Manchester City Council
Environmental Health

AIR QUALITY REVIEW AND ASSESSMENT FOR MANCHESTER

PHASE TWO DETAILED ASSESSMENT

A Report of the Review and Assessment of Air Quality, as required under Part IV of the Environment Act 1995, representing the Detailed Assessment of Phase Two of the Local Air Quality Management process.

March 2004

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Executive Summary

Manchester City Council is committed to environmental protection. The city council has stated that one of its corporate aims and objectives is;

" To develop and sustain a healthy, safe and attractive local environment which contributes to the City's and its people's economic and social well being"

The city council considers the delivery of the air quality objectives to be a key way in which this aim will be achieved, and as such, the council has committed itself to achieving the air quality objectives.

Previous assessments of air quality in Manchester have shown that the city will meet the air quality objectives for five of the seven pollutants, set out in the Governments National Air Quality Strategy. These assessments have also shown that if no local action is taken to improve air quality, the objectives for two pollutants may not be met. The two air quality objectives which may not be met are for nitrogen dioxide, (a gaseous pollutant, mainly emitted in road vehicle exhaust fumes), and PM_{10} particulate matter, (ultra fine particles, which are emitted from a variety of sources).

Levels of both nitrogen dioxide and PM_{10} are monitored in Manchester.

The concentration of nitrogen dioxide in the city centre, away from major roads, is currently at or just above the target concentration. At roadside locations in the city centre the concentration is currently above the concentration.

Outside the city centre, the concentration of nitrogen dioxide is generally well below the objective level, with the exception of locations very close to major roads.

However, roadside concentrations of nitrogen dioxide are showing a downward trend, as emissions from road vehicles are being reduced, largely due to improved vehicle emissions control technology. This trend was not observed at background locations.

Future concentrations of nitrogen dioxide were predicted, both by projecting existing monitoring data, and by the use of computer based atmospheric dispersion modelling. These predictions indicate that by 2005, exceedences of the air quality objective may occur at a small number of locations, very close to the busiest roads in the city. Concentrations of nitrogen dioxide may also be above the objective at Manchester Airport, but not in areas where the public will be exposed. The council is taking action to reduce nitrogen dioxide concentrations at these locations, but recognises the very challenging nature of the 2005 targets.

The concentration of PM_{10} measured in Manchester is currently below the 2004 objectives. Projections of future concentrations from existing monitoring data, and computer based atmospheric dispersion modelling, both indicated that the 2004 PM_{10} objectives will be achieved at all locations in Manchester.
A new, and more stringent air quality objective has been proposed for 2010. An assessment was carried out for particulate concentrations for the year 2010. This assessment also used projections from existing monitoring data, and computer based atmospheric dispersion modelling. The assessment for 2010 indicated that there would be widespread exceedences of the challenging 2010 annual average air quality objective, at locations close to major roads.

The results from this Detailed Assessment will be used to inform the implementation of the Manchester Air Quality Action Plan. This action plan will involve the introduction of a package of measures, that will aim to improve air quality across the city, and eliminate the areas of predicted exceedences. The air quality action plan will be implemented by Manchester City Council in partnership with Manchester residents, Manchester Airport Plc, the Greater Manchester Passenger Transport Authority, and other stakeholders.

1: Introduction

Local air quality management was introduced under Part IV of the Environment Act 1995. The Act required Local Authorities to assess current air quality, and predict future air quality, against a set of health based air quality objectives.

The legislation focused on seven of the key air pollution species, which affect human health. For each pollutant an 'air quality objective' was set. The current objectives are shown in the table below.

Figure 1:1 Table of air quality objectives, for Local Authorities in England, located outside of London.

Pollutant	Air Quality Objective		Date The Objective Is To Be Achieved By
	Concentration	Time Period	
Benzene (C_6H_6)	16.25 ug/m^3	running annual mean	31/12/2003
	5.00 ug/m^3	annual mean	1/1/2010
1,3-Butadiene (C_4H_6)	2.25 ug/m^3	running annual mean	31/12/2003
Carbon Monoxide (CO)	10.00 mg/m^3	maximum daily running 8 hour mean	31/12/2003
Lead (Pb)	0.50 ug/m^3	annual mean	31/12/2004
	0.25 ug/m^3	annual mean	31/12/2008
Nitrogen Dioxide (NO_2)	40 ug/m^3	annual mean	31/12/2005
	200 ug/m^3	1-hour mean not to be exceeded more than 18 times in one year	31/12/2005
Particulate Matter (PM_{10})	40 ug/m^3	annual mean	31/12/2004
	50 ug/m^3	24-hour mean not to be exceeded more than 35 times in one year	31/12/2004
Sulphur Dioxide (SO_2)	350 ug/m^3	1-hour mean not to be exceeded more than 24 times in one year	31/12/2004
	125 ug/m^3	24-hour mean not to be exceeded more than 3 times in one year	31/12/2004
	266 ug/m^3	15-minute mean not to be exceeded more than 35 times in one year	31/12/2005

In addition to the seven pollutants listed above, the air quality regulations also included an objective for ozone (O_3). However, the responsibility for achieving the ozone objective rests with central Government, and Local Authorities are not expected to include an assessment of ozone in their local air quality management programme.

Local authorities were required to assess current and future concentrations of the seven pollutants, and compare the predicted future concentrations against the objectives. This assessment was carried out according to a defined procedure, and became known as a 'Review & Assessment of Air Quality'.

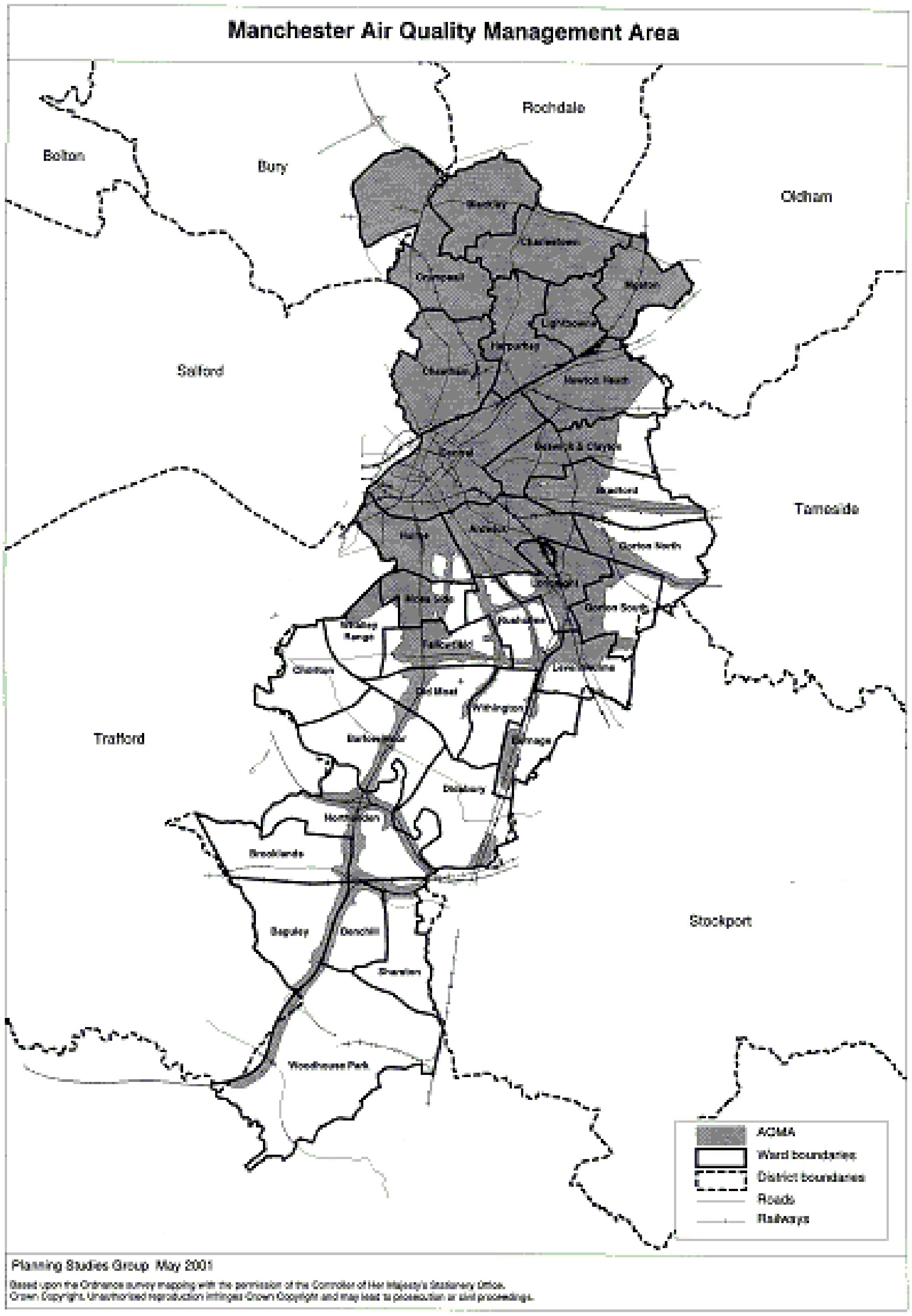
The review & assessment was split into four stages. For Manchester, Stages 1 and 2 were simple screening exercises, that identified which air pollution sources required in-depth investigation. The Stage 3 review & assessment used sophisticated computer modelling to identify those areas in which the air quality objectives may not be met.

Local authorities, including Manchester City Council, were then obliged to declare an 'Air Quality Management Area' (AQMA), covering those locations where members of the public may be exposed to predicted future concentrations of the seven pollutants, above the objective concentrations. Local Authorities were also obliged to produce an 'air quality action plan', setting out a programme of actions to improve air quality in the Air Quality Management Area.

Manchester City Council declared an Air Quality Management Area in July 2001. The Air Quality Management Area represented areas in which the annual average objective for nitrogen dioxide would not be met. The Stage 3 review & assessment also identified a small number of locations where the 24 hour PM_{10} objective would not be met. However, the areas of PM_{10} exceedence all fell within the areas included in the Air Quality Management Area on the basis of nitrogen dioxide exceedence, and a separate Air Quality Management Area for PM_{10} was therefore not required.

The current Manchester Air Quality Management Area is shown in Map 1:1.

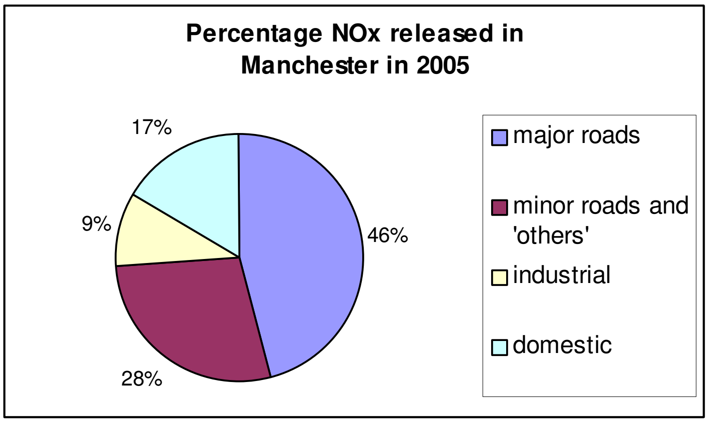
Figure 1:2 Map of Air Quality Management Area in Manchester

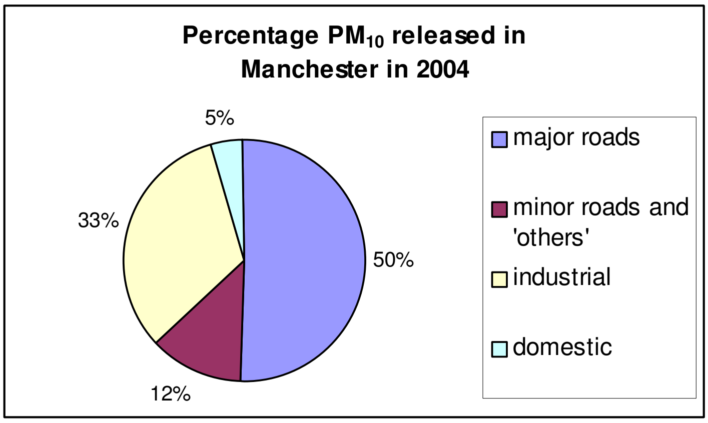


A Stage 4 review & assessment was carried out after the declaration of the air quality management area. The Stage 4 assessment involved source apportionment modelling, to identify the relative contribution from the separate sources of air pollution, and to inform the Air Quality Action Plan.

The Stage 4 review & assessment identified that emissions from vehicles using major roads were the major contributors to both nitrogen dioxide and PM_{10} in Manchester. The relative contribution of each source is shown below;

Figure 1.3 relative contribution of major source categories of nitrogen dioxide and PM_{10} emissions.





Following a review of the Local Air Quality Management process by DEFRA, changes to the review & assessment were introduced in 2002. The Phase Two of the Local Air Quality Management programme involves an initial Update and Screening Assessment, completed in Manchester in May 2003, followed by a Detailed Assessment of the pollutants (nitrogen dioxide and PM_{10}) which require further consideration and are the subject of this report.

2: Summary of Findings From the Phase Two Update & Screening Assessment

The Manchester City Council Phase Two Update & Screening Assessment was published in May 2003, the findings being accepted by DEFRA in June 2003.

The Update & Screening Assessment investigated the potential for future exceedences of carbon monoxide, benzene, 1,3-butadiene, lead, sulphur dioxide, nitrogen dioxide and PM_{10}.

In summary the conclusions were:-

1. Five pollutants required no further assessment. These were benzene, 1,3-butadiene, carbon monoxide, lead, and sulphur dioxide. The objectives for these pollutants would be met at all locations in Manchester.

2. The Update & Screening Assessment concluded that exceedences were possible for the 2004 24-hour PM_{10} objective, the 2005 1-hour nitrogen dioxide objective, and the 2005 annual average nitrogen dioxide objective.

3. The potential exceedences of the objectives were related to road traffic derived emissions.

4. The Update & Screening Assessment also recommended that residential locations close to Manchester International Airport should be considered in this Detailed Assessment.

2: <u>Manchester City Council Phase Two Update & Screening Assessment</u>

The Manchester City Council Update & Screening Assessment was submitted to DEFRA on the 1st May 2003. This report examined the seven pollutants, and assessed whether or not the relevant objectives were likely to be met. The conclusions of the report were accepted by DEFRA, in full, in June 2003. The Update & Screening Assessment identified those locations that would require additional investigation in this Detailed Assessment. The conclusions of the Update & Screening Assessment are set out below.

2.1 Summary of findings for pollutants that meet the objectives

Carbon Monoxide

The Update & Screening Assessment for carbon monoxide included a review of carbon monoxide monitoring results, and a brief investigation of the impact of emissions from road vehicles. The results of the carbon monoxide monitoring programme, operated by Manchester City Council, indicated that both background and roadside concentrations of carbon monoxide were well below the air quality objective concentration for carbon monoxide. The assessment revealed that emissions from road vehicles were unlikely to lead to exceedences of the air quality objectives. It was concluded that no Detailed Assessment would be required for carbon monoxide.

Benzene

The Update & Screening Assessment for benzene included a review of benzene monitoring results, and an assessment of the impact of emissions from road vehicles, industrial sources, and petrol handling facilities. The results of the benzene monitoring programme indicated that both background and roadside concentrations of benzene were well below both the 2003 and 2010 air quality objectives. There were no exceedences at locations where public exposure was possible. The assessment revealed that emissions from road vehicles were not likely to lead to exceedences of the objectives at any location. No industrial sites in Manchester were found to have significant emissions of benzene and no petrol stations in Manchester were found to have emissions of benzene, that could lead to an exceedence of the objectives at the nearest sensitive receptor. It was concluded that no Detailed Assessment would be required for benzene.

1,3 - Butadiene

The Update & Screening Assessment for 1,3-Butadiene included an assessment of the impact of emissions from industrial processes. No industrial sites in Manchester were found to have significant emissions of 1,3-Butadiene, and it was concluded that no Detailed Assessment would be required for 1,3-Butadiene.

Lead

The Update & Screening Assessment for lead included a review of lead monitoring results, and an assessment of the impact of emissions from industrial sources. The lead monitoring programme revealed that lead concentrations across the city were well below both the 2004 and 2008 objectives. No industrial sources were found to have significant emissions of lead, that would lead to exceedences of the air quality objectives for lead. It was concluded that no Detailed Assessment would be required for lead.

Sulphur dioxide

The Update & Screening Assessment for sulphur dioxide included a review of monitoring results, and an assessment of the impact of emissions from industrial sources, railway vehicles, and domestic fuel use. The results of the sulphur dioxide monitoring programme indicated that concentrations of sulphur dioxide were below all of the air quality objectives. The Update & Screening Assessment indicated that emissions from industrial premises would not lead to any exceedences of the sulphur dioxide air quality objectives. The assessment revealed that emissions from rail vehicles would not lead to an exceedence of the objectives. Emissions from domestic fuel use were also found to be insignificant, and no exceedences of the objectives as a result of domestic coal use were identified. It was concluded that no Detailed Assessment would be required for sulphur dioxide.

2.2 Pollutants requiring further consideration

Nitrogen dioxide

The Update & Screening Assessment for nitrogen dioxide included a review of nitrogen dioxide monitoring results, and an assessment of the impact of emissions from all sources, including road vehicles, industrial sources, and aircraft. The results of the nitrogen dioxide monitoring programme indicated that there were numerous areas of the city where the 2005 annual average objective for nitrogen dioxide were likely to be exceeded. The Update & Screening Assessment indicated that emissions from road vehicles were a major contributor to these exceedences of the nitrogen dioxide air quality objectives. No industrial sites in Manchester were found to have emissions of nitrogen dioxide, that would lead to exceedences of the objectives.

The Update & Screening Assessment identified a number of locations for inclusion in the Detailed Assessment, based on the fact that these locations may suffer from an exceedence of the annual average nitrogen dioxide objective. These locations are listed below.

The following locations were identified in the Update & Screening Assessment as being at risk of suffering an exceedence of the annual average nitrogen dioxide objective. These locations were identified using the criteria set out in the Department of the Environment, Food, and Rural Affairs, technical guidance note LAQM TG(03),

- Narrow congested streets in the city centre, (within the existing Air Quality Management Area), with nearby residential properties.
- Busy junctions in the Air Quality Management Area, identified as being at risk of experiencing an exceedence of the objectives.
- Busy shopping streets and outdoor café/bars in the Air Quality Management Area.
- Bus stations in the Air Quality Management Area, and the area around Piccadilly Gardens which is heavily used by buses.

