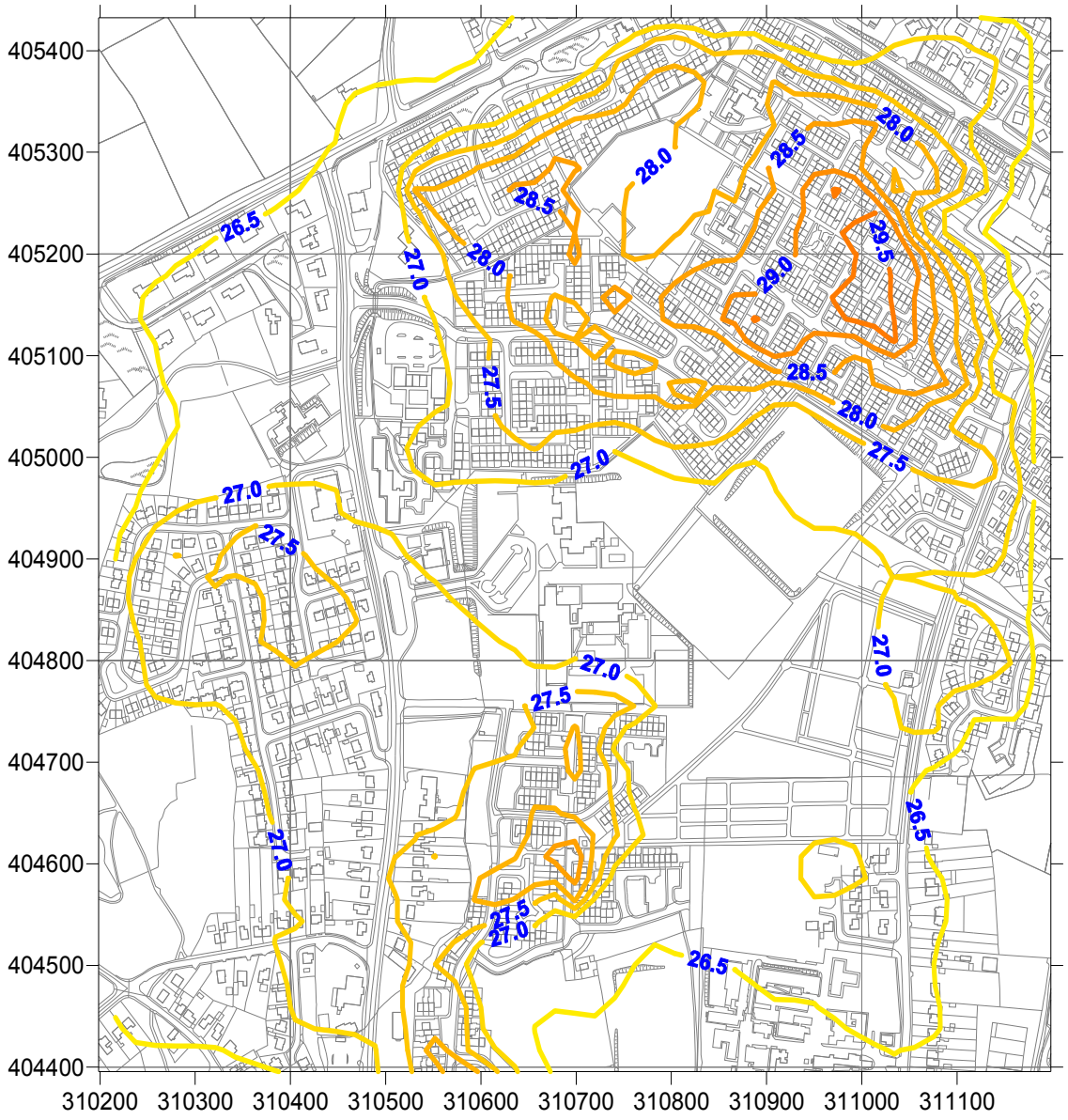

Figure 5.9 Dunclug modelled 2010 90.4 percentile daily mean PM_{10} concentrations* (µg m^3)

***Correction applied for monitoring data using Carrickfergus modelling**

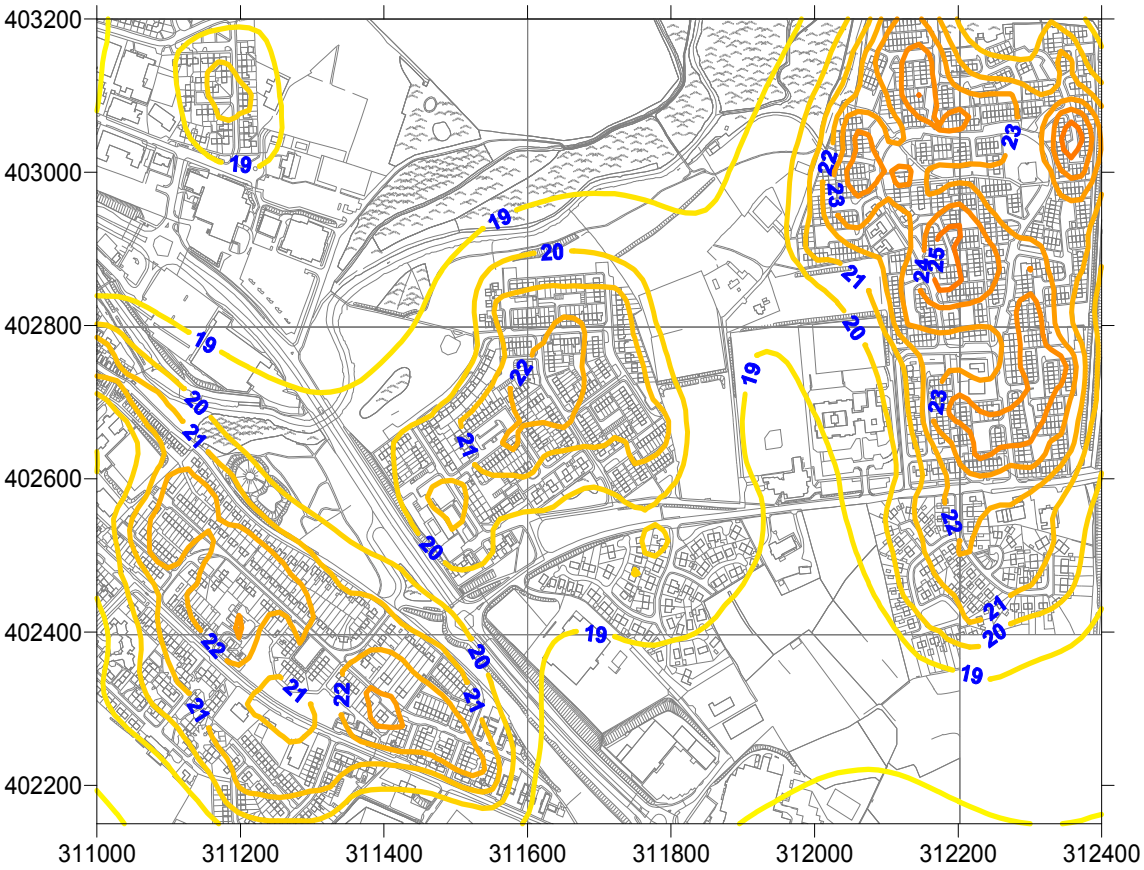

Figure 5.10 Ballykeel modelled 2004 Annual mean PM_{10} concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

