Executive Summary

As part of the National Air Quality Strategy, North Lincolnshire Council is required to undertake a review and assessment of air quality within its boundaries. All potential sources of pollution (primarily industry and traffic related sources) must be taken into consideration and seven major pollutants are considered. These are PM_{10} (particulate matter), Nitrogen Dioxide, Sulphur Dioxide, Carbon Monoxide, Benzene, 1,3-Butadiene and Lead. The concentrations of these pollutants in the air are compared to air quality objectives, which are based on current medical evidence for the health effects of each pollutant.

The intention of this report is to carry out the Stage 3 Review & Assessment of Nitrogen Dioxide, which was identified in the Stage 2 Review & Assessment as potentially exceeding the annual average Air Quality Objectives for this pollutant.

Westlakes Scientific Consulting Ltd. was commissioned by North Lincolnshire Council to prepare an emissions inventory and undertake appropriate dispersion modelling studies for Nitrogen Dioxide in the Scunthorpe and Bottesford area.

The prediction of the concentrations of Nitrogen Dioxide in 2005 has been achieved using the advanced air pollution dispersion model, Airviro. The accuracy of the predicted Nitrogen Dioxide concentrations has been validated by comparing them with monitored concentrations of Nitrogen Dioxide.

The model predictions of the annual average air concentration for the 2005 emission scenario showed that none of the residential areas in Scunthorpe and Bottesford were likely to exceed the objective. Concentrations of $40\mu g/m^3$ (micrograms per cubic metre) were predicted to the north east of Scunthorpe steel works, but again not in any residential area.

The following roadside locations were at a low risk of just exceeding the annual average Nitrogen Dioxide objective level when the greatest level of uncertainty of the dispersion model was considered.

- The intersection of Ashby Road and Queensway
- The intersection of Queensway and Grange Lane
- Within 50 m of Brigg Road.

However even though these roadside locations could be viewed as being at a low, but possible risk of exceeding the objective no residential properties are contained within them.

This report concludes that no Air Quality Management Areas need to be designated within the Scunthorpe area at the present. However concentrations of Nitrogen Dioxide are sufficiently close to the annual average objective level, when the uncertainty limits of the model are considered, that further monitoring and assessment will be conducted. This will form part of the second round of air quality review and assessment that the Authority is required to complete by the end of 2003.

NORTH LINCOLNSHIRE COUNCIL

AIR QUALITY REVIEW & ASSESSMENT

Stage Three Report

NORTH LINCOLNSHIRE COUNCIL

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1.0 Introduction

The concept of Local Air Quality Management was introduced under Part IV of the Environment Act 1995 ('The Act'). Section 82 of the Act placed a duty on all Local Authorities to review air quality in their area.

In 1997 The National Air Quality Strategy (NAQS) was published This laid down a number of proposed Air Quality Objectives that were to be achieved by 2005. The Air Quality Objectives were subsequently formalised in the Air Quality Regulations 1997 ('The Regulations').

Air Quality Objectives can be defined as the Governments medium term objectives. They are based on Air Quality Standards set by the Expert Panel on Air Quality Standards (EPAQS) and are the maximum acceptable level of a pollutant in the air that will not present a risk to the health of the most susceptible groups in the population. The Air Quality Objectives include date(s) by which the Standards must be achieved. The length of time to achieve the Standard for each pollutant takes into account the costs to industry, the expected rate of improvements in available technology and the health effects on the country's population.

In January 1999 the Government consulted on proposals to revise the NAQS. This amended strategy was subsequently included in the Air Quality (England) Regulations 2000. The new Air Quality Objectives reduced the pollutant concentration for some pollutants and brought forward the compliance date for others.

The Air Quality (England) Regulations 2000 set Air Quality Objectives for seven pollutants which must be achieved by varying dates, the latest being 31st December 2008. The Air Quality Objectives for the seven pollutants are listed in Table 1. Where an Objective is unlikely to be achieved within North Lincolnshire the area must be designated an Air Quality Management Area. The Authority must then develop and implement a local action plan setting out measures to reduce pollution levels.

To assist Local Authorities the Department of Environment, Transport and the Regions (DETR) produced general and technical guidance documents. Local Authorities must have regard to this guidance when conducting their Review & Assessment of Air Quality. The first guidance note produced entitled the "Framework for Review & Assessment of Air Quality" proposed that a phased approach should be adopted by Local Authorities. The three stages involve the initial identification and screening of potential pollutant sources, followed by a more detailed examination of the pollutants, using actual monitored or modelled data and finally the use of more sophisticated modelling and monitoring techniques.
This is designed so that Local Authorities only undertake that work which is necessary to determine the air quality in their area and comply with their duties under the Act.

Table 1
Objectives in the Air Quality (England) Regulations 2000

Pollutant	Objective		To be Achieved By
	Concentration	**Measured as**	
Particles PM_{10} *(1)	50μg/m^3 *(2)	24-Hour Mean not to be exceeded more than 35 times a year.	31/12/2004
	40μg/m^3	Annual Mean	31/12/2004
Nitrogen Dioxide	200μg/m^3	1-Hour Mean not to be exceeded more than 18 times a year.	31/12/2005
	40μg/m^3	Annual Mean	31/12/2005
Sulphur Dioxide	350μg/m^3	1-Hour Mean not to be exceeded more than 24 times a year.	31/12/2004
	125μg/m^3	24-Hour Mean not to be exceeded more than 3 times a year.	31/12/2004
	266μg/m^3	15-Minute Mean not to be exceeded more than 35 times a year.	31/12/2005
Carbon Monoxide	11.6mg/m^3 *(3)	Running 8-Hour Mean	31/12/2003
Benzene	16.25μg/m^3	Running Annual Mean	31/12/2003
1,3-Butadiene	2.25μg/m^3	Running Annual Mean	31/12/2003
Lead	0.5μg/m^3	Annual Mean	31/12/2004
	0.25μg/m^3	Annual Mean	31/12/2008

*(1) "PM_{10}" - Particulate Matter less than 10 microns in diameter.
*(2) "μg/m^3" - micrograms per cubic metre.
*(3) "mg/m^3" - milligrams per cubic metre.

2.0 Background to North Lincolnshire

North Lincolnshire is an area of around 85,000 hectares located on the southern side of the Humber estuary and occupying tracts of land on either side of the River Trent. The administrative area of North Lincolnshire was created in March 1995 by Parliamentary Order and on 1st April 1996 the new Unitary Authority area of North Lincolnshire came into being.

North Lincolnshire covers a large, mainly agricultural area. The pattern of settlements in the area reflects this with market towns surrounded by many small villages. An important exception to this is the substantial urban area of Scunthorpe and the adjoining town of Bottesford.

Almost half of North Lincolnshire's population, which is approximately 73,250 people, live in Scunthorpe and the adjacent town of Bottesford. Overall, 71 percent of the population live in this main urban area and other towns.

The local economy of North Lincolnshire was built on traditional industries such as steel manufacturing and related industries and agriculture. More recently there has been the establishment of two oil refineries and the introduction of several gas fired power stations.

The M180 motorway and several primary and strategic routes, including the A18 and A15, are located within North Lincolnshire. By rail there are regular freight movements to and from Scunthorpe Steelworks and Humber port related industries. North Lincolnshire is well positioned to take advantage of water transport. Along the banks of the Humber and the Trent there are several wharf facilities.

3.0 Purpose of this Report

The Stage 1 Review & Assessment published in December 1998 identified the need to conduct a Second Stage Review & Assessment for all the pollutants contained within the Air Quality (England) Regulations 2000. The Stage 2 report was published in May 2001 and identified a possible exceedance of the Air Quality Objectives for Nitrogen Dioxide within Scunthorpe.

The purpose of this report is to present the findings of the Stage 3 Review & Assessment in respect of Nitrogen Dioxide within the Scunthorpe area as identified by the Stage 2 report as likely to breach the Air Quality Objectives.

For the purposes of this report all potentially significant sources of Nitrogen Dioxide identified in the Stage 1 and 2 Review & Assessments have been considered. This includes Part A and B processes and traffic sources within Scunthorpe.

To determine the scope of the Stage 3 Review & Assessment the Pollutant Specific Guidance LAQM.TG4 (00) issued by the DETR has been followed. Paragraph 1.17 states:

"The Air Quality Regulations 2000 provide that the achievement or likely achievement of the objectives is to be determined by reference to the quality of the air at locations which are situated outside of buildings or other natural or man-made structures above or below ground, and ***where members of the public are regularly present****. For the purposes of determining the focus of the review and assessment, local authorities should have regard to those locations where members of the public are likely to* ***be regularly present and are likely to be exposed over the averaging period of the objective****. Authorities should* ***not*** *consider exceedences of the objectives at any location* ***where relevant public exposure would not be realistic****."*

4.0 Recommendations of the Stage 2 Review & Assessment for Each Pollutant

4.1 PM_{10}

A Stage 3 Review & Assessment is not required.

4.2 Nitrogen Dioxide

A Stage 3 Review & Assessment be conducted for the following locations and processes –

a) *The area in the town centre around Britannia Corner, Mary Street and Oswald Road in Scunthorpe.*

b) *The vicinity of Brigg Road and Station Road in Scunthorpe.*

c) *Ashby Road in Scunthorpe.*

d) *Scunthorpe Steelworks.*

4.3 Sulphur Dioxide

A Stage 3 Review & Assessment is not required.

4.4 Carbon Monoxide

A Stage 3 Review & Assessment is not required.

4.5 Benzene

A Stage 3 Review & Assessment is not required.

4.6 1,3-Butadiene

A Stage 3 Review & Assessment is not required.

4.7 Lead

A Stage 3 Review & Assessment is not required.

5.0 Third Stage Review & Assessment of Nitrogen Dioxide

5.1 Introduction

Nitrogen Dioxide (NO_2) and Nitrogen Oxide (NO) are commonly referred to as Oxides of Nitrogen (NO_x) and are produced by all combustion processes. Currently road transport accounts for about 50% of the total UK emissions; electricity generation contributes about 20% and the industrial and commercial sectors contribute about 17%.

5.2 The Health Effects of Nitrogen Dioxide

Nitrogen Dioxide is known to have an adverse effect on human health. It is a respiratory irritant. It affects airways and reduces lung function giving feelings of breathlessness during exercise and increasing the likelihood of coughing and other respiratory problems. Asthmatics as a group can be particularly affected by even short exposure to high levels of Nitrogen Dioxide.

5.3 Air Quality Objective for Nitrogen Dioxide

The objective for Nitrogen Dioxide, included in the 1997 Strategy and Regulations, is 150ppb (287$\mu g/m^3$) measured as an hourly mean and 21ppb (40$\mu g/m^3$) when expressed as an annual mean. The objective was to be achieved by the end of 2005. The Objectives take account of the both the effects caused by short-term exposure to high levels and long term exposure to lower concentrations. The recent NAQS (National Air Quality Strategy) proposed the following revised objective.

- 200$\mu g/m^3$ (104ppb) measured as an hourly mean, which can be exceeded up to 18 times a year (and conversely may be defined as a 99.8^{th} percentile of less than 200$\mu g/m^3$)

- 40$\mu g/m^3$ expressed as an annual mean. The Air Quality (England) Regulations 2000 state a compliance date of the end of 2005.

5.4 The National Perspective

Conclusions drawn from the 1997 NAQS suggested that to meet the 2005 objectives a reduction in NO_x emissions over and above that achieved by national measures would be required.

The recent NAQS consultation document states that whilst existing policies and other measures, such as technological advances, are likely to have a significant effect on Nitrogen Dioxide levels in 2005, they are unlikely themselves to lead to the 1997 strategy objectives being met at all busy roadside locations.

Traffic management measures, as identified in the Integrated Transport White Papers, are likely to be needed in some heavily trafficked urban areas if the objective is to be met in all locations.

5.5 Modelling of Nitrogen Dioxide in Scunthorpe and Bottesford

North Lincolnshire Council commissioned Westlakes Scientific Consulting to prepare an emissions inventory and undertake dispersion modelling studies for Nitrogen Dioxide (NO_2) in the Scunthorpe area. Although the Stage 2 Review & Assessment is fairly specific in the areas of Scunthorpe where an exceedance of the Air Quality Objectives for Nitrogen Dioxide could occur the whole of Scunthorpe and the adjoining village of Bottesford was considered for thoroughness. An emissions database for the area was set up in the Indic Airviro air quality management system so that the dispersion modelling studies could be carried out in accordance with the requirements of the Pollutant Specific Guidance LAQM.TG4 (00). The dispersion modelling studies were based on the results of North Lincolnshire Council's Stage 2 Review and Assessment of Air Quality. The complete report including the methodology and results of the dispersion modelling studies are documented in **Appendix 1** of this report along with an overview of the set-up used for this study. The result of this dispersion modelling study is the basis of the Stage 3 Air Quality Review & Assessment.

5.6 Information Supplied by North Lincolnshire Council

As stated in Westlakes Scientific Consulting's report North Lincolnshire Council provided information on industrial processes and road sources. These are detailed in Appendix 2. North Lincolnshire Council also provided monitoring data for validation of the dispersion model, which is also listed in Appendix 2.

5.6.1 Point Sources

Point sources are emissions from chimneystacks as part of each industrial process considered for the dispersion model. Point sources included in this study account for most non-traffic sources of Nitrogen Dioxide in the Scunthorpe area. The processes included are-

Table 2 -
Industrial Sources of Nitrogen Dioxide Included in the Dispersion Model

Keadby Generation Ltd
Fibrogen Ltd
Transco
Koppers UK Ltd
Edinburgh Oil and Gas PLC
Corus (British Steel)

The Nitrogen Dioxide emission data and physical stack properties for each can be found in Appendix 2.

5.6.2 Line Sources

Line sources refer to road traffic. The roads listed below are considered individually whilst other road sources are accounted for as area sources.

Table 3 -
Road Sources of Nitrogen Dioxide Included in the Dispersion Model

Ashby Road	Ashby High Street
Brigg Road	Burringham Road
Chancel Road	Church Lane
Doncaster Road	East Common Lane
Ferry Road	Frodingham Road
Grange Lane South	Messingham Road
Normanby Road	Oswald Road
Phoenix Parkway	Queensway
Rowland Road	Scotter Road
Station Road	West Common Lane
Winterton Road	

The traffic data for each can be found in Appendix 2.

5.6.3 Area Sources

To include the large number of small sources found in any town, for which emissions data are often unavailable area sources were used. These use information from the National Atmospheric Emissions Inventory (NAEI) and provide a means of including emissions from numerous small sources and widely dispersed sources such as minor roads, railways, residential areas, and small industry.

5.6.4 Monitoring Data

To validate the results of the dispersion modelling they were compared to the Nitrogen Dioxide concentrations recorded by the monitoring station placed at Britannia Corner public conveniences. (See Appendix 4 for the location.) It was equipped with a continuous NO_x monitor, using the chemiluminesence principle of detection.

Table 4 -
Summary of Nitrogen Dioxide Concentrations Recorded at Britannia Corner

Year	Annual Mean Concentration ($\mu g/m^3$)	No. of Exceedences of 1-Hour Mean Concentration of 200$\mu g/m^3$
2000*	28.9	0

* February 2000 to December 2000

Also used were the diffusion tube data for Scunthorpe (See Appendix 4 for the location.) measured in the year 2000.

Table 5 –
Diffusion Tube Data - Annual Mean NO_2 Concentrations ($\mu g/m^3$)

	Annual Mean Concentration in 2000[1] ($\mu g/m^3$)
Britannia Corner, Scunthorpe (PH)	56.0
Britannia Corner, Scunthorpe (F2)	37.0
Britannia Corner, Scunthorpe (F3)	37.0
Sheffield Street	37.0
West Common Lane	37.0
Gloucester Avenue	32.0
Mary Street	58.0
Brigg Road	50.0
Ashby Road	43.0
Old Brumby Street	41.0
Queensway	44.0

The complete data set for the diffusion tube survey is also in Appendix 2 and a discussion of quality assurance/quality control of both data sets is contained within Appendix 3.

The diffusion tube located at Britannia Corner and numbered F2 is situated at the same location as the continuous Nitrogen Dioxide monitor to validate the accuracy of the diffusion tube data. From the results gathered at Britannia Corner for the year 2000 the diffusion tube data shows a mean concentration of $8\mu g/m^3$ greater than that of the continuous monitor.

As detailed in **Appendix 3** the laboratory North Lincolnshire Council employs (Rotherham Metropolitan Borough Council Environmental Health Laboratory) to analyse all the diffusion tubes located within the Authority. This laboratory's performance classification under WASP (Workplace Analysis Scheme for Proficiency) is ***Good***. However the results for January 2001 do show a positive bias of 9.5% for 8th January 2001 and 6.5% for 30th January 2001.

Both the comparison against the continuous monitor and the laboratory results suggest that the data from Nitrogen Dioxide diffusion tubes is greater than in reality. A suitable scaling factor could be applied to the data, but it was decided not to as the data is used mainly to highlight the spatial distribution of Nitrogen Dioxide concentrations across North Lincolnshire.

6.0 Results

This section presents the Nitrogen Dioxide (NO_2) air concentrations predicted by the Airviro model for the year 2000 and year 2005 emission scenarios. It is a summary of the results provided by Westlakes Scientific Consulting within their report which is reproduced in full in Appendix 1.

6.1 Model Predictions of Annual Mean Concentrations for 2000

The Airviro model was run for the year 2000 emission scenario to assess the current levels of Nitrogen Dioxide within Scunthorpe and to validate the dispersion model by comparing the model predictions with monitoring data.
The model results show that air concentrations in the centre of Scunthorpe are dominated by the contribution from traffic sources with the highest concentration contours being associated with the major roads around the town centre. A peak in concentration is also predicted to the northeast of the steelworks site, though the maximum concentration contour (42$\mu g/m^3$) occurs over an unpopulated area. The roadside sites that were modelled to have the highest air concentrations of Nitrogen Dioxide are Ashby Road, Britannia Corner, Brigg Road and Queensway.

6.1.1 Britannia Corner (Including Mary Street and Oswald Road)

Model predictions for the area around Britannia Corner demonstrate that both Frodingham Road and Oswald Road are both close to the 40$\mu g/m^3$ annual mean Air Quality Objective, with an exceedence predicted at Britannia Corner itself. Elsewhere roadside locations on Oswald Road, Station Road and Rowland Road are also predicted to exceed the annual mean objective.

6.1.2 Ashby Road

Concentrations of Nitrogen Dioxide at Ashby Road show that air concentrations close to the road typically exceed the annual mean objective of 40$\mu g/m^3$, with peak a concentration of 44$\mu g/m^3$ occurring at the intersection between Ashby Road and Queensway.

6.1.3 Brigg Road

The model predictions show that annual mean concentrations reach 46$\mu g/m^3$ at the intersection of Brigg Road and Station Road and are above 40$\mu g/m^3$ at locations up to 50 metres to the east of the road. Due to the prevailing south-westerly wind direction, concentrations are usually lower on the west side of the road. The 40$\mu g/m^3$ contour does not extend more than 10 metres from the west side of the road.

6.14 Queensway

The results show that the annual mean air quality objective is currently exceeded at roadside locations. The concentrations peak at 46$\mu g/m^3$ at the intersection of Queensway and Grange Lane.

6.2 Validation of Model Predictions of Annual Mean Concentrations

The predictions of the dispersion model were compared with monitoring data on the annual average air concentrations of Nitrogen Dioxide from 12 sites across Scunthorpe measured in 2000. (The results are shown in Table 8, Appendix 2.) The root mean squared analysis demonstrated that the uncertainty limits for the dispersion model were $\pm$ 7.5μg/m^3.

6.3 Validation of Model Predictions of the 99.8th Percentile of 1-Hour Mean Concentrations

The 99.8th percentile of 1-hour mean concentrations were calculated from the modelling results around Britannia Corner. The results show that the 99.8th percentile objective of 200μg/m^3 is not exceeded at this location.
The 99.8th percentile of 1-hour mean modelled concentrations at Britannia Corner was compared with the 99.8th percentile of 1-hour concentrations measured using continuous monitoring equipment located at this site. The comparison shows that the model over predicted the 99.8th percentile of hourly means by 18 % which is within the $\pm$ 50 % tolerance given in section 7.25 of the Selection and Use of Dispersion Models LAQM.TG3 (00). Assuming that this error is a random error rather than a systematic bias, then predicted air concentrations above 170μg/m^3 can be assumed to be within the model uncertainty limits of the short-term NAQS objective for Nitrogen Dioxide.

