Report

Air Quality Review and Assessment

Stage 4 - Detailed Modelling for Domestic Fuel Combustion

A report for Carrickfergus 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 NI Environment 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. Following a stage 3 review and assessment, an exceedence was concluded likely in Carrickfergus Town and Greenisland and therefore Carrickfergus Borough Council proceeded to declare AQMAs.

This report forms a Stage 4 Air Quality Review for domestic emissions sources within Carrickfergus 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 areas, Carrickfergus Town and Greenisland.

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 Carrickfergus Borough Council are not predicted to cause an exceedence of the PM_{10} objectives at relevant receptors within the assessed areas

Sulphur dioxide (SO_2)
Detailed modelling has shown that SO_2 emissions arising from domestic fuel combustion in Carrickfergus Borough Council are not predicted to cause an exceedence of the air quality objectives at relevant receptors within the assessed areas. This further confirms the findings of the earlier stage 3 assessment.

The modelling has not predicted any exceedance of the regulated objectives.

Carrickfergus Borough Council may wish to consider revocation of the AQMA on the basis of these results. Should they wish to revoke an AQMA, The Local Air Quality Management Policy Guidance (LAQM.PGNI (03) details the process for revocation and the grounds on which this should be based.

Any revocation of AQMAs should be following the advice of the Department for Environment Northern Ireland.

Maps reproduced within this document

Acronyms and definitions

ADMS	Atmospheric Dispersion Modelling System
AQDD	Air Quality Daughter Directives
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
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NIHE	Northern Ireland Housing Executive
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
ppb	parts per billion
SO_2	Sulphur dioxide
$\mu g\ m^{-3}$	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 for Carrickfergus Borough Council, covering domestic fuel combustion.

Carrickfergus Borough Council has already completed a stage 3 review and assessment based on local fuel use surveys. The stage 3 review and assessment predicted that the air quality objectives for PM_{10} are unlikely to be achieved at relevant locations. This triggered the designation of two AQMAs in Carrickfergus Borough Council.

As a result of the designation of an AQMA it is now necessary to:

- Refine knowledge of the sources of pollution so that air quality action plans can be properly targeted within the declared areas.

This will allow Carrickfergus Borough Council to determine effective policy measures, such as for example fuel conversion, and enable the preparation of an appropriate action plan.

This study:

- Assesses the air quality in 2004 and 2005 (PM_{10} and SO_2 respectively) for a revised business as usual (BAU) base case
- Assesses the air quality in 2010 the BAU base case
- Assesses the air quality in 2010 assuming NIHE conversion

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 μg 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 Carrickfergus 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 Order (NI) 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 Order (NI) 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 Order (NI) 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 actors 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 μg 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 µg m^{-3}	Running annual mean	31.12.2003
	3.25 µg m^{-3}	Running annual mean	31.12.2010
1,3 Butadiene	2.25 µg m^{-3}	Running annual mean	31.12.2003
Carbon Monoxide	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31.12.2003
Lead	0.5 µg m^{-3}	Annual mean	31.12.2004
	0.25 µg m^{-3}	Annual mean	31.12.2008
Nitrogen Dioxide[1]	200 µg m^{-3} not to be exceeded more than 18 times a year	1 hour mean	31.12.2005
	40 µg m^{-3}	annual mean	31.12.2005
Particles (PM_{10})[2] **Gravimetric**[3]	50 µg m^{-3} not to be exceeded more than 35 times a year	24 hour mean	31.12.2004
	40 µg m^{-3}	annual mean	31.12.2004
Sulphur Dioxide	350 µg m^{-3} not to be exceeded more than 24 times per year	1 hour mean	31.12.2004
	125 µg m^{-3} not to be exceeded more than 3 times per year	24 hour mean	31.12.2004
	266 µg m^{-3} not to be exceeded more than 35 times per year	15 minute mean	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. Road emissions have been modelled at a resolution of 10m while the domestic at 25m. This is consistent with recommendations within the latest technical guidance.

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 (Northern Ireland) 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 objective

3 Pollutants Assessed

This chapter gives information about the three 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 that 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 µg 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 µg 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 µg 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 this review and assessment of domestic fuel combustion sources.

4.1 INFORMATION PROVIDED BY CARRICKFERGUS BC

The following information from Carrickfergus Borough Council was used to complete this Review and Assessment:

- Local air quality monitoring data
- Domestic Fuel Combustion Survey
- NIHE Conversion Programme
- Local Fuel Data
- Information on Kilroot Power Station.

4.2 LOCAL AIR QUALITY MONITORING DATA

Carrickfergus Borough Council has carried out monitoring of SO_2 and PM_{10} since July 2002 with continuous monitors in Carrickfergus Town (341130, 387999). The instrumentation employed uses UV fluorescence for the measurement of SO_2 and the TEOM technique for PM_{10}, these methods are appropriate for Detailed 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 this local air quality monitoring programme.

netcen has not undertaken any scaling or ratification of the dataset provided by Carrickfergus Borough Council. However, netcen has undertaken a review of the data comparing the trends of the pollutants to other nearby National Network monitoring stations. The Carrickfergus dataset follows the same temporal variation as seen at the AURN station at Belfast Centre, providing a degree of confidence in the dataset.

4.3 FUEL COMBUSTION DATA

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

- Fuel Use Survey 2004 (including type of fuel, consumption, XY variables etc.),
- GIS shape files with and
- COMPASS data file, which contains information for all the houses across the Borough.
- NIHE Conversion (properties identified and timescale (programme))

4.4 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

4.5 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.

4.6 MAPS

Carrickfergus Borough Council provided maps of the grids to be modelled.

4.7 MET DATA USED IN THE DISPERSION MODELLING

Hourly sequential data was obtained for 2003 and 2004 for the Aldergrove site for input into the ADMS dispersion model. Data covering the period October 2003 – September 2004 were used for the modelling to bias correct the modelling work as this covers the most recent of monitoring data available for PM_{10} and SO_2. Further details are given in Appendix 2.

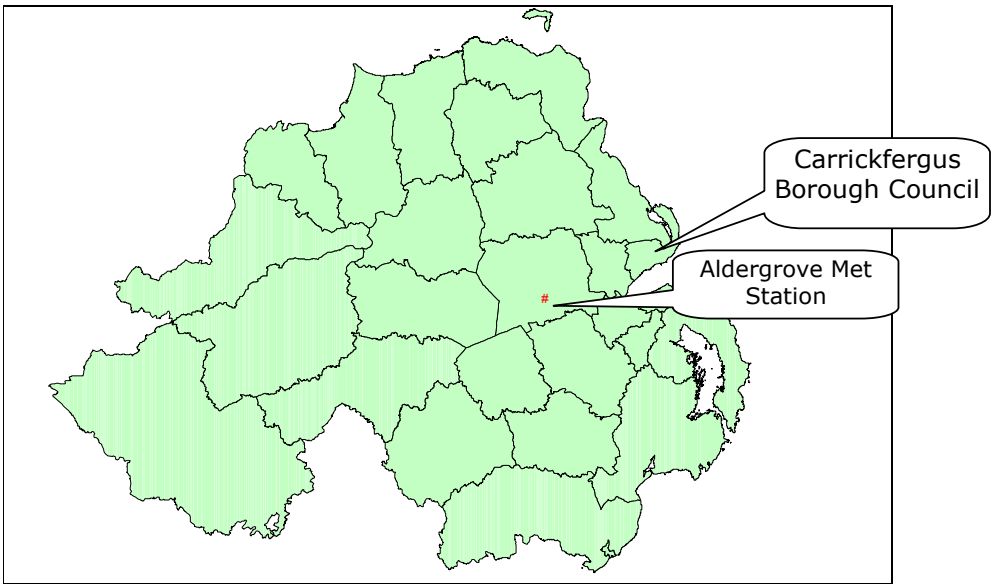


Figure 4.1 Location of Aldergrove Meteorological Station

4.8 OVERVIEW OF THE MODELLING APPROACH

Dispersion modelling of Domestic fuel combustion has been carried out using DISP model 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-3.2 to provide dispersion kernels over a grid. ADMS could not be used on its own as there is a limit of 100 point

sources that can be modelled. In this assessment, emissions from around 4,000 houses have been modelled.

4.8.1 Model verification and adjustment

The monitoring site at Carrickfergus Town (Rosebrook Avenue) has been used as a reference site to bias correct the model results. The monitoring data was reviewed by **netcen** as explained in section 3.1.

The purpose of this adjustment was to ensure that the modelled concentrations equalled the measured values at the monitoring locations. The same modelling methodology has been used at other Local Authorities to maintain consistency in the modelling approach and thus minimise the uncertainty of applying a generic bias correction.

More details of the bias correction are given in Section 5.5.5

4.8.2 Model uncertainties

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;
- 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 is representative and will remain representative of the fuel use at the time of the objectives. As we are assuming the fuel use profile will remain the same there is no need to correct the fuel use survey to the year of the objective. Predicted future background concentrations have been applied.

The dispersion modelling is based upon the meteorology for October 2003 to September 2004 and emissions for 2004, 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.

The monitoring data was provided by Carrickfergus Borough Council for October 2003 to September 2004.

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

4.8.3 Relationship between annual means and short term concentrations

For PM_{10}, DISP has been used to model the daily mean contributions of domestic fuel combustion. However, for SO_2, DISP has only been used to model the annual mean contribution of domestic fuel combustion. (Due to computer run time, it was impractical to run DISP for each hour, or 15 min period, of the year.)

In order to predict short term AQ objectives, we have made use of empirical relationships between annual mean and short term concentrations.

4.8.3.1 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 4.2 show the regression equations that will

be applied to a map of annual mean concentrations to produce the respective map of short term mean sulphur dioxide concentrations.

Table 4.2 Regression equations used to predict sulphur dioxide 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.

This assessment forms the further assessment within the AQMA areas.

5.2 CARRICKFERGUS BOROUGH COUNCIL FUEL USE SURVEY

Carrickfergus Borough Council undertook a fuel use survey in 2004. A total of 2150 households (50% of the properties) were surveyed between the two specific areas of interest. The findings are summarised below:

5.2.1 Carrickfergus Town

There were a total of 2838 properties within Carrickfergus Town and the survey covered 1386 of these. 32% of the properties surveyed use oil as their main, 29% use mains gas with coal and solid fuel accounting for 25% (see table 5.1).

Table 5.1 Fuels for heating purposes

	Number of Properties Surveyed [1]	*% of Properties*
Oil	443.5	32
Gas	406.5	29
Coal / Solid Fuel	341.5	25
Electricity	193.5	14
Other	1	0
Total	1386	100

[1] some properties use more than one type of fuel. In such cases equal weighting has been given to each fuel type.

5.2.2 Greenisland

There were a total of 1364 properties within Greenisland and the survey covered 764 of these. The fuel breakdown is shown below:

Table 5.2 Fuels for heating purposes

	Number of Properties Surveyed [1]	*% of Properties*
Oil	224	29
Gas	148.5	19
Coal / Solid Fuel	160.5	30
Electricity	231	21
Total	1386	100

[1] some properties use more than one type of fuel. In such cases equal weighting has been given to each fuel type.

5.3 NIHE CONVERSION

Carrickfergus Borough Council provided details of the NIHE Conversion programme, including the identification of properties and timescale for conversion to mains gas.

A total of 365 properties within Carrickfergus Town are included in the in the NIHE Conversion programme. Of which 100 properties were already identified as using mains gas in the 2004 fuel use survey.

No details of the NIHE Conversion programme within Greenisland were available.

5.4 KILROOT POWER STATION

Figure 5.1 shows the location of Kilroot Power Station. Its characteristics are as follow for 2002

- Grid reference: (343896, 388585)
- SO_2 emissions: 5.48e+2 and PM_{10} emissions: 0
- Height: 200 m
- Diameter: 5.5 m
- Exit temperature: 120 degrees C
- Exit Velocity: 17.64 m/s.

