Local Air Quality Management Stage IV

Environmental Protection Services
Glasgow City Council

October 2003

Note

This version of Glasgow City Council's Local Air Quality Management Stage IV was prepared by the Pollution Control Unit of Environmental Protection Services and finalised in February 2004. This document supersedes all previous draft versions of the document and includes corrections to the calculated contributions to total NOx within Glasgow's Air Quality Management Area from respective vehicle categories.

Executive Summary

Under the Environment Act 1995, local authorities are required to undertake a regular review and assessment of air quality in their area with regard to the National Air Quality objectives as detailed in the Air Quality (Scotland) Regulations 2000, and amendments 2002. These procedures should be carried out in a phased manner with the results of each stage indicating whether it is necessary to proceed to the next.

In previous reviews of air quality in Glasgow carried out by the City Council and incorporating both monitoring data and modelling programmes (Stages I-III), it was concluded that concentrations of NO_2 at certain sites within the city were likely to exceed the National Air Quality objectives for NO_2. Consequently, upon completion of the Stage III document in June 2001, Glasgow City Council was obliged to declare the affected area as an Air Quality Management Area (AQMA) and conduct a fourth stage of review and assessment.

This report constitutes the fourth stage of Glasgow City Council's review and assessment of air quality as required under the Environment Act 1995 and includes data of current and projected future concentrations of nitrogen dioxide from monitoring, the emissions inventory and the application of an air dispersion model. In addition, the designation and validity of the Air Quality Management Area declared after Stage III were considered.

Ambient concentrations of NO_2 have been monitored extensively in Glasgow via both chemiluminescent monitoring and the application of NO_2 diffusion tubes. Data from the monitoring conducted during 2000 to 2002 revealed that concentrations of NO_2 within the city centre commonly exceeded the annual mean objective of 40 $\mu g\ m^{-3}$, whilst at a few locations, more than the permitted 18 exceedences of the 200 $\mu g\ m^{-3}$ 1-hour objective were also observed. Furthermore, recent information obtained from both chemiluminescent sampling (mobile unit) and diffusion tubes also indicated an exceedence of the annual objective for NO_2 at Byres Road. This finding was particularly significant, as this location is located outwith the declared AQMA and was therefore considered to require further investigation. Projected concentrations of NO_2 in 2005 based on monitoring results showed a similar trend to those currently observed in Glasgow, with widespread exceedences of the annual objective within the city centre and at Byres Road, and exceedences of the 1-hour objective at a few city centre locations.

In addition to data obtained from monitoring, modelling of NO_2 concentrations within Glasgow city centre was also conducted following the construction of an up to date emissions inventory. The results of the modelling study indicated that all areas within the designated AQMA were likely to exceed the annual mean objective for NO_2 and therefore differ from the results of the monitoring study, which suggested that only parts of the city centre would fail to comply. Data from the modelling also indicated that the area of exceedence may also be wider than the current boundary of the AQMA.

Following consideration of both monitoring and modelled data of NO_2 within Glasgow, it was concluded that the boundary of the AQMA is to remain unchanged and continues to be valid for the city centre area, but will be subject to review in future review and assessment documents.

CONTENTS

1. Introduction

In an age when society has a greater awareness of the effect of its own actions, one of the major environmental topics for discussion has been that of air quality.

The quality of the air and its effects on human health has led to greater investigation of the consequences of emissions to air from a wide range of pollutants and from a variety of sources. The debate has progressed from concerns regarding the thick smogs from home and factory chimneys which used to envelop our towns and cities a generation ago.

Today air pollution is a global issue with the effects dependent upon a number of factors that include climate, industry, roads, transportation and energy generating methods.

The City of Glasgow has been part of this debate. With a population of around 600,000 Glasgow is also the focus of a larger urban area. It is the largest manufacturing centre in Scotland and the third largest in the United Kingdom outside of London. In common with many modern cities it has expanding road vehicle numbers and a requirement to transport people in and out of the City quickly and effectively.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, first published in 1997 and revised in January 2000, provides a framework for reducing air pollution at national and local levels. The strategy sets objectives for key pollutants to protect public health. The objectives apply at outdoor locations where people are regularly present and might be exposed to air pollution.