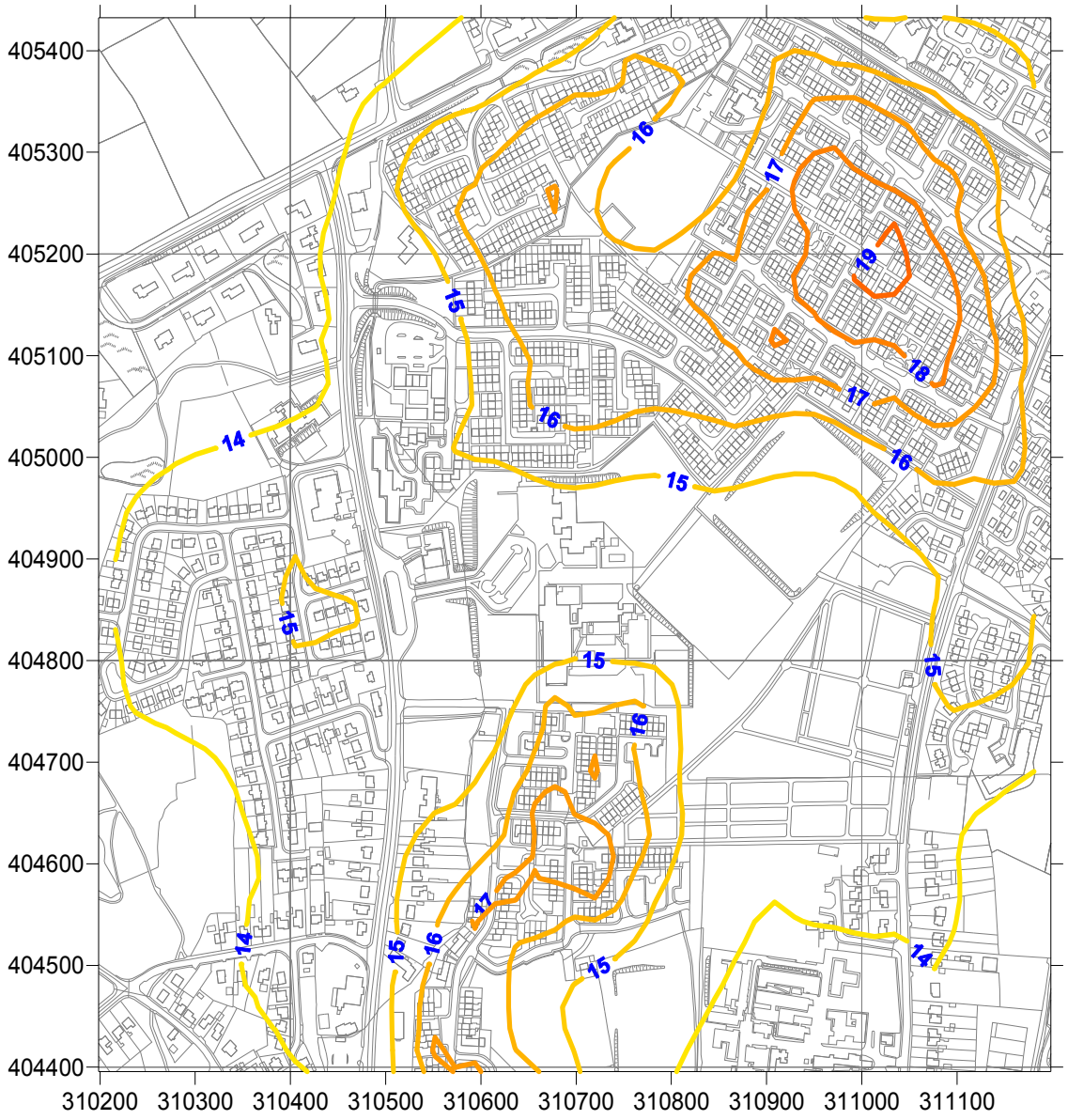

Figure 5.11 Dunclug modelled 2004 annual mean PM_{10} concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

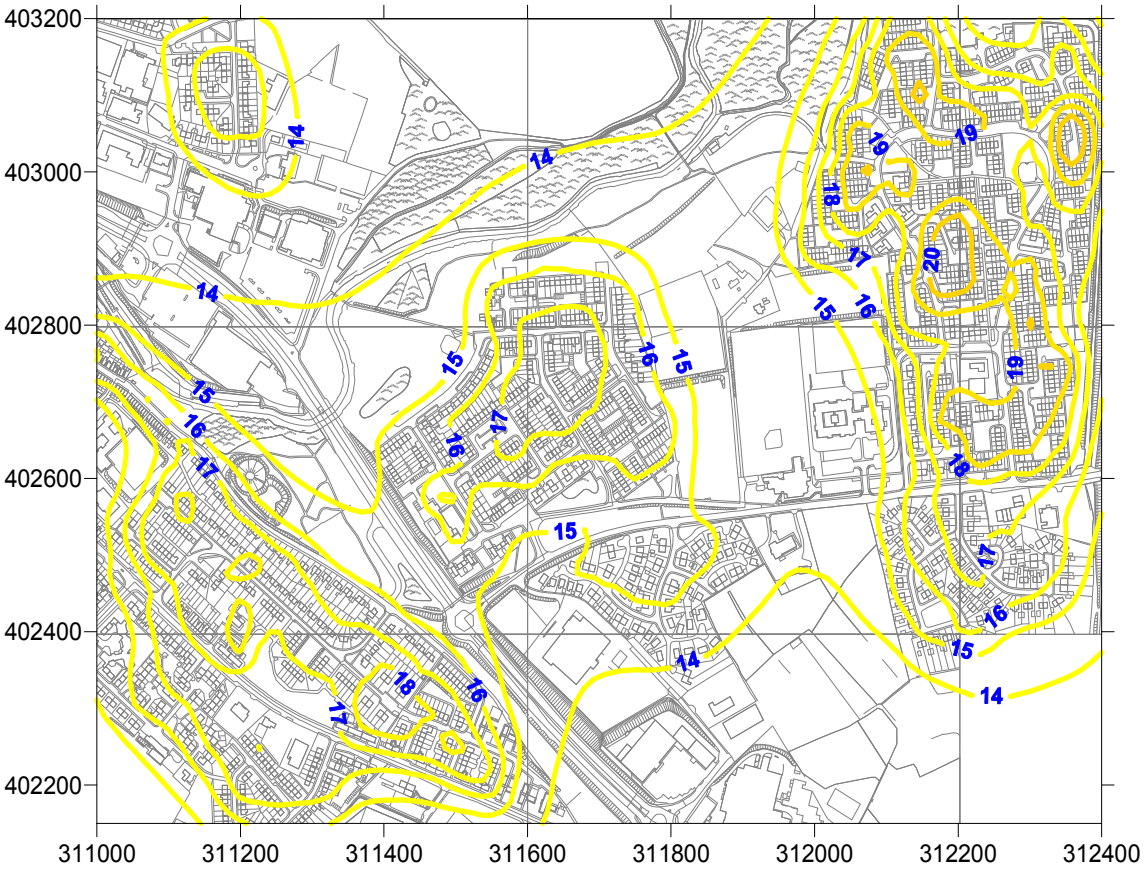

Figure 5.12 Ballykeel modelled 2010 Annual mean PM_{10} concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