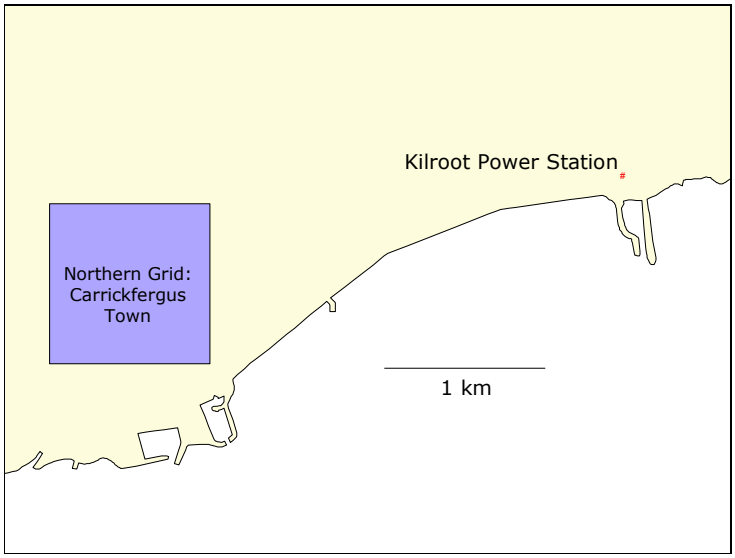


Figure 5.1 Location of Kilroot Power Station

5.5 DOMESTIC SOURCES REVIEW AND ASSESSMENT

The fuel use survey undertaken by Carrickfergus Borough Council has been used in combination with **netcen**'s DISP model to determine whether domestic fuel combustion is likely to cause exceedences of the SO_2 and PM_{10} objectives. The 15 minute mean SO_2 objective of 266 µg m^{-3} is the most stringent of the three SO_2 objectives. The 24 hours mean PM_{10} objective is the most stringent of the PM_{10} objectives. Therefore the DISP modelling was carried out relevant to these objectives. If these objectives can be met the other objectives will also be met.

For PM_{10}, the DISP model was used to calculate the daily contribution for each day of the annual period and then the 90^{th} percentile values were extracted.

For SO_2, the DISP model has been used to calculate the annual contribution to SO_2. Conversion factors from Pye and Vincent (2003) have been used to calculate the 99.9 percentile of 15 minute means for SO_2.. 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 5.3 shows the regression equation to the annual mean concentrations to estimate the 15 minute mean sulphur dioxide concentrations.

Table 5.3 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

5.5.1 Emissions rates

The PM_{10} and SO_2 emission rate for each dwelling has been calculated using information from the fuel use survey. Using the emissions rates in table 5.4 and assumptions about annual fuel consumption, an annual emission rate for each dwelling was calculated (see table 5.6)

Table 5.4 Domestic Emissions Factors taken from the NAEI

	SO_2 kt/mt fuel burnt	*PM_{10} kt/mt fuel burnt*
Oil	0.58	2.31
Gas	-	-
Electricity	-	-
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

Table 5.5 Annual fuel consumption per household

Fuel Type	*Amount*	*Units*
Oil	2202	litres
Coal	2.8	tonnes
SSF	2.8	tonnes
Logs / sticks	9.2	tonnes
Turf / peat	5.4	tonnes

Table 5.6 Emission rates resulting from domestic fuel combustion

Fuel Type	*SO_2*	*PM_{10}*	*Units*
Oil	0.0427	4.9	kg pa
Gas	-	-	kg pa
Coal / Solid Fuel [1]	54.7	26.7	kg pa
Electricity	-	-	kg pa

[1] assuming the following breakdown Coal 64%, SSF 25%, Logs / sticks 6% and Turf / peat 5%

For properties not included in the survey the following assumptions have been made:

- Base case 1: an average emission rate based on properties on the same street that were included in the survey.
- Base case 2: an emission rate based solely on oil use.

5.5.2 Point source characteristics (Domestic Heating)

The assumptions in the modelling exercise are:

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

5.5.3 Background PM_{10} concentrations

Background PM_{10} concentrations for 2003 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 5.7 Background PM_{10} concentrations 2003 from national mapping (µg m^{-3})

	Carrickfergus	*Greenisland*
Primary		
Road transport - exhaust	0.30	0.31
Road transport – brake and tyre wear	0.11	0.12
Domestic	5.37	2.99
Other	7.27	7.23
Secondary	3.98	3.98
Total	17.02	14.63

Table 5.8 Background PM_{10} concentrations 2003 excluding sources modelled explicitly (µg m^{-3})

	Carrickfergus	*Greenisland*
Base Case 1	15.05	13.93
Base Case 2	15.55	13.96

Base Cases 1 and 2 exclude the contribution to background from explicitly modelled sources, 1.97 µg m^{-3} Carrickfergus and 0.70 µg m^{-3} Greenisland and 1.48 µg m^{-3} Carrickfergus and 0.67 µg m^{-3} Greenisland respectively.

The background for 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.

Table 5.9 Background PM_{10} concentrations monitoring period excluding sources modelled explicitly (µg m^{-3})

	Carrickfergus	*Greenisland*
Base Case 1	11.35	10.50
Base Case 2	11.73	10.53

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

	Carrickfergus	*Greenisland*
Total	13.34	12.19
Base Case 1	11.37	11.48
Base Case 2	11.86	11.52

Base Cases 1 and 2 exclude the contribution to background from explicitly modelled sources, 1.97 µg m^{-3} Carrickfergus and 0.70 µg m^{-3} Greenisland and 1.48 µg m^{-3} Carrickfergus and 0.67 µg m^{-3} Greenisland respectively.

To calculate total annual mean PM_{10} concentrations the background concentrations have been added to the modelled concentrations. 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.

5.5.4 Background SO_2 concentrations

Background SO_2 concentrations for 2003 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 5.11 Background SO_2 concentrations 2003 from national mapping and excluding sources modelled explicitly (µg m^{-3})

	Carrickfergus	*Greenisland*
Total	6.98	2.90
Base Case 1	4.57	2.07
Base Case 2	5.83	2.37

Base Cases 1 and 2 exclude the contribution to background from explicitly modelled sources, 2.40 µg m^{-3} Carrickfergus and 0.83 µg m^{-3} Greenisland and 1.15 µg m^{-3} Carrickfergus and 0.53 µg m^{-3} Greenisland respectively.

The background for monitoring period (1st October 2003 to 30th September 2004) is scaled from 2003 by the ratio 0.90 based on AURN data from Belfast East and Derry.

Table 5.12 Background SO_2 concentrations monitoring period excluding sources modelled explicitly (µg m^{-3})

	Carrickfergus	*Greenisland*
Base Case 1	4.10	1.86
Base Case 2	5.23	2.13

Background SO_2 concentrations for 2005 and 2010 have been kept constant at the 2003 levels.

To calculate total annual mean SO_2 concentrations the background concentrations have been added to the modelled concentrations.

The 99.9th percentile of 15 minute mean SO_2 concentrations has been estimated from the annual mean using the relationship:

$$SO_{2\ 99.9th\ \%ile\ 15\ minute\ mean} = 15.568 * SO_{2\ annual\ mean} - 23.673$$

5.5.5 Model verification and adjustment

The annual mean PM_{10} concentrations were then compared with monitoring data from the Carrickfergus station and a bias adjustment factor derived.

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

Table 5.13 Bias adjustment factors for annual mean PM_{10}

	Monitoring data [1] (µg m^{-3})	*Background [2]*	*Modelled [3]*	*Adjustment factor f*
Base Case 1	17	11.35	2.48	1.23
Base Case 2	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]

Table 5.14 Bias adjustment factors for the 90th %ile of 24 hour mean PM_{10}

	Monitoring data [1] (µg m^{-3})	*Background [2]*	*Modelled [3]*	*Adjustment factor f*
Base Case 1	36	19.08	6.04	1.43
Base Case 2	36	19.70	5.29	1.44

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

The annual mean SO_2 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]

Table 5.15 Bias adjustment factors for annual mean SO_2

	Monitoring data [1] ($\mu g\ m^{-3}$)	*Background [2]*	*Modelled [3]*	*Adjustment factor f*
Base Case 1	6	4.10	4.69	0.68
Base Case 2	6	5.23	3.05	0.72

[1] Carrickfergus station
[2] Scaled from NAEI excludes contribution to background from explicitly modelled sources
[3] ADMS 3.2 includes Kilroot power station

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.

$$SO_{2\ \text{monitoring data}} = (15.568 * (SO_{2\ \text{background (monitoring period)}} + SO_{2\ \text{modelled}}) - 23.673) \times f$$
[99.9th %ile of 15 min mean]

Table 5.16 Bias adjustment factors for the 99.9th %ile of 15 min mean SO_2

	Monitoring data [1] ($\mu g\ m^{-3}$)	*Modelled + Background [2]*	*Adjustment factor f*
Base Case 1	85	113.26	0.75
Base Case 2	85	105.34	0.81

[1] Carrickfergus station
[2] Scaled from unadjusted annual mean

5.6 MODEL RESULTS

The bias adjusted model results form **netcen**'s DISP model are presented below.

Table 5.17 Maximum 90th %ile of 24 hour mean PM_{10} concentrations

	Monitoring Period	*2010*
Carrickfergus - Base Case 1	48.87	48.91
Carrickfergus - Base Case 2	45.59	45.92
Greenisland - Base Case 1	43.27	45.63
Greenisland - Base Case 2	42.78	45.18
Carrickfergus - NIHE 1		48.65
Carrickfergus - NIHE 2		44.88

NIHE 1 assumes that properties in the NIHE Conversion Programme are converted to mains gas, and assumptions regarding other properties in line with base case 1

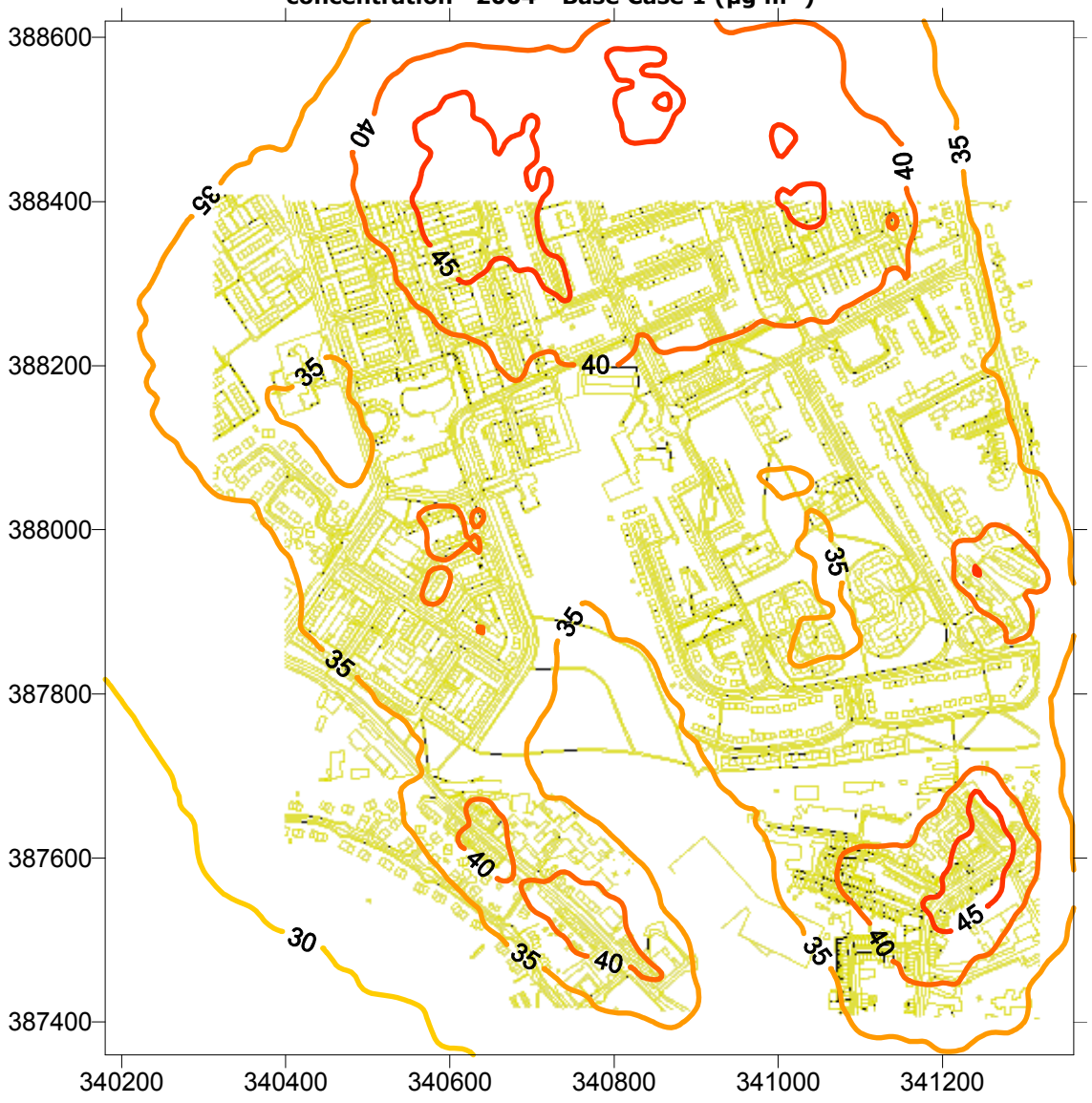
NIHE 2 assumes that properties in the NIHE Conversion Programme are converted to mains gas, and assumptions regarding other properties in line with base case 2