In addition to the locations shown above, Technical Guidance note LAQM TG(03) box 6.2(M) suggests that locations in the vicinity of major airports, (with a passenger throughput in excess of 5 million passengers per annum), should be made the subject of a Detailed Assessment. This recommendation applies even where locations near to the airport are not predicted to be at risk of an exceedence of the objectives. There are no predicted exceedences of the objectives near Manchester International Airport. However, based on the advice given in the Technical guidance note, the following locations have been included in this Detailed Assessment;

- Residential locations near to Manchester International Airport.

There is also a short term (1 hour) objective for nitrogen dioxide. Technical Guidance note LAQM TG(03) box 6.2(E) recommended that a Detailed Assessment of 1 hour nitrogen dioxide concentrations should be completed where predicted 2005 annual average nitrogen dioxide concentrations exceed 40 ug/m^3 on busy streets where people may spend more than 1 hour. These locations included busy shopping streets and busy streets with outdoor seating areas associated with café bars. The following locations met the criteria for requiring a Detailed Assessment of 1-hour nitrogen dioxide;

- Busy shopping streets in the City Centre, Cheetham Hill and Longsight.
- Café bar locations in the City Centre, Fallowfield, Chorlton-cum-Hardy, and Didsbury.

<u>Particulate matter PM_{10}</u>

The Update & Screening Assessment for PM_{10} included a review of PM_{10} monitoring results, and an assessment of the impact of emissions from all sources, including road vehicles, industrial sources, aircraft, and emissions arising from domestic fuel use.

The results of the PM_{10} monitoring programme indicated that there had been exceedences of the 2004 24-hour objective concentration, during 2001, at the Manchester Piccadilly Automatic Urban & Rural Network air quality monitoring site. The area around this monitoring site was subject to an extensive programme of redevelopment during 2001, which included the cutting of concrete slabs, and other building works which generated airborne particulate matter. It is thought that particulate matter from the redevelopment works was a major source of the high PM_{10} concentrations measured in 2001, as exceedences of the 24-hour objective were not measured in any other year.

Annual average PM_{10} concentrations, (measured at the Manchester Piccadilly Automatic Urban & Rural Network air quality monitoring site), were above the proposed 2010 annual average objective in every year between 1996, (when monitoring began), to 2003.

In addition to reviewing the data from the monitoring programme, the Update & Screening Assessment also included assessments of specific sources of PM_{10} emissions. These various sources were assessed in order to determine whether they had emissions likely to cause a localised exceedence of the objectives.

No industrial sites in Manchester were found to have emissions of PM_{10} that would lead to exceedences of the air quality objectives. The assessment also indicated that emissions from domestic fuel use would not lead to exceedences of the 2004 objectives.

However, the Update & Screening Assessment indicated that there were numerous locations in the city, where both the 2004 and 2010 objectives could be exceeded as a result of emissions from road vehicles. Specifically seven road junctions were identified, where the roads involved were used by a high proportion of HGV vehicles, and which therefore experienced significant PM_{10} emissions. Also, one road was identified as having a very high bus flow, with subsequent significant emissions of PM_{10}.

To summarise, the Update & Screening Assessment identified the following locations as requiring a Detailed Assessment for $PM_{10.}$

- Seven busy junctions in the Air Quality Management Area, identified as being at risk of experiencing an exceedence of the objectives, based on the high proportion of HGVs using the junction.
- One road within the Air Quality Management Area that was used by a high proportion of buses, and that was highlighted in the Update & Screening Assessment as being at risk of exceeding the 24 hour objective for 2004.

In addition to the locations shown above, Technical Guidance note LAQM TG(03) box 8.4(M) requires that locations in the vicinity of major airports, (with a passenger throughput in excess of 5 million passengers per annum), should be made the subject of a Detailed Assessment. This recommendation applies even where locations near to the airport are not predicted to be at risk of an exceedence of the objectives. There are no predicted exceedences of the objectives near Manchester International Airport. However, based on the requirements of the Technical guidance note, the following locations have been included in this Detailed Assessment;

- Residential locations near to Manchester International Airport.

There were no locations identified as being at risk of suffering an exceedence of the 2004 annual average PM_{10} objective.

3: Detailed Assessment of Nitrogen Dioxide (against the 1 hour objective)

The Update & Screening Assessment identified a number of locations where there was at risk of the 1-hour objective for nitrogen dioxide being exceeded.

These areas included busy shopping streets, and city centre streets with outdoor café bars.

In July 2003 Air Quality Consultants Ltd, (AQC) [1], published an alternative method for assessing the likelihood of exceedences of the 1-hour objective, based on whether or not the annual average nitrogen dioxide concentration at a particular location was above 60 ug/m^3.

The new AQC assessment methodology was applied to all of the locations identified in the Update & Screening Assessment.

Using the new assessment methodology, none of these locations were found to be at risk of suffering an exceedence of the 1-hour objective.

[1] Analysis of the relationship between 1 - hour and annual mean nitrogen dioxide at UK roadside and kerbside monitoring sites. Laxen and Marner 2003

3: Detailed Assessment of Nitrogen Dioxide (against the 1 hour objective)

Technical Guidance note LAQM TG(03) box 6.2(E) provides a methodology for assessing the vulnerability of specific locations against the 1 hour objective for nitrogen dioxide.

The Technical Guidance identified busy streets, where people may be exposed for 1 hour or more at roadside locations, as being the key locations requiring assessment. Busy shopping streets, and café bars with outdoor, roadside seating, were specifically identified. The Technical Guidance stated that if these locations had a predicted 2005 annual average nitrogen dioxide concentration in excess of 40 ug/m^3, then a Detailed Assessment would be required.

In the Update & Screening Assessment a number of busy shopping streets in Manchester were identified as fulfilling the criteria that would trigger the requirement for a Detailed Assessment. These busy shopping streets were as follows;

Figure 3:1 Impact of NO_X emissions from vehicles on outdoor shopping streets calculated using the atmospheric dispersion model from the Design Manual for Roads and Bridges (DMRB)[2]

Shopping Street	Annual average daily traffic flow	Speed (km/h)	% Light duty vehicles	2005 annual average NO_2
Longsight				
Stockport Road - *from junct with Dickenson Rd to junct with Slade Lane*	21193	36	92%	40.4
Stockport Road - *at junction with Slade Lane*	23140	28	92%	41.4
Stockport Road - *from junct with Slade Lane to junct with Crowcroft Rd*	19247	36	92%	40.1
Cheetham Hill				
Cheetham Hill Road - *from junct with Woodlands Rd to junct with A6010 ring road*	11229	36	92%	38.8
City Centre				
Deansgate - *from junct with Victoria St to junct with John Dalton St*	16069	20	94%	45.3
Cross Street - *from junct with Market St to junct with John Dalton St*	9212	24	78%	47.1
				NO_2 results in ug/m^3

[2] Design Manual for Roads and Bridges Version 1.01 - Highways Agency - 2003

In addition to these busy shopping streets, a number of locations were identified where café bars had outdoor seating for patrons, very close to busy roads. The café bar locations are shown in figure 3.2;

Figure 3.2 Impact of NO_X emissions from vehicles on outdoor café / bar locations calculated using the atmospheric dispersion model from the Design Manual for Roads and Bridges.

Outdoor Café / Bar Exposure Site	Annual average daily traffic flow	Speed (km/h)	% Light duty vehicles	2005 annual average NO_2
City Centre				
Deansgate Locks - *Whitworth St West*	11924	34	94	42.3
Peter Street - *Great Northern development area*	11756	21	96	41.8
Canal Street	3354	20	91	38.8
Fallowfield				
Wilmslow Road - *Area adjacent to the junction of Wilmslow Rd and Wilbraham Rd*	19295	33	90	41.6
Chorlton-cum-Hardy				
Wilbraham Road - *Area adjacent to the junction of Barlow Moor Rd and Wilbraham Rd*	17647	37	96	34.3
Didsbury				
Wilmslow Road Road - *Area adjacent to the junction of Barlow Moor Rd and Wilmslow Rd*	11896	40	93	34.2
				NO_2 results in ug/m^3

The 2005 annual average nitrogen dioxide concentrations were calculated using the DMRB screening tool. Traffic flows, speeds, and the percentage of light duty vehicles were supplied by GMTU. Many of the locations assessed were predicted to have a 2005 annual average nitrogen dioxide concentration above 40 ug/m^3, indicating that a Detailed Assessment would be required.

However, since the publication of LAQM TG(03) additional research work has been carried out into short term episodes of nitrogen dioxide. A report on short term nitrogen dioxide concentrations was published by Air Quality Consultants Ltd (AQC) in July 2003[1]. Section 4.2 of this report states that "it would be appropriate for local authorities to base the decision of a likely exceedence of the 1-hour nitrogen dioxide objective on an exceedence of 60 ug/m^3 as an annual mean".

[1] Analysis of the relationship between 1 - hour and annual mean nitrogen dioxide at UK roadside and kerbside monitoring sites. Laxen and Marner 2003

This conclusion was based upon a detailed analysis of the relationship between annual average and short term peak concentrations of nitrogen dioxide measured across the Automatic Urban and Rural Network of air quality analysers, since 1980, that was carried out by AQC.

The results of the DMRB assessment, shown in figure 3.2, reveal that none of the identified locations have a 2005 annual average nitrogen dioxide concentration in excess of 60 ug/m^3. On the basis of these results, and considering the recommendations included in the AQC report, it is unlikely that any of these locations will experience an exceedence of the 1-hour nitrogen dioxide objective. This conclusion is supported by results from the AURN monitoring stations in Manchester, which have not recorded an exceedence of the 1-hour objective since 1994. Whilst not roadside sites, Manchester Piccadilly in particular is located in the city centre, where people would be exposed, and is surrounded by busy, congested, city centre streets.

Additionally, some of the locations identified in the Update and Screening Assessment are subject to air quality monitoring, at relevant roadside locations, using diffusion tubes. The nitrogen dioxide diffusion tubes used by Manchester City Council are supplied, prepared, and analysed by Casella Ltd, at their UKAS accredited facilities in Trafford Park. Diffusion tubes used by Manchester City Council are all prepared using the 10% TEA in water method. Diffusion tubes have been co-located with the chemiluminescent NO_X analysers at both the Manchester Piccadilly and Manchester Town Hall AURN sites. Co-location of tubes with chemiluminescent analysers allowed the calculation of diffusion tube bias, using the methodology in Technical Guidance note LAQM TG(03) Boxes 6.3 and 6.4. A full description of the bias adjustment calculation is provided in Appendix A of this report.

The results from this monitoring exercise are shown below.

Figure 3.3 Bias adjusted roadside concentrations of nitrogen dioxide

Year	Monitoring site		
	Princess Street	Oxford Road	Cheetham Hill Road
1999	56.35	74.88	47.09
2000	45.05	61.85	42.00
2001	59.20	64.00	34.40
2002	50.06	44.03	28.35
2003	51.86	61.02	33.56
			NO_2 results shown in ug/m^3

Figure 3.4 Projected future roadside concentrations of nitrogen dioxide

Monitoring Site	Bias adjusted annual average nitrogen dioxide (ug/m^3) 2003	Annual average nitrogen dioxide (ug/m^3) scaled to 2005
Princess Street	51.86	49.16
Oxford Road	61.02	57.84
Cheetham Hill Road	33.56	31.81

Princess Street and Oxford Road are both city centre streets, and are broadly representative of the shopping streets and café bar locations. Cheetham Hill Road is a shopping street which was identified as being relevant to 1 hour exposure.

The predicted 2005 concentrations are below the 60 ug/m^3 that would trigger the requirement for a Detailed Assessment. As such, the technical assessment indicates that it is highly unlikely that the 1-hour objective will be exceeded at any of these locations.

Section 6.06 of technical guidance note LAQM TG(03) points out that emissions of NO_X from road traffic are likely to reduce in future, as improved emissions control technology penetrates the national fleet. Other emission sources, (such as industrial emissions), are not predicted to achieve as significant reductions, as those predicted for road traffic. However, there were no significant industrial or commercial sources of nitrogen dioxide identified in the USA, which could produce an exceedence of the 1-hour objective.

If there are no predicted exceedences of the 1-hour objective in 2005, and emissions of NO_X are predicted to decline between 2005 and 2010, it can be surmised that there will be no exceedences of the 1-hour objective in 2010. This matter will, however, be kept under review, and the 2010 1 hour objective value will be investigated and reviewed again if there are any major changes to the road network in Manchester.

Monitoring of nitrogen dioxide through both the AURN sites and the diffusion tube sites will be employed to monitor the future trends in relation to the 1-hour objective.

4: Detailed Assessment of Nitrogen Dioxide (against the annual average objective)

The Update & Screening Assessment identified a number of locations where there was a risk of the annual average objective for nitrogen dioxide being exceeded.

These areas included locations with relevant public exposure close to a number of busy road junctions, narrow and congested streets in the city centre, roads used by a high proportion of buses or HGVs, locations near the recently completed inner ring road, and residential locations close to Manchester International Airport.

Air quality monitoring carried out in Manchester indicates that there are exceedences of the annual average nitrogen dioxide objective. When these monitoring results were scaled to future years, they predicted that there could also be exceedences in the future.

The modelling carried out for this Detailed Assessment utilised a higher modelling resolution that was available for the Stage 3 Review & Assessment. The results indicated that there was a likelihood of exceedences of the annual average objective at locations close to busy roads and junctions across the city.

The Update & Screening Assessment predicted predicted for;

1. Busy, narrow and congested streets in the city centre
2. City centre roads used by a high proportion of buses.
3. Locations close to Manchester International Airport.
4. Residential locations close to motorways.

The areas of exceedence of the annual average objective identified by this modelling exercise, are much smaller than the areas of exceedence identified by the Stage 3 Review & Assessment carried out in 2001. The area of predicted exceedence of the annual average nitrogen dioxide objective has shrunk by 90%, from approximately 65 km^2, (from the Stage 3 Review & Assessment in 2001) to 6 km^2 in the results of this Detailed Assessment in 2004.

4: <u>Detailed Assessment of Nitrogen Dioxide (against the 2005 and 2010 annual average objectives)</u>

The Government has adopted an annual average air quality objective for nitrogen dioxide, of 40ug/m^3.

Additionally, in 1999 the European Union introduced the First Air Quality Daughter Directive, (1DD), which set objectives for a number of key air pollutants. The 1DD objectives for nitrogen dioxide match the UK 2005 objectives, (in terms of target concentrations and numbers of permitted exceedences), but are set with a target date of 2010. These 1DD objectives have been transposed into UK legislation.

The EU First Daughter Directive objectives are;

- 1 hour limit of 200 ug/m^3, not to be exceeded more than 18 times per year, to be achieved by 1 January 2010.

- Annual average limit concentration of 40 ug/m^3, to be achieved by 1 January 2010.

The Phase One, Stage 3 Review & Assessment concluded that exceedences were likely, in locations where public exposure would occur, in 2005.

In 2001 Manchester City Council declared an AQMA, based on exceedences of the annual average nitrogen dioxide objective. The AQMA covered the city centre, the north of the city, and locations near to busy roads in the south east of the city. Map 1.1 shows the extent of the AQMA.

Manchester City Council operate two nitrogen dioxide analysers in the city centre, located at Piccadilly Gardens and Manchester Town Hall. The Manchester Piccadilly analyser has recorded annual average concentrations above the 40 ug/m^3 objective every year since monitoring began in 1996, with the exception of 2002, when the concentration was 38 ug/m^3. The Manchester Town Hall analyser has recorded annual average nitrogen dioxide concentrations above the objective concentration of 40 ug/m^3 every year since 1994.

The Manchester City Council Phase Two Update & Screening Assessment was completed in May 2003. Results from the USA identified a number of locations in the City where the annual average nitrogen dioxide objective may be exceeded, or based upon Technical Guidance note LAQM TG(03) specific locations where a Detailed Assessment is required.

These locations included;

- Portland Street in the city centre, which is subject to a very high flow of buses.
- The length of the A57M southern ring road, which has substantially changed traffic flows since the completion of Phase One of the review & assessment process.
- Locations in the vicinity of the Cannon Street and Piccadilly Gardens bus stations.
- Residential locations close to Manchester International Airport.

Additional locations highlighted in the Update & Screening Assessment as requiring inclusion in the Detailed Assessment were;

- Locations around the boundary of the existing AQMA, to ascertain whether the boundary requires amendment in light of the new emission factors, and other scientific developments.
- Junctions identified in the Update & Screening Assessment as having nearby residential locations at risk of exceeding the annual average objective, (20 junctions).
- Narrow congested streets, with nearby residential properties, identified in the Update & Screening Assessment as being at risk of exceeding the annual average objective, (9 roads).

Technical Guidance note LAQM TG(03) sections 6.53 to 6.73 provides a methodology for carrying out a Detailed Assessment of nitrogen dioxide. The Technical Guidance note stresses that the Detailed Assessment should focus on locations where maximum relevant public exposure is likely to occur, and to define the magnitude and geographic extent of any exceedences in these areas. The Detailed Assessment therefore involves two elements. Firstly, the results from Manchester's air quality monitoring programme will be used to determine whether or not exceedences of the objective are likely. Secondly, if likely exceedences are predicted, atmospheric dispersion modelling will be used to define the magnitude and geographic extent of the exceedence, with a particular focus on those areas identified by the analysis of the monitoring data.

4.1 Real time monitoring of nitrogen dioxide

Technical Guidance note LAQM TG(03) sections 6.58 and 6.59 provide a methodology for estimating future annual average nitrogen dioxide concentrations, based on current measured concentrations.

Three chemiluminesent nitrogen dioxide analysers are operated in Manchester, at Piccadilly Gardens in central Manchester, (a busy public square categorised as an 'Urban Central' location), at Manchester Town Hall, (an 'Urban Background' site), and finally at a site in Heald Green, close to Manchester International Airport, (Manchester South, a 'Suburban' site).

All of these instruments are part of the Automatic Urban and Rural Network, (AURN), of air quality analysers. Data from AURN analysers is subject to full quality assurance by NETCEN including two weekly operator calibration, and six monthly network intercalibration. Data is scaled and adjusted by NETCEN based on the results of the six monthly calibration, and is published in the national database.