6.4 Model Predictions of Annual Mean Concentrations for 2005

In 2005 Nitrogen Dioxide concentrations around the road network can be seen to be much lower than those modelled for 2000, with concentrations peaking at 32μg/m^3. Concentrations to the northeast of the steelworks were slightly lower than estimated from the year 2000, though peak concentrations were still found to reach 40μg/m^3. As the area over which these peak concentrations occur is not residential then the annual mean objective is not exceeded.

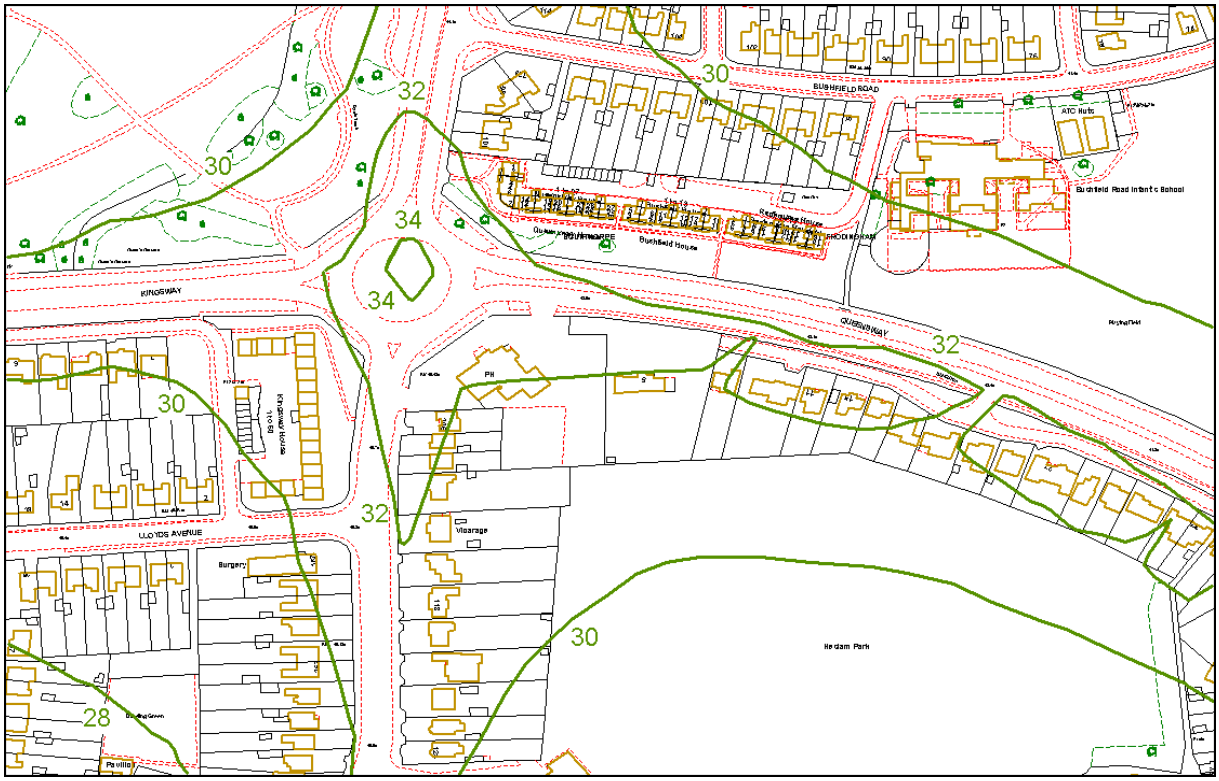
6.4.1 Britannia Corner (Including Mary Street and Oswald Road)

The model results show that the highest roadside Nitrogen Dioxide concentrations were close to 32μg/m^3 and, as such, were likely to be within the objective limits set in the National Air Quality Strategy. Even if the model uncertainty of $\pm$ 7.5μg/m^3 is taken into consideration, the highest air concentrations do not exceed the annual mean objective for NO_2. Therefore this area should be viewed as being at little risk of exceeding the annual mean air quality objective in 2005.

6.4.2 Ashby Road

Roadside concentrations of NO_2 modelled in more detail in the area around Ashby Road, were found to peak at 32μg/m^3, but a higher concentration of 34μg/m^3 is predicted at the intersection between Ashby Road and Queensway.
Air concentrations at this intersection are below the objective level, however, when the model uncertainty of ± 7.5μg/m^3 is taken into consideration, the concentration of Nitrogen Dioxide could be in exceedence of the annual mean objective. Any residences within the 34μg/m^3 contour could be viewed as being at low to moderate risk of exceeding the objective by 2005. However from Figure 1. it can be seen that there are no residential properties or other locations where members of the public might be regularly exposed to this potential area of exceedence. Therefore this area should be viewed as being at little risk of exceeding the annual mean air quality objective in 2005.

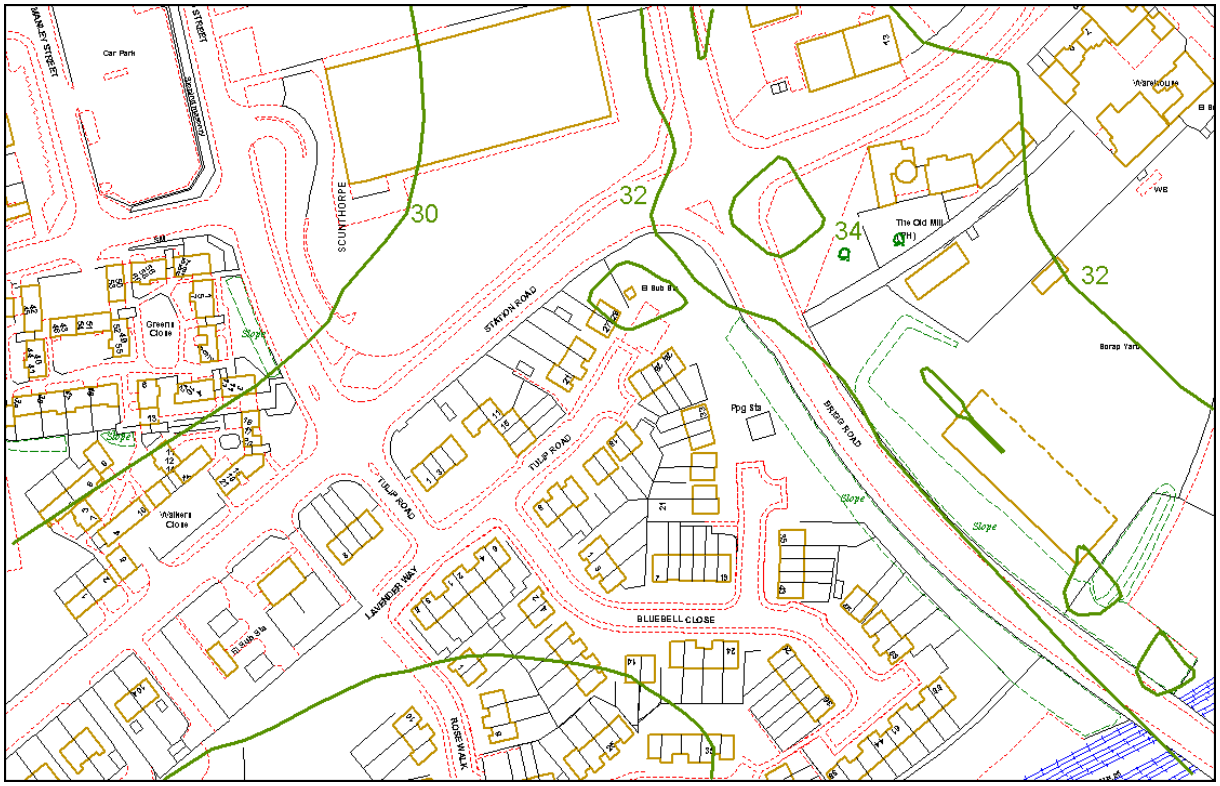
Figure 1 –
Ashby Road, where the Peak Annual Mean NO_2 Concentrations (μg/m^3) are Predicted



6.4.3 Brigg Road

The area within 100 metres of the road was predicted to be within the 32μg/m^3 contour and hence is at little risk of exceeding the annual mean objective. Some roadside locations within 50 metres of Brigg Road were found to be within the 34μg/m^3 contour and so when the ± 7.5μg/m^3 uncertainty limits of the model are considered, the area may be at risk of exceeding the annual mean objective for Nitrogen. As such, these areas should be viewed as being at low to moderate risk of exceeding the NAQS objective. However from Figure 2. it can be seen that there are no residential properties or other locations where members of the public might be regularly exposed to this potential area of exceedence. Therefore this area should be viewed as being at little risk of exceeding the annual mean air quality objective in 2005.

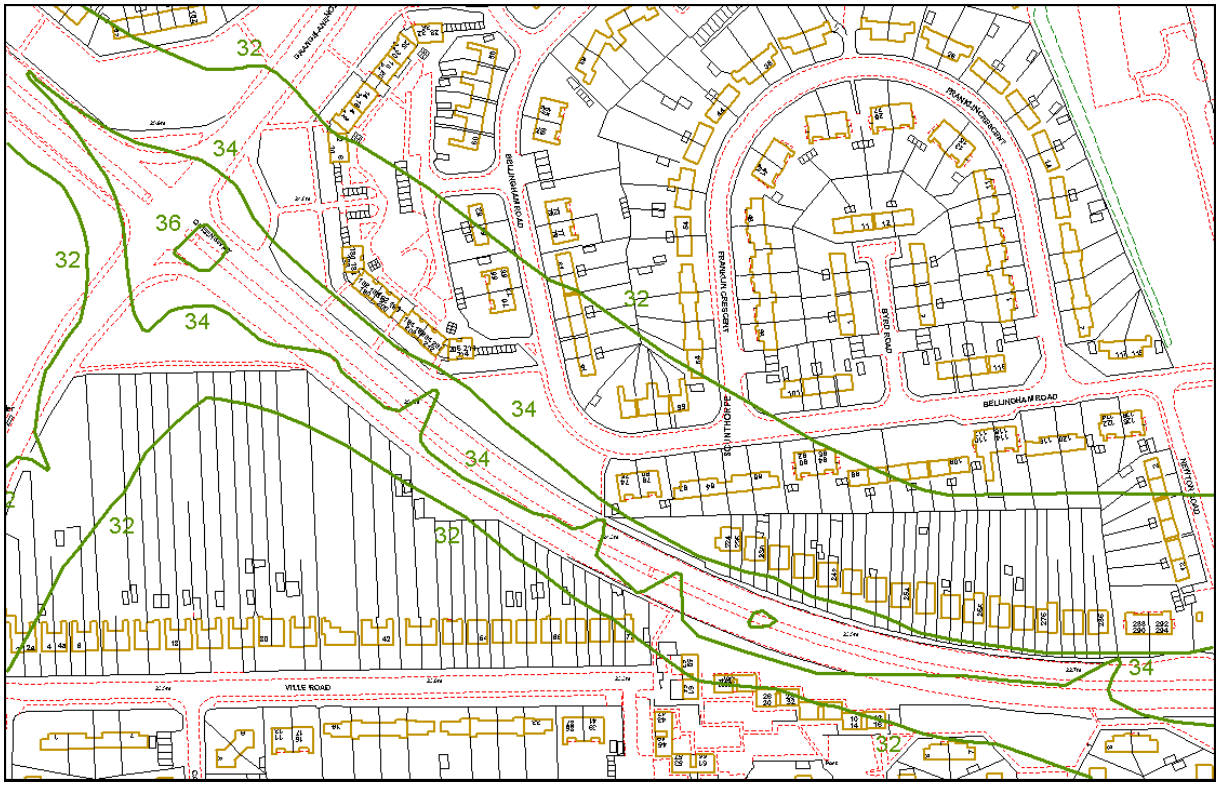
Figure 2 –
Brigg Road, where the Peak Annual Mean NO_2 Concentrations (μg/m^3) are Predicted



6.4.4 Queensway

The 32μg/m^3 contour was found to extend to between 30 to 100 metres from the roadside indicating that there is little risk of exceeding the annual mean objective. Some locations within 25 metres of the roadside were found to be within the 34μg/m^3 contour and the intersection between Queensway and Grange lane was predicted to be in the 36μg/m^3 contour. Any residences within these contours are at risk of exceeding the annual mean objective when the ± 7.5μg/m^3 uncertainty of the model predictions is considered. However from Figure 3. it can be seen that there are no residential properties or other locations where members of the public might be regularly exposed to this potential area of exceedence. Therefore this area should be viewed as being at little risk of exceeding the annual mean air quality objective in 2005.

Figure 3 –
Queensway, where the Peak Annual Mean NO_2 Concentrations (μg/m^3) are Predicted



6.5 Potential Exceedences of the Annual Mean Objective

Exceedences of the annual mean objective of 40μg/m^3 were only predicted for non-residential areas to the north east of the steelworks. None of the roadside locations that were investigated in detail were predicted to exceed the objective, however, several locations were identified to be at risk of exceedence when the uncertainty of the model is taken into consideration. However there are no residential properties or other locations where members of the public might be regularly exposed to these potential areas of exceedence. Therefore these areas are viewed as being at little risk of exceeding the annual mean air quality objective in 2005.

6.6 Model Predictions of the 1-Hour Mean Concentrations for 2005

The model predictions demonstrate that the highest 99.8th percentile concentrations are predicted to occur to the northeast of the steelworks. The concentrations at this point are between 130 and 140μg/m^3, which is less than both the short-term objective of 200μg/m^3 and the objective accounting for model uncertainty of

170μg/m^3. Therefore none of the locations that were investigated in Scunthorpe will exceed, or be at risk of exceeding, the NAQS objective for the 99.8th percentile of 1-hour mean Nitrogen Dioxide concentrations of 200μg/m^3.

7.0 Conclusions

7.1 Annual Mean Air Quality Objective

The results for the year 2000 emission scenario demonstrated that many roadside locations within Scunthorpe are currently at, or exceeding, the annual mean NAQS objective of 40μg/m^3. The following areas are shown to have NO_2 concentrations above the NAQS objective:

- North east of the steelworks
- The junction between Ashby Road and Queensway (A18)
- Britannia Corner
- The intersection of Brigg Road and Station Road
- The intersection of Queensway and Grange Lane

The model predictions of the annual mean concentration for the 2005 emission

scenario showed that none of the residential areas in Scunthorpe are likely to exceed the objective, though air concentrations of 40μg/m^3 are predicted to the north-east of the steelworks site.

The following roadside locations are close to, or just exceeded the annual mean objective level when the ± 7.5μg/m^3 uncertainty limits of the dispersion model are taken into consideration. As such, these roadside locations could be viewed as being at a low, but possible, risk of exceeding the NAQS objective.

- The intersection of Ashby Road and Queensway
- The intersection of Queensway and Grange Lane
- Within 50 m of Brigg Road.

However there are no residential properties within these possible areas of exceedence so they shall not be considered further in this report.

Monitoring and assessment will continue at these sites and others around Scunthorpe and Bottesford to ensure that the NAQS objective will be met by 2005. A further reason for this is the large reductions in NO_x emissions from vehicles that are predicted to occur due to improvements in vehicle technology have in some locations not been observed so far in the Scunthorpe Nitrogen Dioxide monitoring data. Also the speed-related emissions factors for 2005 are currently under review by the DETR and further modelling using the new emissions factors may be necessary when they are issued.

7.2 1-Hour Mean Air Quality Objective

None of the locations that were modelled are predicted to exceed the objective of 200μg/m^3 set for the 99.8th percentile of 1-hour NO_2 concentrations, even when a model uncertainty of ± 30μg/m^3 was included so they shall not be considered further in this report.

8.0 Future Air Quality Review & Assessments

For North Lincolnshire this is the last stage of the first round of Air Quality Review & Assessments. By the end of 2003 a second round of reviews must be completed. This will allow the Authority to reconsider the decision not to declare any Air Quality Management Areas in the light of further monitoring, changes in emission factors, additional Air Quality Objectives or unforeseen changes in number or size of potential local emissions. To achieve this next round of review & assessment North Lincolnshire Council will commence their Stage 1 Review & Assessment of Air Quality at the start of 2002 with the aim of completing this and stage 2 during that year. Assuming a Stage 3 Review & Assessment is necessary this will be completed during 2003.

9.0 References and Sources of Information

The Pollutant Specific Guidance LAQM.TG4 (00) issued by the DETR.

Selection and Use of Dispersion Models LAQM.TG3 (00) issued by the DETR.

Review & Assessment of Air Quality for the purposes of Part IV of the Environment Act 1995 issued y the DETR.

Framework for Review & Assessment of Air Quality LAQM.G (00).

The Environment Agency Internet website, www.environment-agency.gov.uk

DETR Internet website, www.aeat.co.uk/netcen/airqual

Stage 1 Air Quality Review & Assessment - North Lincolnshire Council.

Stage 2 Air Quality Review & Assessment - North Lincolnshire Council.

North Lincolnshire Profile - North Lincolnshire Council.

Local Transport Plan, Technical Annex - North Lincolnshire Council.

NO_2 Dispersion Modelling Assessment – Westlakes Scientific Consulting

Appendix 1

North Lincolnshire Council Airviro System

NO_2 Dispersion Modelling Assessment

Commercial in Confidence

North Lincolnshire Council
Airviro System – NO_2 Dispersion Modelling Assessment

	Name	Signature	Date
Author:	R Hill K Simpson		
Checked:	C Colhoun		
Authorised:	SB Bradley		

Customer Name: North Lincs Council	Agreement No: EW00196	
Project: 00129 NLC – NO_2 Modelling		
Document Type: First Issue	Document No: 000298/01	Date: 10 April 2001

Westlakes Scientific Consulting Ltd
Westlakes Science & Technology Park
Moor Row
Cumbria
CA24 3LN

Telephone: (01946) 514094
Fax: (01946) 514091

e-mail: EnvSci@westlakes.ac.uk

Certificate No. Q13950

Executive Summary

As part of the National Air Quality Strategy, local authorities are required to undertake a three-stage assessment of air quality within their Boroughs. All potential sources of pollution (primarily industry and traffic related sources) must be taken into consideration and seven major pollutants are considered: carbon monoxide; benzene; 1,3-butadiene; lead; nitrogen dioxide; sulphur dioxide; and PM_{10} (particulate matter). The concentrations of these pollutants in the air are compared to air quality objectives, which are based on current medical evidence for the health effects of the particular pollutant and provide a framework for determining the extent to which authorities should aim to improve air quality.

In order to comply with the National Air Quality Strategy, Westlakes Scientific Consulting Ltd (WSC) was commissioned by North Lincolnshire Council (NLC) to prepare an emissions inventory and undertake appropriate dispersion modelling studies for NO_2 in the Scunthorpe area. An emissions database for the NLC area was set up in the Indic Airviro air quality management system so that the dispersion modelling studies could be carried out in accordance with the guidelines for a Stage 3 assessment. The dispersion modelling studies were based on the results of the Stage 2 review and assessment of air quality carried out by NLC. The methodology and results of the Stage 3 dispersion modelling studies are documented in this report along with a brief overview of the set-up used for NLC. The results of these dispersion modelling studies may be used by NLC as the basis of their formal Stage 3 assessment and may assist in the forward planning of future air quality management in the area.

The Indic Airviro air quality management system has three main functional areas:

- the emission database (EDB)
- the dispersion module
- the Indico presentation package

These three modules are integrated to provide a complete air quality management system, which can be accessed and updated, as the user requires.

The system interface is based around a map of the area under investigation (in this case North Lincolnshire), upon which the various pollutant sources are located. Also included are topographical and physiographical data to give the map a three-dimensional aspect, required for dispersion modelling. Meteorological information is also available in the system, again a requirement of dispersion modelling.

The pollutant sources included in the emissions database are point sources (such as factories), grid sources (such as large diffuse sources or numerous small sources) and road sources.
In consultation with NLC, data from various sources were used to create the emissions database within the Airviro system. NLC provided information on industrial processes and roads. The National Atmospheric Emissions Inventory provided information on large diffuse sources or smaller sources which would have been too small to enter individually, which were entered into the EDB as grid sources. The Environment Agency website provided emission information on Part A authorised industrial processes, which were entered as point sources. Speed-related emissions factors for road traffic were obtained from the London Research Centre (LRC) Emissions Factors Database.

A report detailing the assumptions, estimations and extrapolations made in the North Lincolnshire EDB has been produced and is included as an appendix to this document (Appendix B). Any assumptions made were based on either national mean data or the closest similar data available.

The Stage 2 review and assessment carried out for pollutant sources in and surrounding North Lincolnshire revealed that further investigations were necessary into sources and concentrations of NO_2 in the Scunthorpe area. More detailed assessments were thought to be necessary in order to determine whether there was a likelihood of the NAQS objectives being exceeded in this area.