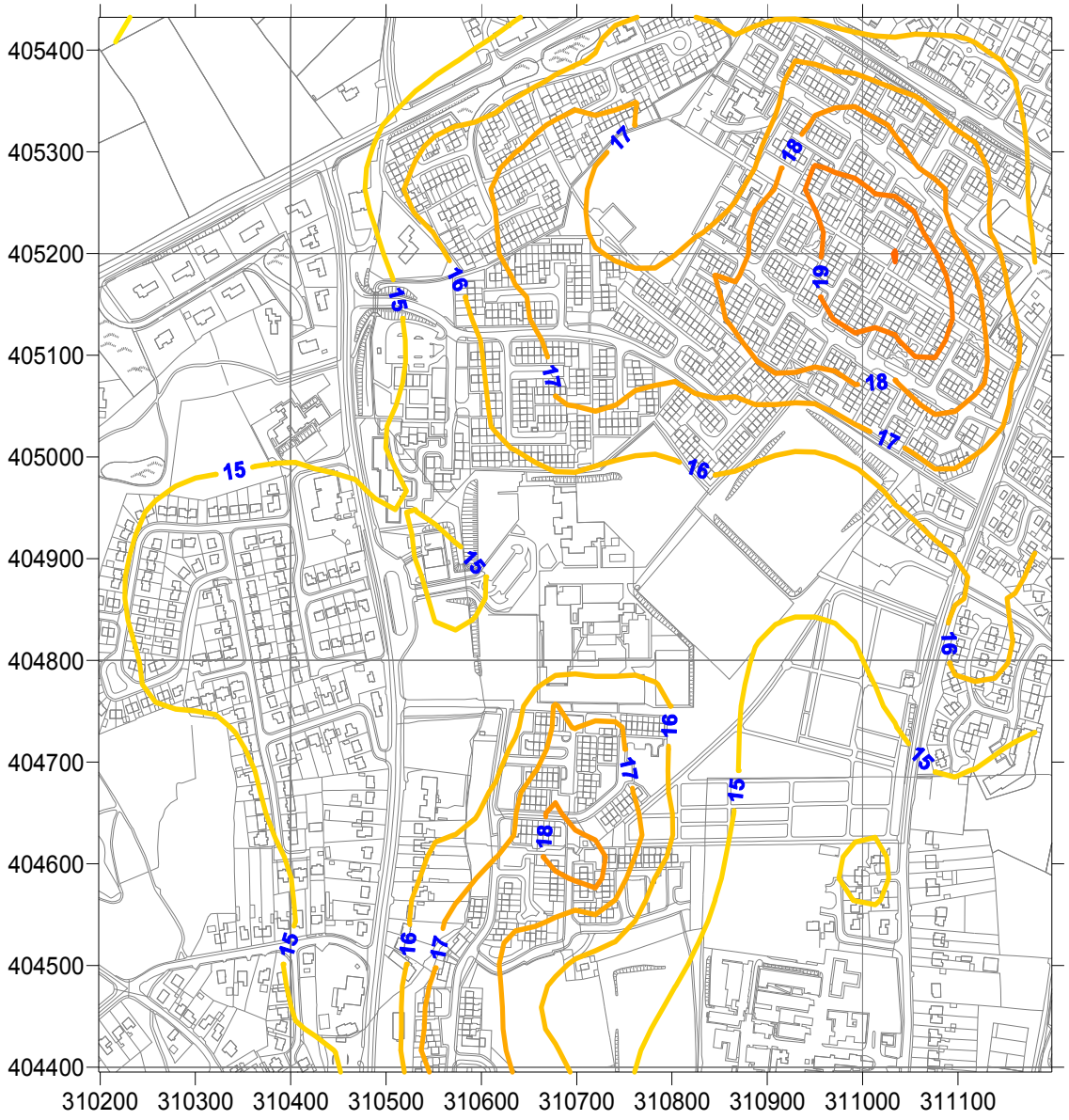

Figure 5.13 Dunclug modelled 2010 annual mean PM_{10} concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

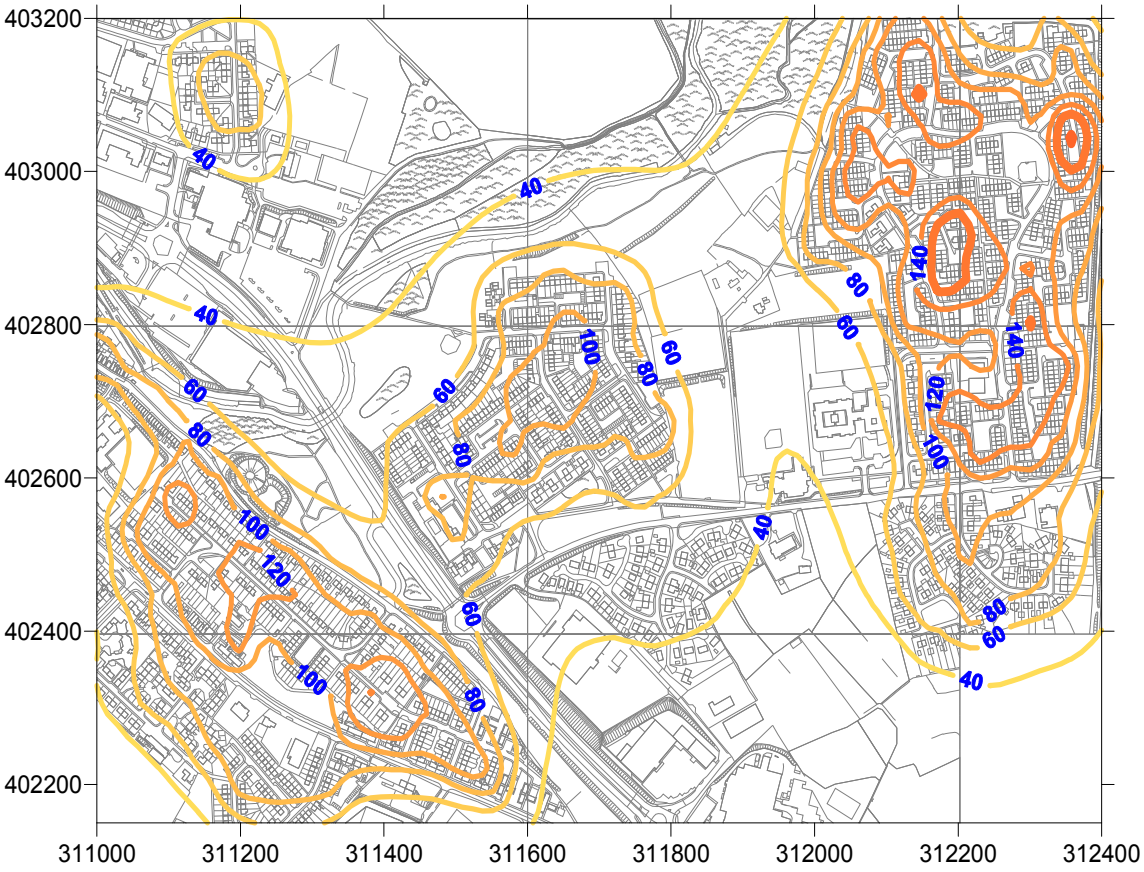

Figure 5.14 Ballykeel modelled 2005-2010 99.9 percentile 15 minute mean SO_2 concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

The SO_2 2010 99.9 percentile 15 minute mean plots are not presented as they are the same of the plots shown for 2005.