Part IV of the Environmental Protection Act 1995 places a requirement on local authorities to periodically review air quality in their areas. This involves consideration of the present and likely future air quality objectives detailed in the Air Quality (Scotland) Regulations 2000, as amended in 2002.

The government recommended a phased approach to air quality review and assessment involving three stages. The first stage required all authorities to identify all sources of pollution and assess their potential to cause exceedences of the prescribed air quality objectives. In areas identified by the first stage as having the potential to experience elevated pollution levels, an authority required to undertake Stage Two review. If the second stage review indicated the relevant air quality criteria would not be achieved, a detailed and accurate third stage review of those pollutants would be required.

If after the completion of the Stage Three it was still anticipated that objectives were likely to be exceeded, the authority was required to declare the affected area an Air Quality Management Area. After an AQMA has been declared the authority must carry out a further Stage Four assessment of the designated area. This Stage Four should supplement the information previously gathered and confirm the validity of the original designated area.

Following the declaration of an Air Quality Management Area the authority must produce an action plan detailing measures to improve air quality in the designated area.

2. Summary of Stage Three Review and Assessment

Glasgow City Council completed a Stage Three Review and Assessment of Air Quality in 2001. The study used a combination of continuous monitoring data, passive monitoring data and the application of ADMS-Urban air quality model to predict exceedences of the air quality objectives for Nitrogen Dioxide and PM_{10}. The Stage One and Two reports had not indicated the potential for any other pollutants to exceed air quality objectives.

The Stage Three report predicted that many parts of the City centre would be subject to exceedences of the Nitrogen Dioxide objectives and therefore an Air Quality Management Area must be declared.

It was further concluded that this would be most effectively managed by declaring an Air Quality Management Area for the whole of the City centre area.

The Air Quality Management Area came into force on the 1st January 2002 and a copy of the order is included in Appendix 1.

3. Objectives of Stage Four Report

This report, known as the Stage Four, will provide further information to supplement the work undertaken in the earlier review and assessment process.

This report will aim to focus on:

- additional air quality monitoring work undertaken since the publication of the Stage Three
- additional air quality modelling work undertaken since the publication of the Stage Three
- information available from further emissions inventory work

4. Nitrogen Dioxide Monitoring Results

The Stage Three Review and Assessment included data up to and including 1999. This report will update that information and incorporate the last three years of monitoring data, from 2000 to 2002, to determine current trends in NO_2, and to confirm whether conclusions reached at the end of the Stage Three Review and Assessment are still valid.

4.1 Changes since Stage Three

The main source of NO_2 in the City centre is emissions from road traffic, so any changes in the road network since completion of Stage Three could have an influence on NO_2 concentrations and so would have to be noted. However, since this time, no significant changes to the network have been made, and for these purposes it is safe to assume that it is identical to before.

There are also no significant changes in industrial, commercial and domestic emissions since Stage Three, and so these sources can be assumed to be unchanged.

4.2 Monitoring methodology

Monitoring of NO_2 is carried out across the city in different ways. Automatic monitoring using chemiluminescent samplers takes place at six locations across the city, although they are concentrated in or just outside the city centre AQMA. Use of this instrument is recommended in the guidance note, *Review and Assessment: Technical Guidance LAQM.TG (03)*.

Monitoring of NO_2 levels across the city is also undertaken using diffusion tubes. Diffusion tubes have been located at almost eighty positions around the city. The number and types of sites at which monitoring takes place has developed over the years but all sites are changed on a calendar monthly basis and as such give an average NO_2 value for the exposure period.

Diffusion tube measurements are less accurate than chemiluminescent monitoring. Their advantage lies in that they are a relatively inexpensive method of monitoring NO_2 levels at multiple locations.

Most of the diffusion tube sites that were included in the Stage Three review and assessment have been continued and the updated data is represented in the following tables. Additional tubes have been initiated in the intervening time. Some have been in response to specific concerns and others have been placed to provide better geographical cover in areas that were previously under-represented. All new sites are reported in this review and assessment.