The Indic Airviro air quality management system was used to model the emissions and atmospheric dispersion of NO_x. The following input data were used in the modelling system:

- Emissions of pollutants from grid, road and point sources
- Topography data on terrain height, surface roughness and percentage of urban area / open area / forest in each grid cell
- Meteorological data (wind speed, wind direction, standard deviation of the wind direction, temperature and temperature difference with respect to height)

The modelling studies were conducted in three stages as follows:

- Annual average concentrations of each pollutant were plotted across the Scunthorpe area using climatological data to allow any potential "hot-spots" to be identified
- Specific modelling studies were conducted to compare the expected pollutant concentrations with the NAQS objectives in the identified "hot-spot" areas and in areas requested by NLC.
- Validation studies for NO_2 were carried out by comparing modelled concentrations with a selection of the available monitoring data

The Airviro Air Quality Management system contains three atmospheric dispersion models that could be applied in a Third Stage Assessment for the National Air Quality Strategy. These are the Grid model, the Gauss model and the Canyon model. The modelling studies contained in this report were assessed using the Gauss model. The Gauss model is particularly suited to local-area dispersion studies (SMHI, 1997) and was therefore considered appropriate for use in the Scunthorpe area.

The results for the year 2000 emission scenario demonstrated that many roadside locations within Scunthorpe were currently at, or exceeding, the annual mean NAQS objective of 40 μg m^{-3}. The following areas were shown to have NO_2 concentrations above the NAQS objective:

- North east of the steelworks
- The junction between Ashby Road and the A18 (Queensway)
- Britannia Corner
- The intersection of Brigg Road and Station Road
- The intersection of Queensway and Grange Lane

The air concentrations predicted for the year 2000 emission scenario were compared with the available monitoring data. All the model predictions were well within the ± 50 % limit deemed to be acceptable in the TG3 technical guidance (DETR 2000a). A model uncertainty of ± 7.5 μg m^{-3} was determined for the annual average objective and ± 30 μg m^{-3} for the 99.8^{th} percentile of hourly concentrations objective.

The model predictions of the annual average air concentration for the 2005 emission scenario showed that none of the residential areas in Scunthorpe were likely to exceed the objective, though air concentrations of 40 μg m^{-3} were predicted to the north east of the steelworks plant.

The following roadside locations were at a low risk of just exceeding the annual average NO_2 objective level when the ± 7.5 μg m^{-3} uncertainty of the dispersion model was taken into consideration. As such, these roadside locations should be viewed as being at a low, but possible risk of exceeding the NAQS objective.

- The intersection of Ashby Road and Queensway
- The intersection of Queensway and Grange Lane
- Within 50 m of Brigg Road.

Further monitoring and assessment should be considered at these sites to ensure that the NAQS objective will be met by 2005. This was identified as being particularly necessary because the large reductions in NO_x emissions from vehicles that are predicted to occur due to improvements in vehicle technology have not so far been observed in the Scunthorpe NO_2 monitoring data.

None of the locations that were modelled were predicted to exceed the 2005 objective of 200 μg m^{-3} set for the 99.8^{th} percentile of hourly NO_2 air concentrations, even when a model uncertainty of ± 30 μg m^{-3} was included.

This report concludes that no Air Quality Management Areas need to be designated within Scunthorpe at the present. However, air concentrations are sufficiently close to the annual average objective level, when the uncertainty limits of the model are considered, that further monitoring and assessment should be conducted.

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1. Introduction

As part of the National Air Quality Strategy, local authorities are required to undertake a three-stage assessment of air quality within their boroughs. All potential sources of pollution (primarily industry and traffic related sources) must be taken into consideration and seven major pollutants are considered: carbon monoxide, benzene, 1,3-butadiene, lead, nitrogen dioxide, sulphur dioxide and PM_{10} (particulate matter). The concentrations of these pollutants in the air are compared to air quality objectives, which are based on current medical evidence for the health effects of the particular pollutant and provide a framework for determining the extent to which authorities should aim to improve air quality.

Stage 1 of the three-stage review and assessment process identifies potentially significant pollutants in and surrounding the borough. Stage 2 of the process considers the sources of these pollutants in and surrounding the borough, together with background air quality data. Based on the Stage 2 assessment, recommendations may be made for the review process to proceed to a 3rd stage, where further monitoring or modelling may be required if there is a significant risk of an air quality objective not being achieved. In the worst-case, designation of an Air Quality Management Area (AQMA) may result from the Stage 3 process.

In order to comply with the National Air Quality Strategy, Westlakes Scientific Consulting Ltd (WSC) was commissioned by North Lincolnshire Council (NLC) to prepare an emissions inventory and undertake dispersion modelling studies for NO_2 in the Scunthorpe area. An emissions database for the North Lincolnshire area was set up in the Indic Airviro air quality management system so that the dispersion modelling studies could be carried out in accordance with the guidelines for a Stage 3 assessment. The dispersion modelling studies followed on from the Stage 2 review and assessment of air quality in the Scunthorpe area. The methodology and results of the Stage 3 dispersion modelling studies are documented in this report along with a brief overview of the North Lincolnshire Airviro system. The results of these dispersion modelling studies may be used by NLC as the basis of their formal Stage 3 assessment and may assist in the forward planning of future air quality management in the area.

2 Airviro, the emissions database and the North Lincolnshire system

2.1 Airviro

The Indic Airviro air quality management system has three main functional areas:

- the emission database (EDB)
- the dispersion module
- the Indico presentation package

These three modules are integrated to provide a complete air quality management system, which can be accessed and updated, as the user requires. A schematic diagram of the Airviro system is shown in Figure 1.

The system interface is based around a map of the area under investigation (in this case North Lincolnshire), upon which the various pollutant sources are located. Also included are topographical data on land use across the map area. Meteorological information is also available in the system, which is a requirement for dispersion modelling.

The types of pollutant sources that can be included in the emissions database are point sources (such as factories), area sources (such as villages burning solid fuel), grid sources (such as diffuse emissions) and road sources.

2.2 Emissions database (EDB)

An Airviro EDB contains three different types of database: primary, underlying and geographical.

2.2.1 Primary databases

The primary databases in Airviro contain information on specific sources of pollution, for example the location, chimney height and emission rate from a specific factory. They are subdivided into three databases by the type of source which is being considered. These databases are the point and area source database, the road source database and the grid source database.
Point and area sources are stored in the same database. The information that can be entered into the database to define the source includes:

- Location of source
- Name of the source
- Mass emission rate
- Substance released

The following information can be entered for point sources only:

- Chimney height
- Release temperature
- Release velocity
- Height of adjacent building

Where information is not available on the mass emission rate, emissions can be estimated from the fuel type burned or type of substance by linking the source to the Fuels and Substances underlying database. The time variation of emissions can also be included by linking the point or area source to a Formula defined in the underlying Formula database.
The Road source database contains information on specific road sections (termed links). The data contained in the road source database includes:

- The position of the link on the map
- The name of the link
- Number of vehicles travelling on the link
- Number of lanes of traffic
- The average vehicle speed

Each road source is associated with a road type from the underlying Road Types database which allows the vehicle fleet composition and the time variation in emissions to be modelled.

The Grid source database allows diffuse sources that can extend over large areas to be modelled. The records contained in the Grid database are referred to as "layers". The following information is entered into the Grid source database:

- The name of the grid layer
- The grid resolution
- The minimum and maximum X co-ordinates
- The minimum and maximum Y co-ordinates
- The substances that are emitted from the layer
- A formula to describe the time variation of emissions

Each cell within a grid layer is given separate emission rates for each of the substances that have been associated with that layer. This enables the modelling of very complex emission patterns where several different types of pollutant occur. For example, grid sources are often used to model small road sources, which have a very patchy spatial distribution, and can result in a number of different types of pollutant being emitted to the atmosphere. Such sources would be too numerous to enter individually.

2.2.2 Underlying databases

The underlying databases contain generic information that may be required to model the emissions from many of the sources contained in the primary databases. The Substance database is an example of an underlying database as it contains a comprehensive list of the 254 substances that can be modelled using Airviro. The other underlying databases that were applied in this project were the Road Type database, the Vehicle database and the Searchkeys database. The Formula database, Fuels database and Substance Groups databases were not applied in this project and so will not be described.

The Road Type database allows roads with similar characteristics to be grouped. These characteristics can include similar vehicle compositions or similar diurnal variations. Each road section defined in the Roads database is allocated a road type from the Road Type database.

The Vehicle database allows vehicles with similar emission characteristics to be grouped. For example, it is typical that all light goods vehicles are defined by a single vehicle type rather that by attempting to model each make and model of vehicle separately. The Vehicle database contains the speed related emission factors for each Vehicle type. Each road type, defined in the Road Type database, can be given several vehicle types defined in the Vehicle database. This linking of Road – Road Type – Vehicle Type allows the EDB to operate efficiently whilst still being able to model the complexities that exist when dealing with mobile sources.

The Searchkeys database allows the up to 5 different types of identifiers to be assigned to each source (point/area, road or grid layer), allowing detailed searches of the data in the EDB. An example of the use of Searchkeys would be to denote the various methods used to derive emission data, such as "Measured Data", "Modelled Data" or "Estimated Data", this would enable an assessment of the quality of data contained within the EDB.

2.2.3 Geographical databases

Airviro is based around a geographical interface, with most of the input and output from the model being accessed through the map. An Airviro map is made up of several different

"layers" each of which is given a unique identifying colour. The three that are most relevant to the current study are:

- Land
- Town
- Water

Files of map data for the area of interest may be obtained from Ordnance Survey (Meridian DXF data). These data can be converted into a format suitable for use in Airviro using GIS software such as ArcView and the Airviro Map Editor program.
Topographical and physiographical databases are linked to the Airviro map. Topographical data (terrain heights) may be obtained from the Ordnance Survey and entered into the Airviro system. However, these data were not entered into the North Lincolnshire Airviro system as the area is sufficiently flat that the dispersion modelling studies could assume uniform terrain. Physiographical data on land use type and surface roughness at a 1 km grid resolution were determined by the Airviro model from the colours present on the map.

2.3 The North Lincolnshire EDB

The map area covered in the North Lincolnshire EDB includes the whole NLC area, plus surroundings reaching to the coast in the east and including Doncaster in the west, Gainsborough in the south and Hull in the north.
In consultation with NLC data from various sources were used to create the emissions database within the Airviro system. The main sources of information on emissions were:

- NLC
- The UK National Atmospheric Emissions Inventory (UK NAEI) website (http://www.aeat.co.uk/netcen/airqual/welcome.html)
- The Environment Agency website (http://www.environment-agency.gov.uk/)
- London Research Centre (LRC) Emissions Factors Database

NLC provided information on industrial processes and roads. The National Atmospheric Emissions Inventory provided information on gridded emissions, for 1998, which were entered into the EDB as grid sources. The Environment Agency website provided emission information on Environmental Protection Act 1990 (EPA 1990) Part A authorised industrial processes, which were entered as point sources.

The industrial point sources entered into the database were specified as being either a Part A process or a Part B process, as defined by the Environmental Protection Act 1990. Emissions data and static data about the point sources were then entered into the EDB where available. The point sources included in the EDB are shown in Figure 2.

The road source information was provided by NLC. The road sources were entered into the emissions database as individual road sections and were named according to the North Lincolnshire Stage 2 NAQS Review and Assessment report. In order to make use of the road sections entered into the EDB, information on annual average daily traffic flow (AADT), the number of lanes, the average speed of vehicles on the road section (in km per hour) and the "road type" of each section of road was entered. The road types used in the Scunthorpe EDB were based on the percentage of HGVs travelling on the section of road. The road types were named as:

1 – 5 % HGV	6 – 10 % HGV	11 – 15 % HGV
16 – 20 % HGV	21 – 25 % HGV	26 – 35 % HGV

Within each road type, information is contained regarding the vehicle types travelling on the road, their relative proportions and daily variations in traffic flows. Within the Scunthorpe EDB, these sets of information were the same for each road type, except for the proportions of each vehicle making up the total fleet of vehicles on that particular road type. The proportions of the different vehicles were based on national average fleet composition data supplied by the DETR, but were then adjusted for the percentages of HGVs on each road type. The calculation of the fleet compositions on each road type is discussed further in the EDB assumptions document attached as Appendix B.

The vehicle types included in the database were petrol cars, diesel cars, petrol LGV, diesel LGV, rigid HGV, articulated HGV, buses and motorcycles. All of the vehicle types were assumed to be present on all of the road types, but in different proportions, as discussed in Appendix B. Each type of vehicle was assigned specific speed-related DETR emission factors for NO_x.

No variations in traffic flows from month to month were entered due to lack of data. The daily variations in traffic flow were taken from the Birmingham City Airviro EDB and provide general information for use on any non-specific road type. Instead of entering scenarios for the increase in traffic over the next 10 years into the EDB, two EDBs were created, one containing the year 2000 traffic flows and one containing the 2005 traffic flows. This permitted scenarios for model validation (using the year 2000 monitoring data) and for predicting NO_2 concentrations in-line with the NAQS objectives to be modelled. The 2000 and 2005 traffic flow data were provided by NLC.

Grid sources, based on data from the UK National Atmospheric Emissions Inventory were split into domestic emissions, minor industrial emissions, road-traffic emissions and "other" emissions. The different sources were kept separate so that each layer could be assessed individually. It must be noted that double-counting of certain sources, particularly road sources may occur if road sources themselves and the UK NAEI-derived road traffic grid sources are assessed at the same time. To avoid this, the NAEI gridded emission data were compared with the road and point sources that were explicitly detailed in the emissions database. The NAEI gridded data were edited to remove grid elements where areas of overlap were identified. The gridded emission data included in the EDB are shown in Figure 3.
A report detailing the assumptions, estimations and extrapolations made in the North Lincolnshire EDB has been produced and is included as an appendix to this document (Appendix B). A designated search key (Search key 5) in the EDB has been used to indicate where the data for each source were obtained. Any assumptions made were based on either national mean data or the closest similar data available.

2.3.1 Emission Scenarios modelled

Two different emission scenarios were modelled using the Airviro EDB, these were for emissions in 2000 and in 2005. The main difference in emissions between these two years was predicted to be due to changes in road traffic emissions. Road traffic emissions in 2000 were calculated for specific links in Scunthorpe, shown in Figure 2, from traffic counts and road types supplied by NLC and from speed-related emission factors from LRC for 1999. Road traffic emissions in 2005 were calculated from predicted changes in traffic counts for

each road link supplied by NLC and by applying the LRC emission factors for 2005. A reduction factor of 0.7 was applied to the Road Traffic grid layer to account for the reduced emission from vehicles in 2005 as recommended in LAQM.TG4 (DETR 2000b).

3 Dispersion modelling studies

The Stage 2 review and assessment carried out for pollutant sources in and surrounding the NLC area revealed that further investigation was necessary into sources and concentrations of NO_2. More detailed assessments were thought to be necessary in order to determine whether there was a likelihood of the NAQS objectives being exceeded for NO_2 in the Scunthorpe area.

3.1 Aim

To determine whether the objective of 200 μg m^{-3} (105 ppb) as a 1-hour mean not to be exceeded more than 18 times per year, recommended by EPAQS, will be achieved in Scunthorpe by the end of 2005. Additionally, to determine whether the objective of 40 μg m^{-3} (21 ppb) as an annual mean, recommended by EPAQS, will be achieved in Scunthorpe by the end of 2005.

3.2 Methodology

The Indic Airviro air quality management system was used to model the emissions and atmospheric dispersion of NO_x. The following input data were used in the modelling system:

- Emissions of NO_x from grid, road and point sources
- Meteorological data (wind speed, wind direction, air temperature and temperature difference with respect to height)

The modelling studies were conducted in four stages as follows:

- The grid source data contained in the whole North Lincolnshire EDB (1 km resolution) were modelled to determine background concentrations of NO_x.
- Annual average concentrations of each pollutant were plotted across the Scunthorpe area to allow any potential "hot-spots" to be identified
- Specific modelling studies were conducted at a high resolution (25 m grid) to compare the expected pollutant concentrations with the NAQS objectives in the identified "hot-spot" areas and in areas requested by NLC.
- Validation studies for NO_2 were carried out by comparing modelled concentrations with a selection of the available monitoring data

3.2.1 Choice of model

The Airviro Air Quality Management system contains three atmospheric dispersion models that could be applied in a Third Stage Assessment for the National Air Quality Strategy. These are the Grid model, the Gauss model and the Canyon model. The modelling studies contained in this report were assessed using the Gauss model. The Gauss model is particularly suited to local-area dispersion studies (SMHI, 1997) and was therefore considered appropriate for use in the Scunthorpe area. The Eulerian Grid model is designed for application over long ranges and where three-dimensional wind fields are required and

was therefore not thought to be necessary for modelling in the Scunthorpe area. The Canyon model is designed for use on individual streets with tall buildings at either side. No significant street canyons were identified by NLC.

3.2.2 Meteorological data

The meteorological data used in the modelling assessments were supplied by the UK Met office from their station at Waddington (near Lincoln) for the period 01/01/2000 to 31/12/2000. Data were supplied as an hourly time series and were processed using the Airviro KLMSTAT program to determine their statistical properties, subdividing the data into 60 wind direction classes and 6 air-stability classes. This type of analysis provided a significant saving in the time taken to process model simulations, allowing the detailed evaluation of four locations within Scunthorpe at a high grid resolution (25 m x 25 m) for both the current year (2000) and future (2005) emission scenarios.

3.2.3 Conversion of NO_x results to concentrations of NO_2

Annual mean concentrations of NO_x provided by the modelling study results were converted into annual mean concentrations of NO_2 using the Derwent-Middleton function (Derwent and Middleton, 1996). Details of this conversion calculation are included in Appendix C. Concentrations of NO_x arising from all the sources (including background) were totalled before applying the Derwent Middleton function to the NO_x results.

3.2.4 Calculation of the 99.8th percentile of hourly NO_2 concentrations

The 99.8th percentile of hourly NO_2 concentrations was calculated from the annual mean NO_x concentration using the surrogate statistics method derived by Pratt and Dalton (2000). The details of this simple conversion calculation are included in Appendix C.

3.2.5 Background concentrations

The Airviro system allows pollutants to be modelled at grid resolutions between several tens of kilometres to a minimum of 25 m. The setup for North Lincolnshire made full use of this facility of Airviro by overlaying model results calculated at different resolutions. This enabled a wide (77 km x 54 km) area to be modelled at a coarse (1 km) grid resolution and the results overlayed on much smaller areas (e.g. 1.5 km x 1.5 km) modelled at a fine grid resolution (25 m). This method of overlaying results allowed the model to accurately treat dispersion of material from sources a long way from a receptor point[1], whilst at the same time accurately modelling the local dispersion of sources very close to the receptor.

Air concentrations in the vicinity of Scunthorpe also arise from sources outside the area that was modelled, due to the long-range atmospheric transport of material from national scale sources, for example dispersion from large power stations or adjacent cities. These national scale background concentrations were determined by subtracting the air concentrations modelled using Airviro at the 1 km grid resolution from air concentrations modelled at a national scale by NETCEN. These national scale background concentrations are shown in Table 1.

3.2.6 Model validation

The uncertainty associated with modelling results can be assessed by comparison of model predictions to monitoring data from a site within the modelled area. It is suggested in the NAQS guidance document TG3 (DETR 2000a), that an acceptable level of uncertainty for

[1] A receptor point is the modelling terminology used to denote a specific point of interest where detailed model results are required, such as a school, monitoring station or a particular residential area.

dispersion modelling results is ± 50%. Modelling results are unavoidably subject to some degree of uncertainty as dispersion models are designed to provide a simple representation of a highly complex real environment. Figure 4 shows some of the sources of uncertainty in dispersion modelling. The uncertainty does not undermine the validity of the modelling results, but it does emphasise the need for validation studies. Miller and Hively (1987) in a review of validation studies for the Gaussian plume atmospheric dispersion model state that:

> *"...when the model has the proper parameters, annual average air concentrations over flat terrain can be predicted within a factor of 2 to 4."*

All of the results from the Scunthorpe dispersion modelling studies were compared to monitoring data from within the NLC area in order to assess the uncertainty associated with the modelling results. The uncertainties are described in the following results section.

3.3 Results

This section presents the NO_2 air concentrations predicted by the Airviro model for the year 2000 and year 2005 emission scenarios. The contour plots referred to in this section can be found as figures in Appendix A.