Ratified data from these analysers is shown in the figure 4.1. The data is also projected to 2005 and 2010 using the correction factors shown in Box 6.7 of LAQM TG(03).

Figure 4.1 Current and projected future concentrations of nitrogen dioxide in Manchester

Year		Manchester South	Manchester Town Hall	Manchester Piccadilly
1997	**Annual average**	**23**	**51**	**42**
	Data capture	95%	96%	91%
1998	**Annual average**	**25**	**41**	**40**
	Data capture	98%	97%	95%
1999	**Annual average**	**15**	**41**	**44**
	Data capture	71%	99%	95%
2000	**Annual average**	**14**	**42**	**42**
	Data capture	81%	95%	97%
2001	**Annual average**	**21**	**48**	**44**
	Data capture	96%	99%	72%
2002	**Annual average**	**18**	**44**	**38**
	Data capture	88%	98%	90%
2003	**Annual average**	**21**	**44**	**45**
	Data capture	96%	96%	92%
2005	Projected '05 concentrations based on scaled '03 results	20	42	43
2010	Projected '10 concentrations based on scaled '03 results	17	36	40
All annual average NO_2 results in ug/m^3				

There are no clear trends in nitrogen dioxide concentrations measured at the AURN sites in Manchester. The sites showed relatively high concentrations in 2001 and 2003, and relatively low concentrations in 2002.

The projected future nitrogen dioxide concentrations show that these sites will achieve the objectives in 2010, and are approaching the objectives in 2005. The Town Hall and Piccadilly sites are classified as urban background and urban central respectively, and are characteristic of the kind of locations where public exposure most often occurs, and suggests that most Manchester residents will not be exposed to exceedences of the objective. However, the results from the AURN analysers do not reveal what concentrations may be at residential locations close to roads.

4.2 Diffusion tube results

The results shown in section 4.1 indicate that there could be exceedences of the objective at urban background locations. However, as stated earlier, the Review & Assessment must focus on the areas of maximum public exposure. Manchester City Council operate an extensive network of nitrogen dioxide diffusion tubes, some of which are located in relevant areas of exposure to high concentrations. The results from this diffusion tube network are shown in figure 4.2.

Figure 4.2 Bias adjusted concentrations of nitrogen dioxide in Manchester based on nitrogen dioxide diffusion tube results.

Year	Princess St (roadside city centre)	Junction 4 M56 Motorway (roadside motorway)	Oxford Rd (roadside city centre)	Oldham Rd (roadside Eastern suburbs)	Cheetham Hill Rd (roadside Northern suburbs)
1997	-	52	-	-	-
1998	-	49	72	59	50
1999	-	57	75	53	47
2000	-	59	62	44	42
2001	59	59	64	45	34
2002	50	49	44	31	28
2003	52	60	61	37	34
					Results in ug/m^3

Figure 4.2 (Contd.) Bias adjusted concentrations of nitrogen dioxide in Manchester based on nitrogen dioxide diffusion tube results.

Year	Cheethams School (urban background - city centre)	Ashton Old Rd (roadside Eastern suburbs)	Clayton Day Nursery (urban background - Eastern suburbs)	Piccadilly Gardens (urban central)	Bollin Valley Farm, Styal (suburban background)
1997	-	-	36	52	26
1998	-	48	28	41	20
1999	41	43	31	43	19
2000	43	37	29	44	21
2001	47	39	33	50	22
2002	36	25	31	45	21
2003	43	31	36	51	26
					Results in ug/m^3

The diffusion tube results show that concentrations of nitrogen dioxide are decreasing at non-motorway roadside sites. The trend of reductions of concentrations at the roadside sites will lead to a reduction in the area of exceedence, where exposure is an issue.

The concentrations measured at background monitoring sites do not show such a clear trend.

The reduction in nitrogen dioxide concentration at the roadside sites is largely due to the increasing use of emission control technology, which is fitted to new road vehicles. For example, since 1995 new cars sold in the UK have been fitted with catalytic converters. Over time, pre 1995 cars are retired from the national fleet, and are replaced with newer vehicles, with lower NO_X emissions. The impact of this emission reduction from road vehicles is most pronounced at roadside sites, where emissions from road vehicles are by far the most significant source of NO_X. The effect of emission reduction from road vehicles is less pronounced at background sites, where road traffic derived emissions form a lower proportion of the overall NO_X loading.

Traffic counts, (supplied by GMTU)[3], show that traffic is growing more quickly on the motorway network than on the non-motorway roads. GMTU traffic counts, projected forward, indicate that the traffic growth on the road network in Manchester would be as follows;

Figure 4.3, Projected traffic growth in Manchester

Road	Projected traffic growth 2001-2005	Projected traffic growth 2005-2010
M56 motorway (junction 1 to 6)	+7%	+14%
M60 (junction 2 to 5) in south of city	+4%	+4%
M60 (junction 18 to 21) in north of city	+8%	+9%
Non-motorway road network	+6%	+7%

The large growth in traffic predicted for the M56 motorway may partially offset the emission reductions delivered through improved vehicle technology, leading to the projected increase in concentrations at the M56 roadside site. However, the M60 does not have as high a projected increase in traffic flow, (as was predicted for the M56), and consequently is unlikely to experience such an increase in nitrogen dioxide concentration.

The diffusion tube results shown in figure 4.2 show that exceedences of the objective are predicted for busy roadside locations in the city centre, and at locations close to the motorway.

[3] GMTU report number 819 - GMTU - January 2003

At urban background locations in the city centre, the projected annual average concentration was shown to be approximately at, or below, the objective. At urban background locations outside of the city centre, the projected concentrations are below the objective.

Urban background locations are representative of the majority of locations where public exposure is likely to occur. As the annual average objective is predicted to be achieved at urban background locations, it is clear that the majority of Manchester residents will not be exposed to exceedences of the nitrogen dioxide objective.

Based on these projected diffusion tube results, it appears that exceedences of the objective are only likely to occur at near roadside locations.

The diffusion tube results support the results from the chemiluminescent analysers, and show that exceedences are possible, but also providing a wider spatial distribution of nitrogen dioxide measurement.

4.3 Atmospheric dispersion modelling of nitrogen dioxide

The results from diffusion tube monitoring are shown in figure 4.2. With the exception of the Bollin Valley Farm site all of these diffusion tubes are located within the existing Manchester AQMA, and provide an indication of future concentrations in the AQMA.

However, the limited number of monitoring sites available means that monitoring alone cannot be used to accurately define areas of exceedence. Atmospheric dispersion modelling was therefore undertaken to provide an accurate assessment of the magnitude and geographic extent of the new, (and potentially reduced), area of exceedence.

For many years Manchester City Council has worked in partnership with nine other Greater Manchester local authorities, to carry out atmospheric dispersion modelling exercises. The ten local authorities jointly purchased the ADMS-Urban atmospheric dispersion model, and commissioned consultants from the Atmospheric Research Information Centre, (ARIC), to work in partnership with the Local Authorities and the Greater Manchester Transportation Unit to carry out the modelling.

The ADMS-Urban atmospheric dispersion model was selected for use in this Detailed Assessment, to ensure continuity with previous results.

4.3.1 Model validation

ADMS-Urban has been subject to a number of national validation studies, most recently in 2003[4] when CERC compared results from the ADMS-Urban system to those obtained from modelling carried out by NETCEN and ERG. The comparison showed that ADMS-Urban gives slightly higher annual average NO_2 at roadside sites, and slightly lower NO_2 at background sites, in comparison to the other two models examined in the study. This Detailed Assessment is focused on areas of maximum exposure, and these areas are generally at near roadside locations. The tendency of ADMS-Urban to predict slightly higher than average concentrations, at roadside locations, is therefore an advantage, as the model will generate precautionary results. However, the accuracy of an atmospheric dispersion model is dependent upon the quality of the data used as inputs to the model, and the Greater Manchester Local Authorities in partnership with GMTU and ARIC have continued to develop a best practice database to support the model. The inputs used in the modelling exercise are described below.

[4]Comparison of ADMS-Urban, NETCEN and ERG air quality predictions for London. Carruthers, Blair & Johnson, (CERC), 2003

4.3.2 Model inputs - EMIGMA emissions inventory

Manchester City Council participate in the preparation of the Emissions Inventory of the Greater Manchester Authorities, (EMIGMA)[5]. The EMIGMA database covers emissions from sources located in the ten Greater Manchester Local Authority areas, covering an area of 1552 square kilometres. All emission sources within the Greater Manchester area are accounted for, and are divided into different sectors such as road transport emissions, point sources, and area sources, etc.

4.3.3 Model inputs - road transport emissions

The Greater Manchester Transportation Unit, (GMTU), is a transport engineering consultancy which operates under the auspices of the Association of Greater Manchester Authorities, (AGMA). GMTU operate a Sub-Regional Highways Model based on the TRIPS traffic management software, which is used to calculate vehicle flows, vehicle type splits, vehicles speeds, and diurnal profiles of traffic characteristics. The SRHM model is used to calculate traffic characteristics on the entire major road network, ('A' and 'B' roads and motorways), across Greater Manchester. SRHM calculates traffic characteristics for the morning peak traffic period (08:00-09:00), the evening rush hour, (17:00-18:00), and the average inter-peak hour for the period 09:30-15:30. The SRHM model is calibrated against actual traffic counts, and traffic counts were used in favour of SRHM derived results, wherever they were available. Approximately 30% of the roads in Manchester had available traffic count data. 2001 was chosen as a definitive year for appropriate data for EMIGMA, Part B sources, traffic data and weather. GMTU advised that October was the most representative month of the year, (with regard to annual traffic data), and therefore where more than one traffic count was available, the count taken closest to the 1st October 2001 was used.

The SRHM produces traffic volumes based on road class, and position of the road between key destination points. Traffic speeds were derived from volume-speed curves, weighted according to the speed limit on the link in question. Additionally the model will assign a vehicle split, (cars and motorcycles, HGV, LGV and buses), based on road link class and position. The SRHM did not predict traffic characteristics for entire roads, but rather split each road into numerous discreet links, (links were stretches of road between major junctions), and junction units. Traffic characteristics of minor roads could not be derived from the SRHM. GMTU therefore calculated emissions from minor roads separately. Vehicle flows and relative vehicle type were derived from traffic counts, and origin - destination surveys, carried out in 1999, 2000 and 2001. In addition to emissions from minor roads, GMTU also calculated emissions from cold start and hot soak vehicle activities. Locations and numbers of cold starts and hot soaks were derived from the results of driver origin - destination surveys carried out by GMTU.

[5]The Greater Manchester and Warrington Emissions Inventory, (ARIC), 2002

Road traffic emissions were both projected for the objective years, and were also calculated for the base year of 2001. Predictions of future traffic flow were usually based on the National Road Traffic Forecast (NRTF) growth factors, (the 'central' or 'medium' growth factor was used). It was assumed that there would be no growth in the numbers of buses using the Manchester road network. The traffic flow predictions for 2005 also included traffic that would use the Manchester - Salford Inner Relief Route, which had not been completed in 2001, but which would be fully operational in 2005. Traffic counts from 2003 were used for the projections to 2005 for this section of road. Another case where NRTF growth factors were not used were roads leading to and from Manchester Airport. In this case, the projected growth in the number of passengers using the airport was used as a substitute traffic growth figure. This provides a more precautionary approach, as the GMTU substitute growth factor is slightly higher than the NRTF growth factor. The higher growth factor was also considered appropriate for the airport, as there has been a continued ongoing increase in demand for air travel in the north west of England.

The completed traffic flow and fleet composition data, produced by GMTU, were forwarded to ARIC for inputting to the model. Vehicle emissions were calculated based on vehicle type category, (cars and motorcycles, HGV, LGV, and buses), and traffic speed. Speed related emissions factors were obtained from the National Atmospheric Emissions Inventory (NAEI), and were added to the EMIGMA database.

The only model inputs that were changed for the 2010 modelling scenario were traffic flows, and vehicle emission factors. Traffic flows for 2010 were derived by scaling existing traffic data, using National Road Traffic Forecast growth factors, (the 'central' or 'medium' growth factor was used). Appropriate speed weighted vehicle emissions factors for 2010 were taken from the NAEI database.

4.3.4 Model inputs - point source emissions

A variety of point sources were considered during the preparation of the EMIGMA database. Emissions from processes Authorised under Part 1 of the Environmental Protection Act 1990 are included in EMIGMA as point sources. Details of 'Part A' processes were obtained direct from the Environment Agency. The process details involved included in EMIGMA were site location, exhaust stack characteristics, (stack height, efflux velocity, stack diameter, pollutant emission rate, etc), and details of the type of process being undertaken. Individual Local Authorities provided similar details for the 'Part B' processes. Additionally, Local Authorities also surveyed their areas, to identify the location of industrial and municipal boilers of 2MW and above. All of the point source data was forwarded to ARIC for inclusion in the EMIGMA database.

Details of actual pollutant emission rate were not available for all of the identified point sources, as some of the Authorised processes were not required to measure the concentration of pollutants being emitted. Pollutant emissions rates were derived for these point sources, based on the rate of fuel consumption or rate of production at the site. The derived emissions rates were calculated by ARIC using emission factors taken from the National Atmospheric Emissions Inventory, (NAEI), or from the US EPA Appendix 42 emissions factor database. Point source emission details from 2001 were used as the base year for this modelling exercise.

One point source located outside of Greater Manchester was included in the modelling. This point source was the Fiddler's Ferry coal fired power station, which is located in the borough of Warrington, approximately 40 km from Manchester. Fiddler's Ferry is one of the two main electricity generating stations in the north west, the other generating station is located at Heysham in Lancashire. Heysham is a nuclear power station, and does not have emissions of interest to this Detailed Assessment. However, unlike Heysham, Fiddler's Ferry is a major regional emitter of PM_{10} and NO_X, and has four main release stacks each over 200m high. Modelling carried out as part of the Phase One LAQM programme suggested that emissions from Fiddler's Ferry would, under certain meteorological conditions, make a contribution to levels of PM_{10} and NO_X in Greater Manchester. Emissions characteristics for Fiddler's Ferry were obtained from the Environment Agency. No other point sources located outside Manchester were identified as being relevant.

Emissions from point sources were not forecast to change between 2001 and the objective years. The only exception is where industrial processes had closed since 2001, in which case their emissions were removed from the EMIGMA database.

4.3.5 Model inputs - other emission sources

Other sources of pollution in Greater Manchester, (other than point sources and roads), were aggregated and treated as 'volume' sources, of a size 1km by 1km by 10m. An area of 1km by 1km was selected for volume sources, as this area is sufficiently small to take account of areas of high density of sources, (such as high density housing projects), whilst being large enough to minimise the total number of volumes that would need to be modelled. A volume depth of 10m was recommended by CERC, the developers of the ADMS-Urban model. In total 2852 volumes were modelled across Greater Manchester.

The emissions sources that were aggregated for each volume included domestic combustion sources, commercial combustion sources, emissions from rail vehicles, and emissions from aviation activities.

Transco Plc provided data on domestic and industrial gas usage for each council ward in Greater Manchester. The Greater Manchester Research Unit, (an AGMA agency), then provided details of population for each 1km by 1km area, in every ward. Gas use was then calculated for each 1km area by dividing the total ward usage value by the proportion of ward population in that 1km area. Emissions from domestic gas use were the calculated using gas volume related emission factors taken from the NAEI.

The Energy Savings Trust, and Local Authority officers working on the Home Energy Conservation Act, then provided details of domestic fuel split for each council ward. Used with the total volume of gas consumed in each ward, this fuel split data allowed an estimation to be made of domestic coal and oil use in each 1km by 1km area. Once again emissions were calculated using NAEI emission factors.

Industrial gas emissions were calculated by dividing the gas usage per ward by the number of km^2 that made up the area of the ward. Again, emission factors were used. Where a large gas fired boiler had been identified, and included as a point source, its volume of gas used was subtracted from the total ward volume, before the $1km^2$ gas use was calculated.

Emissions from railway transport vehicles in Manchester were calculated by the London Research Centre, who aggregated these emissions to $1km^2$ areas.

Emissions from aviation activities at the airport were calculated by Manchester Airport Plc. These emissions did not include emissions from road vehicles visiting the airport, as they were included as part of the overall road transport network emissions. Aviation activities were taken to include the use of ground vehicles to service the aircraft, (including the use of electrical generators, diesel powered mobile baggage conveyors, mobile fuel pumps, diesel powered de-icers, and a host of other support vehicles), the use of aircraft auxiliary power units, aircraft taxiing and engine testing, and aircraft landing and takeoff movements. Airborne aircraft emissions were also accounted for, between takeoff and the aircraft reaching 1000m, and from the aircraft descending below 1000m to landing. Emissions factors for these activities were taken from the National Atmospheric Emissions Inventory, (NAEI), or from the US EPA Appendix 42 emissions factor database, or were supplied by the International Civil Aviation Organisation.

All of the above emissions were aggregated to form a single volume emission source for each $1km^2$ area.

Emissions from the $1km^2$ areas immediately surrounding the Greater Manchester area were also included in the modelling. Data on emissions for these areas was obtained from the NAEI and NETCEN background maps.

4.3.6 Model inputs - background concentrations

In addition to the detailed emissions from NO_X generated within Greater Manchester, consideration was also given to the pollutant loading being emitted beyond the Greater Manchester boundary, but being part of an external contribution to the Greater Manchester area.

The best way to determine background concentrations would be to measure concentrations of NO_X at a rural location, away from any local sources of pollution. Unfortunately there are no chemiluminescent analysers sited in rural locations in Manchester. This situation was rectified by the installation of a

NO_X analyser at the Glazebury AURN site in 2004 for future reference work, however this still left the problem of finding an appropriate background concentration for the modelling base year of 2001.

Manchester City Council does have a single nitrogen dioxide diffusion tube located in a rural site. This tube is located at Bollin Valley Farm, near the village of Styal, to south of the city. Although results from a diffusion tube could not be used as a background concentration for atmospheric dispersion modelling, the tube result did provide an indication of the likely background concentrations. In 2001 the bias adjusted annual average nitrogen dioxide concentration at Bollin Valley was 22 ug/m^3, and the data capture was 87%. A more acceptable data capture of 94% was obtained for this tube in 2002, when the annual average nitrogen dioxide concentration was 21 ug/m^3.