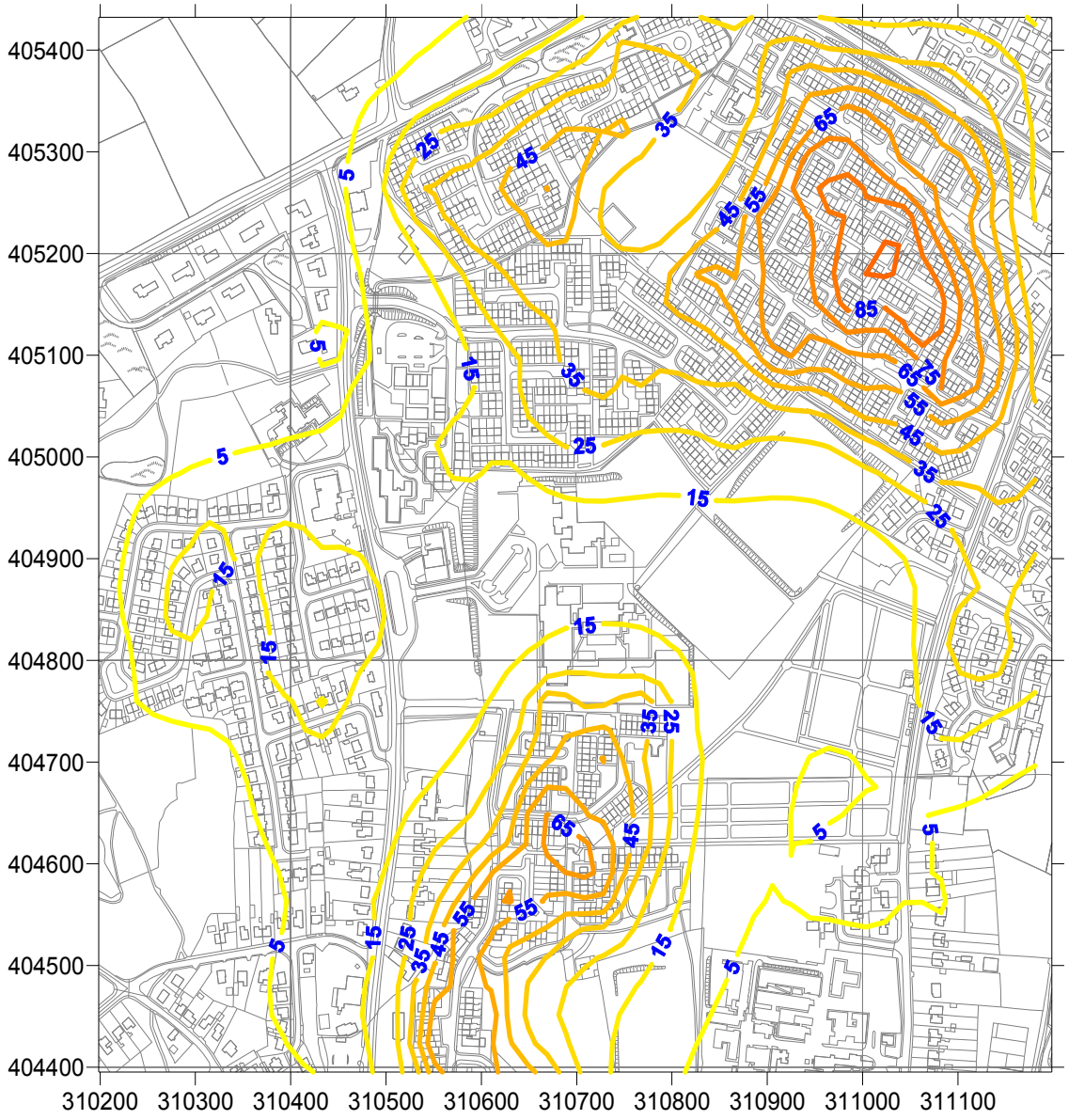

Figure 5.15 Dunclug modelled 2005 – 2010 99.9 percentile 15 minute mean SO_2concentrations* ($\mu g\ m^3$)

***Correction applied for monitoring data using Carrickfergus modelling**

The SO_2 2010 99.9 percentile 15 minute mean plots are not presented as they are the same of the plots shown for 2005.

6 Discussion

It should be noted that all the model plots have been bias adjusted using a bias correction factor from Carrickfergus Borough Council. Therefore all the following results are subject to local verification when data becomes available from the Ballymena continuous monitor, located in an area relevant to domestic fuel combustion.

PM_{10} Daily Objective

Figures 5.6 and 5. show the 90.4 percentile of daily mean PM_{10} concentrations for the period 1st October 2003 to 30th September 2004 for Ballykeel and Dunclug Respectively. This is considered representative of 2004. These plots are directly comparable with the 2004 daily PM_{10} objective of 50 $\mu g\ m^3$. The daily PM_{10} objective of 50 $\mu g\ m^3$ in 2004 is predicted to be exceeded in Ballykeel. The daily PM_{10} objective of 50 $\mu g\ m^3$ in 2004 is not predicted to be exceeded in Dunclug.

Figures 5.8 and 5.9 show the 90.4 percentile of daily mean PM_{10} concentrations for 2010. The particles objective for 2010 is not yet in place and is not included in regulation for the purposes of LAQM. Therefore local councils are only required to assess against the 2004 objectives. These plots are directly comparable with the provisional 2010 daily PM_{10} objective of 50 $\mu g\ m^3$. The daily PM_{10} objective of 50 $\mu g\ m^3$ in 2004 is not predicted to be exceeded in Ballykeel or Dunclug.

PM_{10} Annual Objective

Figures 5.10 and 5.11 show the 2004 annual mean PM_{10} concentrations. These plots are directly comparable with the 2004 annual PM_{10} objective of 40 $\mu g\ m^3$. The annual PM_{10} objective of 40 $\mu g\ m^3$ in 2004 is not predicted to be exceeded in Ballykeel or Dunclug.

Figures 5.12 and 5.13 show the 90.4 percentile of daily mean PM_{10} concentrations for 2010. The particles objective for 2010 is not yet in place and is not included in regulation for the purposes of LAQM. Therefore local councils are only required to assess against the 2004 objectives. These plots are directly comparable with the provisional 2010 Annual Mean objective of 20 $\mu g\ m^3$. The annual PM_{10} objective of 20 $\mu g\ m^3$ in 2010 is predicted to be exceeded in Ballykeel but not predicted to be exceeded in Dunclug.

SO_2 15 Minute Mean Objective

The 15 minute mean is the most stringent of the SO_2 short term objectives. Figures 5.14 and 5.15 show the 99.9 percentile of 15 minute means for SO_2 in 2005. These plots are directly comparable with the 2005 15 minute mean objective of 266 $\mu g\ m^3$. The SO_2 15 minute mean objective of 266 $\mu g\ m^3$ is not predicted to be exceeded in Ballykeel or Dunclug.

Improvement Required

The daily PM_{10} objective of 50 $\mu g\ m^3$ in 2004 is predicted to be exceeded in Ballykeel. This is a regulated objective. This is subject to verification of the modelling using local monitoring data. Continuous monitoring of SO_2 and PM_{10} is already in place to capture this data for the purpose of verification.
The improvement required is a reduction of ambient concentrations of 8$\mu g\ m^3$. In order to assess the reduction in emissions required it is intended that Ballymena will undertake a further model run of an emissions reduction scenario. This will be supplemented in a subsequent draft of this report.

The modelling has predicted also predicted an exceedance of the provisional PM_{10} annual objective of 20 $\mu g\ m^3$ in 2010 in Ballykeel. This objective is not yet in regulation but the reduction required would be 2 $\mu g\ m^3$.

Until model verification can be undertaken these model results are not finalised.

The difference in results between the stage 3 and stage 4 modelling is a result of a number of factors:

- The stage 3 methodology used a conservative screening methodology to identify those areas most at risk of exceeding the objectives.
- The stage 4 modelling employs a technique that enables a level of detailed modelling whereby the emissions for every individual property can be calculated and entered into the dispersion model at the exact location of the point source emission. The stage 3 methodology assigned emissions for all the properties into five volume source areas. The Stage 4 methodology is far more able to account for the spatial dispersion characteristics than the methodology used in the stage 3.
- The emissions factors available in the NAEI have been updated since the Stage 3 modelling and are different to the extent that a significance change in the updated modelling was anticipated. The extent to which these updated emissions factors are responsible for the change in overall emissions is difficult to quantify without further study. For information the key emission factor changes are:

Table 6.1 Domestic Emissions Factors used in reports

	PM_{10} kt/mt Stage 3 report	***PM_{10} kt/mt Stage 4 report***	***Effect assuming no other changes***
Oil	0.01	2.31	Increase PM_{10}
Non smokeless coal	10	9.70	Decrease PM_{10}
Smokeless coal	5.6	3.11	Decrease PM_{10}

The contribution to PM_{10} from solid sources would decrease where this is the main fuel according to the emissions factors. The contribution from oil would increase where it is the main fuel.