3.3.1 Model predictions of annual average concentrations for the year 2000 scenario

The Airviro model was run for the year 2000 emission scenario to assess the current levels of NO_2 and to validate the model by comparing the model predictions with monitoring data.
The model predictions of annual average concentrations of NO_2 across the entire Scunthorpe area, calculated at a 133 m grid resolution, are shown in the contour plot in Figure A1. The model results show that air concentrations in the centre of Scunthorpe are dominated by the contribution from traffic sources with the highest concentration contours being associated with the major roads around the town centre. A peak in concentration is also predicted to the northeast of the steelworks site, though the maximum concentration contour (42 $\mu g\ m^{-3}$) occurred over an unpopulated area. The roadside sites that were modelled to have the highest air concentrations of NO_2 were Ashby Road, Britannia Corner, Brigg Road and Queensway.

Model calculations of the air concentrations of NO_2 at Ashby Road, determined at a 25 m grid resolution, are shown in the contour plot in Figure A2. The results demonstrate that air concentrations close to the road typically exceed the annual average objective of 40 $\mu g\ m^{-3}$, with peak concentrations of 44 $\mu g\ m^{-3}$ occurring at the intersection between Ashby Road and the A18 (Queensway).

The contour plot in Figure A3 shows the model predictions for the area around Britannia Corner demonstrating that both Frodingham Road and Oswald Road were both close to the 40 $\mu g\ m^{-3}$ annual average objective, with exceedences being predicted at the intersection between the two roads. Roadside locations on Oswald Road, Station Road and Rowland Road were also predicted to exceed the annual average objective.

Air concentrations around Brigg Road are shown in the contour plot in Figure A4. The model predictions show that annual average air concentrations reached 46 $\mu g\ m^{-3}$ at the intersection of Brigg Road and Station Road and were above 40 $\mu g\ m^{-3}$ at locations up to 50 m to the east of the road. Due to the prevailing south-westerly wind direction, air

concentrations were typically lower on the west side of the road with the 40 μg m^{-3} contour typically not extending to more than 10 m from the road.
The model predictions for Queensway are shown in the contour plot in Figure A5. The results show that the annual average air quality objective is currently exceeded at roadside locations, with concentrations peaking at 46 μg m^{-3} at the intersection of Queensway and Grange Lane.

3.3.2 Validation of the model predictions of annual average NO_2 concentrations

The predictions of the dispersion model were compared with monitoring data on the annual average air concentrations of NO_2 from 12 sites across Scunthorpe measured in 2000, the results are shown in Table 2. All the dispersion model predictions were within ± 50 % of the measured values, demonstrating that the model had performed acceptably (in-line with the TG3 guidance (DETR 2000a)). A root mean squared analysis was undertaken which demonstrated that the uncertainty limits for the dispersion model were ± 7.5 μg m^{-3}.

3.3.3 Validation of the model predictions of the 99.8th percentile of hourly NO_2 concentrations

The 99.8th percentile of hourly averaged air concentrations were calculated from the modelling results around Britannia Corner. The results of this modelling study are shown in the contour plot in Figure A6 and demonstrate that the 99.8th percentile objective of 200 μg m^{-3} is not exceeded at this location. Indeed, given the similarity in peak annual average air concentrations monitored and modelled at Britannia Corner with those monitored and modelled elsewhere in Scunthorpe, it may also be concluded that the 99.8th percentile objective will not be exceeded at any of the sites considered.

The 99.8th percentile of hourly mean modelled concentrations at Britannia Corner was compared with the 99.8th percentile of hourly concentrations measured using continuous monitoring equipment located at this site. The results of this comparison are shown in Table 3. The comparison shows that the model over predicted the 99.8th percentile of hourly means by 18 %. This is within the ± 50 % tolerance discussed in the TG3 guidance (DETR 2000a), therefore the model can be concluded as having performed adequately. Assuming that this error is a random error rather than a systematic bias, then predicted air concentrations above 170 μg m^{-3} can be assumed to be within the model uncertainty limits of the short-term NAQS objective for NO_2.

3.3.4 Model predictions of annual average concentrations for the year 2005 scenario

Model predictions of NO_2 concentrations for the entire Scunthorpe area in 2005 are shown in the contour plot in Figure A7. Air concentrations around the road network can be seen to be much lower than those modelled using the year 2000 emission scenario, with concentrations peaking at 32 μg m^{-3}. Air concentrations to the northeast of the steelworks site were slightly lower than estimated from the year 2000 emission scenario, though peak concentrations were still found to reach 40 μg m^{-3}. As the area over which these peak concentrations occurred was not residential then the annual average NAQS objective was concluded not to be exceeded.

Air concentrations of NO_2 modelled in more detail in the area around Ashby Road, predicted for 2005, are shown in the contour plot in Figure A8. Roadside concentrations along Ashby Road were found to peak at 32 μg m^{-3}, but a higher air concentrations of 34 μg m^{-3} was predicted at the intersection between Ashby Road and the A18 (Queensway). Air concentrations at this intersection were below the NAQS objective level, however, when the

model uncertainty of ± 7.5 μg m^{-3} (the RMS uncertainty limit) is taken into consideration, the concentration of NO_2 could be in exceedence of the annual average objective. Hence, any residences within the 34 μg m^{-3} contour should be viewed as being at low to moderate risk of exceeding the objective by 2005.

The dispersion model results for the detailed modelling around Britannia Corner for the 2005 emission scenario are presented in the contour plot in Figure A9. The model results show that the highest roadside NO_2 concentrations were close to 32 μg m^{-3} and, as such, were likely to be within the objective limits set in the National Air Quality Strategy. Even if the model uncertainty of ± 7.5 μg m^{-3} is taken into consideration, the highest air concentrations do not exceed the annual average objective for NO_2. Therefore this area should be viewed as being at little risk of exceeding the air quality objective in 2005.

The dispersion model results for the detailed modelling around Brigg Road are shown in the contour plot in Figure A10. The area within 100 m of the road was predicted to be within the 32 μg m^{-3} contour and hence was at little risk of exceeding the annual mean NAQS objective. Some roadside locations within 50 m of Brigg Road were found to be within the 34 μg m^{-3} contour and hence when the ± 7.5 μg m^{-3} uncertainty limits of the model are considered, the area may be at risk of exceeding the annual average objective for NO_2. As such, these areas should be viewed as being at low to moderate risk of exceeding the NAQS objective.

Air concentrations of NO_2 predicted from the detailed modelling study around Queensway are shown in the contour plot in Figure A11. The 32 μg m^{-3} contour was found to extend to between 30 – 100 m from the roadside indicating that this area would be at little risk of exceeding the NAQS objective. Some locations within 25 m of the roadside were found to be within the 34 μg m^{-3} contour and the intersection between Queensway and Grange lane was predicted to be in the 36 μg m^{-3} contour. Consequently, residences within these contours (34 μg m^{-3} and 36 μg m^{-3}) should be viewed as being at risk of exceeding the NAQS annual average objective when the ± 7.5 μg m^{-3} uncertainty of the model predictions is considered.

In conclusion, exceedences of the annual average NAQS objective of 40 μg m^{-3} were only predicted for non-residential areas to the north east of the steelworks site. None of the roadside locations that were investigated in detail were predicted to exceed the objective, however, several locations were identified to be at risk of exceedence when the uncertainty of the model is taken into consideration. These areas should be subject to further monitoring and assessment to confirm that the objective will not be exceeded as the objective date approaches.

A further caveat that should be considered is that the vehicle emission factors applied in the year 2005 emissions scenario are based on a significant reduction in NO_x emissions due to the application of cleaner technologies. Large reductions in NO_2 concentrations in the air in Scunthorpe have so far not been recorded in the monitoring data. This emphasises the need to continue with the environmental monitoring in order to ensure that the NAQS objective will be met in 2005. In addition, the DETR are in the process of re-calculating the vehicle emissions factors for 2005, therefore a further assessment could be made when these new emissions factors are issued.

3.3.5 Model predictions of the 99.8th percentile of hourly concentrations for the year 2005 scenario

The model predictions of the 99.8th percentile concentrations, based on the year 2005 emission scenario, for the entire Scunthorpe area are shown in the contour plot in Figure A12. The results demonstrate that the highest 99.8th percentile concentrations were predicted to occur to the northeast of the CORUS site. The concentrations at this point were between 130 – 140 μg m^{-3} and as such were less than both the short term objective (200 μg m^{-3}) and the objective accounting for model uncertainty, discussed in Section 3.3.3, (170 μg m^{-3}).

The 99.8th percentile of hourly NO_2 concentrations at Ashby Road are shown in the contour plot in Figure A13. Roadside concentrations were found to peak at 110 μg m^{-3} and as such were less than the NAQS objective, even when accounting for model uncertainty.

Dispersion model predictions of the 99.8th percentile of hourly NO_2 concentrations at Britannia Corner are shown in the contour plot in Figure A14. Roadside air concentrations were found to peak at 110 μg m^{-3} and so were significantly less than the NAQS objective, even when accounting for model uncertainty.

The calculations of the short term NO_2 objective for Brigg Road are shown in the contour plot in Figure A15. The highest concentrations that were predicted were in the order of 120 μg m^{-3} and so were significantly less than the NAQS objective, even when accounting for model uncertainty.

Air concentrations around Queensway, calculated as the 99.8th percentile of hourly NO_2 concentrations are shown in the contour plot in Figure A16. The highest concentrations that were predicted were in the order of 120 μg m^{-3} and so were significantly less than the NAQS objective, even when accounting for model uncertainty.
In conclusion, none of the locations that were investigated in Scunthorpe were found to exceed, or be at risk of exceeding, the NAQS objective for the 99.8th percentile of hourly averaged NO_2 concentrations of 200 μg m^{-3}.

4 Summary

The Airviro Air Quality Management System was applied to investigate the levels of NO_2 within Scunthorpe, North Lincolnshire. The two functional areas of the Airviro model that were applied in this study were the emissions database (EDB) and the Gaus atmospheric dispersion model.
The Airviro EDB was set-up to include all sources of NO_x in North Lincolnshire and the surrounding area through the use of gridded emissions data obtained from the UK National Atmospheric Emissions Inventory. In addition, data on point source and road emissions, specific to Scunthorpe, were obtained from NLC. This enabled the contributions of sources distant and close to Scunthorpe to be assessed. Two emission scenarios were modelled: emissions in 2000 and in 2005. Predicted changes in road traffic flow for 2005 were obtained from NLC and predicted vehicle- and speed-specific emission factors were obtained from the London Research Centre (LRC) Emissions Factors Database.

The Airviro Gaus atmospheric dispersion model was applied to determine air concentrations of NO_2 in Scunthorpe as a whole and adjacent to specific road links. A grid nesting method was used to allow air concentrations to be combined from different modelling resolutions. Air concentrations were calculated for both the 2000 and 2005 emission scenarios, with the results from the year 2000 scenario also being used to validate the model against measured

data. Both the annual mean and 99.8th percentile objectives set out in the National Air Quality Strategy (NAQS) were assessed.

The results for the year 2000 emission scenario demonstrated that many roadside locations within Scunthorpe were currently at, or exceeding, the annual mean NAQS objective of 40 μg m^{-3}. The following areas were shown to have NO_2 concentrations above the NAQS objective:

- North east of the steelworks site
- The junction between Ashby Road and the A18 (Queensway)
- Britannia Corner
- The intersection of Brigg Road and Station Road
- The intersection of Queensway and Grange Lane

The air concentrations predicted for the year 2000 emission scenario were compared with the available monitoring data. All the model predictions were well within the ± 50 % limit suggested to be acceptable in the TG3 technical guidance (DETR 2000a). A model uncertainty of ± 7.5 μg m^{-3} was determined for the annual average objective and ± 30 μg m^{-3} for the 99.8th percentile of hourly concentrations objective.

The model predictions of the annual average air concentration for the 2005 emission scenario showed that none of the residential areas in Scunthorpe were likely to exceed the objective, though air concentrations of 40 μg m^{-3} were predicted to the north-east of the steelworks site. The following roadside locations were close to, or just exceeded the annual average objective level when the ± 7.5 μg m^{-3} uncertainty limits of the dispersion model was taken into consideration. As such, these roadside locations should be viewed as being at a low, but possible, risk of exceeding the NAQS objective.

- The intersection of Ashby Road and Queensway
- The intersection of Queensway and Grange Lane
- Within 50 m of Brigg Road.

Further monitoring and assessment should be considered at these sites to ensure that the NAQS objective will be met by 2005. This was identified as being particularly necessary as the large reductions in NO_x emissions from vehicles that are predicted to occur due to improvements in vehicle technology have not been observed so far in the Scunthorpe NO_2 monitoring data. In addition, the speed-related emissions factors for 2005 are currently under review by the DETR and further modelling using the new emissions factors may be necessary when they are issued.

None of the locations that were modelled were predicted to exceed the objective of 200μg m^{-3} set for the 99.8th percentile of hourly NO_2 air concentrations, even when a model uncertainty of ± 30 μg m^{-3} was included.

5 References

Derwent R G and Middleton D R 1996 An empirical function for the ratio $[NO_2]$:$[NO_x]$, Clean Air 26: 57-60.

DETR 2000a Review and assessment: selection and use of dispersion models (LAQM.TG3(00)).

DETR 2000b Review and assessment: pollutant specific guidance (LAQM.TG4(00)).

DETR 1999 Design Manual for Roads and Bridges, Vol 11, Section 3, Part 1, Air Quality.

Miller C W and Hively L M 1987 A review of validation studies for the Gaussian plume atmospheric dispersion model. Nuclear Safety 28(4): 522 – 531.

Pratt M and Dalton H 2000 A method for calculating short period concentration statistics from annual mean concentrations. Clean Air 30(3): 88-93.

SHMI 1997 Airviro: An integrated system for air quality management Airviro specification v2.20 Swedish Meteorological and Hydrological Institute, Sweden.

Table 1: National scale background concentrations used in the modelling assessment.

Year	**Background NO_x ($\mu g\ m^{-3}$)**
2000	20
2005	16

Table 2: Comparison of the predictions of annual average concentrations determined using the Airviro model with NO_2 monitoring of air concentrations in 2000.

Site	**X (m)**	**Y(m)**	**Measured ($\mu g\ m^{-3}$)**	**Modelled ($\mu g\ m^{-3}$)**	**Modelling Accuracy (%)**
Britannia Corner (PH)	489185	411341	56.0	42.5	-24
Britannia Corner (F1)*	489155	411355	28.9	38.8	+34
Britannia Corner (F2)	489164	411347	37.0	39.3	+6
Britannia Corner (F3)	489156	411347	37.0	39.0	+5
Sheffield Street	489100	411800	37.0	36.3	-2
West Common Lane	488372	409425	37.0	32.1	-13
Gloucester Avenue	489600	409200	32.0	34.1	+7
Mary Street	489350	411300	58.0	40.4	-30
Brigg Road	490119	411257	50.0	43.0	-14
Ashby Road	489233	410355	43.0	42.1	-2
Old Brumby Street	489109	409619	41.0	40.5	-1
Queensway	490600	409100	44.0	43.7	-1
Average			41.7	39.3	-6
RMS	7.5				

*Result from continuous monitoring device, other results are from diffusion tubes.

Table 3: Comparison between measured (2000) and modelled 99.8^{th} percentiles of hourly NO_2 concentrations at Britannia corner.

Site	**X (m)**	**Y (m)**	**Measured ($\mu g\ m^{-3}$)**	**Modelled ($\mu g\ m^{-3}$)**	**Modelling Accuracy (%)**
Britannia Corner (F1)	489155	411355	108.16	127.3	+ 18

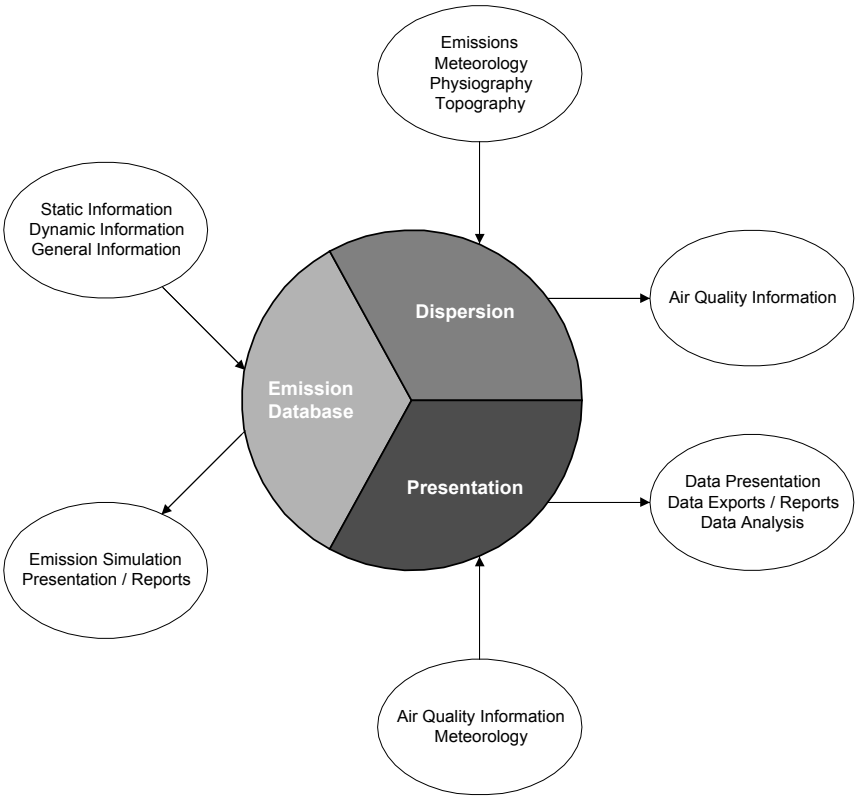


Figure 1: Schematic diagram of the Airviro system.

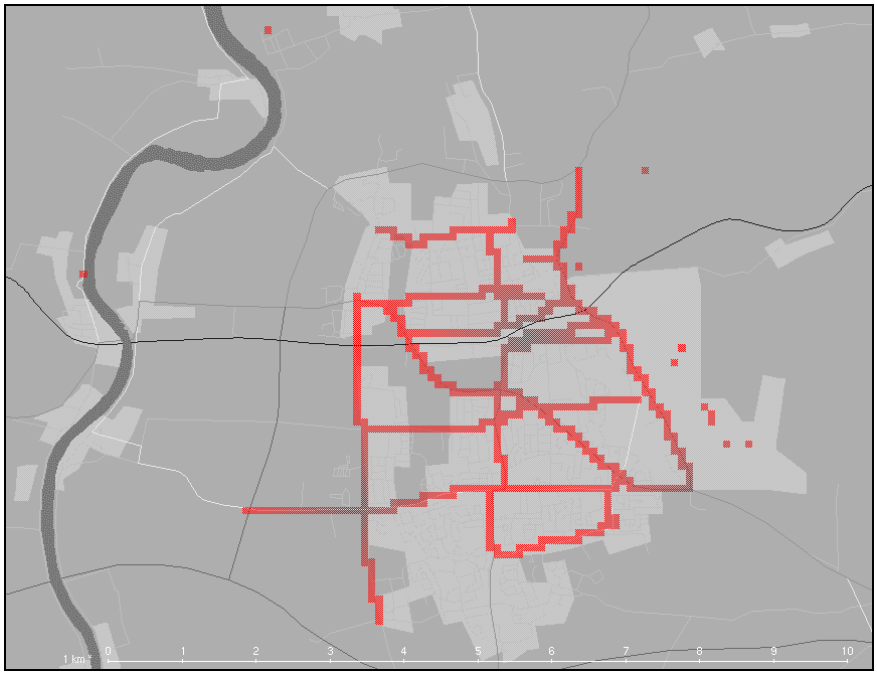


Figure 2: Point and road sources included in the North Lincolnshire Emissions database.

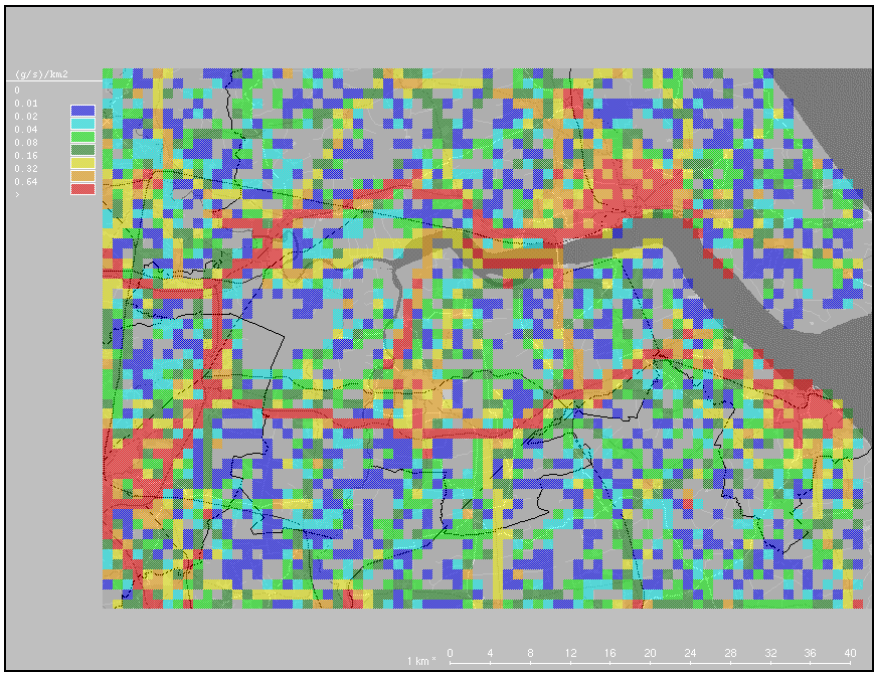


Figure 3: National Atmospheric Emissions Inventory grid sources included in the North Lincolnshire Emissions database.