In addition to the results from the Bollin Valley diffusion tube, the results from the Manchester South AURN site were also considered. Manchester South is located in a field, well away from road transport sources of NO_X. However, Manchester South is located close to the northern end of runway 24R at Manchester Airport, and will be subject to aviation related emissions of NO_X. Nonetheless, this 'suburban' site was the closest to a rural site available. The annual average NO_X and NO_2 concentrations were 46 ug/m^3 and 21 ug/m^3 respectively. These results gave a general indication of the likely background concentrations.

In previous modelling exercises, the Greater Manchester Local Authorities used results taken from the rural AURN site at Ladybower as background concentrations. In 2001 the annual average NO_X and NO_2 concentrations measured at Ladybower were 13 ug/m^3 and 11 ug/m^3 respectively. An alternative source of background pollution data was therefore sought. After looking in detail at all of the AURN sites around Manchester, it was finally decided to use the results from the Wirral Tranmere AURN site as background. Wirral Tranmere is located well away from road traffic sources of NOx, and is located to the south west of Manchester, which is the direction of the prevailing wind, (prevailing wind recorded at Manchester Airport was at 210^o in 2001, Wirral Tranmere lies at approximately 230^o from central Manchester, see section 4.2.7 for a fuller discussion of meteorology). In 2001 the annual average NO_X and NO_2 concentrations measured at Wirral Tranmere were 35 ug/m^3 and 21 ug/m^3 respectively. These results show a good comparison with the rural and suburban measurements made in Manchester.

4.3.7 Model inputs - meteorological data

The nearest Met Office weather station to Manchester is located at Manchester Airport. Hourly sequential meteorology data sets for this site were purchased. The data sets included records of wind speed, wind direction, atmospheric stability, temperature, precipitation rate, cloud cover, and boundary layer height.

Meteorological data from 2001 was used for the base year modelling. However, a comparison was made of the concentrations that arose using met data from a number of years. The highest concentrations were found from the use of met data from 1999, and therefore 1999 met data was used for the prediction of future concentrations.

4.3.8 Model inputs - surface roughness

Surface roughness is a variable used by atmospheric dispersion models to describe the topography of the area, and how much turbulence would be caused by the surface projecting into the air. Values of surface roughness can range from 2 for large cities with numerous tall buildings projecting into the air, to 0.001 for a flat plain. For Manchester a surface roughness of 1 was selected, which according to CERC literature would correspond to "smaller cities". This surface roughness was considered appropriate, as although Manchester is an urban area, the city is not populated with 'skyscraper' office blocks of the size found in London and other large cities.

4.3.9 Model inputs - NO_X to NO_2 conversion

There are a number of functions available for the conversion of NO_X to NO_2. Technical Guidance Note LAQM TG(03) Box 6.9 recommends the use of the empirical NO_X conversion relationship shown below;

$((-0.068 \times \text{Ln}(\text{total } NO_X)) + 0.53) \times \text{road } NO_X = NO_2$ from road transport

NO_2 from road transport + NO_2 background = total NO_2

where road NO_X is presumed to be total NO_X minus background NO_X

This conversion factor was used to calculate NO_2 from the annual average NO_X measured at Greater Manchester AURN sites in 2001. The derived NO_2 was then compared to the actual annual average NO_2 measured at the AURN sites. The calculated NO_2 was less than the actual measured NO_2 for all but one of the AURN sites. The only site for which the NO_2 was not underpredicted was Manchester South, which is a suburban site. The average underprediction of NO_2 was -12%.

In Phase One of the LAQM programme Manchester used a different NO_X to NO_2 conversion factor. The factor used was the Pratt log-log quadratic function, which was derived from the actual NO_X conversion rate measured at Manchester AURN sites between 1998 and 2002. The Pratt function is shown below;

$(NO_X^{1.0741} \times (NO_X^{-0.1581})^{\text{log annual NOx}}) = \text{annual average } NO_2$

The Pratt function was also applied to NO_X measured at Manchester AURN sites in 2001, and the derived NO_2 was compared to actual NO_2 measured at each site. This conversion function only resulted in an underprediction of NO_2

at one site, and the average difference between the derived and measured NO_2 was + 7%.

A comparison of the performance of the two NO_X conversion factors is shown in figure 4.4.

Figure 4.4 NO_X to NO_2 conversion factor performance

AURN site	2001 measured annual average NO_X	2001 measured annual average NO_2	LAQM TG(03) method derived NO_2	Pratt function derived annual average NO_2
Bolton Central	69	36	31	37
Bury Roadside	270	69	58	72
Manchester Piccadilly	107	45	38	47
Manchester South	46	21	25	29
Manchester Town Hall	92	48	36	44
Salford Eccles	92	42	36	44
Stockport Central	80	38	33	40
Wigan Leigh	76	37	32	39
				All results in ug/m^3

The results in the table show that the Pratt function gives a more accurate calculation of NO_2 from NO_X than the empirical function shown in box 6.9 of LAQM TG(03). Also, the Pratt function tends to overpredict the rate of NO_X conversion, whereas the box 6.9 empirical function underpredicts the rate of conversion. As such, the Pratt function was chosen as being the most appropriate conversion factor for this modelling exercise.

4.4 Model verification

The atmospheric dispersion modelling was carried out by ARIC, who were commissioned by Manchester City Council and the other Greater Manchester Local Authorities. Modelling was carried out using the CERC ADMS-Urban dispersion model.

Before the modelling was carried out for future years, the model was run for the base year of 2001. Model output was then compared to actual results from AURN sites in 2001. The comparison allowed the results from the model to be verified, which is described in full in the next section.

Model outputs for 2001 were compared to monitored concentrations at AURN sites across Greater Manchester. In addition, a comparison was made between model output and chemiluminescent analysers which were affiliated to the NETCEN 'Calibration Club', these analysers being subject to the same QA/QC procedures as the AURN site analysers. The results from this comparison, (between modelled and measured NO_X concentrations), were as follows.

Figure 4.5 Modelled and measured NO_X at chemiluminescent analyser sites in Greater Manchester

AURN site name	2001 measured annual average NO_X concentration	2001 modelling output for the site, annual average NO_X
Bolton	69.03	60.23
Bury Roadside	270.20	225.77
Manchester Piccadilly	107.15	62.95
Manchester South	45.69	49.46
Manchester Town Hall	92.29	68.54
Salford Eccles	92.21	73.57
Stockport	79.97	61.65
Tameside Two Trees	53.09	50.72
Wigan Leigh	77.10	54.52
Calibration Club sites below		
Oldham West End Hse.	67.22	65.95
Salford St Marks (M60)	249.29	153.22
Stockport Bredbury	56.21	51.20
Stockport Cheadle	51.43	48.54
Stockport Marple	43.06	44.23
Trafford Moss Park	73.80	55.70
Wigan Parson's Walk	78.00	52.86
		Results in annual average ug/m^3

These results indicated that the model was not accurately predicting NO_X concentrations at these sites. The model was generally underpredicting concentrations at the analyser sites. Only two sites, Manchester South and Stockport Marple, had their NO_X concentrations overpredicted by the model. Model performance was 'best', (there was least error), at the sites located at Manchester South, Tameside, Oldham, and the three Stockport suburbs. These results were significant, as the sites showing the best model performance were those where the analyser was located well away from the nearest road. Additionally, the two sites with an overprediction, (Manchester South and Marple), were both located where there was very little traffic. These results seemed to indicate that the difference between modelled NO_X concentrations, and monitored NO_X concentrations, was probably due to the way that emissions from road transport had been processed, as the error increased in relation to the sites' proximity to roads or urban centres, (where traffic emissions would predominate).

It was recognised that this problem would need to be rectified. Model inputs were checked for suitability and accuracy. Traffic flows, speeds, and fleet composition were checked by GMTU, but no significant errors or omissions were identified. The chosen NO_X to NO_2 conversion factor was re-examined, but the chosen methodology was found to be the best match for NO_X and NO_2 concentration measured in Manchester. The meteorological data set used was taken from the only Met Office weather station within the modelled area. Ultimately it was found that, to the best of our knowledge, appropriate inputs had been used for each of the model variables. It was therefore concluded that the difference between modelled and monitored NO_X could be due partly to a problem with the vehicle emission factors being employed. Speed weighted vehicle emission factors are produced by the Transport Research Laboratory for use across the UK. The emission factors give a speed based figure of g/km of NO_X emissions for an 'average' car or HGV vehicle. The actual emission rate for a vehicle will depend on the vehicle age and driving style. It may be the case that the vehicle fleet in some economically challenged areas of Manchester is comprised of older or more poorly maintained vehicles than the national average, with consequent higher emissions per vehicle than was expressed in the national vehicle emission factors. The development of local transport emission factors was not possible within the time frame provided for this Detailed Assessment.

In order to progress with the modelling exercise, it was decided to adjust the roadside NO_X contribution generated by the model. Technical Guidance Note LAQM TG(03) Appendix 3 provided a number of worked examples, showing how to adjust NO_X and nitrogen dioxide predictions, based on monitored data. These examples were based on cases where there were one or two monitors in the modelled area. The same principles were followed for the modelling carried out for this Detailed Assessment.

4.4.1 Adjustment of modelled NO_X road contribution

The first stage in the adjustment of modelled NO_X was to calculate the road derived contribution to the overall NO_X concentrations in the area. This was calculated for each site using the following equation;

Road derived NO_X contribution = Annual average NO_X - Non-road modelled NO_X - background NO_X

The actual road derived NO_X contribution, obtained from this equation, was then compared to the modelled road contribution, obtained from the emissions inventory and model results file. This comparison is shown in figure 4.6.

Figure 4.6 Modelled and measured roadside NO_X at chemiluminescent analyser sites in Greater Manchester

AURN site name	2001 measured annual average road derived NO_X concentration	2001 modelling output for the site, road derived annual average NO_X
Bolton	21	12
Bury Roadside	236	191
Manchester Piccadilly	62	18
Manchester South	3	7
Manchester Town Hall	47	23
Salford Eccles	43	25
Stockport	38	20
Tameside Two Trees	12	10
Wigan Leigh	35	13
Calibration Club sites below		
Oldham West End Hse.	25	24
Salford St Marks (M60)	208	112
Stockport Bredbury	16	11
Stockport Cheadle	10	7
Stockport Marple	3	4
Trafford Moss Park	31	13
Wigan Parsons' Walk	47	9
		Results in annual average ug/m^3

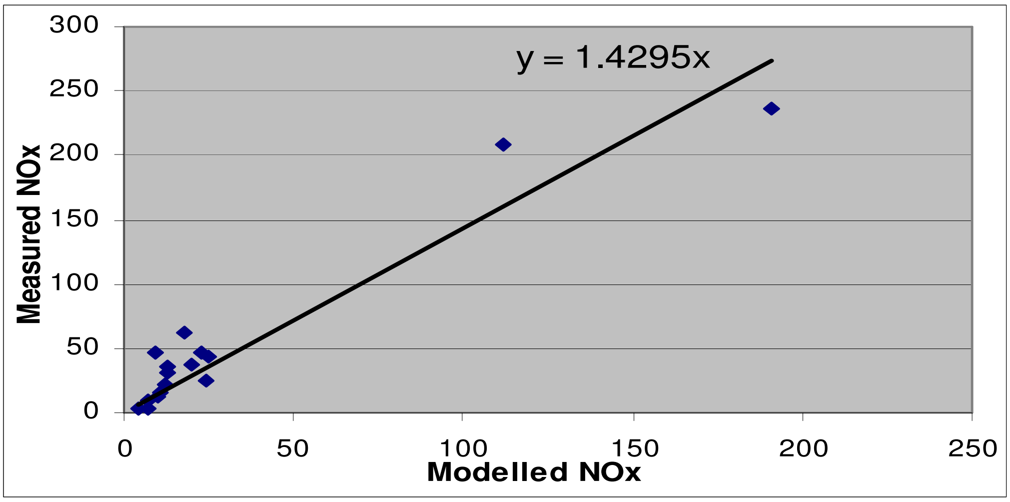
The results show that the sites with the largest difference between modelled and measured NO_X are Bury, St. Marks and Piccadilly. Bury and St. Marks are both roadside locations where the discrepancy in transport emissions will be most pronounced.

The Manchester Piccadilly site is located in Piccadilly Gardens in central Manchester. Piccadilly Gardens is a large public square, which is bordered on three sides by tall buildings and bus lanes.

The analyser at Wigan Parsons Walk is in an unusual location, very close to a large five storey building. This building affects the way in which air moves around the site, and may mean that traffic emissions are unable to effectively disperse around the area, leading to higher measured concentrations.

The comparative measured and modelled NO_X, shown in figure 4.6 above, were then plotted onto a graph, in order to find an appropriate model adjustment factor. The results were plotted both using the results from all of the monitoring sites, and using the results without the Manchester Piccadilly and Parsons Walk sites. The graph used to calculate the adjustment factor is shown in figure 4.7.

Figure 4.7 Plot of monitored and modelled NO_X at chemiluminescent analyser sites in Manchester



results in ug/m³

The plot shows that the average difference between road derived measured and monitored NO_X was 1.4295. It was therefore decided to apply a correction factor of 1.4295 for the road derived NO_X emissions used by the model. As was mentioned earlier a plot was also produced with the data for Manchester Piccadilly and Wigan Parsons Walk excluded, but this produced a smaller correction factor, which would have lead to an underestimation of nitrogen dioxide concentrations at a number of sites.

The model adjustment correction factor was only applied to the road derived NO_X emissions, it was not applied to point source emissions, volume emissions, or background concentrations.

The adjusted road derived NO_X concentrations showed a much better correlation with the measured road NO_X contribution. The adjusted road NO_X contribution is shown in comparison with the unadjusted modelled NO_X, and the measured NO_X, in figure 4.7 overleaf.

Limitations of the atmospheric dispersion model used meant that only a single adjustment factor could be applied across the entire model area. The adjustment factor of 1.4295 was applied during the post-processing of results, meaning that road derived NO_X was modelled first, and the adjustment factor was then applied to NO_X concentrations at each receptor point. Volume emissions and point source emissions were then modelled, and their resultant concentrations were added to the adjusted road NO_X concentrations. All of these concentrations were then added to the background concentrations, to produce the final total NO_X at each point.

Figure 4.8 Measured, unadjusted modelled, and adjusted modelled roadside NO_X at chemiluminescent analyser sites in Greater Manchester

AURN site name	2001 measured annual average road derived NO_X concentration	2001 modelling output for the site, road derived annual average NO_X	Adjusted modelling output of road derived annual average NO_X
Bolton	21	12	17
Bury Roadside	236	191	273
Manchester Piccadilly	62	18	26
Manchester South	3	7	10
Manchester Town Hall	47	23	33
Salford Eccles	43	25	35
Stockport	38	20	28
Tameside Two Trees	12	10	14
Wigan Leigh	35	13	13
Oldham West End House	25	24	34
Salford St Marks (M60)	208	112	160
Stockport Bredbury	16	11	15
Stockport Cheadle	10	7	10
Stockport Marple	3	4	6
Trafford Moss Park	31	13	18
Wigan Parsons Walk	47	9	13
			Results in ug/m^3 NO_X

The adjusted NO_X road contribution was then added to NO_X emissions from volume sources, point sources, and background concentrations. The Pratt log-log quadratic NO_X conversion function was then applied to the total adjusted NO_X concentrations for each location, to produce an adjusted annual average nitrogen dioxide concentration for each site.

A comparison between measured nitrogen dioxide and adjusted modelled nitrogen dioxide concentrations is shown in figure 4.9.

Figure 4.9 Modelled and measured total nitrogen dioxide at chemiluminescent analyser sites in Greater Manchester

AURN site name	2001 measured annual average total NO_2 concentration	Adjusted NO_X modelling output for the site, converted to total annual average NO_2
Bolton	36	36
Bury Roadside	69	76
Manchester Piccadilly	45	38
Manchester South	22	31
Manchester Town Hall	47	40
Salford Eccles	41	42
Stockport	39	37
Tameside Two Trees	31	32
Wigan Leigh	37	34
Calibration Club sites below		
Oldham West End Hse.	35	40
Salford St Marks (M60)	58	64
Stockport Bredbury	35	33
Stockport Cheadle	31	31
Stockport Marple	28	29
Trafford Moss Park	39	35
Wigan Parsons' Walk	36	33
		Results in annual average ug/m^3

The adjusted roadside NO_X emissions, and the unadjusted background concentration, point source emissions, and volume emissions, were converted to nitrogen dioxide using the Pratt function. These nitrogen dioxide concentrations are shown in figure 4.9.

The corrected modelled annual average nitrogen dioxide concentrations show a good comparison with the actual measured values from 2001. Overall, the model overpredicted annual average nitrogen dioxide concentrations by only 1%. Looking at just the urban monitoring sites, the model performance was not quite as good, with an overprediction at those sites of 4%. Nonetheless, the model performance at predicting annual average nitrogen dioxide concentrations is still acceptable.

The original Technical Guidance Note, LAQM TG(00) stated that model performance should be considered satisfactory if measured and modelled concentrations were within 50% of each other. It should also be noted that the atmospheric dispersion modelling carried out as part of the Phase One, Stage 3 Review & Assessment, had an overall annual average nitrogen dioxide underprediction of -7%. By comparison, the modelling carried out for this Detailed Assessment has a degree of accuracy of + 4%.

4.5 Model resolution

The ADMS-Urban atmospheric dispersion model calculates the concentrations of chosen pollutants at hundreds of receptor points in each modelled area. Concentrations between these receptor points are automatically interpolated, and contour maps showing concentrations across the area can then be produced. The resolution of the modelling will critically depend upon the distancing between the receptor points selected.

Technical Guidance Note LAQM TG(03) Appendix A3.154 explicitly states the resolution that was required for Detailed Assessment modelling. The guidance recommends that where roads are the major source of emissions, a receptor point spacing of 5 to 10 metres (at locations close to the road), would be needed to ensure that no areas of exceedence were missed. Furthermore, LAQM TG(03) Appendix A3.151 indicates that in areas where sources other than road traffic predominate, receptor point spacing should not exceed 50 metres.