4.3 Automatic monitoring sites

Three of the chemiluminescent samplers are part of the national Automatic Urban and Rural Network (AURN) run by the Department of the Environment. These are,

- **Glasgow City Chambers**
  The site is located on the 2nd floor of Glasgow City Chambers in Cochrane Street (259527 665297) and samples air from a height of approximately 8 metres. Cochrane Street is a street canyon, and the site is classified as an urban background.

- **Glasgow Centre**
  This site is found in St Enoch Square, a pedestrianised area in the centre of Glasgow (258943 665027). It is around 20m from Argyle Street which has a traffic flow of approximately 20,000 vehicles per day and is classed as an urban centre site.

- **Glasgow Kerbside**
  Positioned at the southern end of Hope Street next to Central Station (258696 665166) close to the junction with Argyle Street. Hope Street is a street canyon. It is a kerbside site with its inlet less than 1m from the road. Traffic flow here is more than 25,000 vehicles per day.

All three AURN sites are within the AQMA, and give a good indication of how air quality can vary over the city centre. Glasgow City Chambers is located at the building façade at elevation within a busy street canyon. This gives an excellent indication of exposure, since there are many residential properties which are situated in this type of position. Glasgow Centre gives a indication of background levels in the AQMA, while Glasgow Kerbside represents the worst-case concentrations of traffic related pollution which can be expected.

Glasgow City Council operates another three air quality monitoring units which monitor for NO_2. The first of these, the Groundhog, has monitored since 1999, but was not used for the Stage Three Review and Assessment as monitored data was insufficient as the time. This is a mobile unit so has monitored at several locations. The dates and locations of Groundhog data that will be included in this report are given in Table 4.1.

Groundhog monitoring locations	
Dates	**Location**
23/12/99 → 29/06/00	*Byres Road*
18/12/00 → 04/04/01	*Office World, Townhead*
17/05/01 → present	*St Patrick's Primary School, Anderston*

Table 4.1 Groundhog monitoring locations

The Byres Road site was at the junction of Byres Road and University Avenue. This is indicative of a typical street found in Glasgow. A narrow, street canyon with residential properties above ground level and heavy traffic. However, the Groundhog was situated in a large break in the 'canyon', so would not experience canyon effects. This site would be classed as roadside.

Office World in Townhead is situated just inside the northern edge of the AQMA, immediately adjacent to the M8. The immediate area is commercial/industrial. Due to its proximity to the M8, this location would also be a roadside site.

St Patrick's Primary School, Anderston is located just outside the AQMA, to the west of the M8. Data from this site is particularly useful, since it is a residential area and hence important for exposure issues. Concentrations from this site will also allow assessment of the boundary of the AQMA to be made. It is likely that this site would be an urban background site, as it is situated over 200m from the M8.

A second mobile unit, known as the Rollalong, has been in operation since May 2001 at Office World, Townhead. This replaced the Groundhog, giving two full years of monitoring data at this location. A third mobile unit has recently gone into operation at Waulkmillglen reservoir towards the southern boundary of Glasgow. This monitors

background concentrations, but has only been in operation for a short time period, and so data from this will not be utilised in this report.
A further air quality monitoring unit is operated by the Land Services department of Glasgow City Council. This unit is moved between sites on a regular basis, usually collecting data in one month periods. For this reason, and because the unit is located on-road, it cannot be compared to the air quality standards, and so will not be included.

4.3.1 Automatic Monitoring Results

In some cases, monitoring data is incomplete over the calendar year. This is particularly the case with the Groundhog, which only monitored for 6 months at Byres Road, and has recently been plagued with communication problems. This has led to large gaps in data in 2001 and 2002.

However, it is possible to make an estimation of annual means by applying adjustment factors to data that is available. The method used to do this is detailed in the guidance note, *Review and Assessment: Technical Guidance LAQM.TG (03).* The adjustment factor is calculated by analysing patterns in pollutant concentrations at sites which do have complete data. Results given below have been adjusted using this technique where appropriate.

The results from monitoring at all five automatic sites are presented below. A figure highlighted red indicates a breach of the relevant objective.