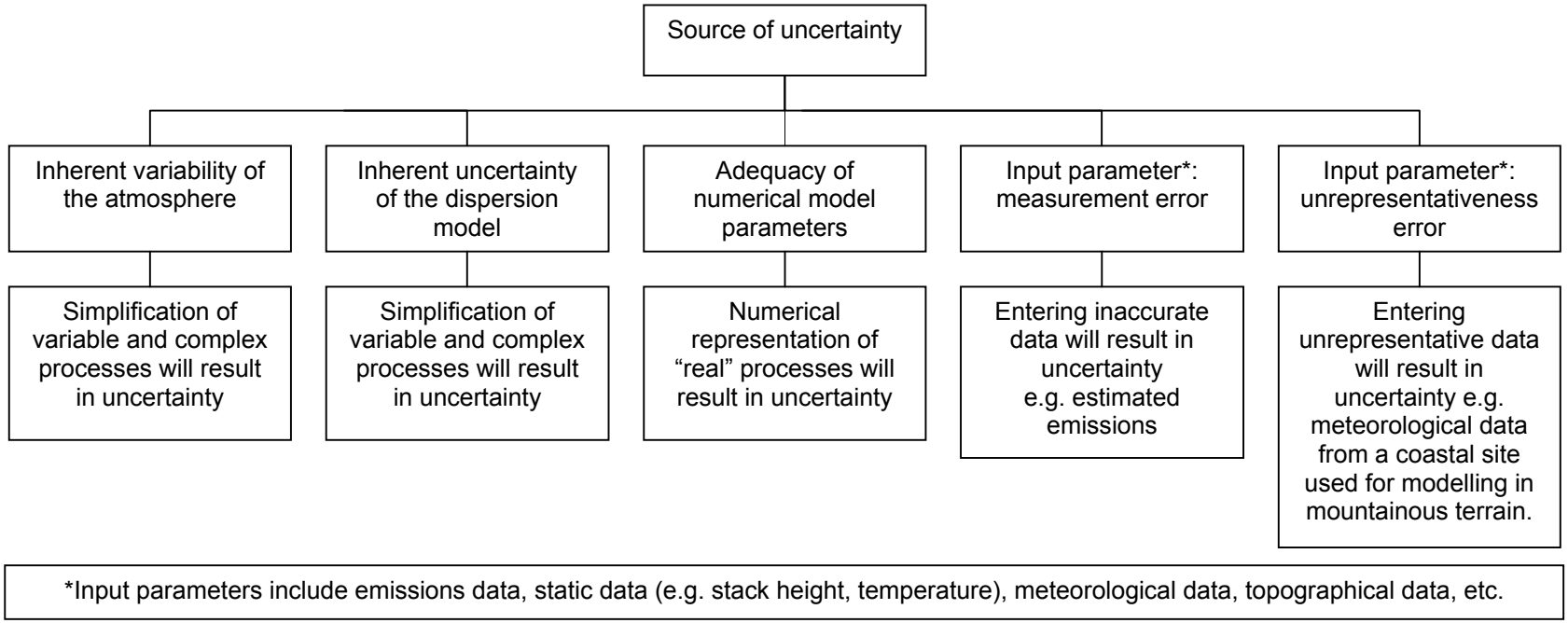


Figure 4: Sources of uncertainty in dispersion modelling.

Appendix A Contour plots of the dispersion modelling results

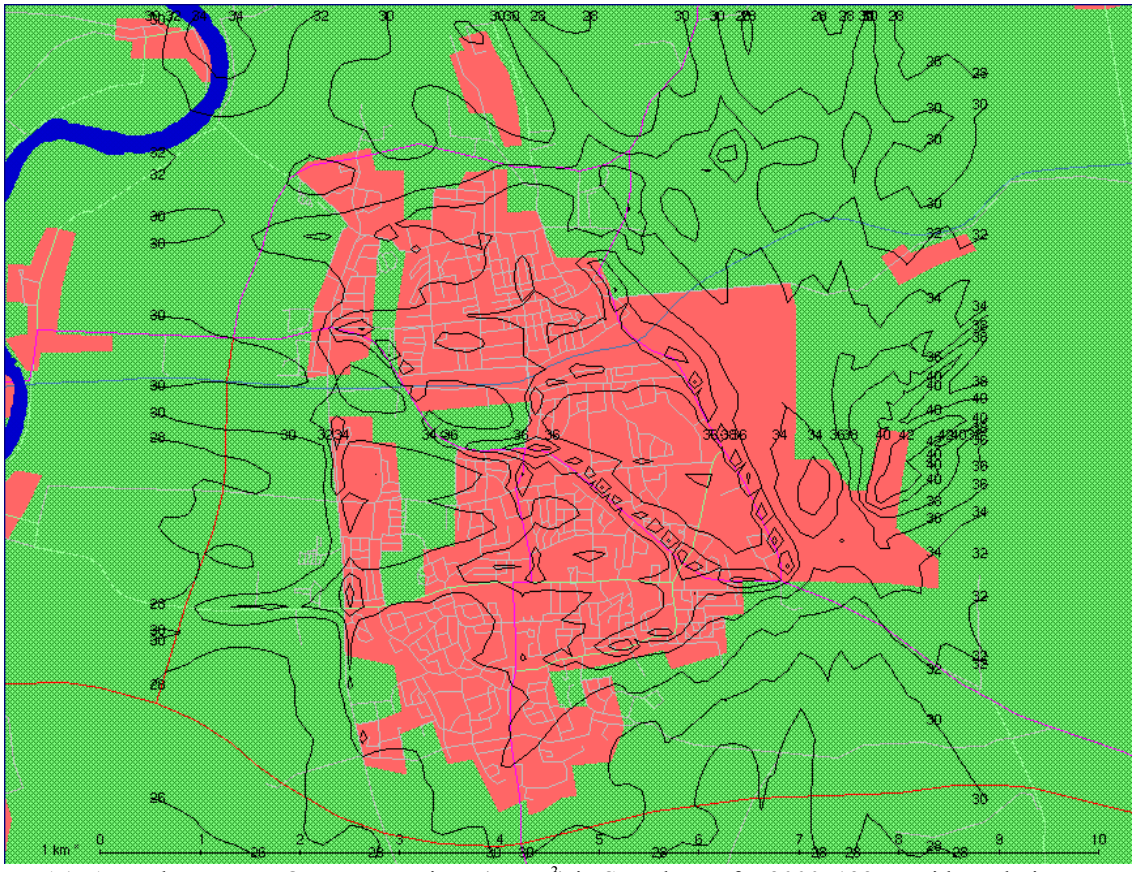


Figure A1: Annual average NO_2 concentrations (µg m^{-3}) in Scunthorpe for 2000. 133 m grid resolution.

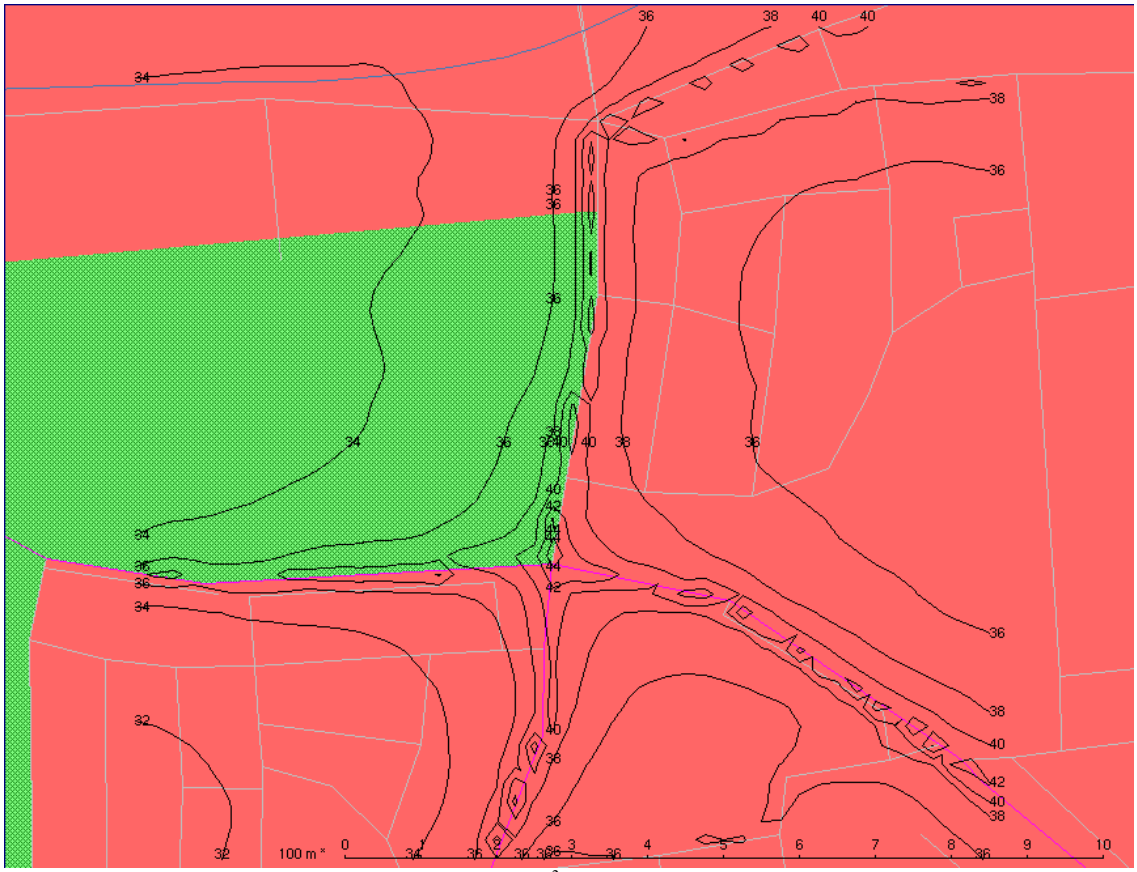


Figure A2: Annual average NO_2 concentrations (µg m^{-3}) around Ashby road for 2000. 25 m grid resolution.

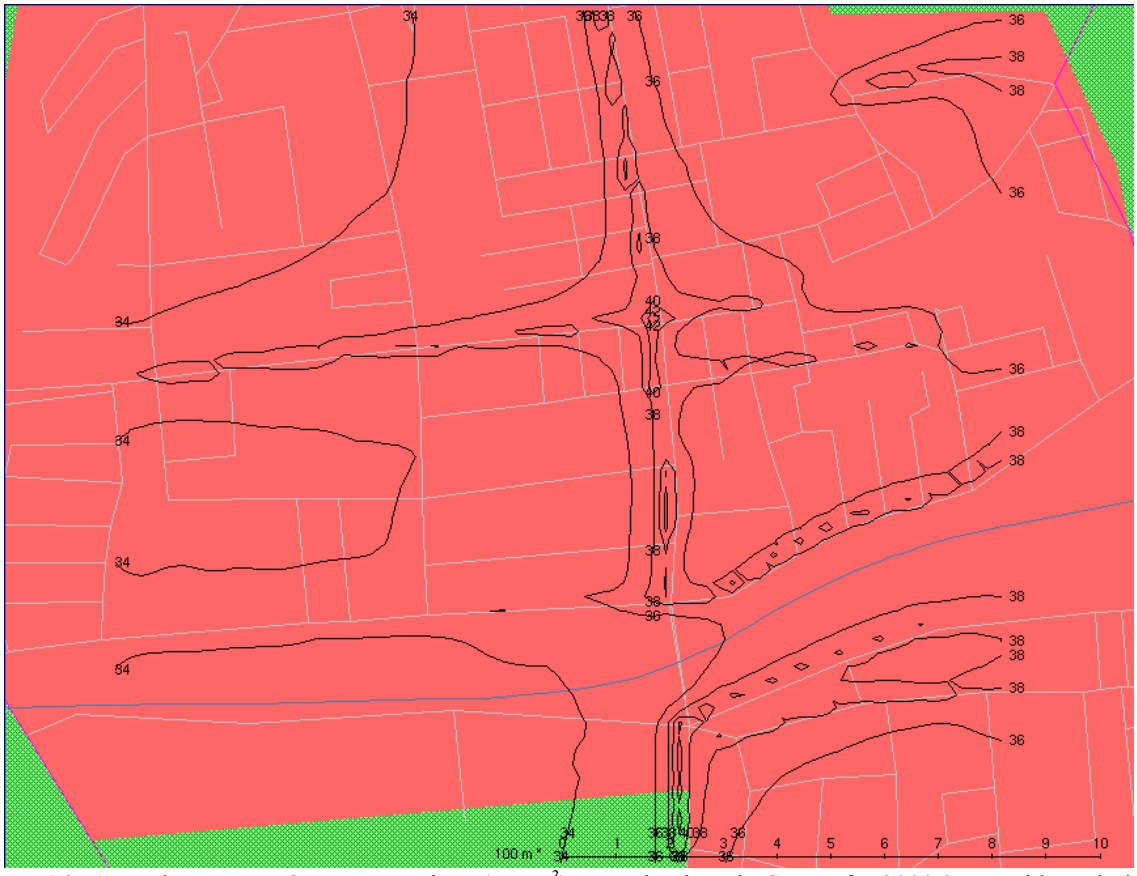


Figure A3: Annual average NO_2 concentrations (µg m^{-3}) around Britannia Corner for 2000.25 m grid resolution.

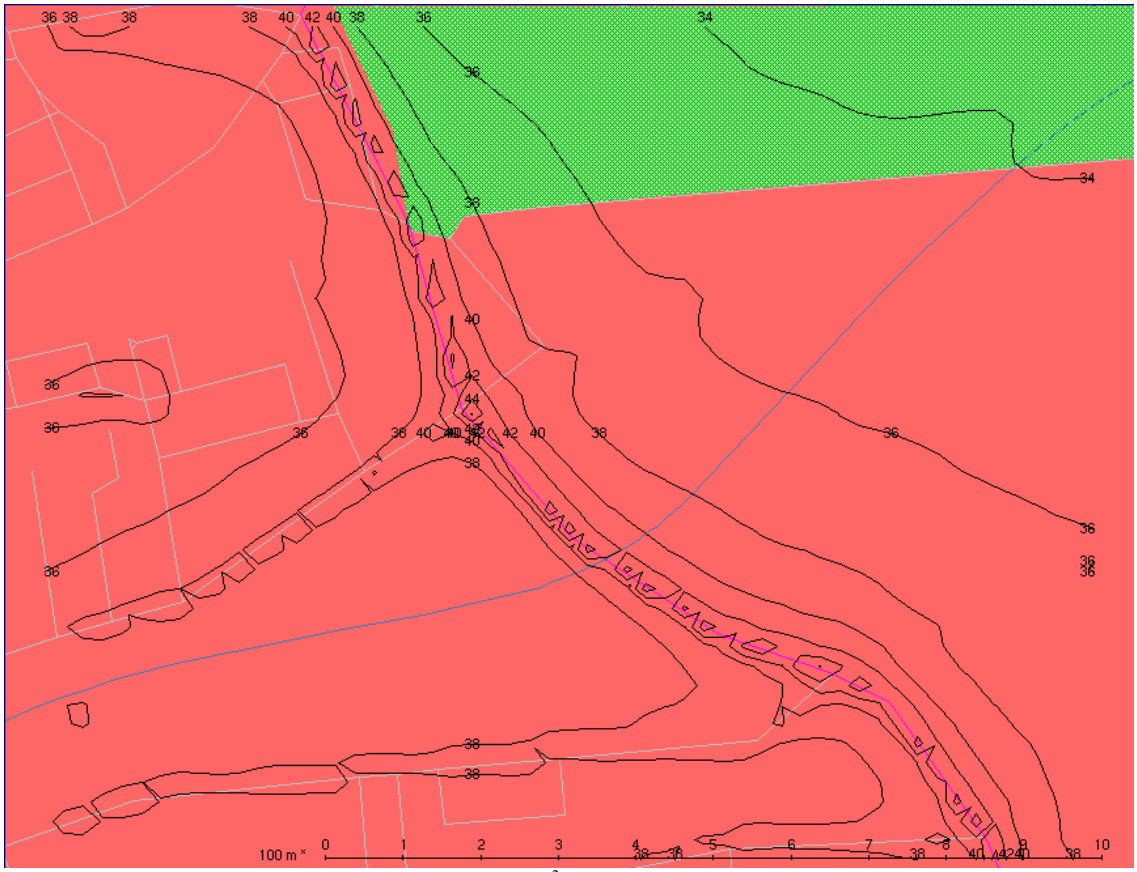


Figure A4: Annual average NO_2 concentrations (µg m^{-3}) around Brigg Road for 2000. 25 m grid resolution.

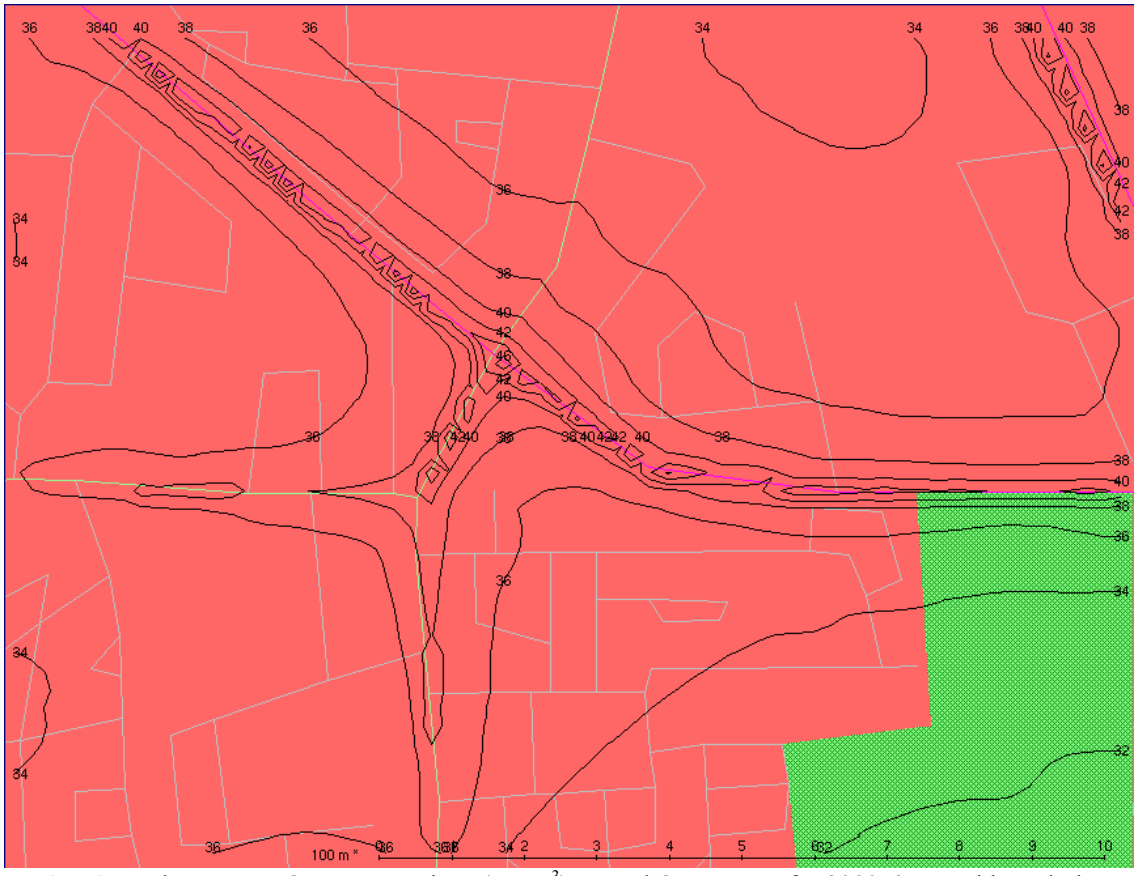


Figure A5: Annual average NO_2 concentrations (µg m^{-3}) around Queensway for 2000. 25 m grid resolution.