Table 6.2 Domestic Emissions Factors used in reports

	SO_2 kt/mt Stage 3 report	***SO_2 kt/mt Stage 4 report***	***Effect assuming no other changes***
Oil	0.42	0.58	Increase in SO_2
Non smokeless coal	10*	20.83	Increase in SO_2
Smokeless coal	16	16.00	No change

* emission factor taken from CRE, 1997.

The change in the oil emissions factor is only slight and so the effect of this may not be highly significant. The non-smokeless coal emission factor change is significant and we would expect a rise in concentrations as a result since the last modelling.

Further to this additional factors that will have affected the results of the modelling include:

- The monitoring data since the stage 3 has shown a general reduction in concentrations at the Carrickfergus site and therefore these are carried through to the Ballymena modelling in the bias correction.

- The fuel use survey information in Ballymena has been much extended since the earlier assessment and this assessment is able to provide better estimates of point source emissions from a greater number of properties than the first assessment. The fuel use profile in this study is therefore more representative of the actual situation than the earlier study.

- The Stage 3 modelling used differing meteorological and monitoring years and therefore had to make corrections in order to match these to each other and the period of the objective. In this study we have been able to use identical meteorological, monitoring and modelling periods, reducing the levels of uncertainty inherent when using correction factors.

- At Carrickfergus the success with which the model predicts concentrations at Stage 4 can be seen by the bias figures applied (Appendix 3). The bias correction factors are near 1 and therefore this means the model is making a good prediction of ambient concentrations at the modelling location. It would therefore be expected that the model would also predict well at Ballymena too. However there could be local factors at each particular location that may affect the ability of the model to effectively estimate concentrations. Until local monitoring data is available for verification in Ballymena then it is difficult to assign a certainty to the Ballymena modelling regarding its ability to accurately represent ambient concentrations at that location.

In summary this Stage 4 study represents a more accurate modelling exercise using more up to date information than the previous stage 3 modelling. The modelling remains subject to verification with local monitoring data. As soon as monitoring data is available it should be considered, bearing in mind location (is it in a hotspot), and compared with the Carrickfergus data as this may provide an early indication of whether verification would maintain or alter the modelling output.

In order to check the requirements of the Stage 4 have been met, the Review and Assessment Stage 4 Checklist has been cross-referenced with this report and is given in Appendix 4.

7 Conclusions

The modelling has predicted an exceedance of the regulated objectives, specifically the PM_{10} daily objective in Ballykeel. This is subject to verification of the modelling using local monitoring data. Continuous monitoring of SO_2 and PM_{10} is already in place to capture these data for the purpose of verification.

The modelling has also predicted an exceedance of the provisional PM_{10} annual objective in 2010 in Ballykeel.

Until model verification can be undertaken these model results are not finalised. This Stage 4 study represents a more accurate modelling exercise using more up to date information than the previous stage 3 modelling. The modelling remains subject to verification with local monitoring data.

It is recommended that the existing monitoring be continued in order to provide data to substantiate these conclusions. The next formal Review and assessment requirement is the production of a progress report in April 2005.

References

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Appendices

CONTENTS

Appendix 1
Automatic Monitoring Station Data

Ballymena Air Monitoring

Ballymena have recently installed continuous monitoring equipment for PM_{10} and SO_2 in one of the areas of interest with respect to solid fuel combustion. This equipment has been in place since early 2005 and therefore there is not yet sufficient data from the site to use for model verification purposes.

The instrumentation employed uses UV fluorescence for the measurement of SO_2 and the TEOM technique for PM_{10}. These methods are appropriate for Stage 4 Assessment under LAQM (LAQM TG (03)). All TEOM data are quoted as gravimetric equivalent in accordance with the guidance. Appendix 1 provides more details about the local air quality monitoring programme.

These data are managed by **netcen** and, when a dataset is available is intended for use in verification and adjustment of the modelled output. In the meantime verification has been undertaken using the bias adjustment at Carrickfergus where the same modelling exercise is being undertaken with the same methodology. There are full datasets available for PM_{10} and SO_2 at a location within the modelled area in Carrickfergus. **netcen** has undertaken calibration and ratification and the data is suitable for use in review and assessment.

Appendix 2
Aldergrove Met Station Data

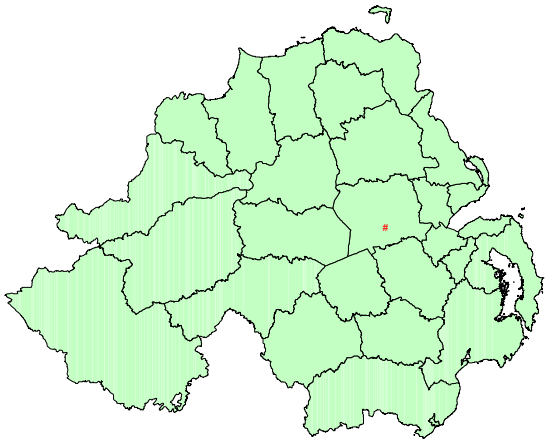


Figure A2- Location of Aldergrove Station

Table A2 - Characteristics of Aldergrove Station

Description – Aldergrove International airport.	
DCNN	9142
Eastings	314700
Northings	379800
Latitude Deg Min	54 39 N
Longitude Deg Min	06 13 W
Station height AMSL (m)	68
Effective height of anemograph (m)	10

Appendix 3
Model Verification and Adjustment

Model Verification Bias correction calculation from Carrickfergus

Model adjustment for PM_{10} at Carrickfergus

Background PM_{10} concentrations 2003 from national mapping (µg m^{-3})

	Carrickferg	Greenisland
Primary		
Road trans	0.30	0.31
Road trans	0.11	0.12
Domestic	5.37	2.99
Other	7.27	7.23
Secondary	3.98	3.98
Total	17.02	14.63

Total PM_{10} emissions in modelled areas (g s^{-1})

	Carrickferg	Greenisland
Base Case	0.75	0.27
Base Case	0.56	0.26

1 Properties with no fuel assigned are assumed to use fuel in the same proportion as other properties on the same street with fuel assigned.
2 Properties with no fuel assigned are assumed to use oil

Contribution to background concentrations 2003 from sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	1.97	0.70
Base Case	1.48	0.67

Background PM_{10} concentrations 2003 excluding sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	15.05	13.93
Base Case	15.55	13.96

The background is then scaled from 2003 to the monitoring period (1st October 2003 to 30th September 2004) based on AURN data from Belfast Clara St. and Derry.

$PM_{10\ background\ (monitoring\ period)} = PM_{10\ background\ (2003)} \times f_{monitoring\ period\ :\ 2003}$

	Scale Factor
$f_{monitoring\ peric}$	0.754232

Background PM_{10} concentrations monitoring period excluding sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	11.35	10.50
Base Case	11.73	10.53

The annual mean PM10 concentrations were then compared with monitoring data from the Carrickfergus station and a bias correction factor derived.

$PM_{10\ monitoring\ data} = (PM_{10\ background\ (monitoring\ period)} + PM_{10\ modelled}) \times f$

[annual mean]

	Monitoring [1]	Backgroun	Modelled [3]	Adjustment factor f
Base Case	17	11.35	2.48	1.23
Base Case	17	11.73	2.11	1.23

1 Carrickfergus station

[2] Scaled from NAEI excludes contribution to background from explicitly modelled sources
[3] ADMS 3.2

The modelled 90th %ile of 24 hour mean PM_{10} concentrations were then compared with monitoring data for the same period and a bias correction factor derived.