Table 5.18 Maximum 99.9th %ile of 15 min mean SO_2 concentrations

SO2	*Monitoring Period*	*2005 (and 2010)*
Carrickfergus - Base Case 1	187.12	192.58
Carrickfergus - Base Case 2	160.69	168.18
Greenisland - Base Case 1	127.31	129.78
Greenisland - Base Case 2	118.42	121.47
Carrickfergus - NIHE 1		190.13
Carrickfergus - NIHE 2		158.68

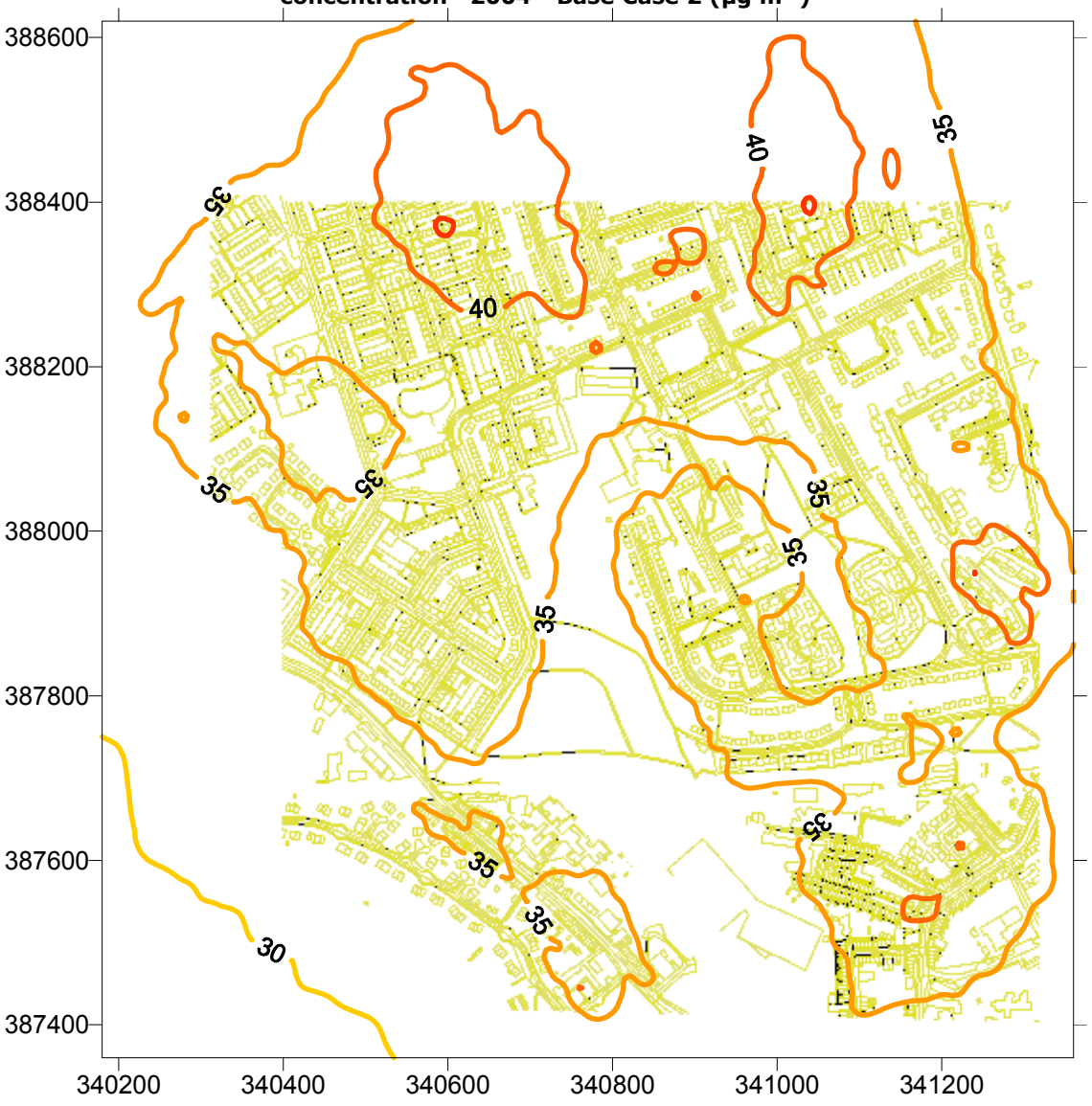
Where plots are presented as 2004, the actual modelled period is modelled 1st October 2003 to 30th September 2004. This is considered representative of 2004. Modelling using the period for which monitoring is available reduces the uncertainty of correcting to the actual 2004 period.

Figure 5.2 Carrickfergus Town modelled 90th percentile of daily mean PM_{10} concentration* 2004 - Base Case 1 (µg m^{-3})



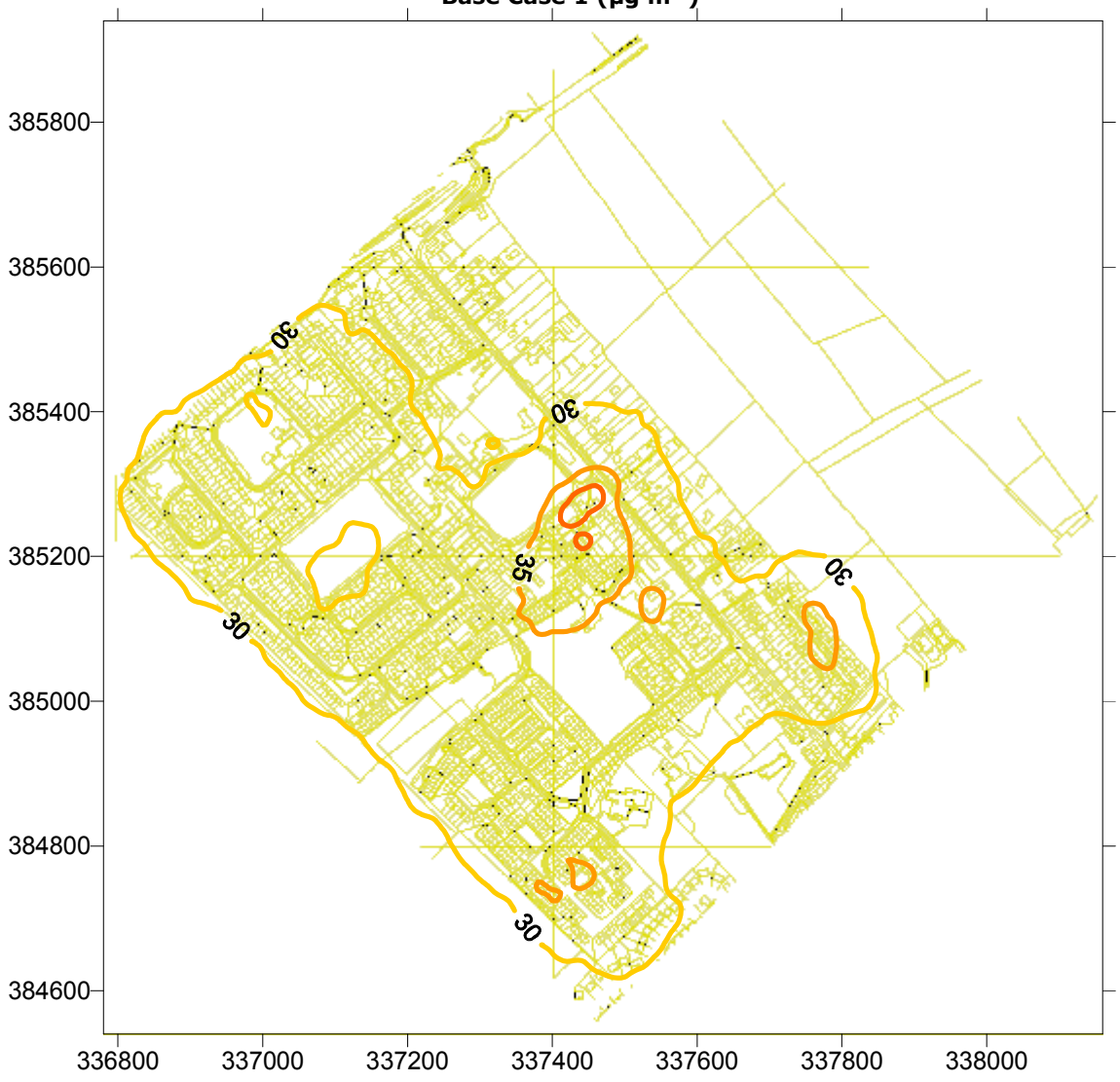
***Bias adjusted to monitoring data**

Figure 5.3 Carrickfergus Town modelled 90th percentile of daily mean PM_{10} concentration* 2004 - Base Case 2 (µg m^{-3})



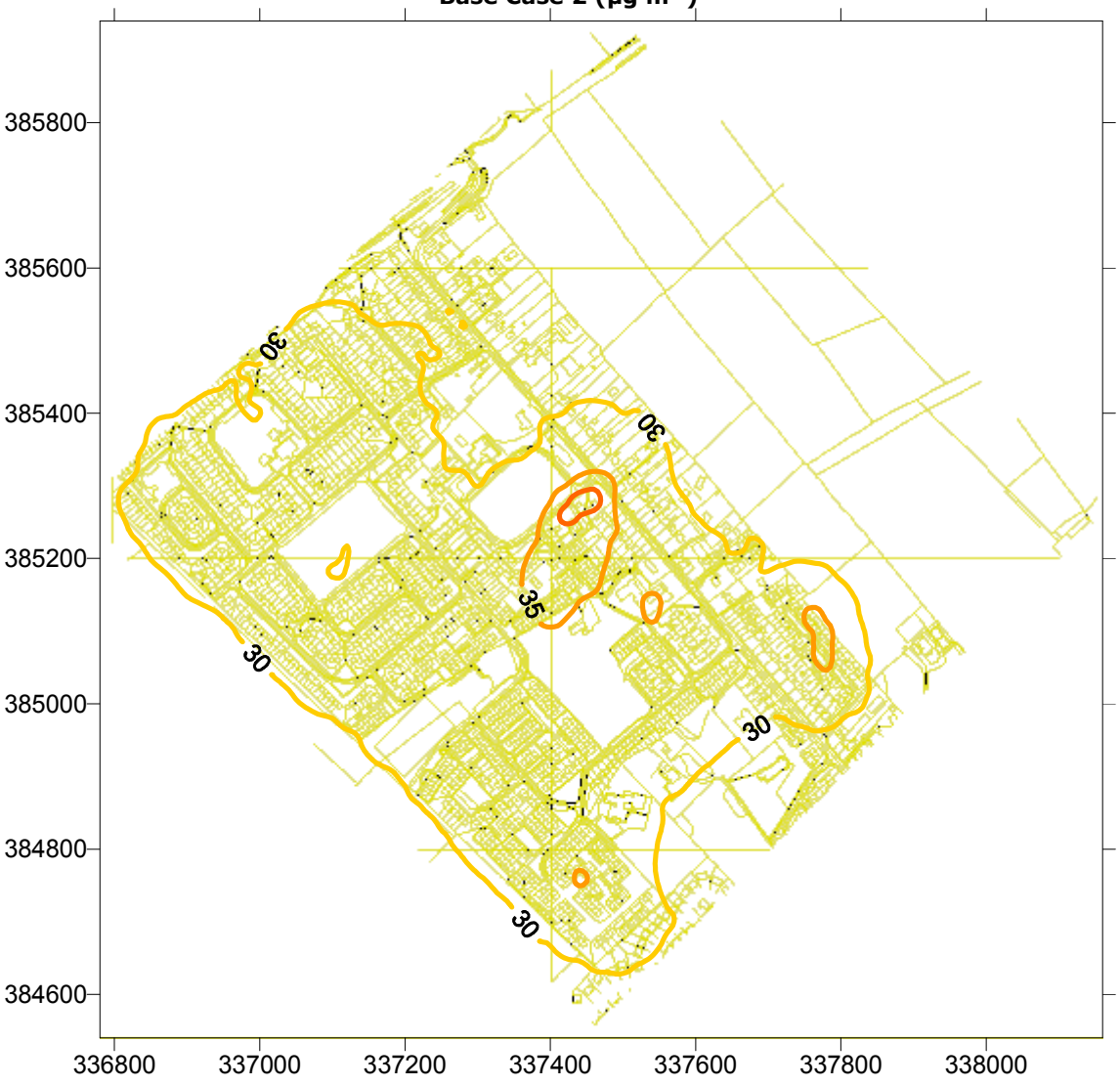
***Bias adjusted to monitoring data**

Figure 5.4 Greenisland modelled 90th percentile of daily mean PM_{10} concentration* 2004 - Base Case 1 (µg m^{-3})