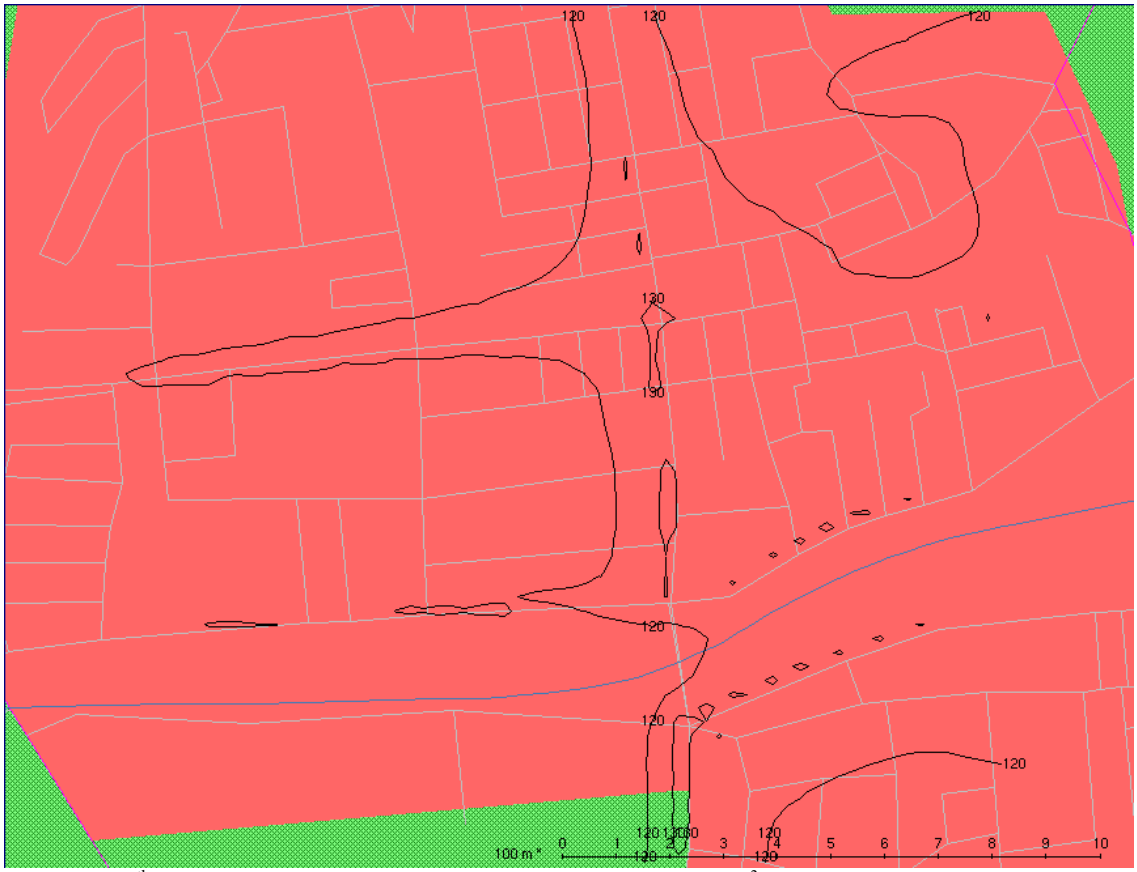


Figure A6: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) around Britannia Corner for 2000. 25 m grid resolution.

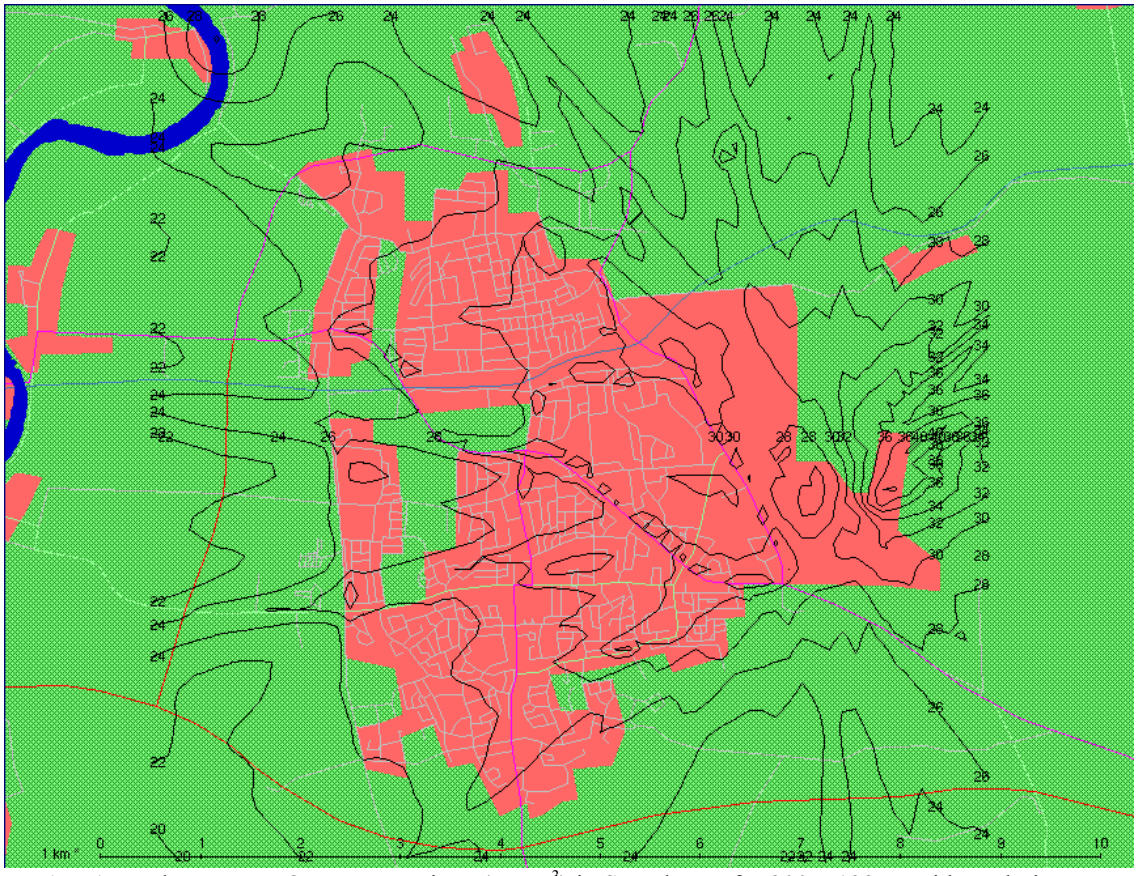


Figure A7: Annual average NO_2 concentrations (µg m^{-3}) in Scunthorpe for 2005. 133 m grid resolution.

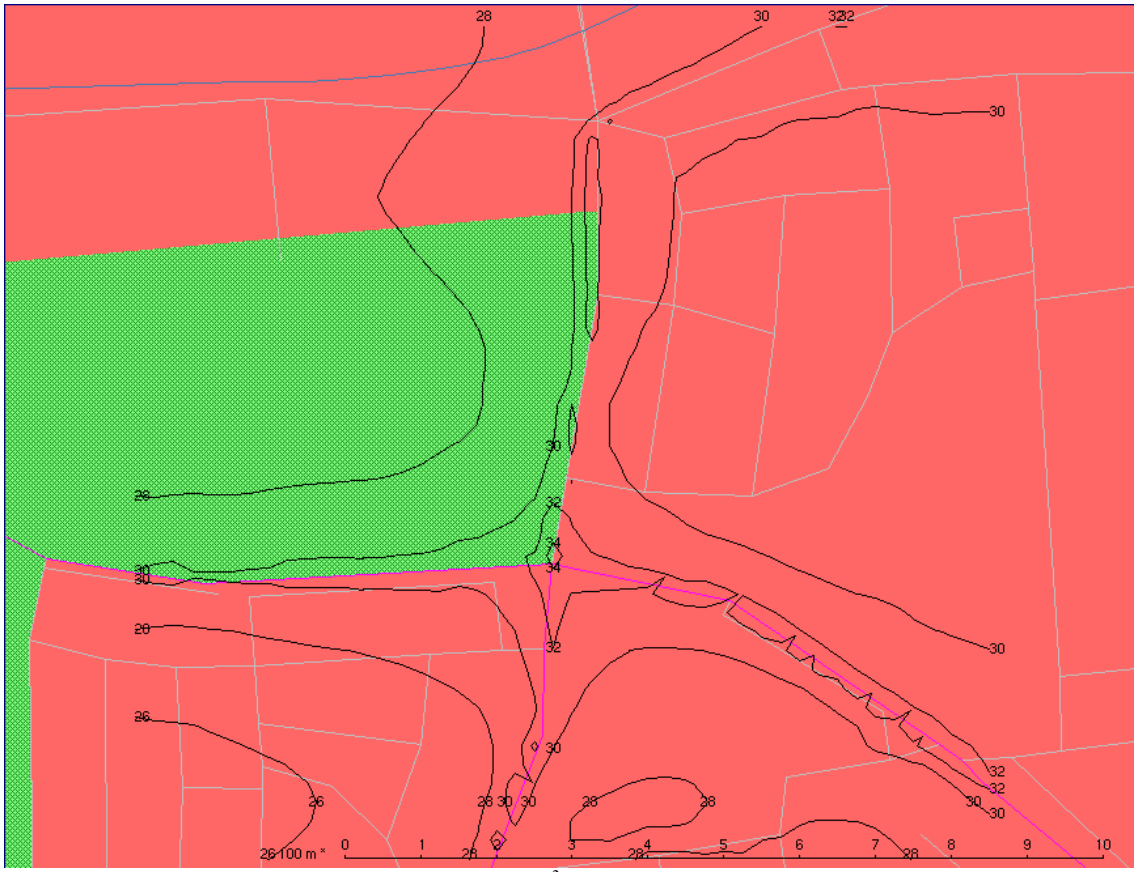


Figure A8: Annual average NO_2 concentrations (µg m^{-3}) around Ashby road for 2005. 25 m grid resolution.

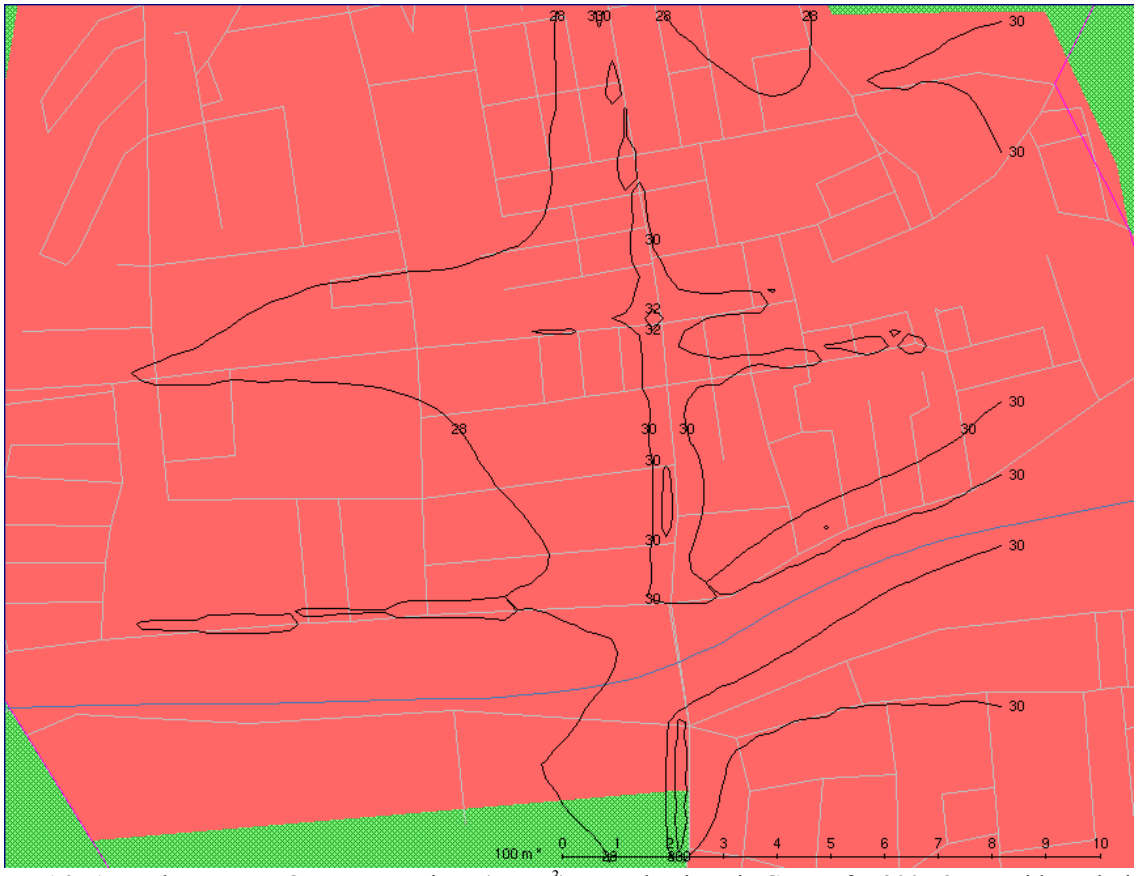


Figure A9: Annual average NO_2 concentrations (μg m^{-3}) around Britannia Corner for 2005.25 m grid resolution.

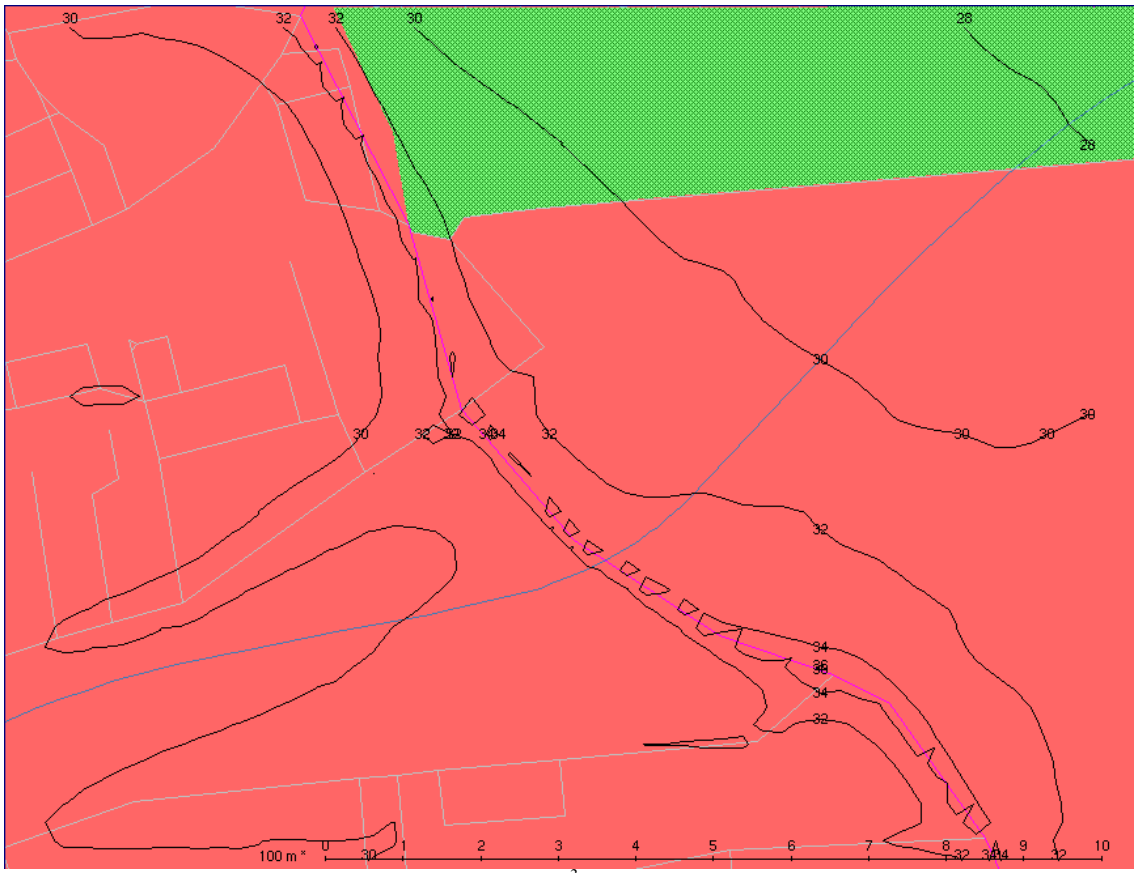


Figure A10: Annual average NO_2 concentrations (□g m^{-3}) around Brigg road for 2005. 25 m grid resolution.

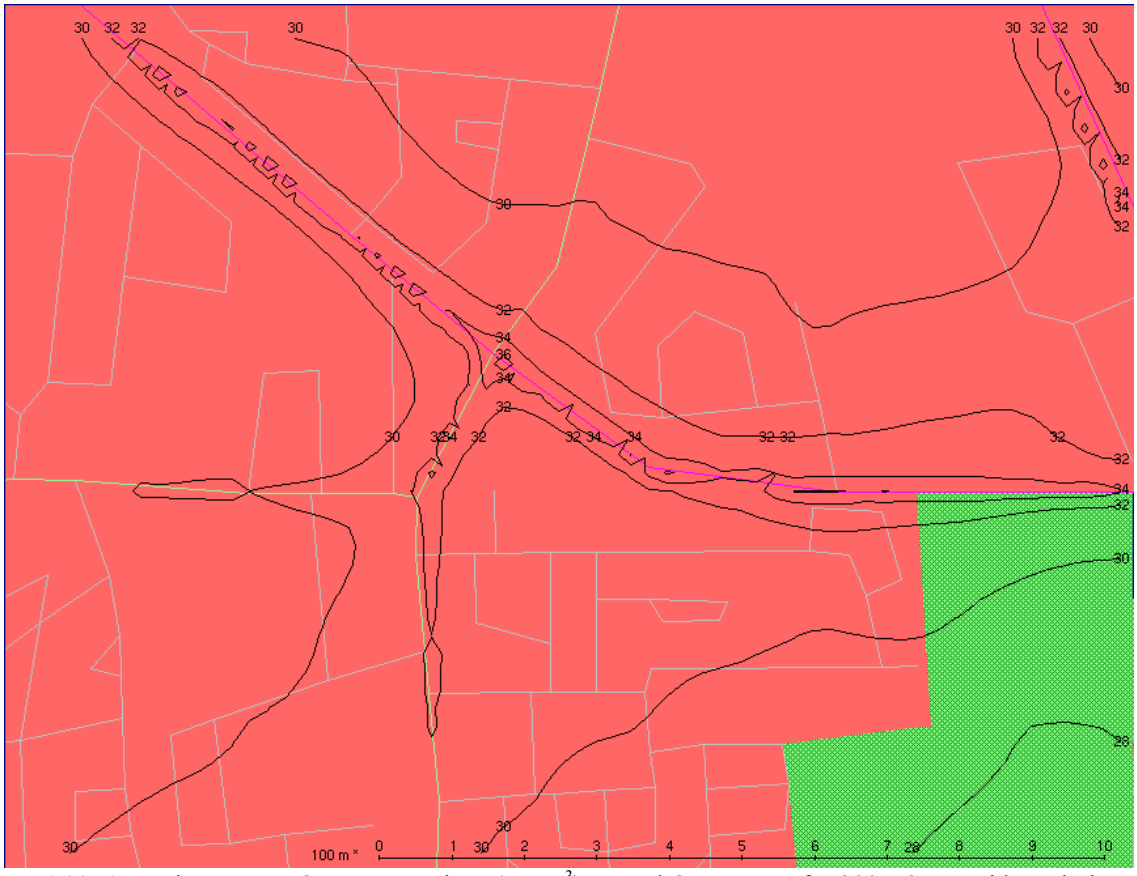


Figure A11: Annual average NO_2 concentrations (µg m^{-3}) around Queensway for 2005. 25 m grid resolution.