$PM_{10\ monitoring\ data} = (PM_{10\ background\ (monitoring\ period)} \times 1.68 + PM_{10\ modelled}) \times f$

[90th %ile of 24 hour mean]

	Monitoring [1]	Backgroun	Modelled [3]	Adjustment factor f
Base Case	36	-	6.04	1.43
Base Case	36	-	5.29	1.44

1 Carrickfergus station

[2] Scaled from NAEI excludes contribution to background from explicitly modelled sources
[3] ADMS 3.2

Background PM_{10} concentrations 2010 from national mapping (µg m^{-3})

	Carrickferg	Greenisland
Total	13.34	12.19

Background PM_{10} concentrations 2010 excluding sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	11.37	11.48

Model adjustment for SO_2 at Carrickfergus

JS

Carrickfergus

5.75	9.92	7.76
4.47		

Greenisland

2.06	2.14	1.75
3.10	6.27	1.96
3.23	2.72	

Kernel

0.38	0.72	0.42
0.61	10.77	0.94
0.49	1.26	0.57

Background SO_2 concentrations 2003 from national mapping (µg m^{-3})

	Carrickferg	Greenisland
Total	6.98	2.90

Total SO_2 emissions in modelled areas (g s^{-1})

	Carrickferg	Greenisland
Base Case	1.24	0.43
Base Case	0.57	0.27

1 Properties with no fuel assigned are assumed to use fuel in the same proportion as other properties on the same street with fuel assigned.
2 Properties with no fuel assigned are assumed to use oil

Contribution to background concentrations 2003 from sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	2.22	0.76
Base Case	1.02	0.48

Background SO_2 concentrations 2003 excluding sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	4.75	2.14
Base Case	5.96	2.43

The background is then scaled from 2003 to the monitoring period
(1st October 2003 to 30th September 2004) based on AURN data from Belfast East and Derry.

$SO_{2\ background\ (monitoring\ period)} = SO_{2\ background\ (2003)} \times f_{monitoring\ period\ :\ 2003}$

	Scale Factor
$f_{monitoring\ peric}$	0.90

Background SO_2 concentrations monitoring period excluding sources modelled explicitly (µg m^{-3})

	Carrickferg	Greenisland
Base Case	4.27	1.92
Base Case	5.35	2.18

The annual mean SO2 concentrations were then compared with
monitoring data from the Carrickfergus station and a bias correction factor derived.

$SO_{2\ monitoring\ data} = (SO_{2\ background\ (monitoring\ period)} + SO_{2\ modelled}) \times f$

[annual mean]

	Monitoring	Backgroun	Modelled [3]	Adjustment factor f
Base Case	6	4.27	4.35	0.70
Base Case	6	5.35	2.82	0.73

1 Carrickfergus station

[2] Scaled from NAEI excludes contribution to background from explicitly modelled sources
[3] ADMS 3.2 includes kilroot power sation

The modelled 99.9th %ile of 15 min mean SO_2 concentrations were then compared
with monitoring data for the same period and a bias correction factor derived.

$SO_{2\ monitoring\ data} = (15.568 * (SO_{2\ background\ (monitoring\ period)} + SO_{2\ modelled}) - 23.673) \times f$

[99.9th %ile of 15 min mean]

	Monitoring	Backgroun	Modelled [3]	Adjustment factor f
Base Case	85	-	-	0.77
Base Case	85	-	-	0.82

1 Carrickfergus station

[2] Scaled from NAEI excludes contribution to background from explicitly modelled sources
[3] ADMS 3.2 includes kilroot power sation

Appendix 4
Stage 4 Checklist

Stage 4 Review & Assessment Checklist

PM_{10}	Response	Comments
7.1.1.1 MONITORING		
• Has further continuous monitoring been undertaken?	**Yes**	Monitoring put in place in early 2005, not yet dataset available
• Is the 'totality' of the monitoring effort sufficient?	**Yes**	The monitoring is in a location relevant for domestic fuel combustion
• Has monitoring confirmed 2004 exceedances?	**No**	Monitoring put in place in early 2005, not yet dataset available
• Has sufficient detail of QA/QC procedures been provided?	**No**	Monitoring put in place in early 2005, not yet dataset available
• Has monitoring amended the conclusions of Stage 3?	**No**	Monitoring put in place in early 2005, not yet dataset available
7.1.1.2 MODELLING		
• Has further modelling been undertaken?	**Yes**	More detailed modelling
• Is the further modelling considered appropriate?	**Yes**	The modelling has taken account of new fuel use data and the latest domestic fuel modelling techniques
• Has the model been appropriately validated?	**Yes**	Yes, the netcen model has been appropriately validated
• Has modelling confirmed 2004 exceedances?	**Yes**	The modelling (not locally bias corrected) has predicted exceedances of the daily objective
• Has modelling amended the conclusions of Stage 3?	**Yes**	An exceedance of the PM_{10} objectives is no longer predicted in dunclug
7.1.1.3 GENERAL		
• Have both the magnitude and geographical extent of any exceedences been further clarified?	**Yes**	Yes. Magnitude has reduced to just part of Ballykeel, no longer exceeding in Dunclug.
• Has the decision to declare an AQMA been reversed at Stage 4?	**No**	No, the decision remains.
• Is this decision soundly based?	**Yes**	
• Has the authority taken account of the new vehicle emission factors	**N/A**	
• Has the primary fraction of total PM10 been determined?	**Yes**	
• Has the authority considered source apportionment?	**Yes**	Yes – accounted for in Background calculations
• Has the authority considered the cost effectiveness of different abatement options?	**N/A**	Not within scope of this report
• Has the authority considered feasibility and effectiveness of different abatement options?	**N/A**	Not within scope of this report
• Has the authority considered the extent to which air quality improvement is required?	**Yes**	A further model scenario is planned to determine the emission reduction associated with the stated concentration reduction

Other Comments

Stage 4 Review & Assessment Checklist

7.1.1.3.1.1 Sulphur Dioxide	Response	Comments
7.1.1.4 MONITORING		
• Has further continuous monitoring been undertaken?	**Yes**	Monitoring put in place in early 2005, not yet dataset available
• Is the 'totality' of the monitoring effort sufficient?	**Yes**	The monitoring is in a location relevant for domestic fuel combustion
• Has sufficient detail of QA/QC procedures been provided?	**N/A**	Monitoring put in place in early 2005, not yet dataset available
• Has monitoring confirmed exceedences of any of the objectives?	**N/A**	Monitoring put in place in early 2005, not yet dataset available
• Has monitoring amended the conclusions of Stage 3?	**N/A**	Monitoring put in place in early 2005, not yet dataset available
7.1.1.5 MODELLING		
• Has further modelling been undertaken?	**Yes**	Yes
• Is the further modelling considered appropriate?	**Yes**	The modelling has taken account of new fuel use data and the latest domestic fuel modelling techniques
• Has the model been appropriately validated?	**Yes**	Yes, the netcen model has been appropriately validated
• Has modelling confirmed exceedences of any of the objectives?	**No**	The modelling (not locally bias corrected) has not predicted exceedances
• Has modelling amended the conclusions of Stage 3?	**Yes**	An exceedance of the SO_2 objectives is not predicted
7.1.1.6 GENERAL		
• Have both the magnitude and geographical extent of any exceedences been further changed?	**Yes**	Yes. Magnitude and extent are reduced below the objective.
• Has the decision to declare an AQMA been reversed at Stage 4?	**No**	No, the decision to declare remains valid until the modelling can be verified with local modelling data. Monitoring put in place in early 2005, not yet dataset available.
• Is this decision soundly based?	**Yes**	Yes
• Has the authority considered source apportionment?	**No**	Not necessary for SO_2 and other sources insignificant
• Has the authority considered the cost effectiveness of different abatement options?	**N/A**	Not within scope of this report
• Has the authority considered feasibility and effectiveness of different abatement options?	**N/A**	Not within scope of this report
• Has the authority considered the extent to which air quality improvement is required?	**No**	Currently no improvement required, subject to model verification with local monitoring data