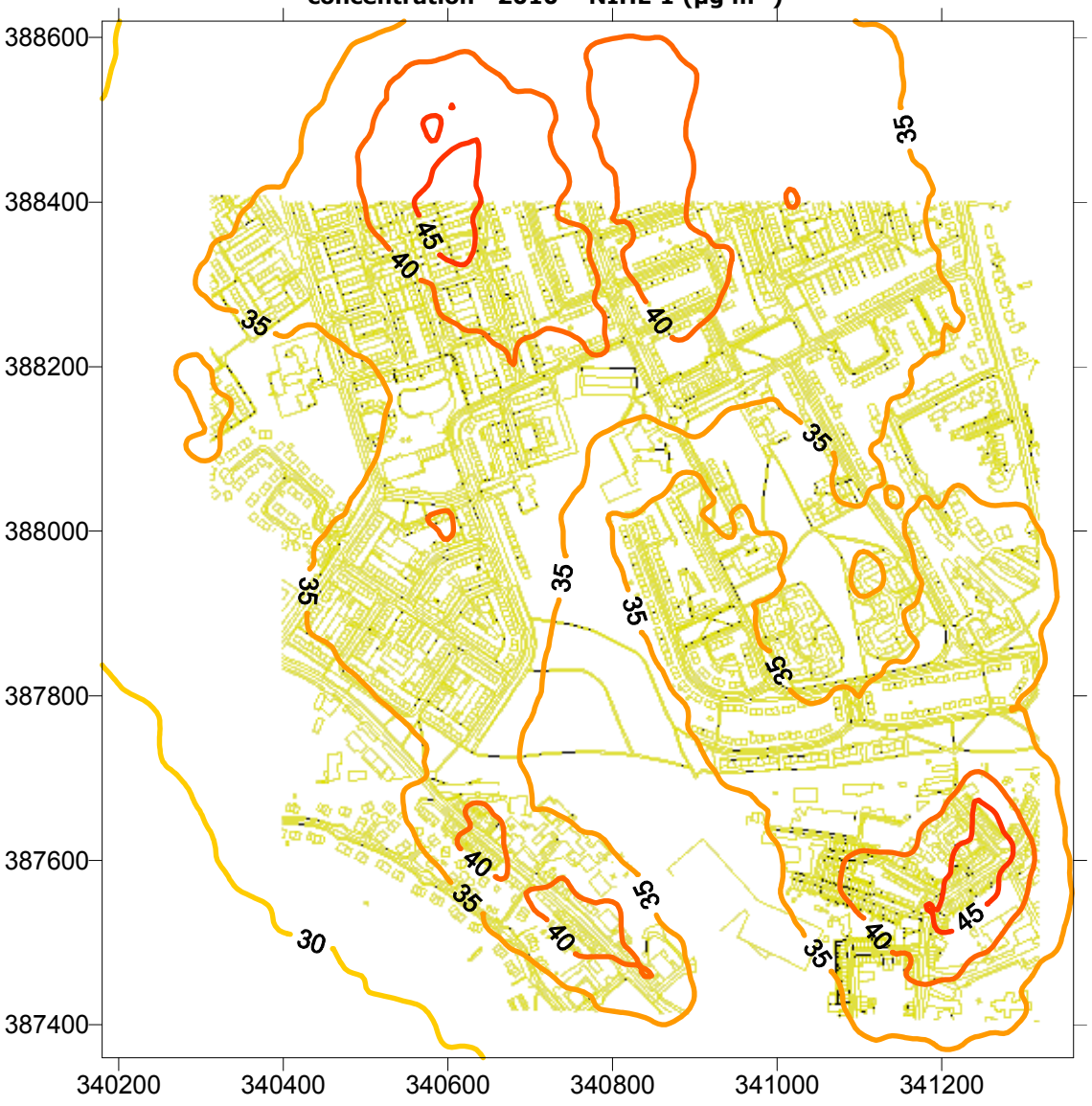
***Bias adjusted to monitoring data**

Figure 5.5 Greenisland modelled 90th percentile of daily mean PM_{10} concentration* 2004 - Base Case 2 (µg m^{-3})



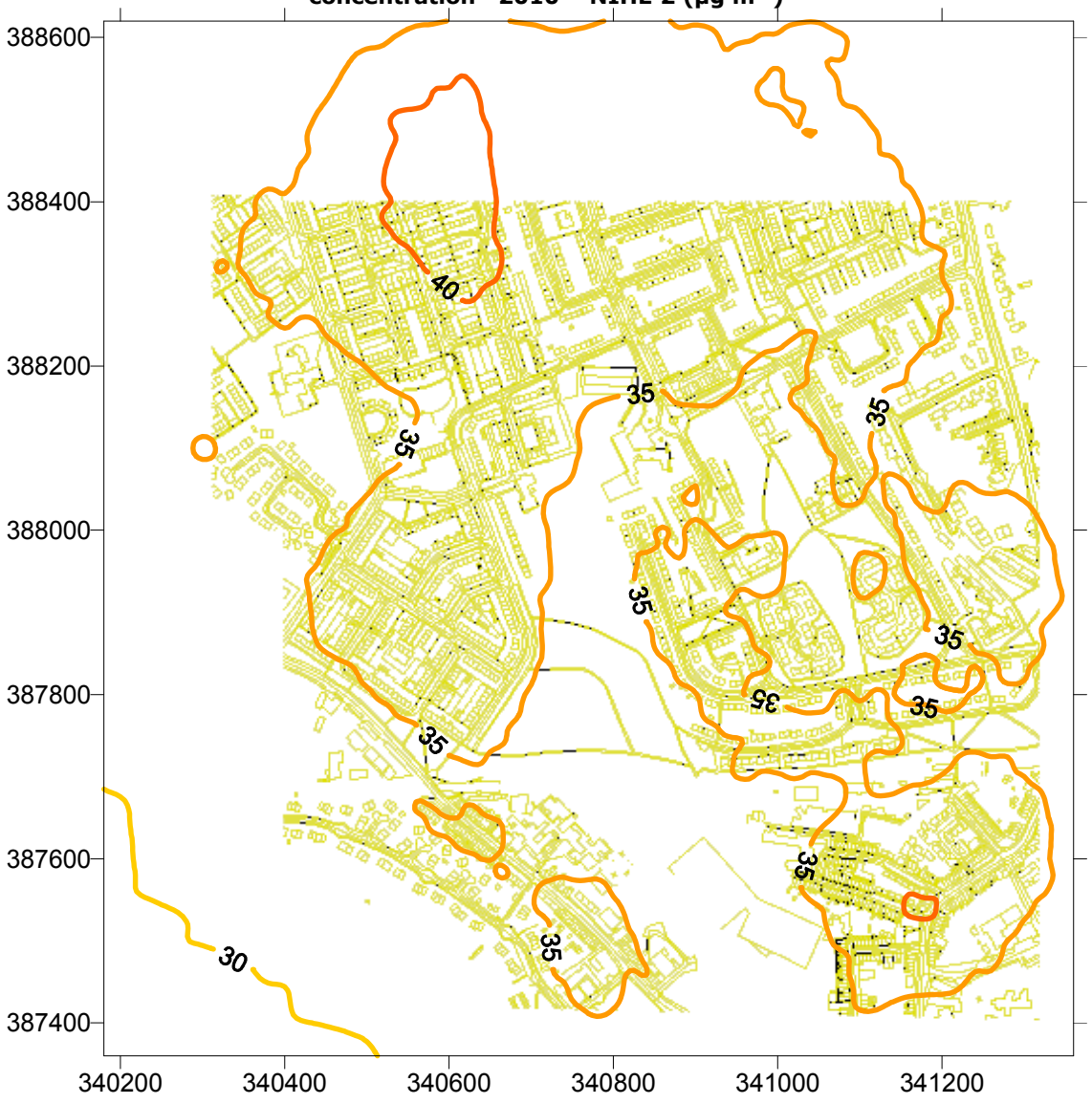
***Bias adjusted to monitoring data**

Figure 5.6 Carrickfergus Town modelled 90th percentile of daily mean PM_{10} concentration* 2010 – NIHE 1 (µg m^{-3})



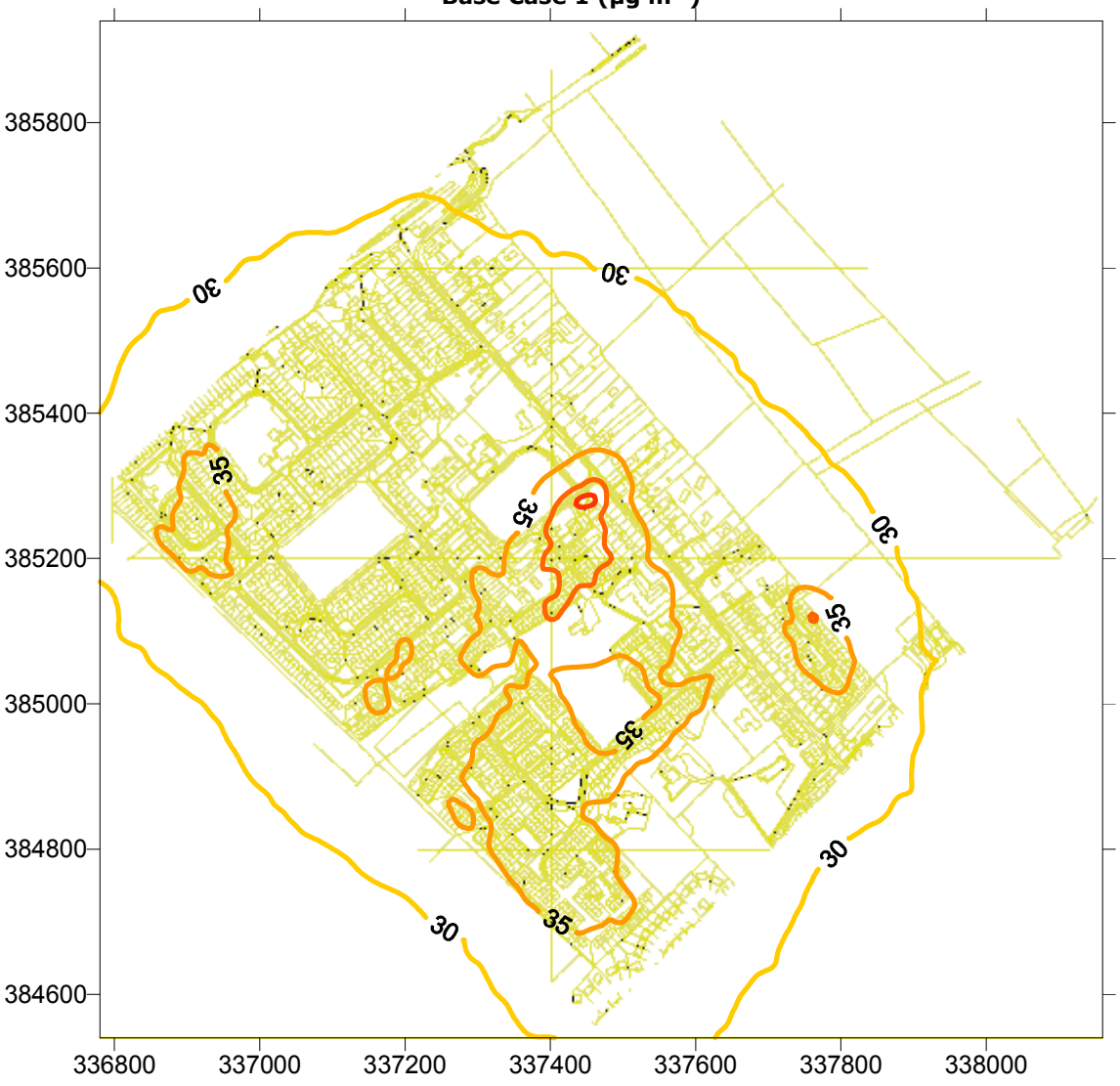
***Bias adjusted to monitoring data**

Figure 5.7 Carrickfergus Town modelled 90th percentile of daily mean PM_{10} concentration* 2010 – NIHE 2 (µg m^{-3})