The version of ADMS-Urban used in this Detailed Assessment includes an 'intelligent gridding' facility, by which receptor points are automatically assigned to closely spaced locations near to roads, and are placed further apart away from roads. In this modelling exercise, receptor points were placed 7m apart from each other at locations within 50m of roads, and are gradually spaced further apart as distance from the road increases, to a maximum spacing of 50m between receptors at background locations. This proposal was subject to detailed consideration, and discussion with the DEFRA modelling helpline, and it is considered that it provides the necessary level of definition to meet the guidance criteria and check that all possible roads and junctions at risk that were identified in the USA were included in the exceedence areas.

This receptor point grid spacing dictated the size of modelling area that could be investigated in each modelling run. Trials revealed that a maximum area of 5km by 5km could be modelled at any one time. An area of 5km by 5km was therefore chosen for each of the model areas investigated, as a balance between model sensitivity and coverage of the city.

The Manchester City Council Update & Screening Assessment identified the locations that should form the focus of the Detailed Assessment. These locations were spread across the city. The wide geographic spread of areas requiring Detailed Assessment, combined with the relatively large 5 by 5 km area used by the model, meant that practically the whole of Manchester was subject to atmospheric dispersion modelling. This fact proved useful for two reasons. Firstly, the wide modelling coverage provides confidence that no areas of exceedence have been missed. Secondly, whole Authority maps can be produced from a mosaic of the model outputs, which were extremely important in defining the extent of the areas of exceedence across the city.
The ADMS-Urban atmospheric dispersion model works by calculating the concentration of pollutants at numerous receptor points, located across the modelled area. Concentrations between the receptor points were

automatically interpolated by the model. As was discussed in section 4.4 of this report, the spacing between the receptor points differs according to distance from the nearest road. The calculated and interpolated concentrations can then be plotted on a map, to form a contour plot of atmospheric concentrations. The output from the model was produced both as a paper 'hard copy' map, and as a GIS layer. The model can also be set up to display results from selected receptor points in a tabular format. The receptor point display was useful as it gave exact predicted concentrations for the receptor point, whereas the contour plots displayed bands of concentration.

These contour plots were produced for predicted annual average concentrations of NO_X, NO_2 and PM_{10}. The calculation of the annual averages used projected emissions for the objective year, along with hourly sequential meteorological data from 1999. The annual average concentrations were produced by summing the results of aggregated emissions and met data to produce an arithmetic mean. This process used considerable computer processing resources. The production of annual average contour plots for Greater Manchester took the equivalent of 15,120 PC hours.

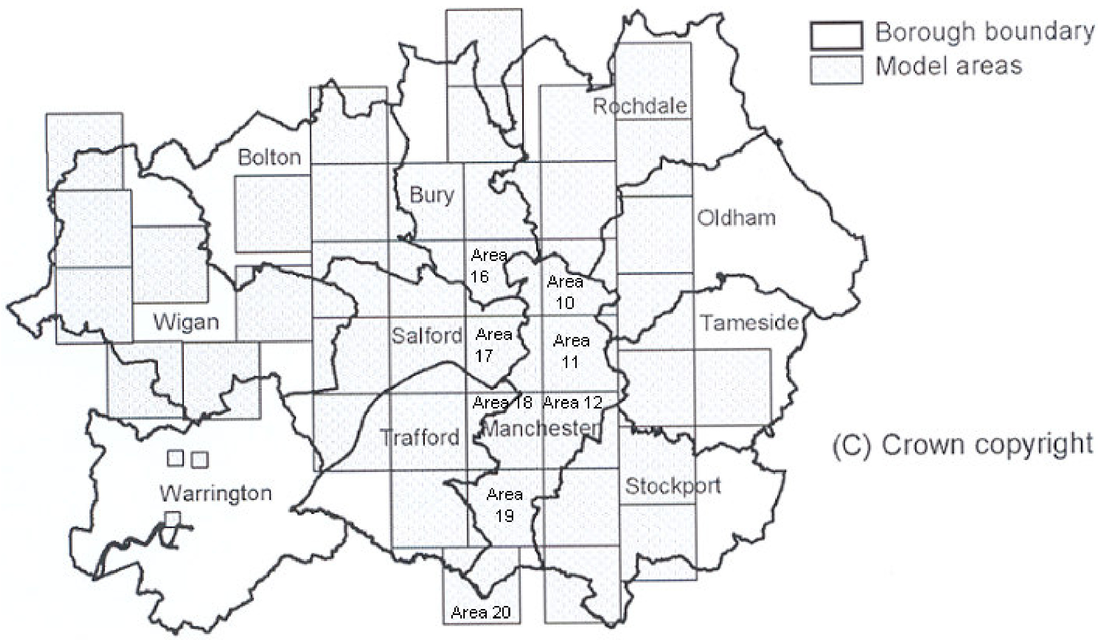
The results from the atmospheric dispersion modelling exercise are shown in the next section of this report.

5 Results of atmospheric dispersion modelling

Atmospheric dispersion modelling can only be carried out for limited geographic areas, during each run of the model. As was discussed in section 4.5 of this report, modelling areas of 5km by 5km were selected for this Detailed Assessment.

For the purposes of this atmospheric dispersion modelling Greater Manchester was split up into 44 separate 5x5km modelling areas. The areas relevant to the Manchester City Council area were numbered 10 to 12, 16 to 19, and 20. The location of the modelling areas are shown in figure 5.1.

Figure 5.1 Location of modelling areas.



These modelling areas cover almost all of the Manchester City Council area. All of the locations identified in the Update & Screening Assessment, (as requiring inclusion in the Detailed Assessment), were located within the modelled areas. A full description of the results for each modelling area can be found in Appendix A (NO_2 diffusion tube bias correction) of this report.

The city of Manchester can be divided into three separate geographic areas. These are the city centre, the area in the vicinity of Manchester Airport, and the rest of the city.

The city centre has a pattern of land use unlike any other area in the city. There are many narrow and congested streets, lined by tall buildings, in the city centre. The city centre is the most densely built up area of the city.

Manchester Airport has been treated separately, as the airport has a unique combination of emission sources, including aircraft, mobile and fixed ground equipment, and traffic.

5.1 The geography of Manchester

The city of Manchester is located in the centre of Greater Manchester, in the north west of England. The city is bounded by Rochdale Metropolitan Borough Council (MBC), Oldham MBC, Tameside MBC, Stockport MBC, Macclesfield Borough Council, Trafford MBC, the City of Salford, and Bury MBC.

Figure 5.2 Location of Manchester city centre, motorways, and Manchester Airport

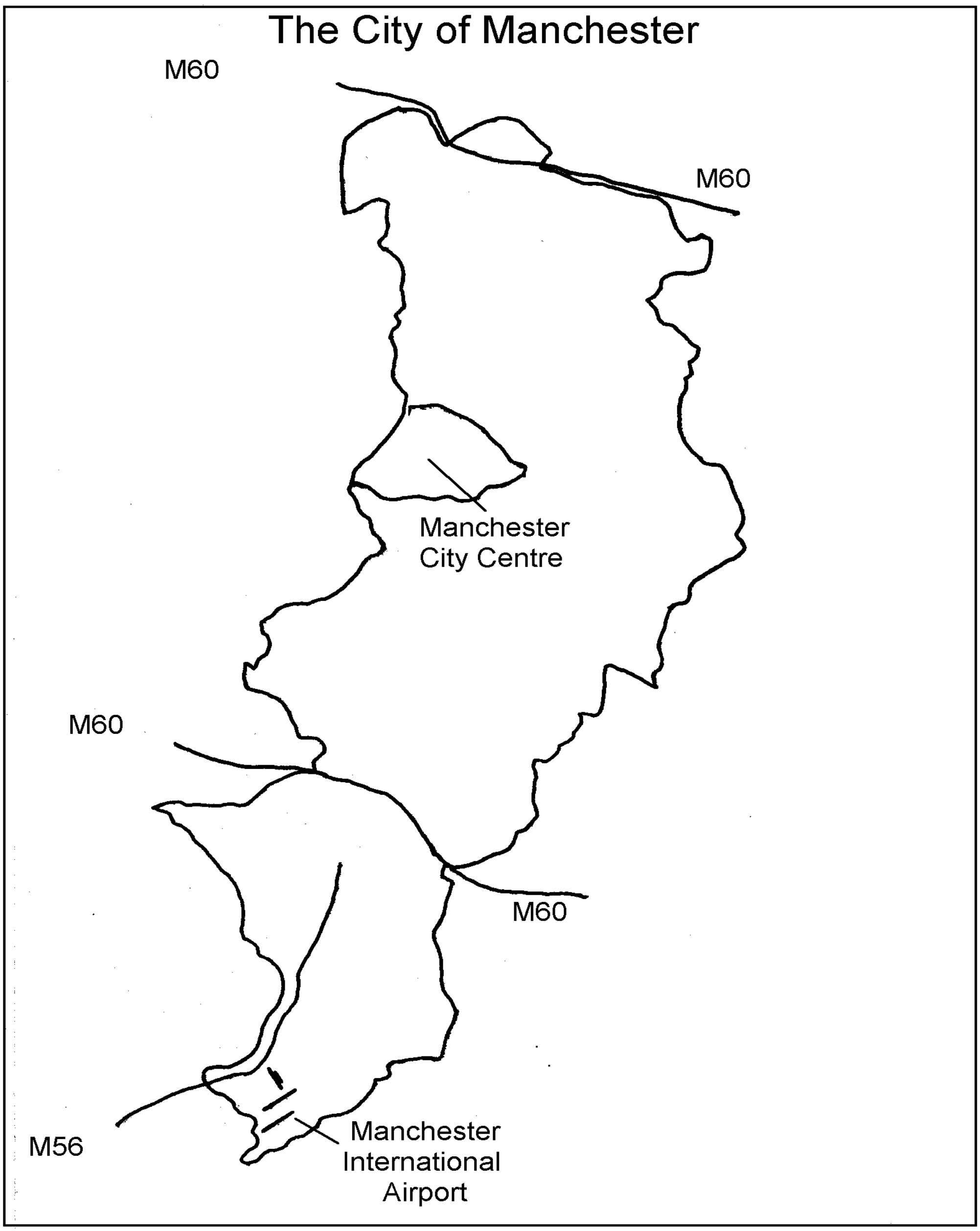


Figure 5.2 shows the relevant locations of the city centre area, (which lies adjacent to the western boundary of the city), the motorways, and the airport.

The M60 is an orbital motorway, which passes through the city to both the north and south of the city centre.

The city of Manchester, was divided into three types of area, (city centre, airport, and rest of city), for the purpose of presenting the results of the atmospheric dispersion modelling. The map below shows selected districts in Manchester, and also shows the location of the airport and city centre.

Figure 5.3 Map showing selected districts in Manchester, and the location of the city centre and airport.

5.2 2005 nitrogen dioxide dispersion modelling results for Manchester city centre

In 2001 Manchester City Council completed the (Phase One), Stage Three Review & Assessment of Air Quality. Based on the results of this Review & Assessment, an Air Quality Management Area, (AQMA), was declared.

The AQMA was based on predicted 2005 exceedences of the annual average nitrogen dioxide objective. The whole of Manchester city centre was included within the AQMA.

Nitrogen dioxide concentrations have been measured in Manchester city centre, using continuous electronic chemiluminescent analysers, since 1987. Nitrogen dioxide diffusion tubes have been used in the city centre since 1986. Bias adjusted diffusion tube results are available from 1997.

The concentration of nitrogen dioxide, measured at roadside locations is currently above the objective. However, roadside concentrations measured in the city centre show a downward trend, and if this trend continues, the concentration at roadside locations will have reduced to approximately the objective, or below the objective level, by 2010. The downward trend at roadside sites is due to the increasing use of vehicle emission control technology, and does not take into account the reductions that will be achieved by the additional local air quality actions being planned.

The concentration of nitrogen dioxide, measured using diffusion tubes at urban background and urban central locations is currently below the objective. The majority of the city centre, (and the majority of locations in the city centre where the public would be exposed), will achieve the air quality objectives by 2005.

Areas of predicted exceedence of the 2005 annual average objective, in the city centre, are confined to locations close to busy roads. Although these areas of exceedence are extremely limited in size, there is some public exposure within these areas.

Manchester City Council is committed to achieving the air quality objectives, through its Air Quality Action Plan. The Action Plan will aim to improve air quality across the city, but with a focus upon the areas where exceedences have been predicted.

Manchester City Council is also working in partnership with the nine other Greater Manchester authorities, on the Greater Manchester Air Quality Action Plan. This plan includes a package of measures that will aim to reduce the concentration of nitrogen dioxide, and eliminate the areas of predicted exceedence.

5.2 2005 nitrogen dioxide dispersion modelling results for Manchester city centre

The location of Manchester city centre is shown in figure 5.2. The city centre area described here is the area which falls within the Manchester Inner Ring Road. The city centre entirely falls within the Central council ward, although it should be noted that this council ward also extends outside of the city centre area described here.

Manchester city centre is a densely urbanised area, comprised of retail commercial and residential land use. The city centre includes numerous narrow and congested streets, which are subject to heavy traffic flows.

The density of buildings in the city centre, combined with the high traffic flows found in this area, create a unique situation in the city, and the city centre has therefore been dealt with separately in this Detailed Assessment, to identify the sources and locations of exceedences, and to inform the Manchester Air Quality Action Plan.

The economic regeneration of Manchester has led to numerous former commercial buildings in the city centre being converted into flats and 'loft style' apartment blocks. Many of these apartments are located in buildings whose facade faces directly onto busy city centre streets, leading to near roadside exposure.

The annual average nitrogen dioxide concentration is measured in Manchester using chemiluminescent analysers, at two AURN monitoring sites. These analysers are subject to AURN QA/QC procedures. The results from these analysers are shown in figure 5.4.

Figure 5.4 Current and projected future concentrations of nitrogen dioxide in Manchester, measured at AURN sites.

Year		Manchester Town Hall	Manchester Piccadilly
1997	**Annual average**	**51**	**42**
	Data capture	96%	91%
1998	**Annual average**	**41**	**40**
	Data capture	97%	95%
1999	**Annual average**	**41**	**44**
	Data capture	99%	95%
2000	**Annual average**	**42**	**42**
	Data capture	95%	97%
2001	**Annual average**	**48**	**44**
	Data capture	99%	72%
2002	**Annual average**	**44**	**38**
	Data capture	98%	90%
2003	**Annual average**	**44**	**45**
	Data capture	96%	92%
2005	Projected '05 concentrations based on scaled '03 results	42	43
2010	Projected '10 concentrations based on scaled '03 results	36	40

The Manchester Town Hall site is located at an urban background location, and the Manchester Piccadilly site is classified as an urban central location. The results from these analysers do not show a clear trend. The results were projected to 2005 and 2010 using the method described in Technical Guidance Note LAQM TG(03) boxes 6.6 and 6.7. The projected results show that the annual average concentration will approximately be at the objective in 2005, and will be below the objective in 2010.

Air quality monitoring is also carried out in Manchester city centre using diffusion tubes, at roadside, urban background, and urban central sites. The results obtained from these diffusion tubes are shown in the table below. Results have been scaled to 2005 and 2010 using the correction factors shown in Technical Guidance Note LAQM TG(03) boxes 6.6 and 6.7

Figure 5.5 Bias adjusted results from diffusion tube monitoring in the city centre

Year	Monitoring Site				
	Princess St	Oxford Rd	Town Hall	Cheethams School	Piccadilly Gardens
	(Roadside)	(Roadside)	(Urban Background)	(Urban Background)	(Urban Centre)
1997	-	-	51	52	-
1998	-	72	41	41	-
1999	-	75	41	43	41
2000	-	62	42	44	43
2001	59	64	48	50	47
2002	50	44	46	45	36
2003	52	61	47	51	43
2005*	50	58	45	49	41
2010*	43	50	39	42	35
Annual average nitrogen dioxide in ug/m^3					

**2005 and 2010 figures projected from 2003 results*

These results show that roadside concentrations have followed a decreasing trend. The Princess St. site is predicted to be almost achieving the objective by 2010. The Oxford Rd. site shows predicted concentrations that would exceed the objectives. The two roadside locations chosen are representative of busy, narrow streets, where there are residential buildings with a façade opening directly onto the pavement, adjacent to the road. As such, these two roadside sites represent worse-case locations for exposure.

Urban background and urban centre sites do not show the clear decreasing trend in concentrations, that has been seen at the roadside sites. The urban background and urban centre sites are predicted to have concentrations approximately at or below the objective by 2010. The urban background and urban central sites are representative of the majority of locations where public exposure will occur. As the objectives are likely to be met at these locations, it is clear that the majority of city centre residents and workers will not be exposed to exceedences of the objective.

However, there are some residential buildings which are located at near roadside locations, where exposure would occur. Dispersion modelling was used to provide a prediction of air quality across the wider city centre area, including both background and roadside sites.

Dispersion modelling of the city centre was carried out for both 2005 and 2010, using the methodology described in section 4.3 of this report. The city centre covers an area larger than the maximum area available for each modelling run. As such the city centre was covered by two separate modelling runs. These modelling runs corresponded to modelling areas 17 and 11 shown in figure 5.1.

The contour plots of annual average concentration produced for the city centre, are shown on the following pages.

The contour plots show that in 2005 the areas of potential exceedence are confined to near roadside locations, adjacent to major roads. Urban background locations in the city centre are not predicted to have exceedences of the objective, based on the results of this modelling work. These findings are supported by the monitoring results for the city centre.

In addition to the contour plots, three city centre receptor points were selected, and their results were displayed in tabular form. The receptor points selected were Cheethams School of Music, (urban background), residential properties on Oxford Road, (roadside), and Manchester Piccadilly, (urban central). Results at these receptor points are shown in table 5.6.