Other Comments

Stage 4 Review & Assessment Checklist

MONITORING & MODELLING WORK	Response	Comments
• Have monitoring uncertainties been addressed fully?	**N/A**	Monitoring put in place in early 2005, not yet dataset available
• Does the additional monitoring assessment appear sufficiently robust?	**Yes**	Monitoring put in place in early 2005, not yet dataset available
• Have modelling uncertainties been addressed?	**Yes**	Uncertainties addressed. Verification using local data will be an important part of reduction of uncertainty
• Has the model been carefully validated?	**Yes**	All netcen models are appropriately validated before use. Further information can be provided if requested
• Does the overall modelling assessment appear sufficiently robust?	**Yes**	
AQO EXCEEDANCES & AQMA DECLARATION	**Response**	**Comments**
•Have areas of exceedence been further defined?	**Yes**	Subject to further verification using local monitoring data put in place in early 2005, not yet dataset available
•Is the decision to amend or revoke the AQMA(s) at Stage 4, soundly based?	**Yes**	The AQMA remains valid for PM_{10}
•Is the decision reached based principally on monitoring?	**No**	Subject to monitoring information
•Is the decision reached based principally on modelling?	**Yes**	Subject to monitoring information
GENERAL	**Response**	**Comments**
•Has the authority focused on areas already identified as predicted to exceed objectives?	**Yes**	The area predicted to exceed was reconsidered in further detail and new information was gathered.
•Has consideration been given to the exposure of individuals in relevant locations?	**Yes**	The receptors are properties within the domestic combustion area
•Has the authority considered new national policy developments?	**N/A**	
•Has the authority considered new local developments?	**N/A**	
•Does the report reach the expected conclusions? (in part/full?)	**Yes**	The report provides, as expected far more detailed modelling than the stage 3 and is suitable for verification using local monitoring data when that becomes available
•Has the authority undertaken further liaison with other agencies (in particular HA and EA?)	**Yes**	The local authority has obtained data from NIHE

Appendix 5
AQMA Map and Order

AIR QUALITY MANAGEMENT AREA ORDER NO. 1

Environment (Northern Ireland) Order 2002, Part III, Article 12 (1)

Ballymena Borough Council, in exercise of the powers conferred upon it by Part III, Article 12 (1) of the Environment (Northern Ireland) Order 2002, hereby makes the following Order:-

1. This Order may be cited as the Ballymena Borough Council Air Quality Management Area Order No. 1 Ballykeel and surrounding area.

2. This Order and the Ballykeel and surrounding area Air Quality Management Area designated there under shall come into effect on 1st November 2004.

3. The areas shown on the map detailed in appendix one, outlined in black, are to be designated as an air quality management area for the Ballykeel and surrounding area.

4. The Area to be designated as an Air Quality Management Area is displayed in map form and can be viewed by visiting the main council offices, 'Ardeevin' 80 Galgorm Road during the period from 2nd November 2004 to 29th December 2004. Further information is available by contacting staff of the Environmental Health Department on Tel 028 25 660 300.

5. The designated air quality management areas incorporate dwellings in the following housing estates:

Ballykeel and surrounding area AQMA

Dwellings in the Ballykeel 1, Ballykeel 2, Chichester Park Central, Chichester Park East and Chichester Park West estates together with certain houses on Crebilly Road, Larne Road, Meadowvale, Moat Road, River View and Knockeen Cresent.

A full list of incorporated streets or parts there of is contained in

Appendix Two.

The Area is designated in relation to a likely breach of the Particulate Matter (PM_{10}) (annual and daily mean) objectives as specified in the Air Quality Regulations (Northern Ireland) 2003.

This Order shall remain in force until it is varied or revoked by a subsequent Order.

Given under the Corporate Seal of Ballymena Borough Council on the 1st day of November 2004.

Present when the Corporate Seal of the Ballymena Borough Council was affixed hereto:-

_____

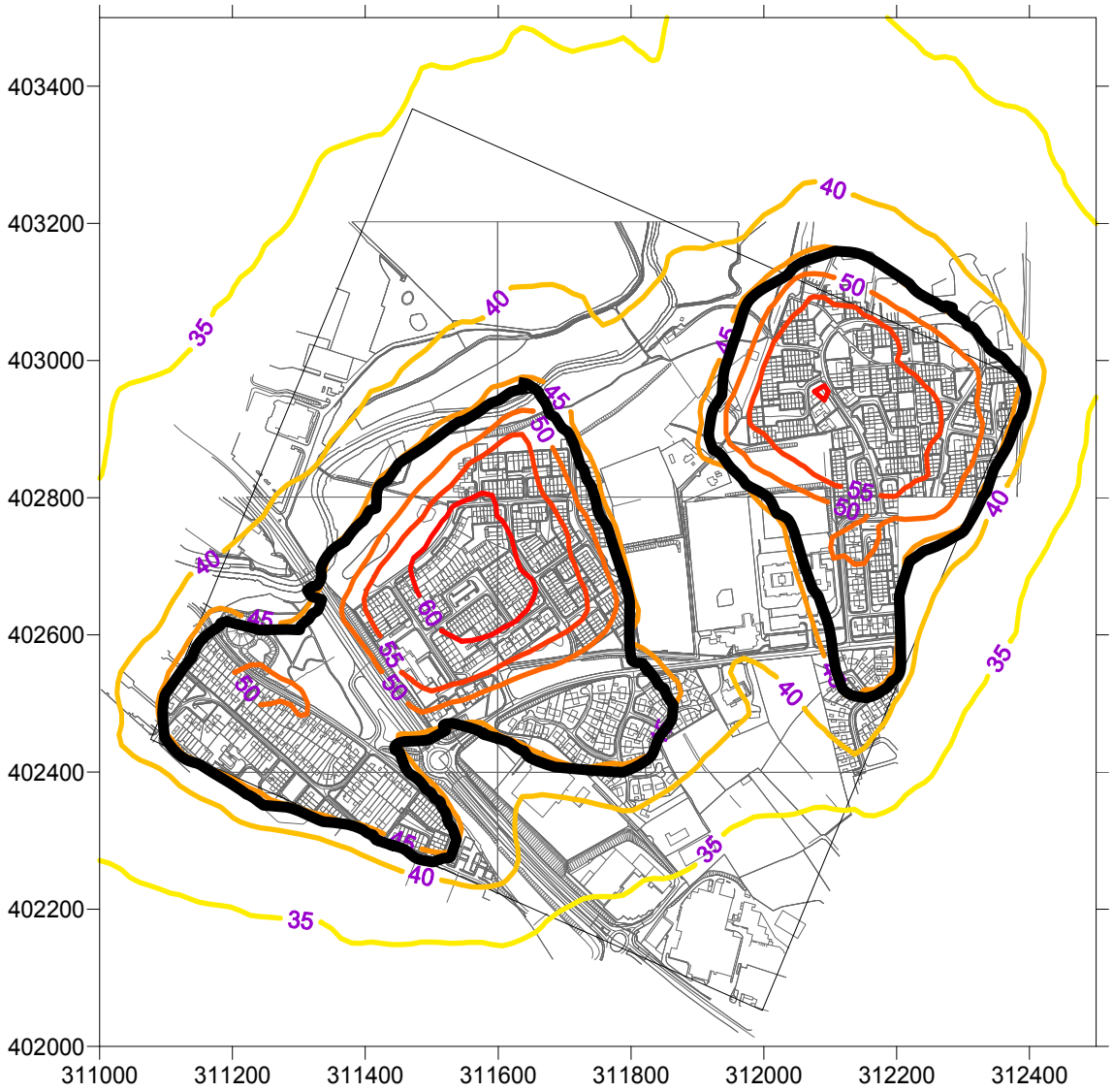
Mayor
Councillor Hubert Nicholl

_____

Town Clerk and Chief Executive
Mervyn G Rankin

Appendix One

Air Quality Management Areas (AQMA) boundaries within Air Quality Management Area (Ballykeel and surrounding area) Order No.1.