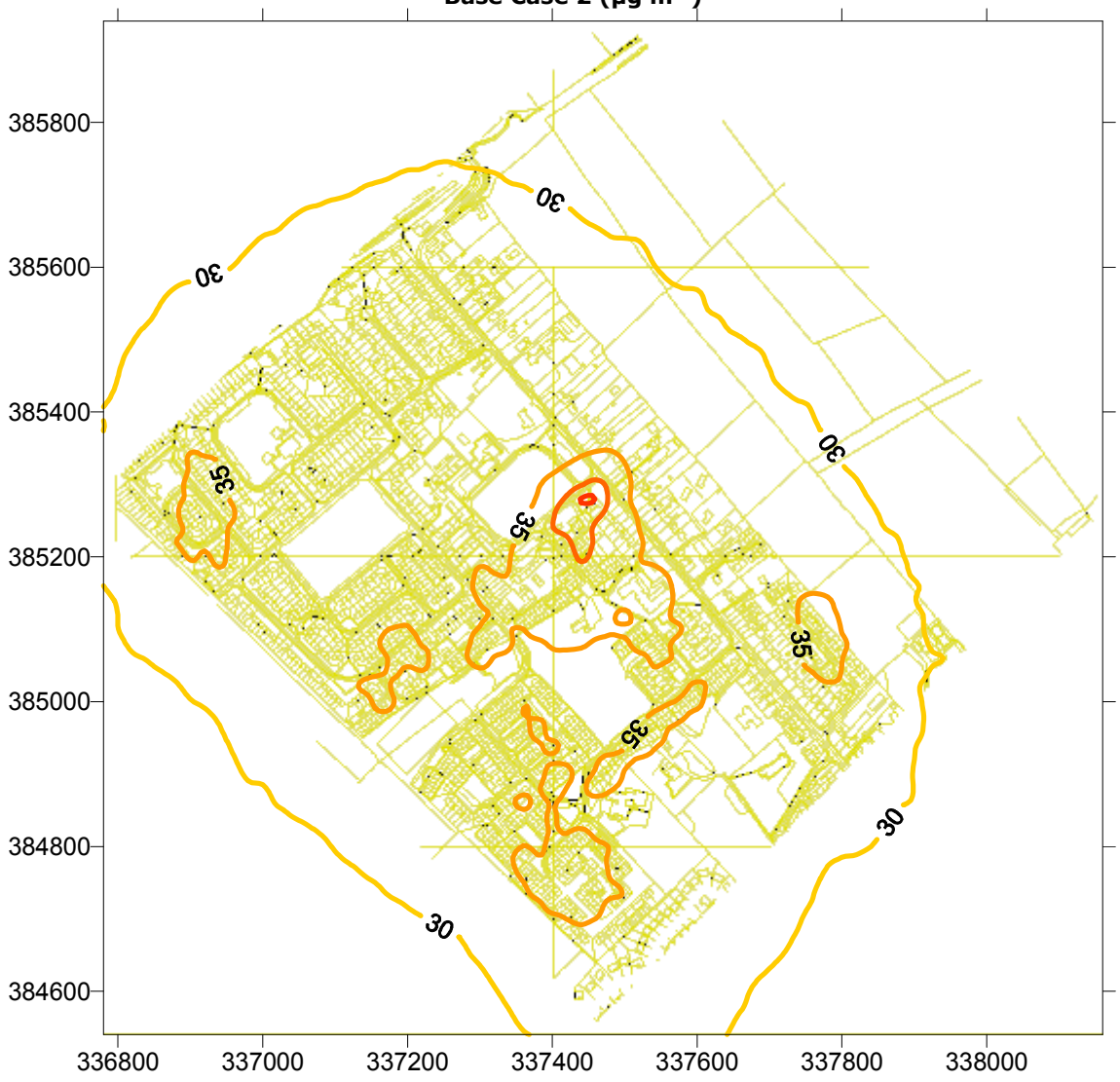
***Bias adjusted to monitoring data**

Figure 5.8 Greenisland modelled 90th percentile of daily mean PM_{10} concentration* 2010 – Base Case 1 (µg m^{-3})



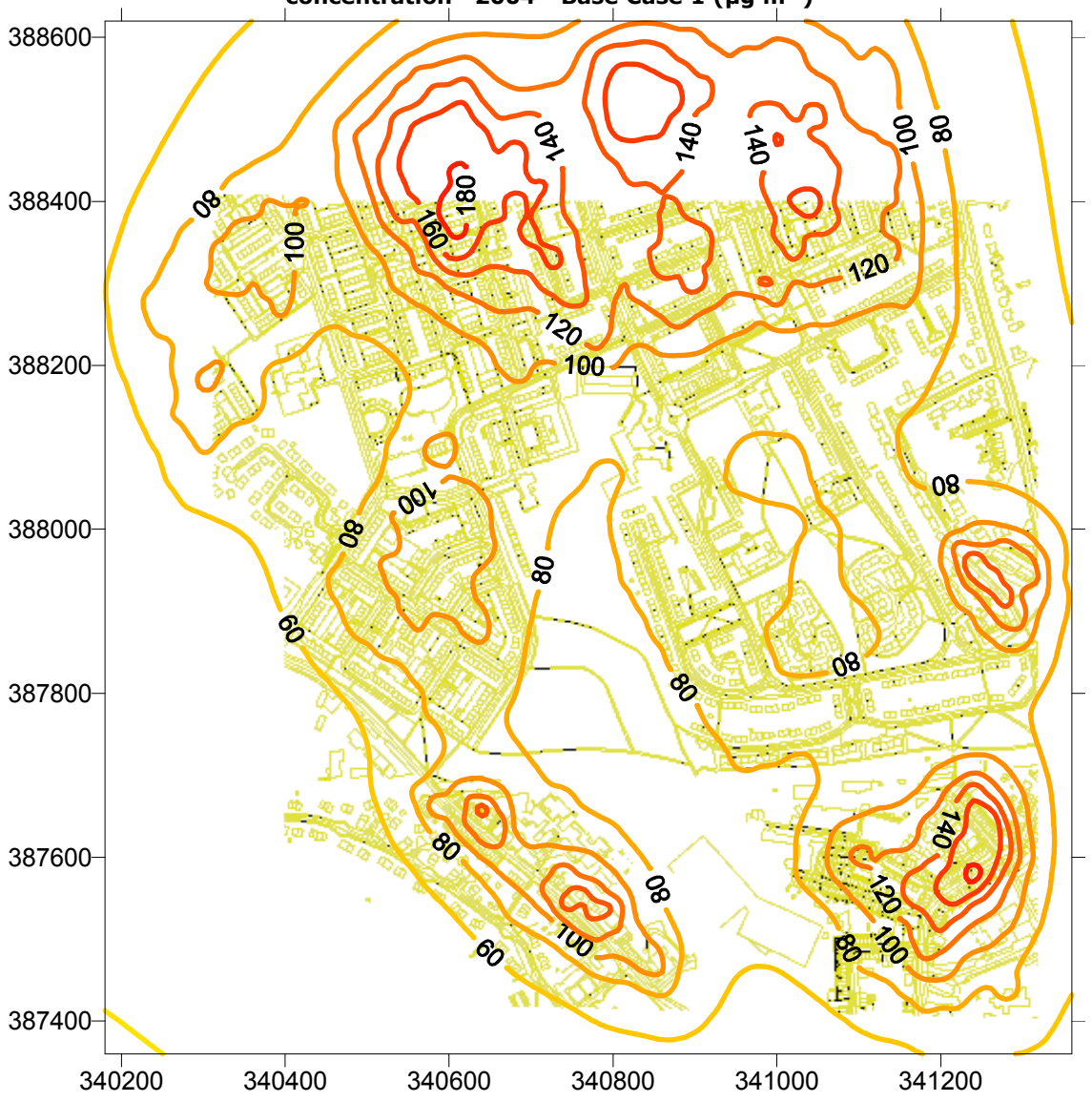
***Bias adjusted to monitoring data**

Figure 5.9 Greenisland modelled 90th percentile of daily mean PM_{10} concentration* 2010 – Base Case 2 (µg m^{-3})



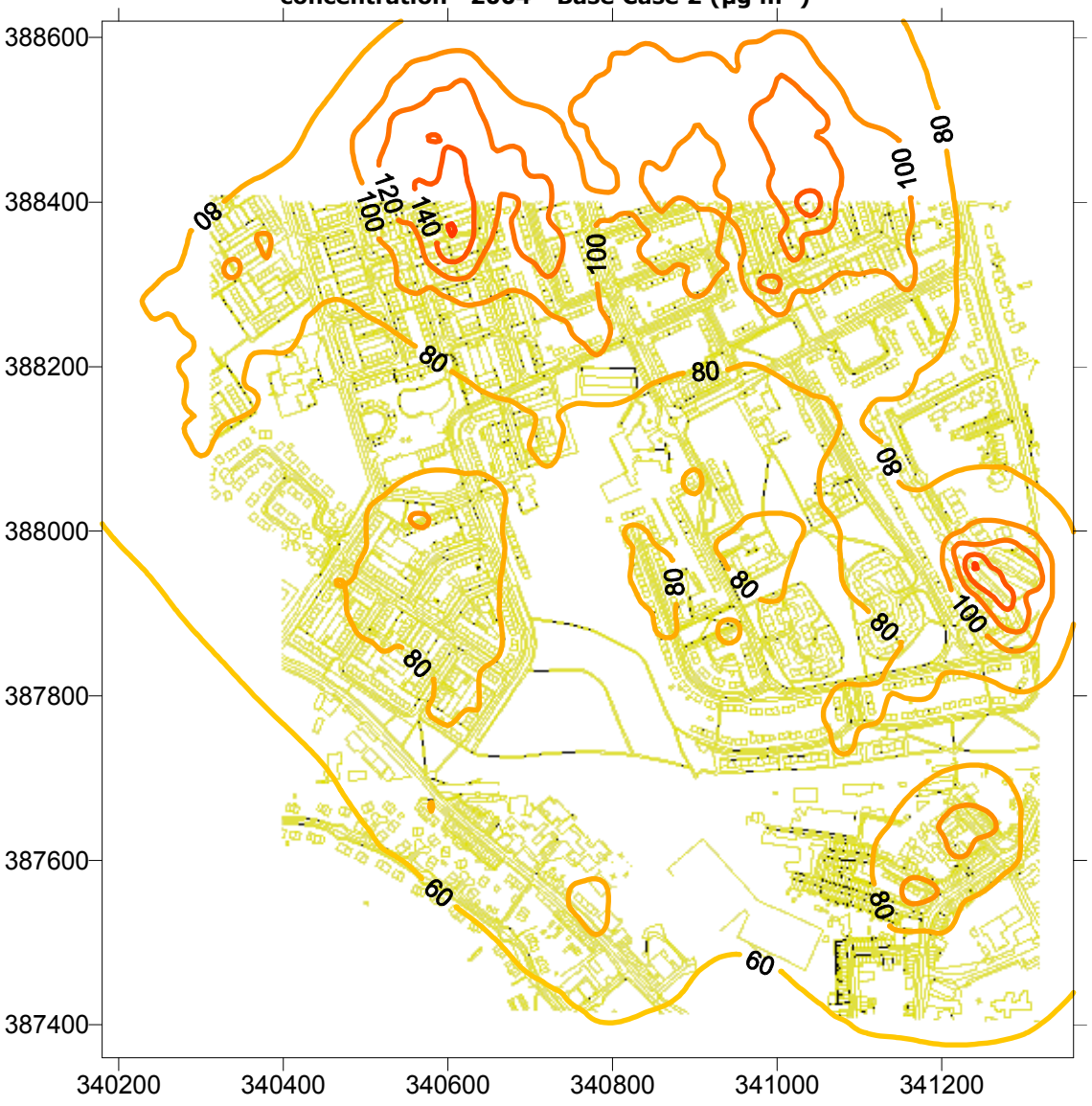
***Bias adjusted to monitoring data**

Figure 5.10 Carrickfergus Town modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2004 - Base Case 1 (µg m^{-3})