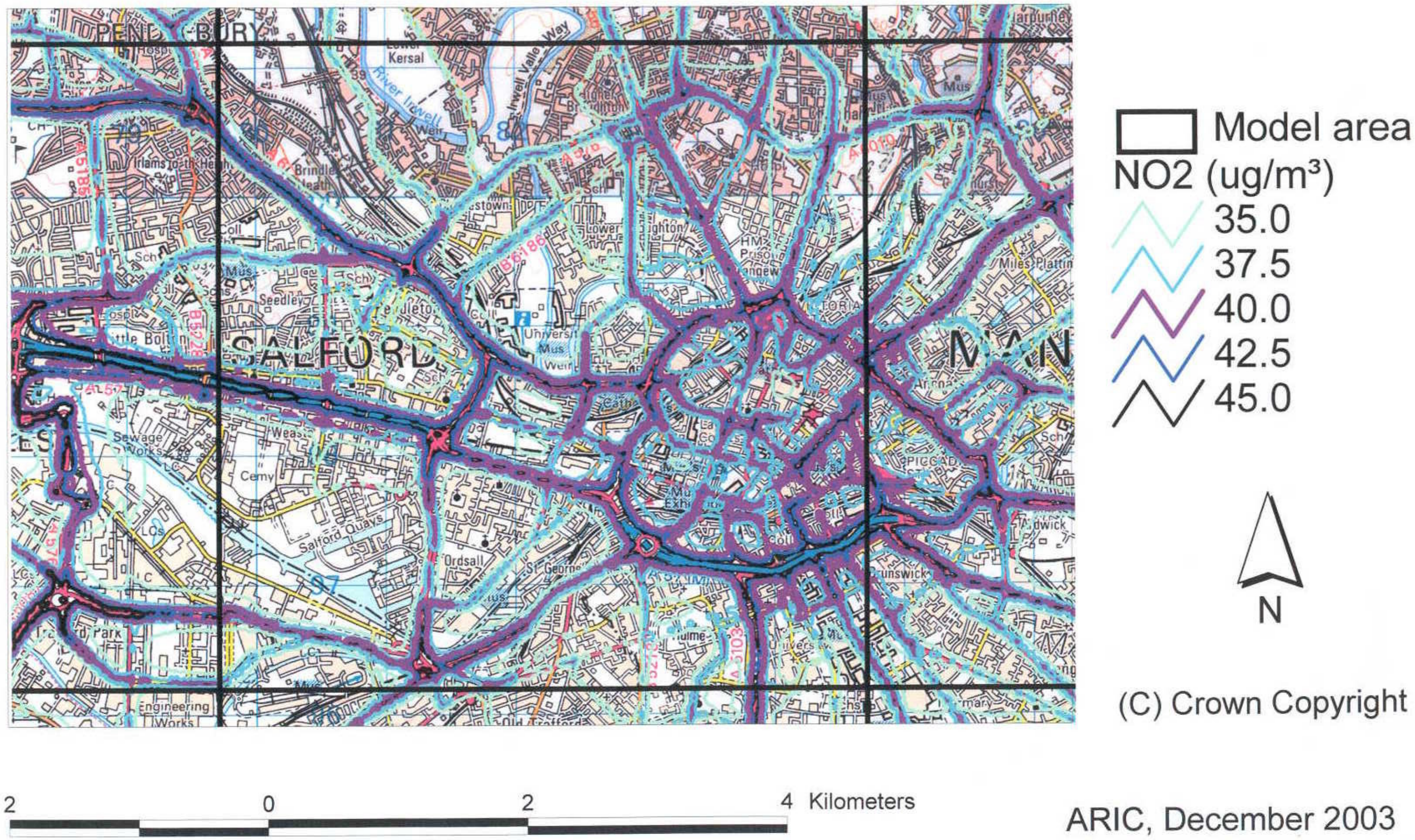
Figure 5.6 Results from dispersion modelling at receptor points in Manchester city centre

Receptor Point Location	Distance to Nearest Road	2005 NO_2 concentration (ug/m^3) from model
Cheethams School of Music	88m to Deansgate	37.82
Residential properties on Oxford Road	3m to Oxford Road	43.85
Piccadilly Gardens AURN Site	100m to Portland St	36.71

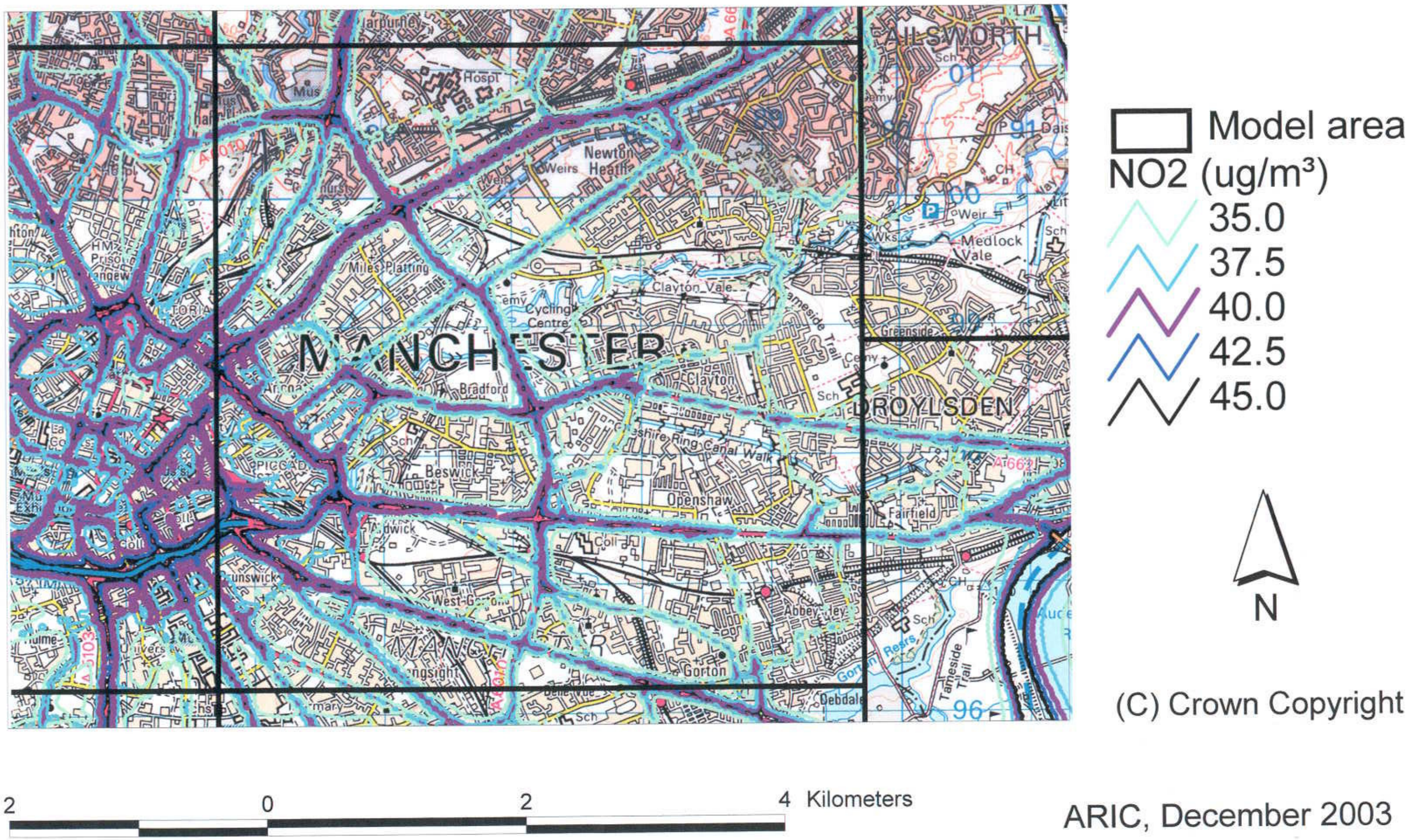
The receptor point results also indicate that there will be exceedences of the objective at roadside locations, but not at the urban background locations where exposure is most likely to occur.

The contour plots, (shown on the following pages), show that the areas of predicted exceedence are associated with the major roads in the city centre. There are no areas of exceedence associated with any other type of emission source, (e.g. industrial or commercial emissions sources), although these sources do contribute to increased background levels of pollution across the city centre. The Update & Screening Assessment did not indicate that there were any relevant non-road emission sources in the city centre area, but emissions from other sources were included in the dispersion modelling runs.

Area 17 - 2005 annual average



Area 11 - 2005 annual average

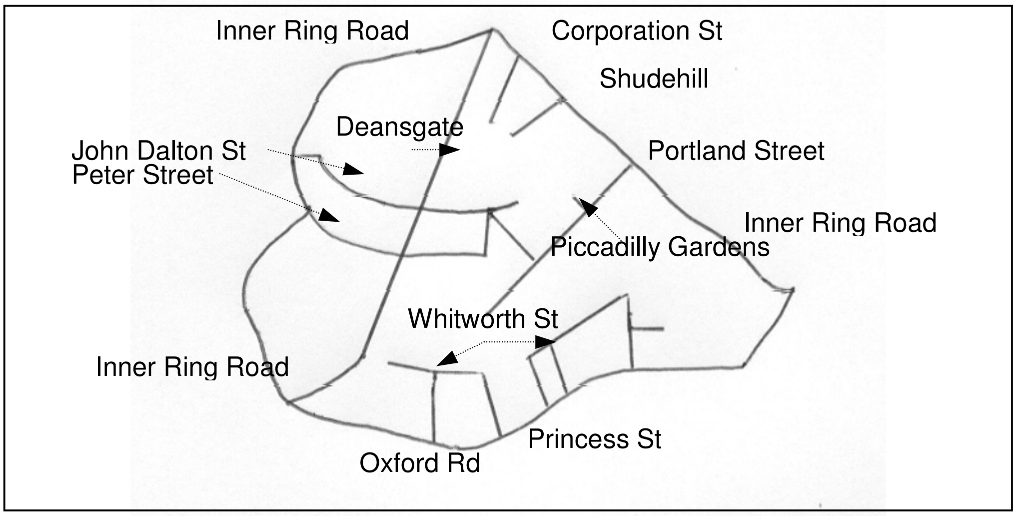


ARIC, December 2003

The contour plots, shown on the previous pages, show that the areas of predicted exceedence follow the major road network in the city centre.

The map below shows the names of the roads in the city centre which are expected to experience exceedences of the objective in 2005.

Figure 5.7 Roads in Manchester city centre, with predicted exceedences of the 2005 annual average nitrogen dioxide objective



The roads shown in figure 5.7 have different sized areas of exceedence associated with them. The details of the individual areas of exceedence are shown in figure 5.8 overleaf. Some of the roads undergo name changes along their length, for example, at the southernmost part of Deansgate, (near the junction with the inner ring road), the name of the road changes from Deansgate to Bridgewater Viaduct. Where a road undergoes a name change, both names are listed in figure 5.8 overleaf.

In addition to the roads listed, certain junctions were shown to have areas of exceedence much wider than the 'corridor' of exceedence which extends along the length of the road. These junctions are also listed in figure 5.8 overleaf.

All of these roads and junctions, (identified as having exceedences from these modelling results), were also identified in the Update & Screening Assessment. There are no areas of the city centre where there are exceedences identified by the modelling, which were not previously identified by the Update & Screening Assessment.

Figure 5.8 Extent of areas of exceedence (2005), associated with roads in Manchester city centre, from atmospheric dispersion modelling

Road name	Distance of boundary of area of exceedence, from centre of road (m)	2005 Traffic flow on road (annual average daily traffic)	Buses / HGV as percentage of traffic flow
Deansgate (including Bridgewater Viaduct)	37	17424	3
John Dalton Street (incl Bridge St)	15	14931	2
Peter St (including New Quay St)	24	13149	1
Corporation St	36	9212	11
Shudehill	31	11053	10
Portland Street	49	10290	14
Oxford Road (including Oxford St)	35	16797	18
Princess Street	47	17413	4
Whitworth Street	37	14101	1
Piccadilly Gardens	28	10230	7
Inner Ring Road, north east segment (Great Ancoats St)	50	31001	3
Inner Ring Road, north west segment (Trinity Way)	45	27993	1
Inner Ring Road, southern segment (Mancunian Way)	68	50760	1
Junction of Mancunian Way & Cambridge St	120	34026	1
Junction of Mancunian Way and Chester Rd	214	48951	1
Junction of Corporation St and Trinity Way	75	42589	6

The results in figure 5.8 indicate that exceedences can be expected near roads with a predicted 2005 daily traffic flow of 13,000 and over, in the city centre area. In addition, exceedences are predicted for roads with an exceptionally high flow of buses or HGVs, (the average bus and HGV proportion on roads in Manchester is 3%). Roads with a bus / HGV flow of 10% or higher have shown exceedences in this modelling. The contribution of emissions from buses and HGVs were assessed in the Manchester City Council Stage 4 Review & Assessment, which identified that buses and HGVs make up 15% and 56% of road transport derived NO_X emissions respectively, (10% and 39% of total NO_X emissions respectively).

The receptor point results indicated that the maximum annual average concentration, at a point where exposure could occur, (which occurred on Oxford Road), was predicted to be 43.85 ug/m^3, 3.85 ug above the objective. A NO_X reduction of 3.78 ug/m^3 would be required to achieve a 3.85 ug reduction in nitrogen dioxide concentration.

The dispersion modelling has included those roads and junctions identified in the Update & Screening Assessment as requiring inclusion in the Detailed Assessment. The roads and junctions identified in the USA as requiring inclusion in the Detailed Assessment all have predicted areas of exceedence associated with them, with one exception, which is described below.

Since the completion of the Update & Screening Assessment, Cannon Street has been closed to traffic, whilst the adjacent Arndale Centre is being extensively redeveloped. The bus station formerly situated on Cannon Street has been closed, and will not re-open. The buses which used to stop on Cannon Street have been temporarily relocated to Chapel Street, which is located in the City of Salford. Presently, these bus stops will be permanently relocated to Shudehill. The modelling carried out in the Shudehill area included emissions from the buses that will shortly be relocated here, from Cannon Street. Shudehill was shown as experiencing an area of exceedence in 2005.

The areas of exceedence in Manchester city centre are all associated with emissions from road traffic. The areas of exceedence form 'corridors' along the major roads, and the majority of the city centre will not suffer from exceedences of the objectives.

The concentration of nitrogen dioxide in these areas of exceedence is predicted to reduce over time, as more vehicles with emission control technology join the local fleet, and older, more polluting vehicles are retired. This reducing trend in roadside nitrogen dioxide concentrations has been observed in the results from the Manchester air quality monitoring programme.

The area of exceedence identified in this Detailed Assessment is not identical to the area of exceedence identified in the Stage 3 Review & Assessment, carried out by Manchester City Council in 2001. The modelling carried out for this Detailed Assessment used the latest vehicle emission factors from the

National Atmospheric Emissions Inventory, (NAEI), and used higher resolution modelling at roadside, (the intelligent gridding facility). The area of exceedence identified from the Stage 3 Review & Assessment, (carried out in 2001), covered the whole of the city centre area, (approximately 4.42km^2). The results from this Detailed Assessment are different, with exceedences confined to the roadside areas close to the major roads. The area of exceedence, identified from this Detailed Assessment, covers an area of approximately 1.64km^2, or 37% of the original area of exceedence.

Although the majority of the city will not experience an exceedence of the objectives, some of the roadside areas of exceedence identified in this report are also relevant to public exposure, and will require continued monitoring and assessment. All of the areas of exceedence listed in table 5.8 contain areas of residential development, (with the exception of Piccadilly Gardens, which is an urban central location where regular public exposure is considered possible). The nitrogen dioxide concentration in these areas is only marginally above the objective, (and the objective will be achieved in due course, as a result of the downward trend in roadside concentrations produced by improving vehicle technology). Manchester City Council has also committed to implementing additional Local Air Quality Management programmes wherever public exposure to exceedences could occur.

Manchester City Council is working in partnership with the nine other Greater Manchester Local Authorities, to implement the Greater Manchester Air Quality Action Plan. The Action Plan will reduce emissions from all sources, but is particularly focused on reducing emissions from road vehicles, and will aim to eliminate these roadside areas of exceedence in the city centre. Traffic management, vehicle emission testing, and the promotion of public transport are all included in the Action Plan, to reduce emissions in the city centre. Additionally, a package of measures are proposed to reduce background concentrations in the city centre, (for example, a programme of encouraging emission reduction from commercial buildings), which will also benefit the areas of exceedence by lowering total NO_X emissions, thereby contributing to a reduction in nitrogen dioxide concentrations.

Air quality will continue to be monitored and assessed in Manchester city centre, and the effectiveness of the Greater Manchester Air Quality Action Plan will be monitored and reported annually.

5.3 2010 nitrogen dioxide dispersion modelling results for Manchester city centre

Section 5.2 of this report concluded that there were certain roadside locations in Manchester city centre, where the annual average nitrogen dioxide concentration may be exceeded in 2005.

Monitoring of nitrogen dioxide, at roadside locations in the city centre, has shown that roadside concentrations are decreasing. Guidance issued by DEFRA indicates that this reduction is likely to continue to the year 2010, and beyond.

Atmospheric dispersion modelling has shown that the areas of predicted exceedence in the city centre will significantly shrink in size, between 2005 and 2010. This reduction in the area of exceedence will be achieved by improving vehicle emission control technologies, which have been introduced at a national level.

Despite the predicted reductions in roadside nitrogen dioxide concentration, some roadside areas of the city could still experience exceedences of the objectives in 2010, without the implementation of the Greater Manchester Action Plan.

5.3 2010 nitrogen dioxide dispersion modelling results for Manchester city centre

In 1999 the European Union introduced the First Air Quality Daughter Directive, (1DD), which set objectives for a number of key air pollutants. The 1DD objectives for nitrogen dioxide match the UK 2005 objectives, (in terms of target concentrations and numbers of permitted exceedences), but are set with a target date of 2010. These 1DD objectives have been transposed into UK legislation.

The EU First Daughter Directive objectives are;

- 1-hour limit of 200 ug/m^3, not to be exceeded more than 18 times per year, to be achieved by 1 January 2010.

- Annual average limit concentration of 40 ug/m^3, to be achieved by 1 January 2010.

An assessment of nitrogen dioxide concentrations against the 2010 1 hour objective was carried out in section 3 of this report. This assessment concluded that there were no locations in Manchester where the 1-hour objective would be exceeded.

However, the assessment of 2005 annual average concentrations, described in section 5.2 of this report, showed that there were areas of Manchester city centre which could experience exceedences of the objectives. The assessment of 2005 concentrations showed that the objective would be met at urban background and urban central locations, but that exceedences could occur at locations close to busy roads, and roads with a high flow of buses / HGVs.

Annual average nitrogen dioxide concentrations measured at roadside locations in the city centre, have exhibited a downward trend. This reduction was produced by the increasing penetration into the national fleet of vehicles fitted with emissions control technology, such as catalytic converters. Technical guidance note LAQM TG(03) section 6.06 states that this downward trend in roadside concentrations is expected to continue up to, and beyond, the year 2010.

Future roadside and background concentrations of nitrogen dioxide were calculated by projecting the results of air quality monitoring carried out in the city centre.