Appendix Two

Air Quality Management Area Order No.1 Ballykeel and surrounding area.

Dwellings in the Ballykeel 1, Ballykeel 2, Chichester Park Central, Chichester Park East and Chichester Park West estates together with certain houses on Crebilly Road, Larne Road, Meadowvale, Moat Road, River View and Knockeen Cresent or Part there of.

Arran Avenue
Barra Drive
Chichester Park Central
Chichester Park East
Chichester Park West
Crebilly Road
Inchkeith Road
Incholm Avenue
Iona Gardens
Kintyre Park
Larne Road
Meadowvale
Moat Road
River View
Shona Green
Colonsay Park
Dalriada Walk
Knockeen Cresent
Knockeen Road
Lewis Park
Orkney Drive
Shetland Gardens
Shetland Park
Skye Park
Staffa Drive

AIR QUALITY MANAGEMENT AREA ORDER NO. 2

Environment (Northern Ireland) Order 2002, Part III, Article 12 (1)

Ballymena Borough Council, in exercise of the powers conferred upon it by Part III, Article 12 (1) of the Environment (Northern Ireland) Order 2002, hereby makes the following Order:-

1. This Order may be cited as the Ballymena Borough Council Air Quality Management Area Order No. 2 Dunclug and surrounding area.

2. This Order and the Dunclug and surrounding area Air Quality Management Area designated there under shall come into effect on 1st November 2004.

3. The areas shown on the map detailed in appendix one, outlined in black, are to be designated as an air quality management area for the Dunclug area.

4. The Area to be designated as an Air Quality Management Area is displayed in map form and can be viewed by visiting the main council offices, 'Ardeevin' 80 Galgorm Road during the period from 2nd November 2004 to 29th December 2004. Further information is available by contacting staff of the Environmental Health Department on Tel 028 25 660 300.

4. The designated air quality management areas incorporate dwellings in the following housing estates:

Dunclug and surrounding area AQMA

Dwellings in the Dunclug Gardens, Dunclug Park, Dunvale, and Millfield, estates together with certain houses within Blacksgrove, Cushendall Road, Doury Road, Garvey Wood, Grove Road, Johnston Close, Moorland Close and Parklands.

A full list of incorporated streets or parts there of is contained in Appendix Two.

The Area is designated in relation to a likely breach of the Particulate Matter (PM_{10}) (annual and daily mean) objectives as specified in the Air Quality Regulations (Northern Ireland) 2003.

This Order shall remain in force until it is varied or revoked by a subsequent Order.

Given under the Corporate Seal of Ballymena Borough Council on the 1st day of November 2004.

Present when the Corporate Seal of the Ballymena Borough Council was affixed hereto:-

_____

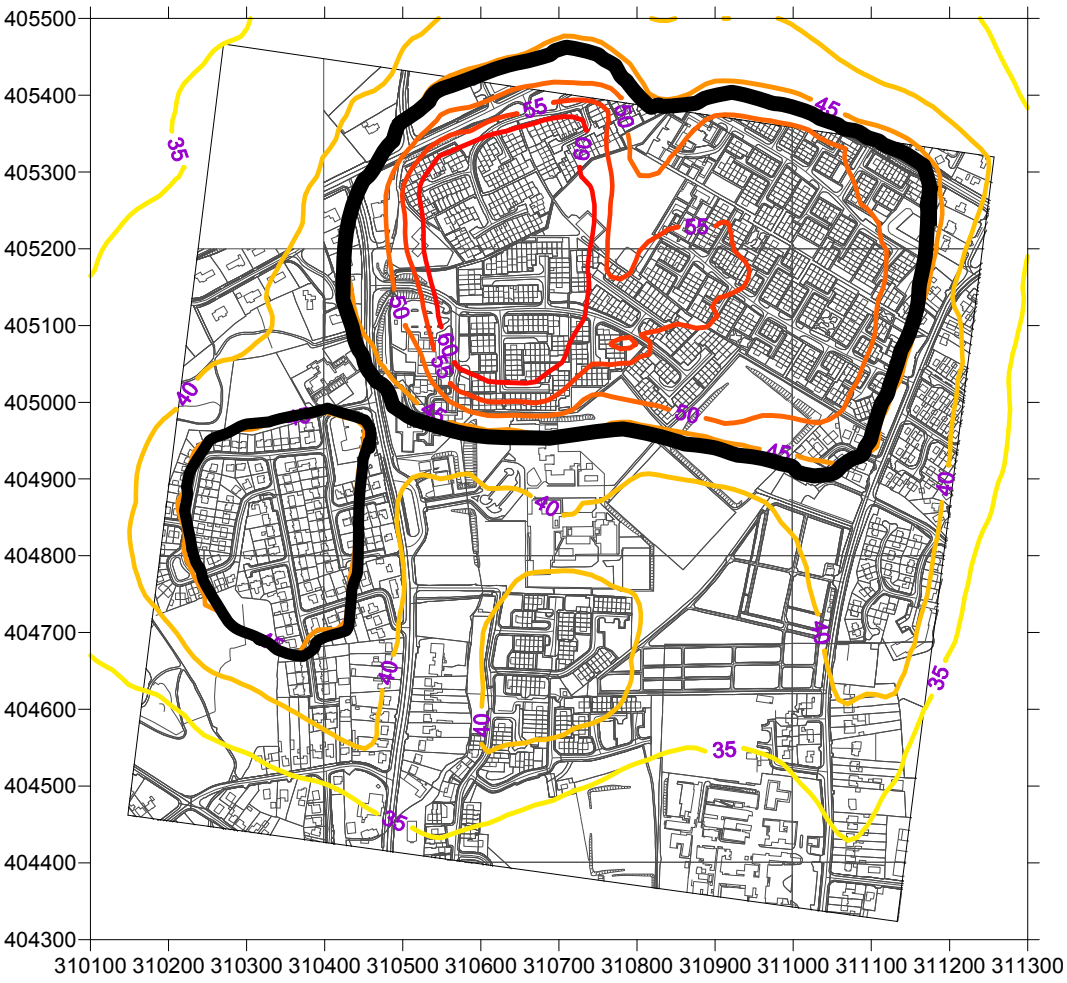
Mayor
Councillor Hubert Nicholl

_____

Town Clerk and Chief Executive
Mervyn G Rankin

Appendix One

Air Quality Management Areas (AQMA) boundaries within Air Quality Management Area (Dunclug and surrounding area) Order No.2.



Appendix Two

Air Quality Management Area Order No.2 Dunclug and surrounding area.

Dwellings in the Dunclug Gardens, Dunclug Park, Dunvale, and Millfield, estates together with certain houses within Blacksgrove, Cushendall Road, Doury Road, Garvey Wood, Grove Road, Johnston Close, Moorland Close, Murob Park, Rowallane Drive and Parklands or part there of.

Alveston House
Blacksgrove
Brampton House
Cherrington House
Cushendall Road
Doury Road
Dunclug Gardens
Dunclug Park
Dunvale
Durleston House
Erlington House
Flaxton House
Garvey Wood
Grove Road
Johnston Close
Millfield
Mooreland Close
Murob Park
Parklands
Rowallane Drive