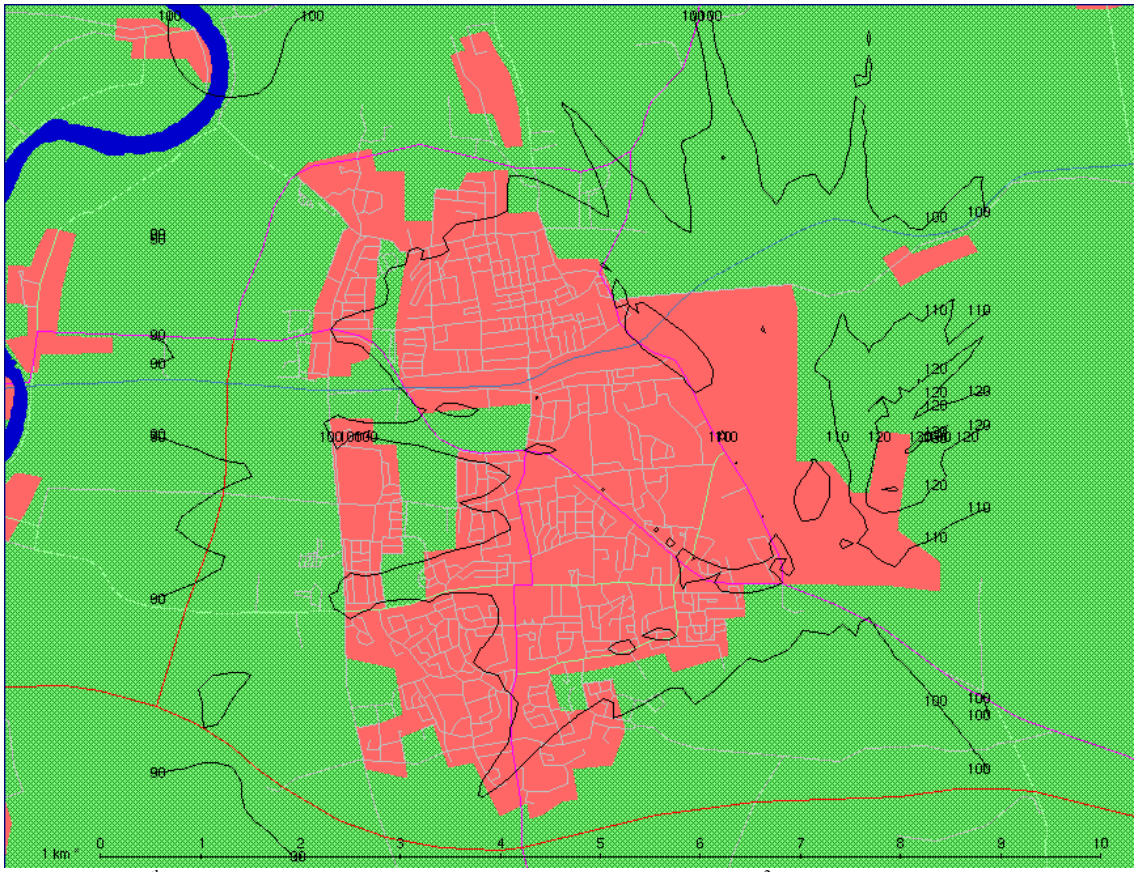


Figure A12: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) in Scunthorpe for 2005. 133 m grid resolution.

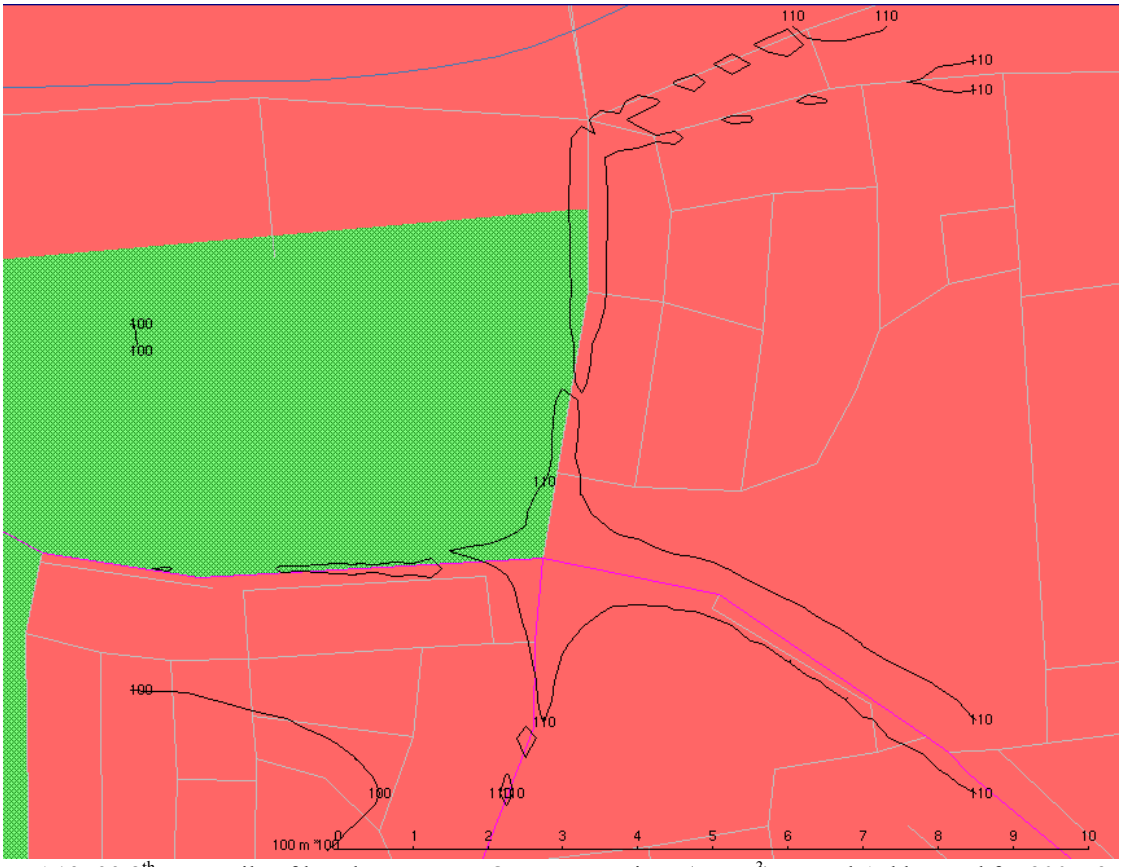


Figure A13: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) around Ashby road for 2005. 25 m grid resolution.

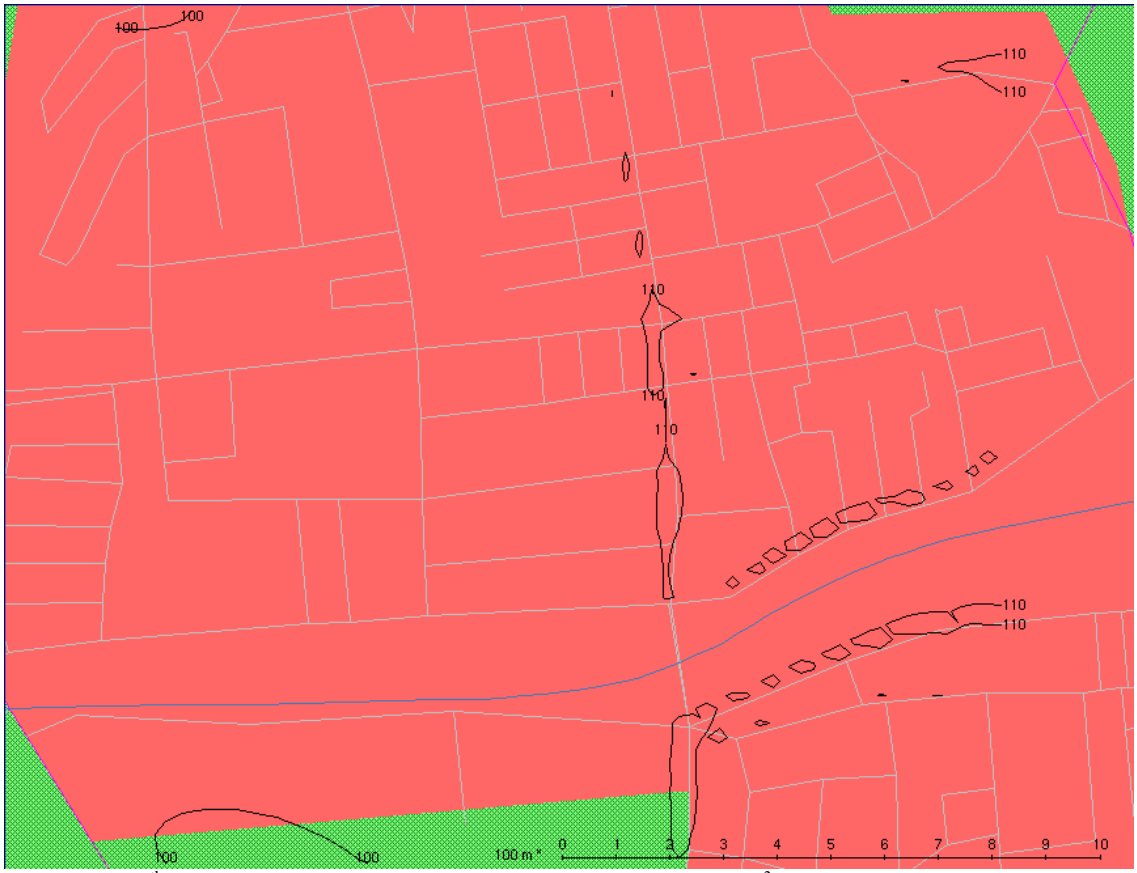


Figure A14: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) around Britannia Corner for 2005. 25 m grid resolution.

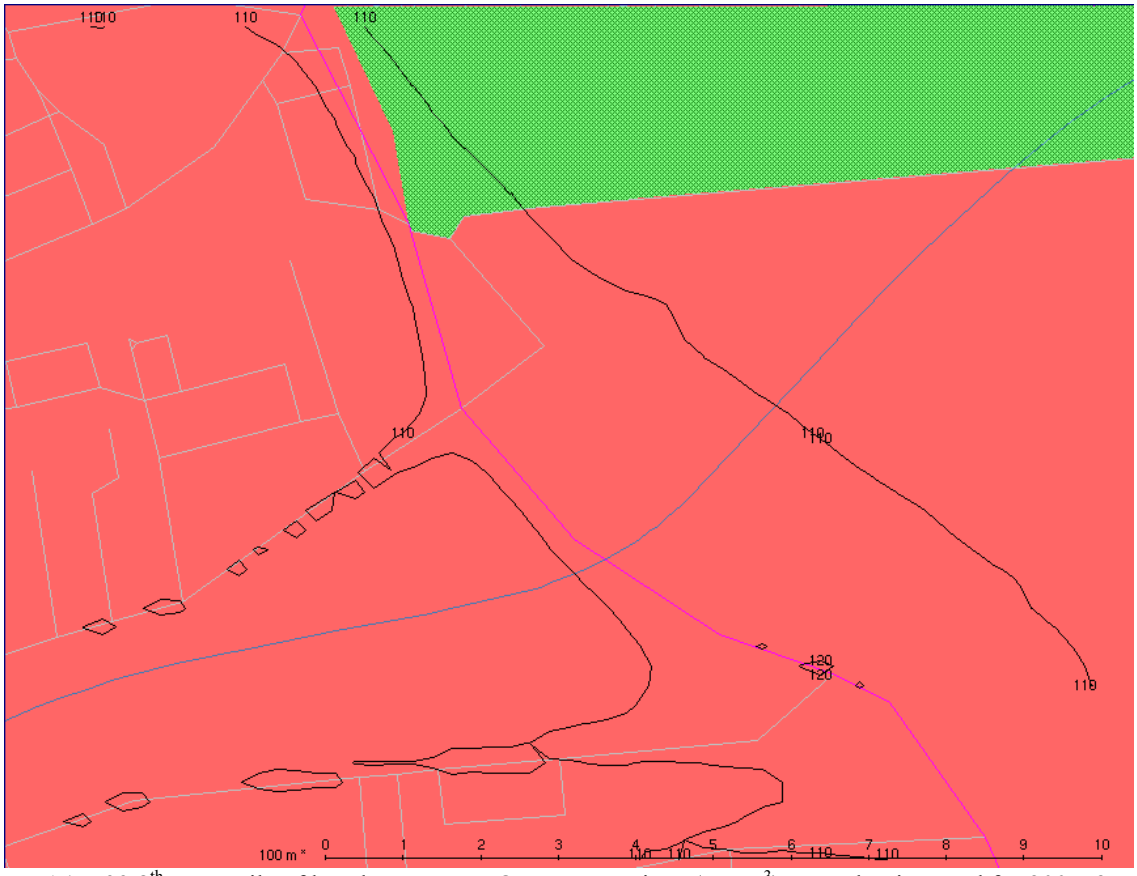


Figure A15: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) around Brigg road for 2005. 25 m grid resolution.

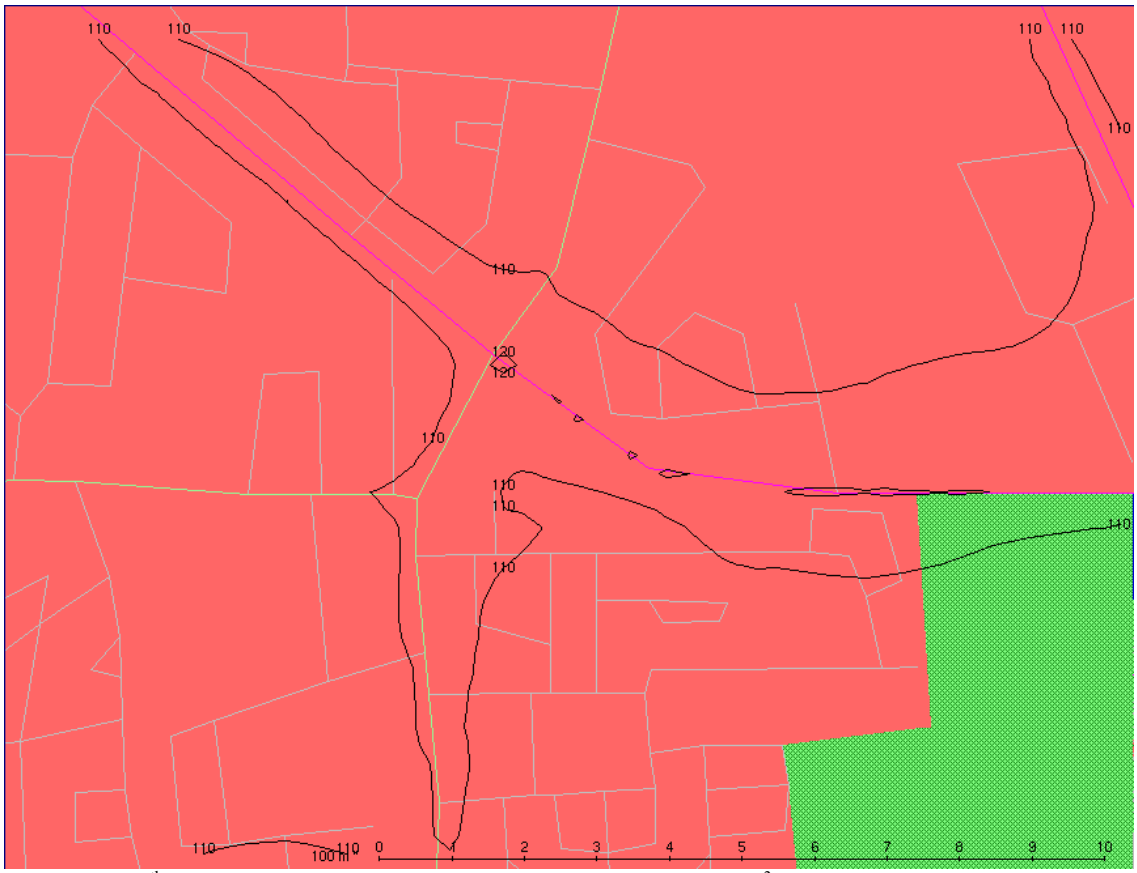


Figure A16: 99.8th percentile of hourly average NO_2 concentrations (µg m^{-3}) around Queensway for 2005. 25 m grid resolution.

Appendix B Assumptions/Estimations in the Scunthorpe Airviro Emissions Database (EDB)

1. Road Traffic Sources

Data on the average speed of traffic, the annual average daily traffic flow (2000 and 2005) and the percentage of HGVs on each road section were taken from the data supplied by NLC.

2. Time, fleet and road type variations

Six different road types were created for the Scunthorpe EDB. These road types were named as follows:

1 – 5 % HGV	6 – 10 % HGV	11 – 15 % HGV
16 – 20 % HGV	21 – 25 % HGV	26 – 35 % HGV

The diurnal variation in traffic flows on roads in the Scunthorpe EDB were taken from a generic data set and were assumed to be the same for every vehicle type and every road type. Monthly variations in traffic flow were not incorporated into the Scunthorpe EDB due to a lack of data.

Predicted annual increases in traffic flow were assumed to be the same as those provided in data supplied by NLC. For the validation EDB the year 2000 traffic flows were used and for the modelling EDB the projected 2005 traffic flows were used.

Each road type was assigned a fleet composition. National fleet composition figures from the DETR web-site were used from which an average fleet composition for all road types has been calculated (see Table B1). The DETR percentages of petrol vs. diesel vehicles were used. The Transport Research Laboratory percentages of rigid vs. articulated HGVs, based on data from the DETR were used. Table B2 shows the national fleet composition based on DETR data adjusted for the percentages of petrol and diesel cars and rigid and articulated HGVs. This generic fleet composition (Table B2) was then adjusted for the measured percentages of HGVs on the different road types in Scunthorpe.

Table B1: National fleet composition based on data from the DETR.

Vehicle type	All roads (DETR)
Cars	82%
Light vans	9%
Goods Vehicles	7%
Other motor vehicles	2%
Total	100%

Table B2: National fleet composition adjusted for the percentages of petrol and diesel vehicles and the percentages of rigid and articulated HGVs.

Vehicle type	All roads – adjusted for % petrol and diesel vehicles and % rigid and articulated HGVs (DETR info.)
Petrol cars	72%
Diesel cars	10%
Petrol LGV*	7%
Diesel LGV*	2%
Rigid HGV†	5%
Articulated HGV†	2%
Buses	1%
Motorcycles	1%
Total	100%

* Percentages of petrol and diesel vehicles were obtained from the DETR

† The proportion of rigid to articulated HGVs was obtained from the Transport Research Laboratory and is derived from DETR 1999 data.

3. Point Sources

Emission rates of NO_x and static data (e.g. stack height, stack diameter etc) for the point sources identified as being significant to the air quality in Scunthorpe were obtained either from the Environment Agency web-site, or from data supplied by NLC and from the process operators themselves. No assumptions had to be made. Emissions of NO_x were entered as annual average emissions and were assumed to be emitted at a constant rate rather than varying throughout the day or year.

4. Grid Sources

In order to include a large number of small sources, for which emissions data are often unavailable and which would be very time consuming to enter into the emissions database individually, grid sources were used. These grid sources use information from the National Atmospheric Emissions Inventory (NAEI) and provide a means of including emissions from numerous small sources or widely dispersed sources such as minor roads, railways, residential areas, small industry and coal burning. In order to avoid overlap with the point and road sources that were entered individually into the emissions database, the gridded data were edited where the individual source had already been entered.

Appendix C Conversion of NO_x to NO_2 and calculation of the 99.8th percentile of hourly mean concentrations from annual average concentrations

1. Chemical conversion of NO_x to NO_2

Annual mean concentrations of NO_2, $\chi_A\{NO_2\}$, were calculated from annual mean concentrations of NO_x, $\chi_A\{NO_x\}$, using the Derwent-Middleton function, Equation C1 (Derwent and Middleton, 1996). Concentrations of NO_x arising from all the sources (including background) were totalled before applying Equation C1. The original values for coefficients *a*, *b*, *c*, *d* and *e*, that were calculated for input and output in ppb, are shown in Table C1 along with the recalculated coefficients for input and output in μg m^{-3}.

$$\chi_A\{NO_2\} = a - \chi_A\{NO_x\}(b - cA_{10} + dA_{10}^{\ 2} - eA_{10}^{\ 3}) \qquad \text{Equation C1}$$

Where $A_{10} = \log_{10}[\chi_A\{NO_x\}]$

Table C1: Coefficients for calculating air concentrations of NO_2 from air concentrations of NO_x using Equation C1.