Existing monitoring data, (from both chemiluminescent analysers and diffusion tubes), were projected forward to 2010. Results from the city centre monitoring network were shown in figures 5.4 and 5.5. The projected 2010 concentrations, (projected from 2003 annual average results), are shown in the tables 5.9 and 5.10.

Figure 5.9 Projected 2010 nitrogen dioxide concentrations at AURN sites in Manchester city centre.

Year		Manchester Town Hall	Manchester Piccadilly
2010	Projected '10 concentrations based on scaled '03 results	36 ug	40 ug
Annual average nitrogen dioxide in ug/m^3			

Figure 5.10 Projected 2010 nitrogen dioxide concentrations at diffusion tube sites in Manchester city centre.

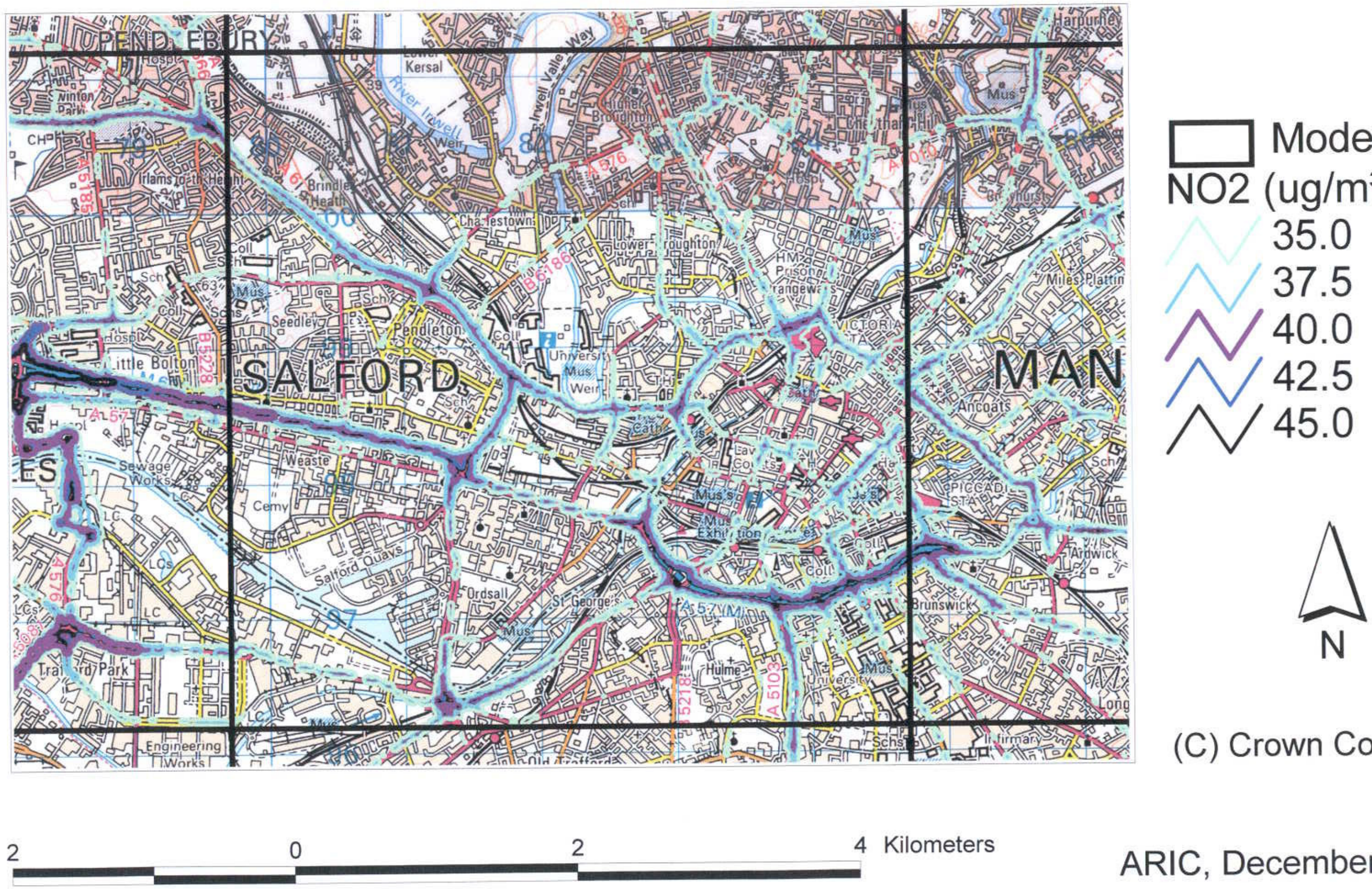
Year	Monitoring Site				
	Princess St	Oxford Rd	Town Hall	Cheethams School	Piccadilly Gardens
	(Roadside)	(Roadside)	(Urban Background)	(Urban Background)	(Urban Centre)
2010	43	50	39	42	35
Annual average nitrogen dioxide in ug/m^3					

The results indicate that in 2010 the concentration of nitrogen dioxide at urban background and urban central locations would be approximately at, or below, the objective level. However, despite the reducing trend in roadside concentrations, some roadside locations could still experience exceedences in 2010.

To give a clear picture of where the exceedences will occur in 2010, and how those areas of exceedence differ from those predicted for 2005, the dispersion modelling exercise was repeated for the year 2010. The same modelling inputs were used for the modelling of 2010 annual average concentrations, as had been used for the modelling of 2005 averages. The only exception, (in terms of model inputs that were changed for 2010), were traffic flows, and vehicle emission factors. Traffic flows for 2010 were derived by scaling existing traffic data, using National Road Traffic Forecast growth factors, (the 'central' or 'medium' growth factor was used). Appropriate speed weighted vehicle emissions factors for 2010 were taken from the National Atmospheric Emissions Inventory database.

As with the modelling for 2005, contour plots of the city centre were produced. The contour plots for 2010 annual average nitrogen dioxide concentration, in the city centre, are shown on the following pages.

Area 17 - 2010 annual average



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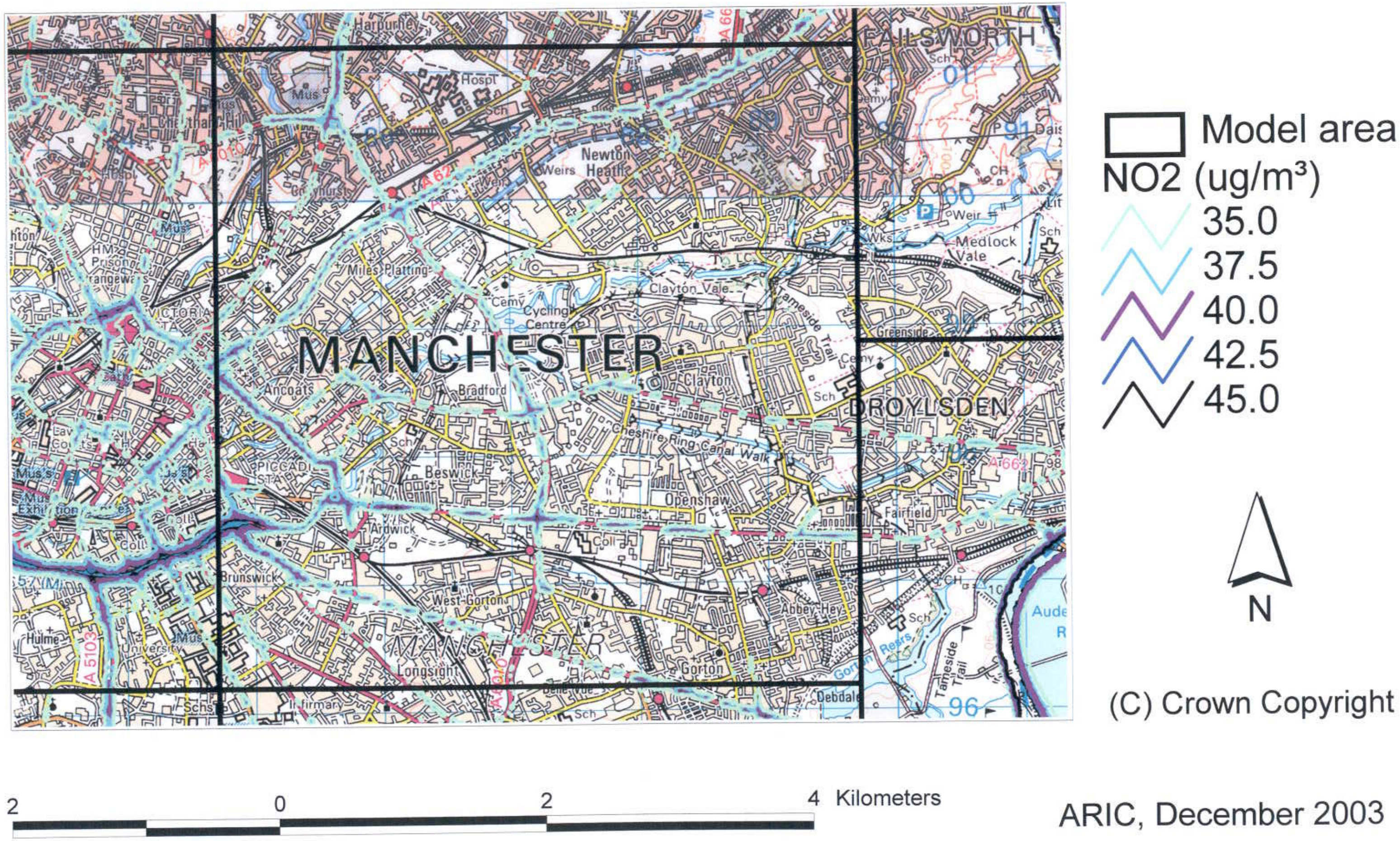
ARIC, December 2003

Area 11 - 2010 annual average



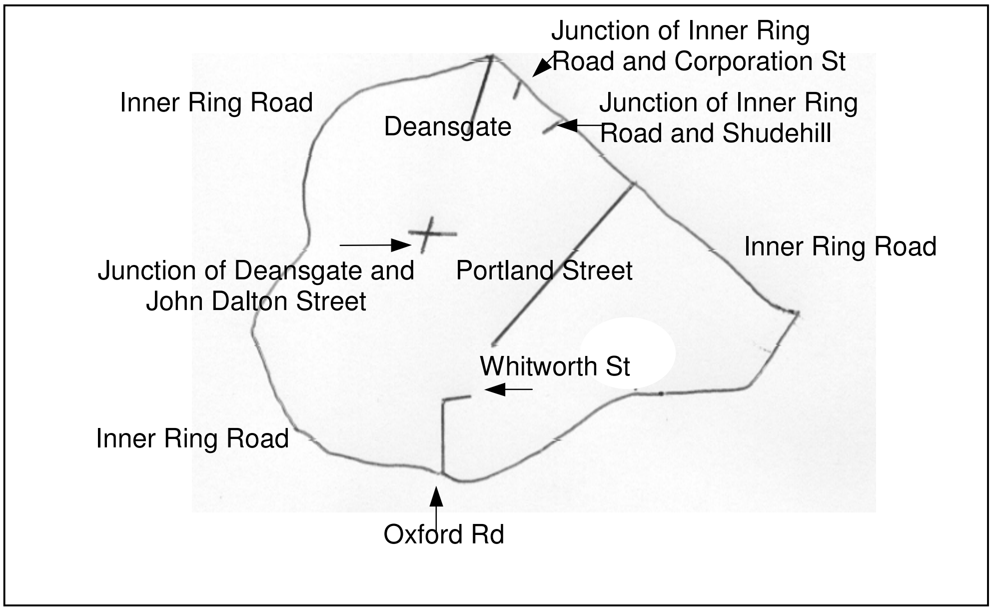
ARIC, December 2003

The contour maps on the previous pages show the annual average concentration of nitrogen dioxide, predicted for 2010, across the city centre.

The areas of exceedence shown on these maps are all at roadside locations, close to major roads in the city centre. The predicted area of exceedence in 2010 is smaller than the area predicted for 2005, due to the predicted continuing downward trend in roadside concentrations. In 2005 the area of exceedence covered approximately 1.64km^2, whereas by comparison, the modelling for 2010 shows an area of predicted exceedence of only approximately 0.77km^2, or 47% of the 2005 area.

The map below shows the names of the roads in the city centre which are expected to experience exceedences of the objective in 2010.

Figure 5.11 Roads in Manchester city centre, with predicted exceedences of the 2010 annual average nitrogen dioxide objective



The roads shown in figure 5.11 have different sized areas of exceedence associated with them. The details of individual areas of exceedence are shown in figure 5.12 overleaf.

Figure 5.12 Extent of areas of exceedence (2010), associated with roads in Manchester city centre, from atmospheric dispersion modelling

Road name	Distance of boundary of area of exceedence, from centre of road (m)	2010 Traffic flow on road (annual average daily traffic)	Buses / HGV as percentage of traffic flow
Deansgate	18	18393	3
Junction of Deansgate and John Dalton St	20	25819	3
Junction of Inner Ring Road and Corporation St	17	39398	5
Junction of Inner Ring Road and Shudehill	13	32683	4
Portland Street	20	11224	14
Oxford Road (including Oxford St)	14	17981	18
Whitworth Street	14	15767	2
Inner Ring Road, north east segment (Great Ancoats St)	21	32799	3
Inner Ring Road, north west segment (Trinity Way)	15	28986	1
Inner Ring Road, southern segment (Mancunian Way)	22	52831	1

The results in figure 5.12 above can be compared to those shown in figure 5.8, (the areas of exceedence predicted for 2005). A comparison of these results shows that the areas of predicted exceedence are much smaller in 2010, than was the case for 2005. Some of the roads that were predicted to have roadside exceedences in 2005 were shown to meet the objectives in 2010.

This reduction in concentrations is primarily due to the expected reduction in the emissions of nitrogen oxides from motor vehicles. Over time older more polluting vehicles, (such as passenger cars build before catalytic converters became mandatory in 1995), will be retired, and replaced by newer, less polluting vehicles. The Manchester Air Quality Action Plan will introduce measures to achieve nitrogen dioxide reductions in addition to those secured by national vehicle emission reduction programmes.

5.4 2005 nitrogen dioxide dispersion modelling results for Manchester Airport

Manchester Airport is located approximately 10 miles south of Manchester city centre. Manchester Airport is the largest airport in the north west of England, and is the third busiest airport in the UK. Nearly 20 million passengers use the airport each year.

Manchester City Council is committed to working in partnership with Manchester Airport Plc, on a variety of environmental protection programmes. The airport programmes of environmental improvement were set out in the Manchester Airport Environment Plan to 2015, which was published for consultation in 2004.

Monitoring of nitrogen dioxide at locations close to the airport has been undertaken since 1997. Results from air quality monitoring using both real time analysers, and diffusion tubes, have shown that the concentration of nitrogen dioxide is below both the 1-hour and annual average objective, at locations representative of where public exposure would be likely. Monitoring results were projected forward to 2005, and these projected results indicated that the objective would be achieved in these locations in 2005.

The Manchester City Council Update & Screening Assessment indicated that Manchester Airport should be included in the Detailed Assessment. This conclusion was based on technical guidance, which stated that airports with a passenger throughput of over 5 million a year would require inclusion in a Detailed Assessment.

Atmospheric dispersion modelling was carried out for Manchester Airport. The results from the dispersion modelling indicated that there would be exceedences of the nitrogen dioxide objective within the boundary of the airport site. These areas of exceedence were expected along the runways and taxiways, around the aircraft parking areas, around the terminal buildings and on site car parks, and along the airport approach road.

None of the areas of exceedence, associated with the airport, extended to any location where non-occupational public exposure was likely. Particular attention was paid to the nearest residential locations to the airport, and these locations were shown to be achieving the objectives.

5.4 2005 nitrogen dioxide dispersion modelling results for Manchester Airport

The location of Manchester Airport is shown in map 5.2. The airport is located in the extreme south of the city. The airport overlaps the boundary between the City of Manchester and Macclesfield Borough Council. However, the majority of the airport, (including the terminal buildings, aircraft parking areas, on-site airport car parks, and the northern runway), lies within the City of Manchester

Manchester Airport is the third busiest airport in the United Kingdom. In 2002 the airport handled 176,178 aircraft movements, (departures and arrivals), and the airport was used by 19,037,880 passengers. Additionally, in 2002, the Manchester Airport World Freight Centre handled 118,000 tonnes of air freight.

Manchester Airport Plc are a major employer in the region, with 18,000 staff employed directly on site, and providing an additional 35,000 jobs across the North West, in off site support services.

Manchester Airport Plc have committed to working in partnership with Manchester City Council on a variety of environmental protection programmes. Since 1996 the Manchester Airport Environment Plan has included performance targets relating to emissions to air. In 2004 Manchester Airport Plc published an 'Environment Plan to 2015', in which the airport committed itself to a variety of measures designed specifically to reduce emissions to the air. These measures included;

- A commitment to reduce the road vehicle to air passenger ratio by 10%, to 1:35, by 2015.

- The investigation of the feasibility of introducing an aircraft emission charge. The results of this feasibility study will be published by 2007.

- A commitment to provide fixed electrical ground power to 98% of aircraft using the site, and the banning of the use of NO_X emitting aircraft auxilliary power units by 2007.

- All diesel powered airport ground vehicles are to be fitted with oxidation catalysts and particulate traps, by 2007, and purchase new Euro IV and V engines.

- The development of a major £60 million transport interchange, allowing air passengers easy access to the airport site via public transport.

Additionally, noise control measures introduced at Manchester Airport are also expected to benefit air quality. Chapter 2 aircraft[4], (aircraft built before 1977), were banned from Manchester Airport in 2001, on the grounds of noise

[4] Chapter 2 – Annex 16 of ' Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft – International Civil Aviation Organisation - 2001

control. However, not only were these old aircraft noisy, but they also produced a disproportionate amount of emissions from the airport. From 2006, aircraft using the airport will have to comply with the latest, Chapter 4, noise controls.

Technical guidance note LAQM TG(03) Box 6.2 (M) states that a Detailed Assessment would be required for airports with an annual throughput of 5 million passengers, or more. The airport is a unique area of the city, where emissions from road vehicles, aircraft, and fixed installations, all occur in a relatively small geographical area. The airport has therefore been dealt with separately in this Detailed Assessment, to identify the sources and locations of exceedences, and to inform the Manchester Air Quality Action Plan.