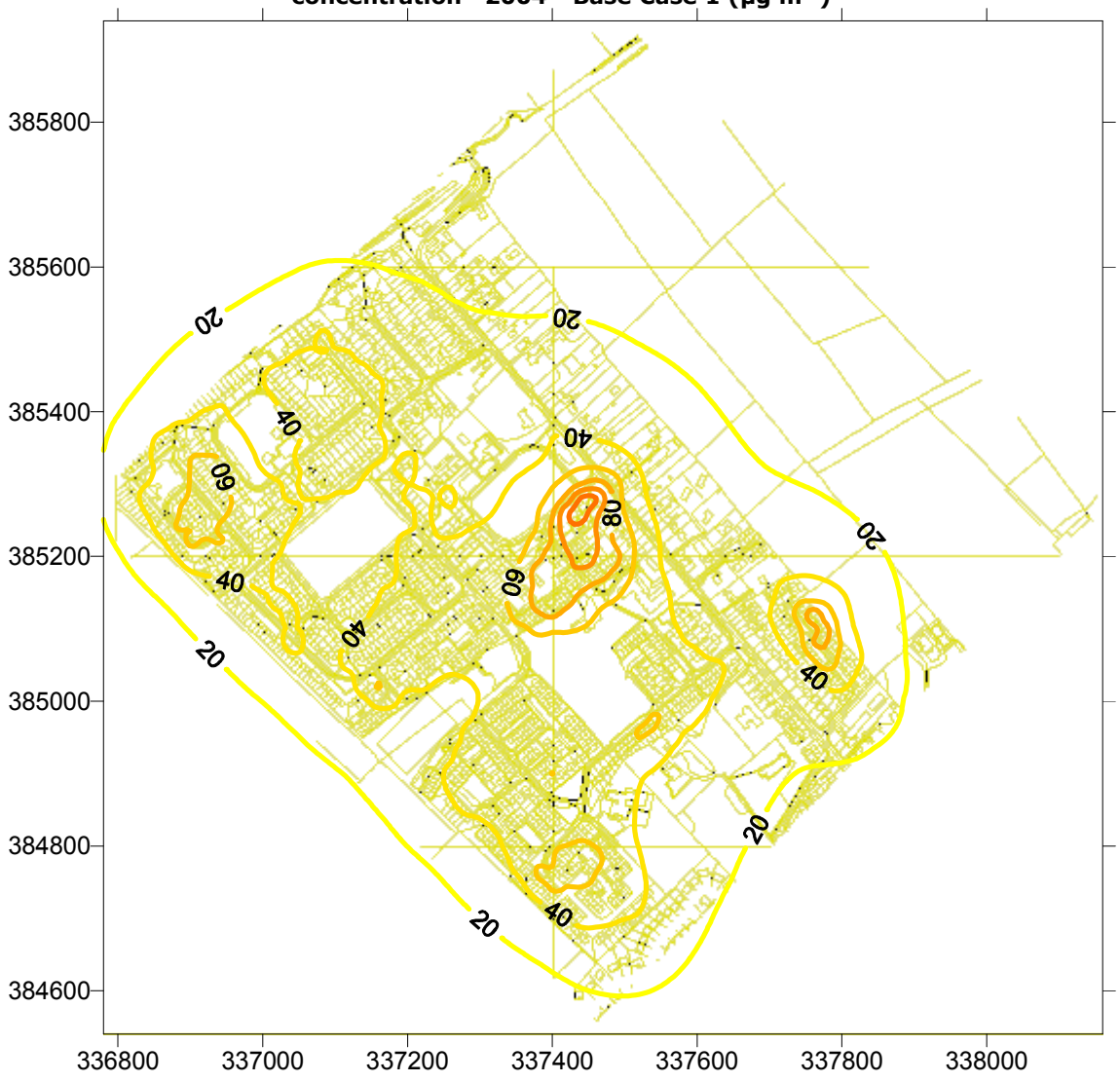
***Bias adjusted to monitoring data**

Figure 5.11 Carrickfergus Town modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2004 - Base Case 2 (µg m^{-3})



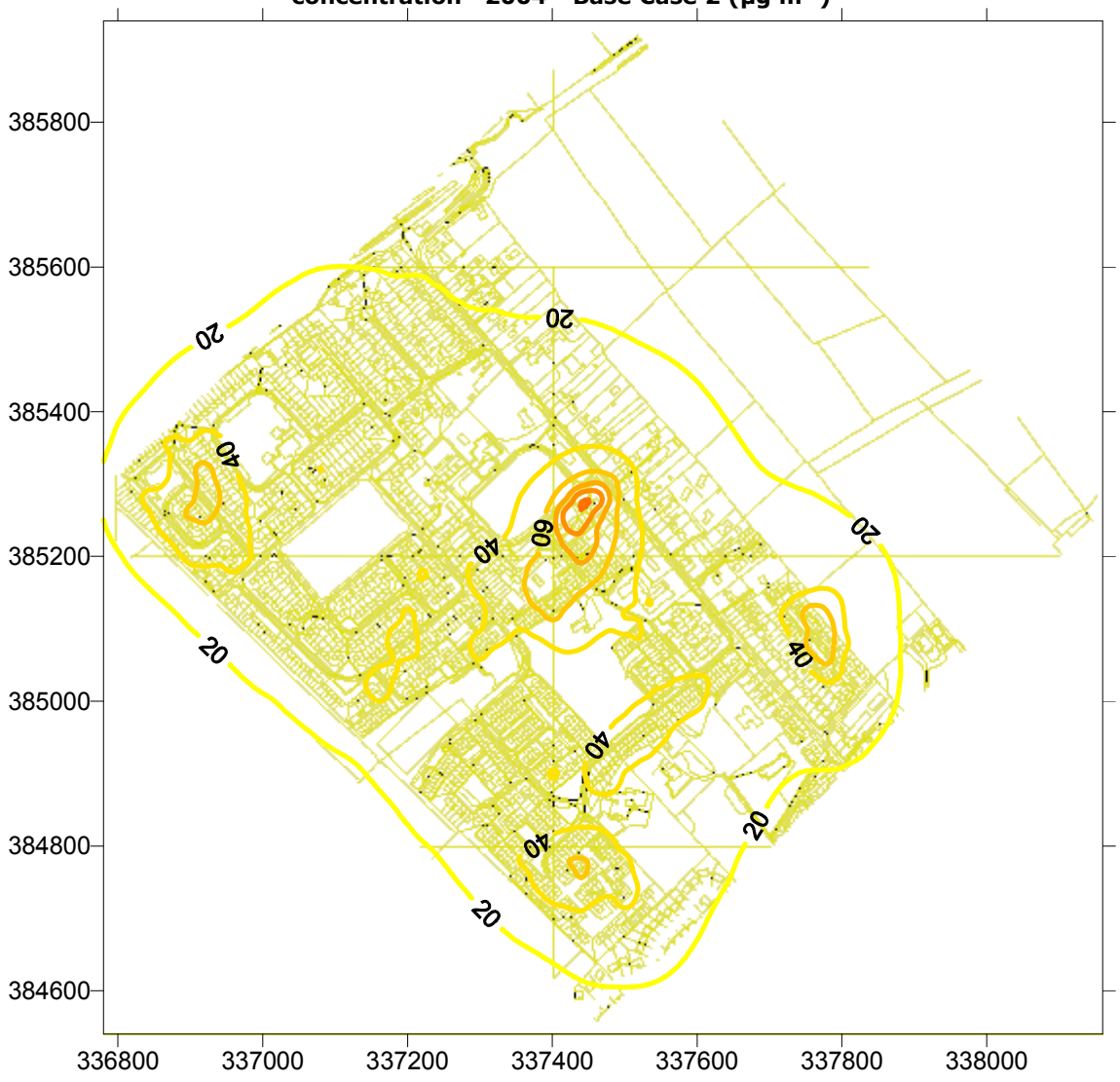
***Bias adjusted to monitoring data**

Figure 5.12 Greenisland modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2004 - Base Case 1 (µg m^{-3})



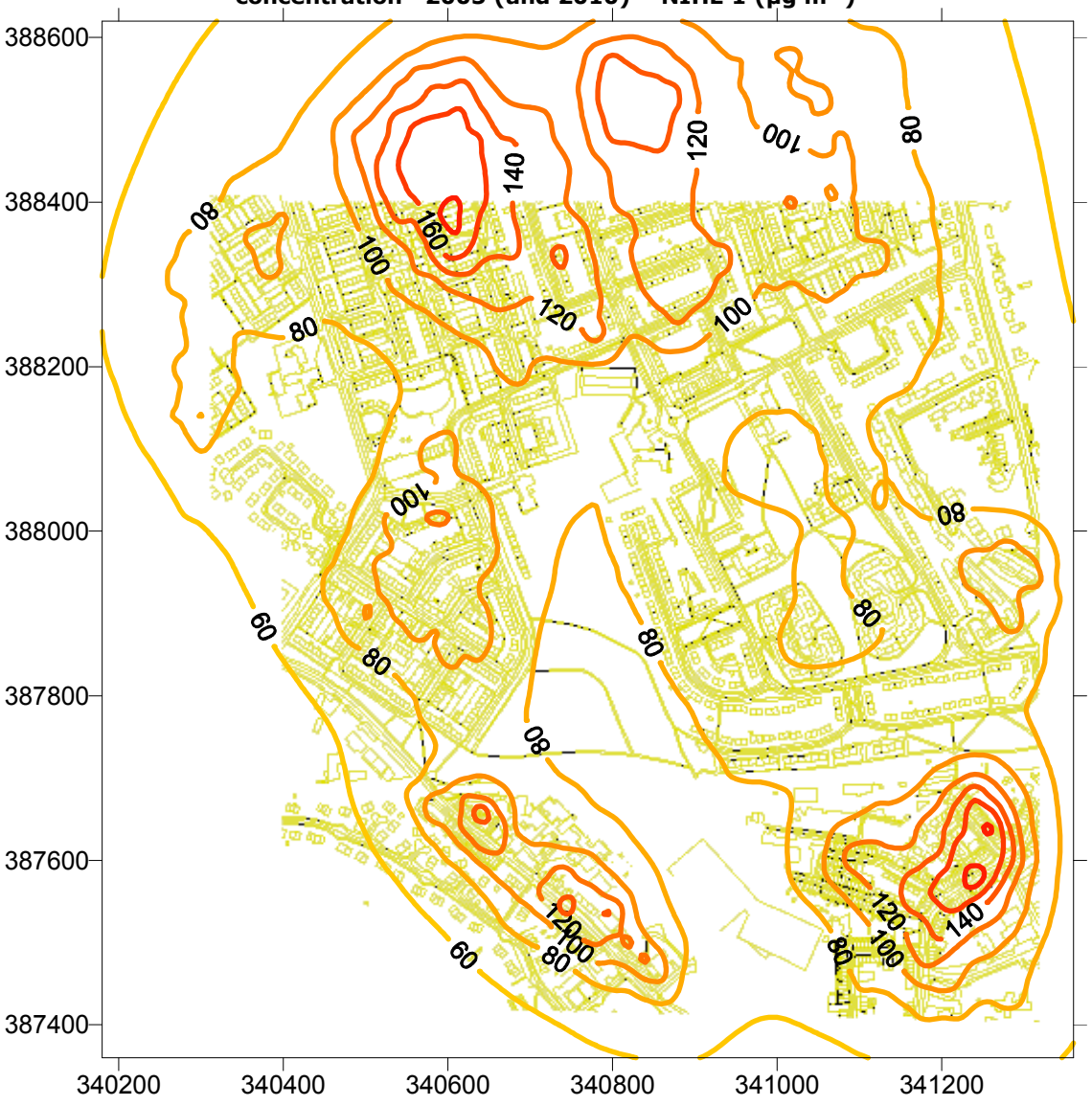
***Bias adjusted to monitoring data**

Figure 5.13 Greenisland modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2004 - Base Case 2 (µg m^{-3})