Coefficient	Input and output in ppb	Input and output in μg m^{-3}
a	2.166	4.13706
b	1.236	2.6415
c	3.348	5.2559
d	1.933	2.652
e	0.326	0.4058

2. Calculation of the 99.8th percentile of hourly NO_2 concentrations

The 99.8th percentile of hourly NO_2 concentrations, $\chi_S\{NO_2\}$, was calculated from the annual mean NO_x concentration, $\chi_A\{NO_x\}$, using the surrogate statistics derived by Pratt and Dalton (2000), shown as Equation 2. The coefficients f and g referred to in Equation C2 are detailed in Table C2.

$$\chi_S\{NO_2\} = (f\ \chi_A\{NO_x\}^g) \qquad \text{Equation C2}$$

Table C2: Coefficients for calculating the 99.8 percentile of hourly mean NO_2 concentrations from the annual mean concentration of NO_x.

Coefficient	Input and output in ppb	Input and output in μg m^{-3}
F	12.8365	18.327
G	0.4604	0.4794

Appendix 2

Tables

Table 6 -
Input Data for Point Sources

Company	Co-ordinates		Authorisation Number	Height (m)	Diameter (m)	Gas Temp. (^{o}C)	NOx Emission Rate (tonnes/yr)
	X	Y					
Keadby Generation Ltd	483500	411500	AB4745	50	0.75	442	1031.1
Fibrogen Ltd	486000	414800	AA3905	38	0.80	200	59.4
Transco	488900	404200	AF7410	14	1.68	520	68.9
Koppers UK Ltd - A12 and A15	490200	411600	AU8296	27	1.00	294	4.446
Koppers UK Ltd - A17	490202	411600	AU8296	17	1.10	280	0.523
Koppers UK Ltd - A72	490203	411600	AU8296	36	1.00	240	12.24
Edinburgh Oil and Gas PLC	491100	412900	AF6871	8	0.4	300	10.0
Corus (Rod Mill)	491500	410300	AF7207	69	2.42	572	72.0
Corus (Iron and Steel - Blast furnaces)	491610	410520	AR0080	61	2.67	240	167.0
Corus (Iron and Steel - 1+2 warm up stacks)	491950	409740	AR0080	40	1.37	600	4.0
Corus (Coke Ovens - Dawes Lane Main Stack))	492000	409500	AF7193	76	3.35	200	881.0
Corus (Central power station)	492001	409500	AA2216	96	3.80	400	262.0
Corus (Coke Ovens - Dawes Ln Ammonia Incintr)	492001	409501	AF7193	56	1.75	760	27.0
Corus (Turbo blower house x 2)	492002	409500	AA2216	76	4.20	200	45.6
Corus (Coke Ovens - Appleby 1+2 main stack)	492002	409502	AF7193	74	3.00	230	136.0
Corus (Coke Ovens - Appleby 3+4 Main Stack)	492003	409503	AF7193	74	3.00	160	111.0
Corus (Iron and Steel- Sinter plant main stack)	492050	409660	AR0080	107	6.40	165	4767.0
Corus (Heavy Plate Mill - G Reheater)	492254	409294	AF7207	18	1.00	132	22.0
Corus (Heavy Plate Mill - J Reheater)	492255	409295	AF7207	47	2.30	362	73.0
Corus (Bloom and Billet Mill Soaking Pits)	492500	409290	AF7207	43	1.40	553	129.0
Corus (Bloom and Billet Mill Soaking pit E12)	492501	409291	AF7207	43	1.40	59	9.0
Corus (Medium Section Mill - furnaces 1+2)	492502	409292	AF7207	55	2.80	199	78.0
Corus (Heavy Section Mill - WBF)	492503	409293	AF7207	60	2.74	425	70.0
Corus (Heavy Plate Mill - K Reheater)	492506	409296	AF7207	55	2.30	495	73.0
Corus (Heavy Plate Mill - N1 normaliser)	492507	409297	AF7207	17	1.20	102	0.3
Corus (Heavy Plate Mill - N3 normaliser)	492508	409298	AF7207	43	1.40	311	17.0

Table 7 -
Input Data for Line Sources

Road	AADT 2000	AADT 2005
Ashby Road	18722	18852
Ashby High Street	10986	11904
Brigg Road	18816	20661
Burringham Road	9556	11007
Chancel Road	8936	8529
Church Lane	6615	6892
Doncaster Road	9991	10306
East Common Lane	7283	7897
Ferry Road	6632	6001
Frodingham Road	15393	17263
Grange Lane South	18347	23072
Messingham Road	10126	10312
Normanby Road	18571	18739
Oswald Road	13901	13582
Phoenix Parkway	16356	20442
Queensway	19080	23195
Rowland Road	9956	10997
Scotter Road	18283	21829
Station Road	9985	9455
West Common Lane	5806	6262
Winterton Road	7104	7623

Table 8 -
NO_2 Diffusion Tube Data - 2000

Month	Britannia Corner (PH) SC/W/1	Britannia Corner F/2	Britannia Corner F/3	Sheffield Street SC/W/2	West Common Lane SC/W/3	Gloucester Avenue SC/W/4	Mary Street E/1	Brigg Road E/2	Ashby Road E/3	Old Brumby Street E/4	Queens-way E/6
January	75	NR	NR	49	49	47	89	64	NR	57	NR
February	62	NR	NR	37	36	34	61	45	46	55	NR
March	59	39	37	42	39	35	62	53	52	42	56
April	53	38	NR	38	31	35	60	46	41	47	35
May	51	41	43	29	30	27	44	46	38	41	36
June	41	NR	31	25	NR	13	46	37	NR	29	31
July	41	23	34	26	NR	23	42	43	28	37	34
August	55	43	38	34	32	25	50	50	38	41	39
September	54	21	40	36	35	35	53	50	29	NR	45
October	55	45	24	36	NR	NR	75	53	44	42	60
November	76	47	46	48	38	40	67	61	58	12	61
December	51	27	44	42	41	43	52	52	52	51	NR
Average	**56**	**37**	**37**	**37**	**37**	**32**	**58**	**50**	**43**	**41**	**44**

Carried out by Rotherham Met. Boro' Council – Env. Health Lab. Services
Units NO2 Concentration in $\mu g/m^3$
Note NR = Tube not returned

Appendix 3

QA/QC

Britannia Corner Monitoring Station

- The monitoring station located at Britannia Corner is equipped with a continuous Nitrogen Dioxide monitor supplied by Signal Ambitech. The monitor uses the chemiluminesence principle of detection. In this the real time chemiluminescent NO_x analyser uses chemiluminescent energy emitted when NO reacts with Ozone (O_3) in an evacuated chamber forming chemiluminescent Nitrogen Dioxide (NO_2). The chemiluminescent reaction is –

  $$NO + O_3 = NO_2 + e + O_2 \quad \text{where e = chemiluminescent energy}$$

  Light from the chemiluminescent NO_2 is incident upon a photomultiplier tube and amplifier that converts the light signal into a voltage. The strength of the analogue output voltage from the photomultiplier is proportional to the concentration of NO in the reaction chamber. One stream passes directly into the reaction chamber to measure the NO concentration whilst the other first passes through a heated molybdenum catalyst which reduces NO_2 to NO. The photomultiplier output is now proportional to the total Oxides of Nitrogen (NO_x). The Nitrogen Dioxide concentration in the ambient sample is determined from the NO_x and NO voltages by subtraction.

- Service and maintenance of the monitoring station is carried out by Signal Ambitech on behalf of the Authority. The site is serviced every six months together with remote maintenance check and reviews of the system conducted via remote PC access.

- The monitor is manually calibrated at fortnightly intervals using zero air and 500ppb Nitrous Oxide in Nitrogen calibration gas. In addition the analyser performs a daily self-calibration routine. The results of both are logged and stored.

- The calibration gas used is supplied by Messer UK Ltd and is certified and traceable.

- The data obtained from the monitoring station is ratified by applying the calibration and manual calibration zero and span factors and excluding from consideration any data affected by calibration procedures or abnormal circumstances such as power failures etc.

Nitrogen Dioxide Diffusion Tube Network

- **Introduction**

  Four of the diffusion tube sites within North Lincolnshire are also part of the UK Nitrogen Dioxide Diffusion Tube Network. This network provides the DETR with information on the spatial and temporal distribution of NO_2 in the UK urban environment. It is important that data from the network is of the highest possible quality. To ensure this laboratory performances are assessed on the basis of both the Workplace Analysis Scheme for Proficiency (WASP).

- **Workplace Analysis Scheme for Proficiency**

  WASP involves a monthly analysis of doped tubes, allowing assessment of overall uniformity of data throughout the year. Performance scores are assigned to the reported analysis results, on the basis of their difference from the known concentration of the analyte and the actual standard deviations.

  Results are classified as follows –

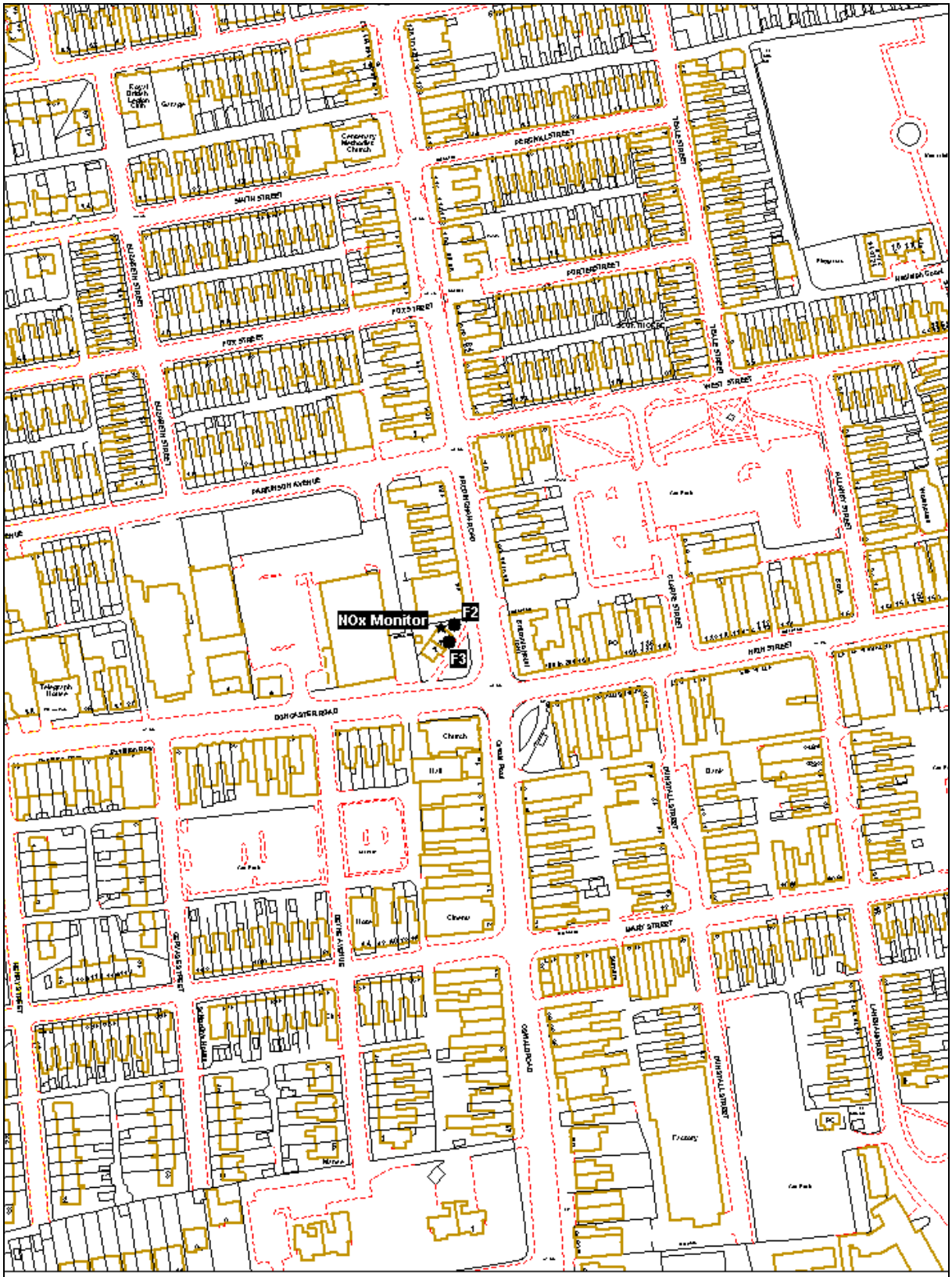
Good	$\leq$ 2 Standard deviations from true analyte concentration.
Warning	2 - 3 Standard deviations from true analyte concentration.
Action	$\geq$ 3 Standard deviations from true analyte concentration.

  North Lincolnshire Council employs Rotherham Metropolitan Borough Council Environmental Health Laboratory to analyse all the diffusion tubes located within the Authority. This laboratory's performance classification under WASP is ***Good;*** therefore results from North Lincolnshire Council's diffusion tube network can be used with confidence.

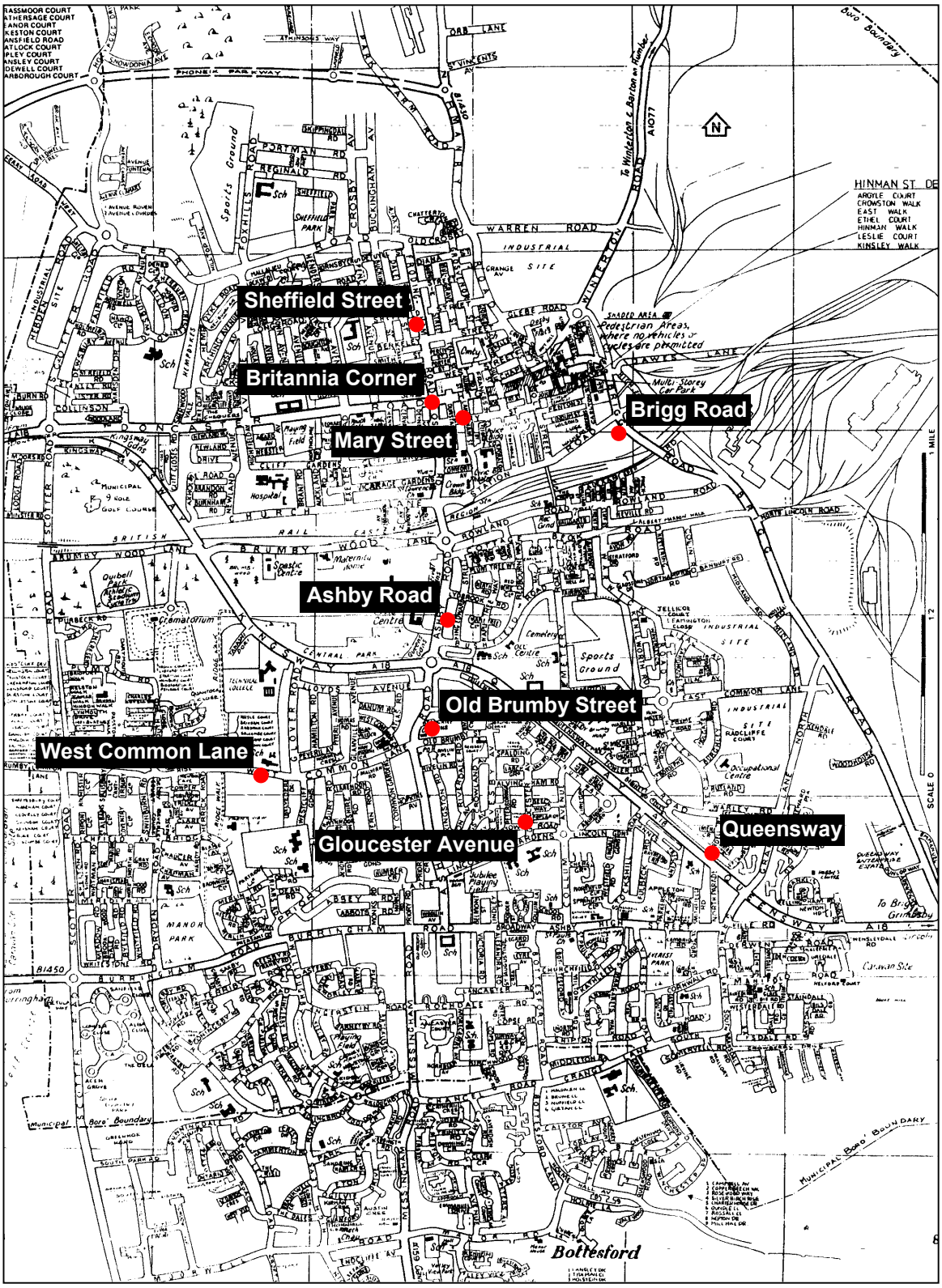
Appendix 4

Maps

Britannia Corner Monitoring Station Location



Diffusion Tube Locations, Scunthorpe


Sheffield Street
Britannia Corner
Mary Street
Brigg Road
Ashby Road
Old Brumby Street
West Common Lane
Gloucester Avenue
Queensway
Bottesford

Appendix 5

Glossary Of Terms

Glossary of Terms

AQMA	Air Quality Management Area. A legally defined area identified as one in which the statutory Air Quality Objectives will not be met. An action plan must be drawn up to improve air quality.
Air Quality Objective	An air quality standard that includes a date by which it must be achieved.
Air Quality Standard	The maximum acceptable level of a pollutant in the air that will not present a risk to the health of the most susceptible groups in the population.
Average Time	The period of time over which a pollutant level must be measured and the average result calculated. This can be a different period for each pollutant and directly affects which locations can be considered relevant.
C_6H_6	Benzene.
CO	Carbon Monoxide.
DETR	Department of Environment, Transport and the Regions. The Government department responsible for U.K. air quality.
Diffusion Tube	A simple, cheap monitoring device. Can be subject to inaccuracies and can only be used to measure Air Quality Objectives over longer time periods such as year. Relatively cheap compared to continuous analysers so a larger number can be used.
Dispersion Model	A computer program which uses emissions inventory data and meteorological data to predict the concentration and distribution of pollutants in the atmosphere.
Emissions Inventory	A catalogue of the sources of a pollutant in an area, with information about their positions and the quantities emitted. Used in dispersion models.
EPAQS	The Expert Panel on Air Quality Standards. The U.K. group appointed by the government to set standards for maximum acceptable levels of pollutants.
Exceedence	Any period of time where the concentration of a pollutant is greater than the appropriate Air Quality Standard.

Fugitive Emissions	Emissions of pollutants from a vent point other than a stack.
$\mu g/m^3$	Micrograms per cubic metre.
mg/m^3	Milligrams per cubic metre.
NAQS	National Air Quality Strategy.
NO	Nitrogen Oxide.
NO_2	Nitrogen Dioxide.
NO_X	Oxides of Nitrogen.
Part A Processes	An industrial process that is required to obtain authorisation from the Environment Agency. Regulation of the emissions to air is included in the authorised document.
Part B Processes	An industrial process that is required to obtain authorisation from the local authority in order to operate. Regulation of the emissions to air is included in the authorised document.
Particulates	Particles so small that they are suspended in the atmosphere, usually invisible, and small enough to be breathed in.
Pb	Lead.
Percentile	The percentage of items in a set of data lying above or below a particular value, e.g. concentration of a pollutant. For example for Nitrogen Dioxide the hourly mean of $200\mu g/m^3$ can be exceeded up to 18 times a year. This is the equivalent of the 99.8^{th} percentile being less than $200\mu g/m^3$ because in one year there are 8760 hours of which 18 hours are 0.2% so 99.8% must be lower than the objective.
PM_{10}	Particulate matter less than 10 microns (millionths of a metre) in diameter.
Ppb	Parts per billion.
ppm	Parts per million.

QA/QC	Quality Assurance/Quality Control. Procedures to ensure that data from pollutant monitoring equipment is representative of the site with good accuracy, precision and data capture.
Relevant Locations	These can differ for each pollutant according to the averaging period considered. Relevant locations are those areas where the public might reasonably be exposed to a pollutant over its averaging time. Long averaging times such as a year mean relevant locations could include schools, houses, hospitals etc. Short averaging times widen the scope, as less exposure time is needed.
Running Mean	As an example the air quality standard for Carbon Monoxide is 11.6mg/m^3 as a running 8-Hour Mean. To assess measured levels against this standard it is necessary to calculate the average of eight consecutive hourly values, e.g. from midnight to 8:00a.m. then from 1:00a.m. to 9:00a.m. and so on throughout the period of interest. As each calculation of the "Running 8-Hour Mean" gives a result there will be 24 opportunities for the standard to be assessed each day. This will hold true for whether an 8-Hour, 24- Hour or Annual Running Mean is the time period under consideration.
SO_2	Sulphur Dioxide.

For more information about Air Quality issues within North Lincolnshire please contact the Environmental Protection Officer for Air Quality on 01724 297620 (Fax. 01724 297643) or by email at adam.dawson@northlincs.gov.uk

NORTH LINCOLNSHIRE COUNCIL

www.northlincs.gov.uk

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