Annual average nitrogen dioxide concentrations are measured at the Manchester South AURN site, which is located very close to Manchester Airport, (1.1km from the northern runway). The Manchester South AURN site is located within the 'Middle Marker' equipment building, for runway 24R, and lies directly under the flightpath of aircraft using this runway.

Annual average nitrogen dioxide concentrations have been measured at the Manchester South site since 1997. Results from this monitoring site are shown in figure 5.13 below.

Figure 5.13 Current and projected future concentrations of nitrogen dioxide measured at Manchester South AURN

Year	Manchester South	
1997	**Annual average**	**23**
	Data capture	95%
1998	**Annual average**	**25**
	Data capture	98%
1999	**Annual average**	**15**
	Data capture	71%
2000	**Annual average**	**14**
	Data capture	81%
2001	**Annual average**	**21**
	Data capture	96%
2002	**Annual average**	**18**
	Data capture	88%
2003	**Annual average**	**21**
	Data capture	96%
2005	Projected '05 concentrations based on scaled '03 results	20
		All annual average NO_2 results in ug/m^3

There are no clear trends in the results from this monitoring site, but both the existing and projected annual average concentrations are well below the objective. In addition, nitrogen dioxide has been measured at two locations close to Manchester Airport. Bias adjusted results from these diffusion tubes are shown in figure 5.14 below.

The diffusion tube monitoring sites selected were the Manchester South AURN site itself, and Bollin Valley Farm, which is located near the village of Styal. Bollin Valley Farm is located 1.5km from the southern runway.

Figure 5.14 Bias adjusted diffusion tube results from the vicinity of Manchester Airport

Year	Bollin Valley Farm, Styal	Manchester South
1997	26	-
1998	20	-
1999	19	-
2000	21	-
2001	22	-
2002	21	-
2003	26	25
		Results in ug/m^3

The results do not show any clear trend in concentrations, but all of the measured annual averages at these sites were well below the objective level.

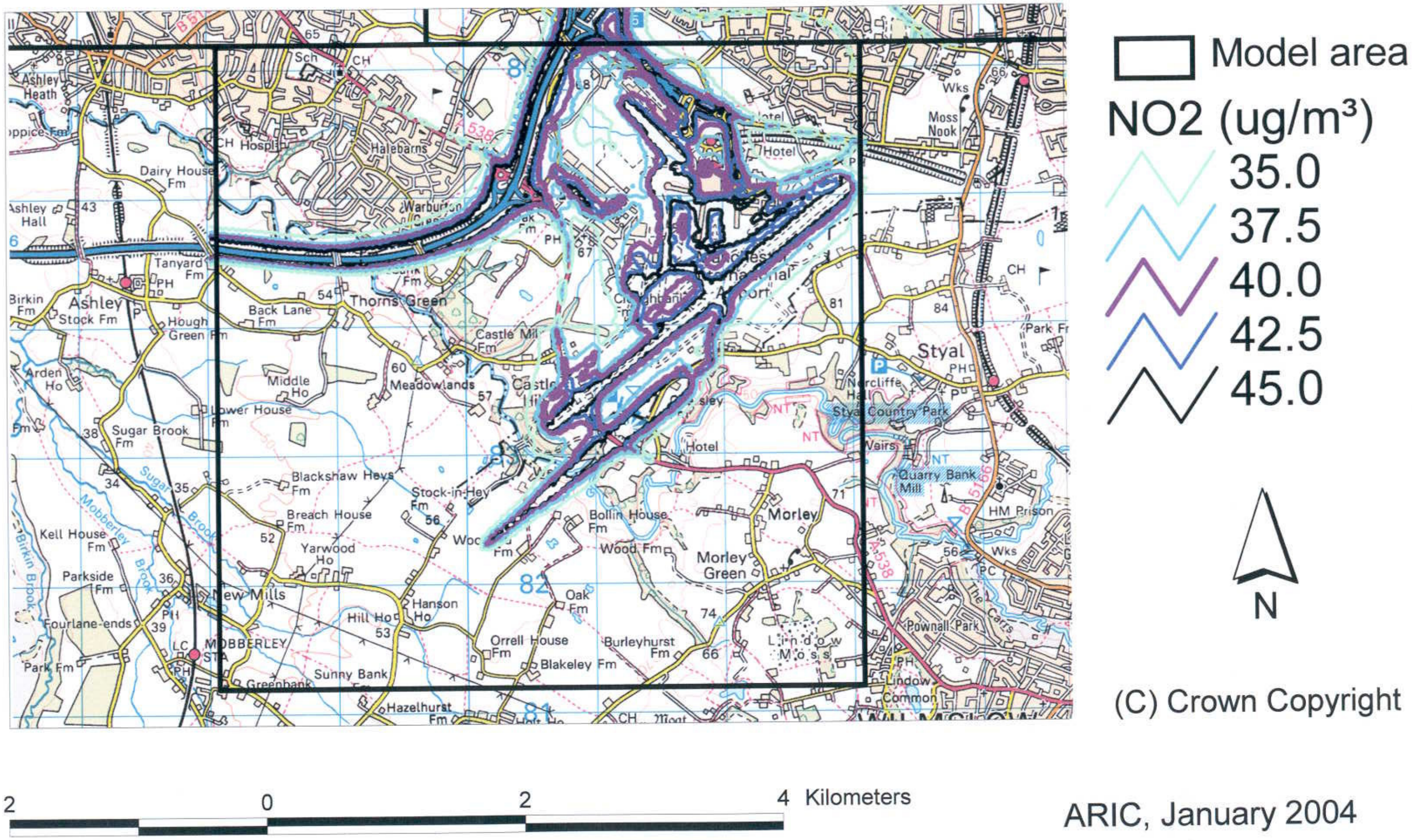
Despite the low concentration of nitrogen dioxide, measured near the airport, the Manchester City Council Update & Screening Assessment had indicated that a Detailed Assessment should be carried out for the airport, on the basis of the passenger numbers using the airport.

Dispersion modelling was therefore used to provide a prediction of air quality across the southern part of the city, including the airport.

Dispersion modelling of the airport was carried out for both 2005 and 2010, using the methodology described in section 4.3 of this report. The airport was covered by modelling area 20 shown in figure 5.1.

The contour plots of annual average concentration produced for Manchester Airport, is shown on the following page.

Area 20 - 2005 annual average



ARIC, January 2004

The contour plots show that in 2005 the areas of potential exceedence are confined to locations within the airport boundary, and along the airport approach road. Specifically, the areas of exceedence cover the runways and taxiways, the aircraft parking areas, and the terminal buildings. None of the areas of exceedence are shown to be occurring at locations where non-occupational public exposure was likely.

In addition to the contour plot, three receptor points were selected, and the results are shown in figure 5.15.

Receptor points were chosen on Ravenscar Crescent (the closest residential area to the runways and taxiways), Hilary Road (the closest residential area to the airport buildings and on-site carparks), and Oak Farm, which was located close to the airport approach road. Hilary Road and Ravenscar Crescent are both located immediately to the north east of the airport, and are within 500m of the airport boundary. Oak Farm is located 100m from the airport approach road, and 100m from junction 6 of the M56 motorway, (the airport approach road is a dual carriageway, linking the airport to the M56 motorway).

The modelling results obtained at these receptor points are shown in figure 5.15 below;

Figure 5.15 Modelled nitrogen dioxide concentrations at locations close to Manchester Airport

Location	Distance to Road	2005 NO_X concentration (ug/m^3)	2005 NO_2 concentration (ug/m^3)
Residential properties on Ravenscar Crescent	N/A (240m to airport)	51.35	27.74
Residential properties on Hilary Road	N/A (300m to airport)	56.48	29.95
Oak Farm	100m to junction 6 of the M56	64.42	35.80

These receptor points represent the closest residential properties to the airport, and the results demonstrate that there are no predicted exceedences of the objectives at these locations.

The results demonstrate that although exceedences of the annual average objective would occur within the airport boundary, and along the airport approach road, no exceedences would occur at locations where non-occupational public exposure was likely.

The air quality situation at Manchester Airport will continue to be monitored. Manchester Airport Plc monitor nitrogen dioxide levels within the airport perimeter, and results from these diffusion tubes will be used to inform both the Manchester City Council Action Plan, and the Manchester Airport Environment Plan.

5.5 2010 nitrogen dioxide dispersion modelling results for Manchester Airport

Section 5.4 of this report concluded that there were certain locations within the Manchester Airport site, where the 2005 annual average nitrogen dioxide objective may not be met. The assessment of concentrations in 2005 also concluded that there were no locations where members of the public could be exposed to the predicted exceedences.

Nitrogen dioxide concentrations are monitored at sites near the airport. These monitoring sites are situated at locations representative of areas where public exposure is most likely to occur, close to the airport boundary. Results from these monitoring sites show that the annual average nitrogen dioxide concentration has been below the objective, in every year since monitoring began in 1997. Projections of future concentrations indicate that the objective is expected to be met in 2010.

Atmospheric dispersion modelling has shown that there will continue to be areas of exceedence at the airport in 2010, but that these areas of exceedence will still be confined to locations where public exposure is unlikely, (for example, along the runways and taxiways).

These results will be used to inform the Manchester City Council Air Quality Action Plan, and the Manchester Airport Environment Plan to 2015.

5.5 2010 nitrogen dioxide dispersion modelling results for Manchester Airport

The European Union First Air Quality Daughter Directive introduced air quality objectives for nitrogen dioxide, to be achieved by the first of January 2010. These objectives are;

- 1 hour limit of 200 ug/m^3, not to be exceeded more than 18 times per year, to be achieved by 1 January 2010.

- Annual average limit concentration of 40 ug/m^3, to be achieved by 1 January 2010.

Section 3 of this report contained an assessment of maximum 1-hour nitrogen dioxide concentrations in Manchester. That assessment found that there were no locations in Manchester where the 1-hour objective was likely to be exceeded.

Annual average concentrations of nitrogen dioxide at Manchester Airport in 2005 were assessed in section 5.4 of this report. The assessment of 2005 annual averages found that exceedences were likely to occur, at locations within the airport boundary, but that no exceedences were likely to occur at locations where public exposure was an issue.

Annual average nitrogen dioxide concentrations measured near Manchester Airport do not show a clear trend. However, these measurements of annual average concentration have been below the objective, since monitoring began in 1997.

Results from nitrogen dioxide monitoring sites, located close to Manchester Airport, were projected to 2010 using the methodology shown in technical guidance note LAQM TG(03) Box 6.7. The projected annual average concentrations are shown in figure 5.16 and 5.17

Figure 5.16 Projected 2010 nitrogen dioxide concentrations at Manchester South AURN site.

Year	Manchester South	
2003	**Annual average**	**21**
	Data capture	96%
2010	Projected '10 concentrations based on scaled '03 results	17
		Annual average NO_2 result in ug/m^3

Figure 5.17 Projected 2010 nitrogen dioxide concentrations at diffusion tube sites in Manchester city centre.

Year	Bollin Valley Farm, Styal	Manchester South
2003	26	25
2010	21	21
		Results in ug/m^3

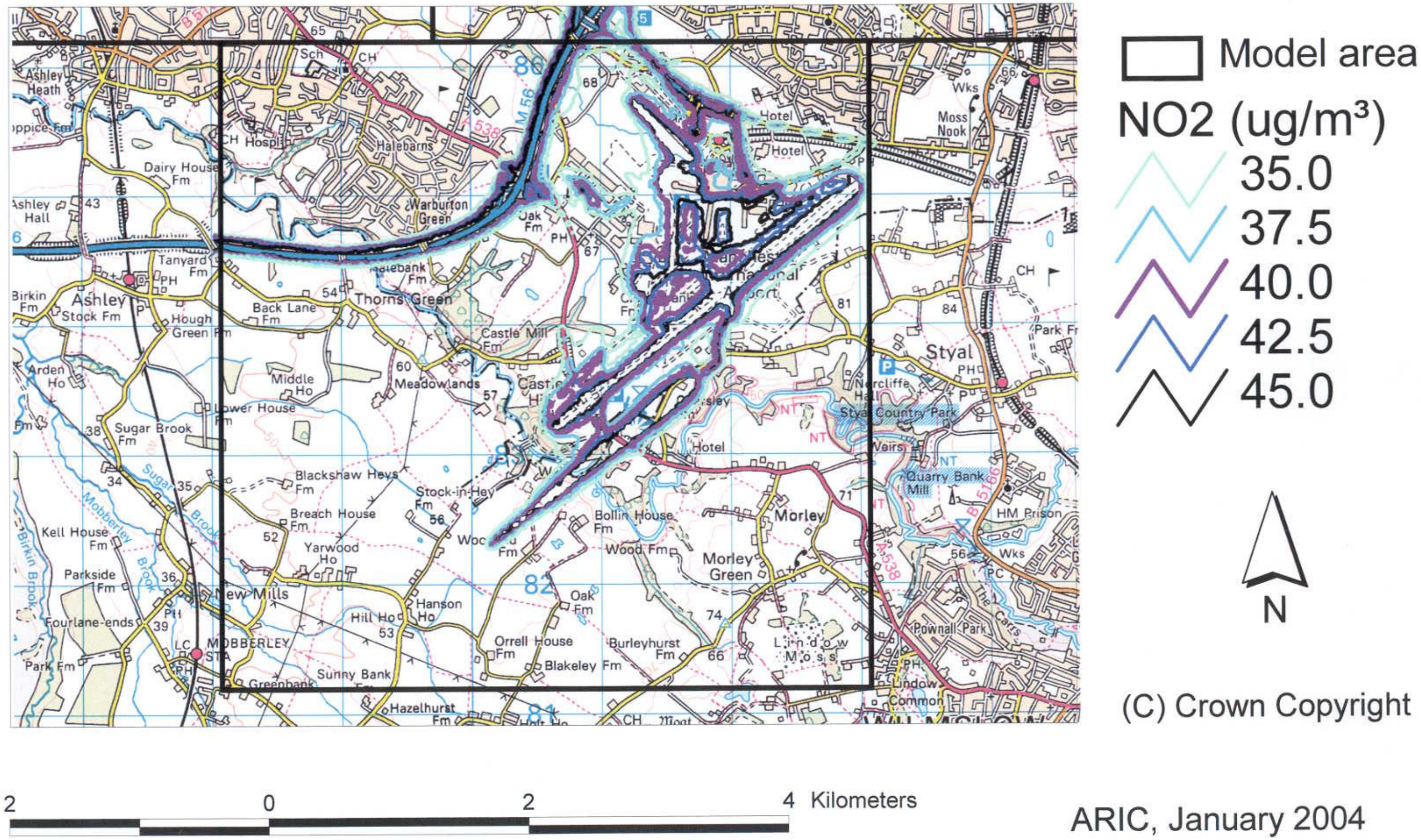
These results demonstrate that not only is the objective currently met at these monitoring locations, but it is expected to continue to do so in 2010.

However, the dispersion modelling carried out for Manchester Airport for 2005 revealed that exceedences could occur at locations actually on the airport site. The dispersion modelling exercise was therefore repeated for 2010, to identify how the pattern of exceedence might change between 2005 and 2010, and to inform the Manchester Airport Environment Plan to 2015, and Manchester Air Quality Action Plan.

The same modelling inputs were used for the modelling of 2010 annual average concentrations, as had been used for the modelling of 2005 averages. The only exceptions, (in terms of model inputs that were changed for 2010), were traffic flows, aircraft emissions, and vehicle emission factors. Traffic flows for 2010 were derived by scaling existing traffic data, using National Road Traffic Forecast growth factors, (the 'central' or 'medium' growth factor was used). Appropriate speed weighted vehicle emissions factors for 2010 were taken from the National Atmospheric Emissions Inventory database. In addition to the traffic growth predicted using the National Road Traffic Growth Forecast, Manchester Airport Plc also provided details of the expected growth in passenger numbers using the airport, and the consequent changes in road traffic flows in the airport vicinity. Manchester Airport Plc and ARIC also produced projections of future aircraft emissions from the airport, based on the predicted air traffic growth expected at the airport. A worst case was used, assuming that the same aircraft types would be used in 2010 as 2001, (assumed no new low emission aircraft).

The result of the dispersion modelling of 2010 annual average nitrogen dioxide concentrations, for Manchester Airport, is shown on the contour plot on the following page.

Area 20 - 2010 annual average



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ARIC, January 2004

The contour plot of annual average concentration in 2010 is very similar to the plot shown in section 5.4 of this report, which showed the predicted areas of exceedence for 2005.

The contour plot for 2010 does show some shrinkage in the area of exceedence, especially around the airport approach road. However, as with the results for 2005, no locations where public exposure is likely are shown as having exceedences in 2010.

It is important to note that the 2010 modelling carried out for Manchester Airport did not take into account all of the possible aircraft emission reductions that could be achieved by the Manchester Airport Environment Plan to 2015, for example, this modelling assumes that aircraft emissions charging has not led to a significant reduction in emissions at the airport. As such, the results shown for Manchester Airport should be considered as a worst case scenario, and the actual concentration of nitrogen dioxide in 2010 may be lower than was shown here. As even these worst case scenario results do not show exceedences at residential locations, it can be assumed that there will be no public exposure to exceedences in 2010.

To provide extra assurance that public exposure would not occur the receptor points used for the 2005 modelling were remodelled for 2010. The results obtained for these receptor points are shown in figure 5.18 below.

Figure 5.18 Modelled nitrogen dioxide concentrations at locations close to Manchester Airport

Location	Distance to Road	2010 NO_X concentration (ug/m^3)	2010 NO_2 concentration (ug/m^3)
Residential properties on Ravenscar Crescent	N/A (240m to airport)	44.90	25.38
Residential properties on Hilary Road	N/A (300m to airport)	48.02	26.68
Oak Farm	100m to junction 6 of the M56	53.47	28.96

Once again, the annual average concentration measured at these locations, (the closest residential locations to the airport), show that there will be no exceedences where the public could be exposed.

As with the 2005 results, these results will help to inform the Manchester City Council Air Quality Action Plan, and the Manchester Airport Environment Plan to 2015, and will be useful in the continuing development of environmental protection strategies for the airport and its surrounding area. Manchester Airport Plc has commissioned its own modelling work, in consultation with the city council. This work will investigate further airport diffusion tube monitoring at 15 locations within the modelling area, and will look at emission estimates for reduced thrust take-off and aircraft fleet modernisation.