***Bias adjusted to monitoring data**

Figure 5.14 Carrickfergus Town modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2005 (and 2010) – NIHE 1 (µg m^{-3})



***Bias adjusted to monitoring data**

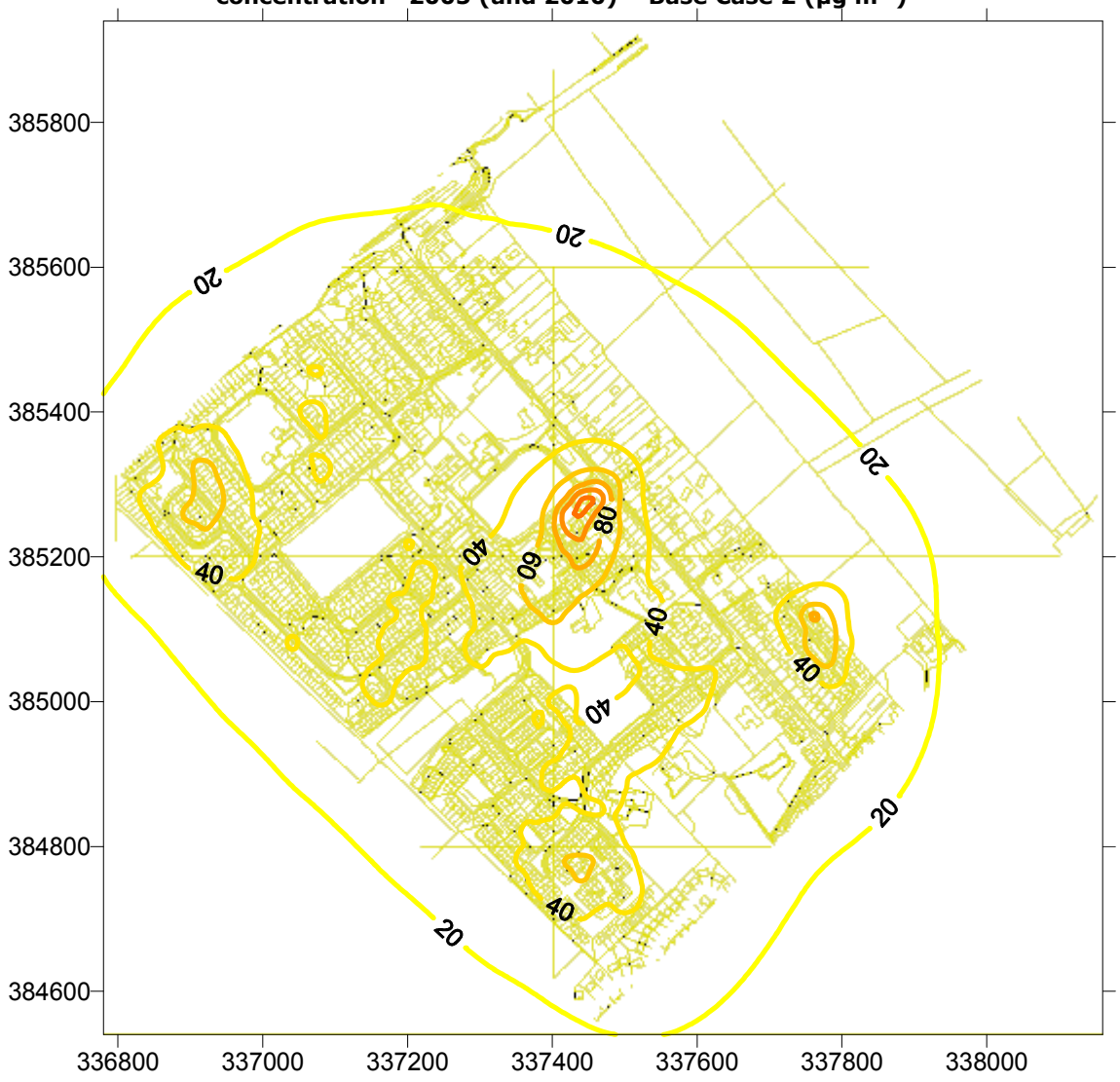
Figure 5.15 Carrickfergus Town modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2005 (and 2010) – NIHE 2 (µg m^{-3})

***Bias adjusted to monitoring data**

Figure 5.16 Greenisland modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2005 (and 2010) – Base Case 1 (µg m^{-3})

***Bias adjusted to monitoring data**

Figure 5.17 Greenisland modelled 99.9th percentile of 15 minute mean SO_2 concentration* 2005 (and 2010) – Base Case 2 (µg m^{-3})



***Bias adjusted to monitoring data**

6 Discussion

6.1 PM_{10} DAILY OBJECTIVE

Figures 5.2 and 5.3 show the modelled 90th percentile of daily mean PM_{10} concentration in Carrickfergus Town for the period 1st October 2003 to 30th September 2004 for base case 1 and base case 2 respectively. This period is considered representative of 2004. These plots are directly comparable with the 2004 daily PM_{10} objective of 50 $\mu g\ m^3$.

Figures 5.4 and 5.5 show the equivalent plots for Greenisland.

The daily PM_{10} objective of 50 $\mu g\ m^3$ in 2004 is not predicted to be exceeded in Carrickfergus Town or Greenisland.

Figures 5.6 and 5.7 show the modelled 90th percentile of daily mean PM_{10} concentration in Carrickfergus Town for 2010 assuming properties in the NIHE Conversion Programme are converted to mains gas, and assumptions regarding other properties in line with base case 1 and base case 2 respectively.

No details of the NIHE Conversion programme within Greenisland were available, so figures 5.8 and 5.9 show the modelled 90th percentile of daily mean PM_{10} concentration in Carrickfergus Town for 2010 for base case 1 and base case 2 respectively.

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 2004 daily PM_{10} objective of 50 $\mu g\ m^3$, which is not predicted to be exceeded in Carrickfergus Town or Greenisland.

Without the implementation of the NIHE programme, detailed modelling model predicts no breaches of the daily mean PM_{10} objective. However, predicted concentrations are only just below the AQ Objectives and it is possible that in years with unfavourable dispersion conditions the daily mean PM_{10} objective may be exceeded within Carrickfergus Town and Greenisland.

The implementation of the NIHE programme further reduces concentrations close to properties directly affected by the programme but has little impact on the maximum predicted concentrations.

6.2 SO_2 15 MINUTE MEAN OBJECTIVE

The 15 minute mean is the most stringent of the SO_2 short term objectives.

Figures 5.10 and 5.11 show the modelled 99.9th percentile of 15 minute mean SO_2 concentration in Carrickfergus Town for the period 1st October 2003 to 30th September 2004 for base case 1 and base case 2 respectively. This period is considered representative of 2004. These plots are directly comparable with the 2005 15 minute mean objective of 266 $\mu g\ m^3$.

Figures 5.12 and 5.13 show the equivalent plots for Greenisland.

Figures 5.14 and 5.15 show the modelled 99.9th percentile of 15 minute mean SO_2 concentration in Carrickfergus Town for 2005 (and 2010) assuming properties in the NIHE Conversion Programme are converted to mains gas, and assumptions regarding other properties in line with base case 1 and base case 2 respectively.

No details of the NIHE Conversion programme within Greenisland were available, so figures 5.16 and 5.17 show the modelled 99.9th percentile of 15 minute mean SO_2 concentration in Carrickfergus Town for 2005 (and 2010) for base case 1 and base case 2 respectively.

The SO_2 15 minute mean objective of 266 μg m^3 is not predicted to be exceeded in Carrickfergus Town or Greenisland.

The detailed modelling has shown that SO_2 emissions arising from domestic fuel combustion in Carrickfergus Borough Council are not predicted to cause an exceedence of the air quality objectives within Carrickfergus and Greenisland.

6.3 DIFFERENCE BETWEEN THE STAGE 3 AND STAGE 4 MODELLING

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 a number of 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 SSF is reduced using the newer emission factors. The contribution from oil will have increased. As seen from the fuel use summary however most fuel use is Solid 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.

We would have expected an increase in SO_2 as a result of the emission factor change. 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. The other factors (listed

here) have negated this expected increase and concentrations are reduced despite the emission factor change.

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 Town site and these are carried through to the modelling in the bias correction.

- The fuel use survey information has been updated and 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.

- The success with which the model predicts concentrations at Stage 4 can be seen by the bias figures applied (Section 5.5.5). 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.

7 Conclusions

This Stage 4 study represents a more accurate modelling exercise using more up to date information than the previous stage 3 modelling. The modelling has not predicted any exceedance of the regulated objectives.

Carrickfergus may wish to consider revocation of the AQMA on the basis of these results. Should they wish to revoke an AQMA, The Local Air Quality Management Policy Guidance (LAQM.PGNI (03) details the process for revocation and the grounds on which this should be based.

Amendments and Revocations of AQMAs (LAQM.PGNI (03))

> 2.20 District councils are able to amend or revoke an existing AQMA order at any time as set out under Article 12 –(4) of the Order. Where a district council considers it necessary to amend or revoke an AQMA, the Department expects the council to consult all the relevant statutory consultees, local stakeholders, businesses and members of the public. Those district councils should submit their further reports for appraisal showing the monitoring results and other evidence to justify their decision to take action. Where it is accepted by the Department that the revocation or amendment is justified, district councils will be expected to take the relevant action within 4 months following receipt of comments from the Department. 2.21 In the future, the Department expects district councils to undertake any amendments or revocations of existing AQMA orders within 4 months following submission of the Detailed Assessments or the further assessments within AQMAs where new AQMAs have been designated (provided there is sufficient evidence to justify the proposed amendment or revocation of an AQMA).
>
> 2.22 However, where a district council feels that it has sufficient evidence to justify the need to amend or revoke an AQMA at any time, it should submit that evidence to the Department for appraisal. For those authorities that have continuous monitoring, the Department would expect them to keep the AQMA under regular review, and to take action, where necessary, sooner rather than await the next round of reviews and assessments.
>
> 2.23 Where an AQMA is revoked, district councils might wish to consider drawing up a local air quality strategy to ensure air quality issues maintain a high profile locally and to respond to any public expectations. Notification of Amendment or Revocation of an AQMA Order
>
> 2.24 Once an amendment or revocation has taken place, the district council should submit the amended or revocation order to the Department for information. District councils should also notify other statutory consultees and publicise the amendment or revocation widely through the local media, so as to ensure that the public and local businesses are fully aware of the situation.

Any revocation of AQMAs should be following the advice of the Department for Environment Northern Ireland.

The next formal Review and assessment requirement is the production of a progress report in April 2005.

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 3.

References

CRE, 1997. PM_{10} emission factors for domestic solid fuels. Report prepared for Belfast City Council. Report number: 7323-3. July 1997.

Defra (2003). Part IV of the Environment Act 1995. Local Air Quality Management. Technical Guidance LAQM. TG(03).

NAEI (2003). UK Emissions of Air Pollutants 1970 – 2001. Report produced by Netcen for Defra, National Assembly of Wales, the Scottish Executive and the Department of the Environment, Northern Ireland.

Pye, S and Vincent, K (2003) Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland. AEAT/ED47047 http://www.airquality.co.uk/archive/reports/cat05/0401151142_NI_PAH_draftv4.pdf

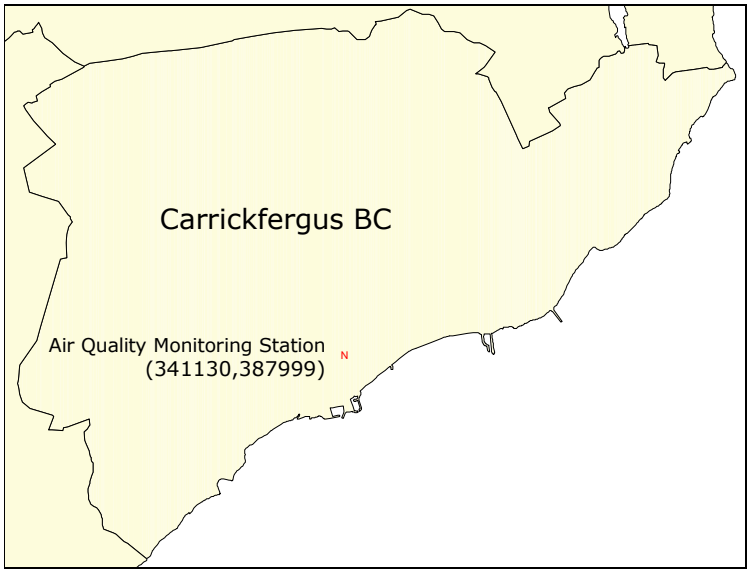
Appendices

CONTENTS

Appendix 1
Automatic Monitoring Station Data

CARRICKFERGUS AMBIENT AIR MONITORING PROGRAMME

Carrickfergus Borough Council has undertaken automatic ambient air monitoring of SO_2 and PM_{10} since July 2002. The instrumentation employed uses UV fluorescence for the measurement of SO_2 and the TEOM technique for PM_{10}, these methods are appropriate for Detailed Assessment under LAQM (LAQM TG(03)). The monitoring station is located in Carrickfergus Town in Rosebrook Avenue. The exact location of the monitoring station is provided below. The station is located in the Carrickfergus Town Centre grid, which has been modelled for domestic fuel combustion. It is therefore in a relevant location.



Location of Automatic Monitoring Station in Carrickfergus

The data presented here has been provided to **netcen** by Carrickfergus Borough Council as finalised data. Thus no further data scaling or ratification of the data has been undertaken. However, a qualitative review of the data has been completed comparing the trends of the pollutants to nearby AURN monitoring stations. As can be seen in Figures 1 & 2 below, the Carrickfergus dataset broadly follows the same temporal variation as seen at the AURN station at Belfast Centre for PM_{10} and Belfast Centre and Belfast East for SO_2. This provides a degree of confidence in the dataset.

The data supplied by Carrickfergus Borough Council, and used in the verification process of the modelling, was uploaded to the **netcen** database and analysis of the data provided the following data summaries. Table 1 provides descriptive statistics of the Carrickfergus data, whilst Table 2 provides comparison against the Air Quality Objective values set down in the Air Quality Regulations (Northern Ireland) 2003.

Table A1.1 Air Quality Summary Statistics, Carrickfergus 30 September 2003 to 30 September 2004

POLLUTANT	PM_{10}	SO_2
Maximum 15-minute mean	344 µg m^{-3}	144 µg m^{-3}
Maximum hourly mean	192 µg m^{-3}	120 µg m^{-3}
Maximum running 8-hour mean	95 µg m^{-3}	67 µg m^{-3}
Maximum running 24-hour mean	52 µg m^{-3}	34 µg m^{-3}
Maximum daily mean	47 µg m^{-3}	29 µg m^{-3}

Average	17 µg m^{-3}	6 µg m^{-3}
Data capture	96.5 %	99.8 %

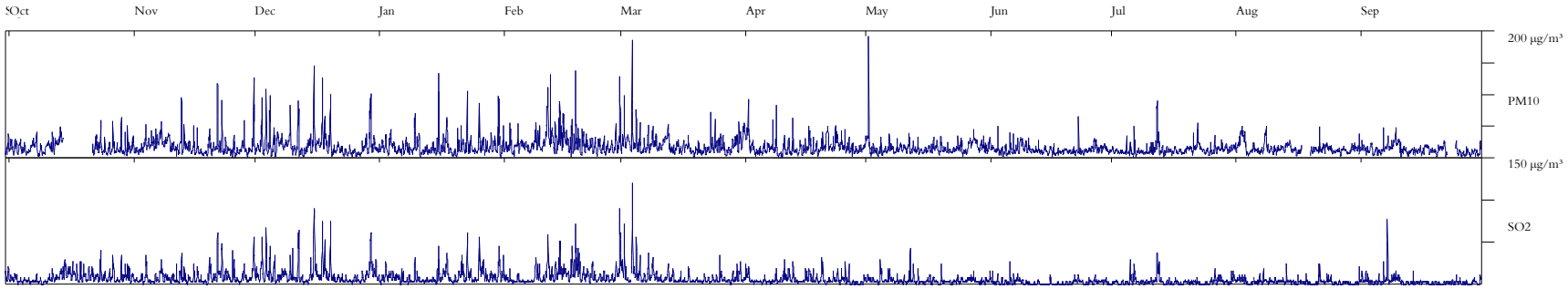
All mass units are at 20'C and 1013mb
NO_X mass units are NO_X as NO_2

Table A1.2: Air Quality Exceedence Statistics, Carrickfergus 30 September 2003 to 30 September 2004

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µg m^{-3}	4	4
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µg m^{-3}	0	-
Sulphur Dioxide	15-minute mean > 266 µg m^{-3}	0	0
Sulphur Dioxide	Hourly mean > 350 µg m^{-3}	0	0
Sulphur Dioxide	Daily mean > 125 µg m^{-3}	0	0

Note: A factor of 1.3 has been used to correct TEOM PM_{10} to gravimetric equivalent PM_{10} (GR_{10} in Table 1)

Figure A1.1 Carrickfergus Rosebrook Avenue Air Monitoring Hourly Mean Data for 30 September 03 to 30 September 04



Appendix 2
Aldergrove Met Station Data

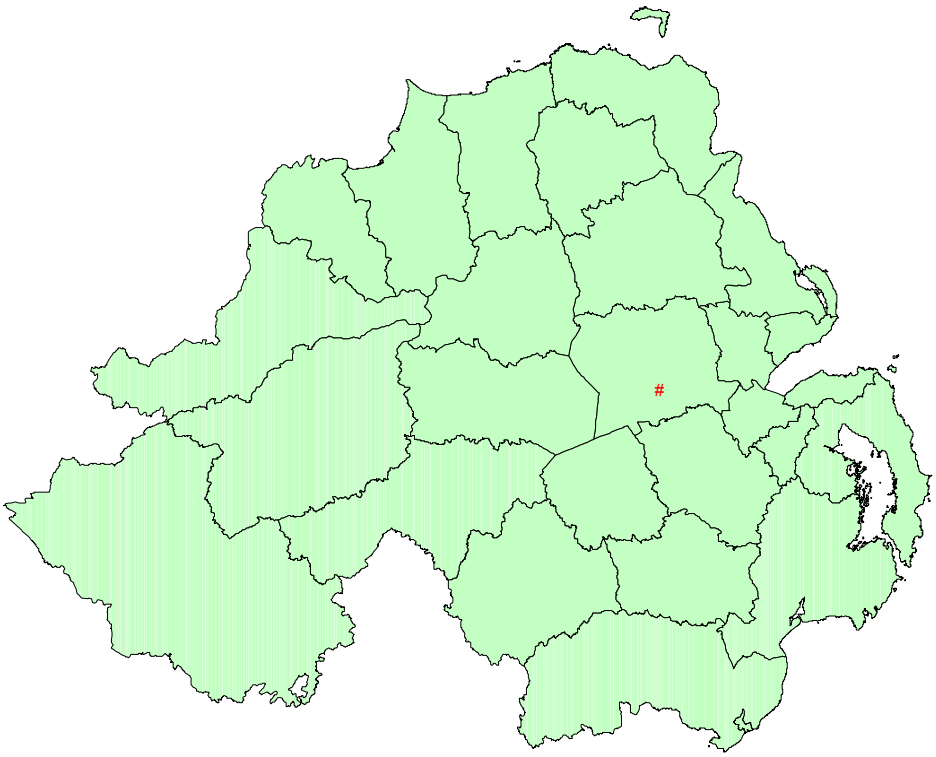


Figure A2.1 Location of Aldergrove Station

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

Table A2.1 - Characteristics of Aldergrove Station

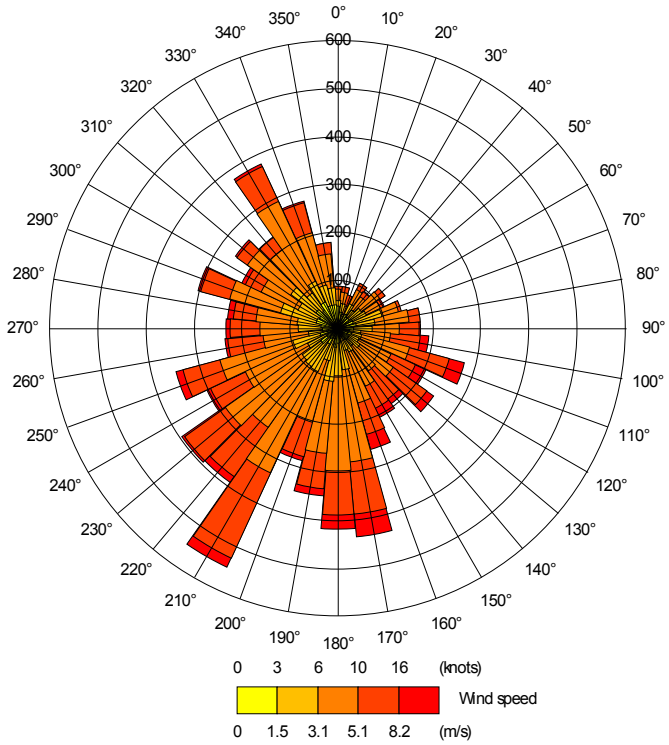


Figure A2.2 Wind rose for the Aldergrove met data
30 September 2003 to 30 September 2004

Appendix 3
Stage 4 Checklist

Stage 4 Review & Assessment Checklist

PM_{10}	Response	Comments
MONITORING		
• Has further continuous monitoring been undertaken?	**Yes**	Ongoing monitoring at Rosebrook Avenue
• 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?		
• Has monitoring confirmed 2004 exceedences?	**No**	
• Has monitoring amended the conclusions of Stage 3?	**Yes**	
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 exceedences?	**No**	The modelling has not predicted exceedences
• Has modelling amended the conclusions of Stage 3?	**Yes**	An exceedance of the PM_{10} objectives is not predicted
GENERAL		
• Have both the magnitude and geographical extent of any exceedences been further clarified?	**Yes**	Magnitude and extent are reduced below the objective.
• Has the decision to declare an AQMA been reversed at Stage 4?	**N/A**	Not within scope of this report
• Is this decision soundly based?	**N/A**	Not within scope of this report
• Has the authority taken account of the new vehicle emission factors	**N/A**	Not within scope of this report
• Has the primary fraction of total PM10 been determined?	**Yes**	
• Has the authority considered source apportionment?	**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?	**N/A**	No improvement required

Other Comments

Stage 4 Review & Assessment Checklist

Sulphur Dioxide	Response	Comments
MONITORING		
• Has further continuous monitoring been undertaken?	**Yes**	Ongoing monitoring at Rosebrook Avenue
• 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?		
• Has monitoring confirmed exceedences of any of the objectives?	**No**	
• Has monitoring amended the conclusions of Stage 3?	**No**	
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 has not predicted exceedences
• Has modelling amended the conclusions of Stage 3?	**No**	An exceedance of the SO_2 objectives remains unlikely
GENERAL		
• Have both the magnitude and geographical extent of any exceedences been further changed?	**Yes**	Magnitude and extent are reduced below the objective.
• Has the decision to declare an AQMA been reversed at Stage 4?	**N/A**	Not within the scope of this report.
• Is this decision soundly based?	**N/A**	Not within the scope of this report.
• Has the authority considered source apportionment?	**N/A**	Not within the scope of this report.
• 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?	**N/A**	No improvement required

Other Comments

Stage 4 Review & Assessment Checklist

MONITORING & MODELLING WORK	Response	Comments
• Have monitoring uncertainties been addressed fully?	**Yes**	Ongoing monitoring at Rosebrook Avenue
• Does the additional monitoring assessment appear sufficiently robust?	**Yes**	Ongoing monitoring at Rosebrook Avenue
• 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**	
•Is the decision to amend or revoke the AQMA(s) at Stage 4, soundly based?	**N/A**	Not within scope of this report
•Is the decision reached based principally on monitoring?	**N/A**	Not within scope of this report
•Is the decision reached based principally on modelling?	**N/A**	Not within scope of this report
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