Year	Data capture (%)	Annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
1987	91.3	59	411	40
1988	85.3	57	250	6
1989	99.0	52	415	34
1990	88.9	50	218	2
1991	98.9	50	407	4
1992	99.0	48	180	0
1993	89.4	52	208	1
1994	98.3	50	252	2
1995	96.7	50	155	0
1996	97.3	52	229	3
1997	97.8	50	294	15
1998	97.9	52	208	4
1999	n/a	52	222	3
2000	98.6	49	262	7
2001	98.7	42	239	8
2002*	96.1	47	209	3

*2002 data not fully ratified

Table 4.2 Glasgow City Chambers AURN

Year	Data capture (%)	Annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
1996	41.7	46	172	0
1997	97.6	44	237	5
1998	66.9	44	351	2
1999	n/a*	38	483	3
2000	67.6	37	418	2
2001	85.6	33	167	0
2002	94.6	32	262	18

Table 4.3 Glasgow Centre AURN

Year	Data capture (%)	Annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
1997	72.9	71	485	35
1998	96.8	71	371	65
1999	n/a*	69	304	46
2000	97.9	72	281	18
2001	98.8	71	405	54
2002	97.3	74	309	38

Table 4.4 Glasgow Kerbside AURN

Year	Data capture (%)	Annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
2001	76.7	42	335	21
2002	63.8	43	224	8

Table 4.5 Office World mobile unit

Year	Data capture (%)	Annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
2001	78.8	31	206	2
2002	48.3	14	86	0

Table 4.6 St Patrick's Primary School

Year	Data capture over period (%)	Measured mean over period ($\mu g/m^3$)	Estimated annual NO_2 mean ($\mu g/m^3$)	Maximum hour ($\mu g/m^3$)	No. of hours >200$\mu g/m^3$
Jan – June 2000	93.7	55	53	373	4

Table 4.7 Byres Road

4.4 Diffusion Tube Monitoring Sites

Glasgow city council operates four diffusion tubes on behalf of the UK nitrogen dioxide network. These tubes fall into the following categories:

Road	(R)	1-5m from a busy road. Formerly named 'Kerbside' (K). One site during years up to and including 2000, 2 sites from 2001 onwards.
Background	(B)	>50m from any busy road (2 Sites per local authority).

Table 4.8 NO_2 diffusion tube categories

Although the Kerbside tubes within the network have been replaced by roadside, a large amount of the tubes operated independently by Glasgow City Council still fall into this category. This has been done to provide a continuity of information over the years of monitoring.

Diffusion tubes of all three categories are found at locations throughout the city, both within and outwith the City centre AQMA.

4.4.1 Diffusion Tube Monitoring Results

Chemiluminescent techniques are the standard method for monitoring NO_2. Recent studies have looked at results from diffusion tube collocation studies carried out by a number of local authorities. This has revealed considerable difference in the performance of tubes prepared by different laboratories.

According to the guidance note, *Review and Assessment: Technical Guidance LAQM.TG (03)*, laboratory bias **must** be determined and allowed for. To this end diffusion tubes have been collocated with chemiluminescent monitors at the AURN sites. Bias correction has been undertaken for diffusion tubes within Glasgow City in accordance with the guidance.

Only the results obtained during 2002 have been adjusted for bias. There was insufficient collocation data available for 2000 and the method which the analytical laboratory used to prepare the diffusion tubes changed during 2001.

Values in the tables on the following pages are given in red when a failure of the NO_2 standard is noted.

Results from monitoring NO_2 levels at kerbside diffusion tube sites in Glasgow City centre are:

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Argyle Street	84.3	-	59	73	60	54	54	46	42	35	-
George Square	98.1	-	82	73	58	52	50	36	36	40	53
Union Street	93.5	-	82	81	57	62	63	51	49	53	69
Glasgow Cross	97.2	-	60	46	36	40	42	28	24	33	42
Bath Street	75	-	88	79	44	26	29	42	46	34	68
Glassford Street	96.3	-	71	67	54	48	56	43	39	43	56
Briggait	98.1	-	54	50	39	35	41	30	26	29	42
St Vincent Street	93.5	-	89	70	63	62	63	48	49	47	86
North Hanover Street	80.6	-	73	56	43	48	47	37	39	41	57
Castle Street	95.4	-	67	56	46	45	48	39	42	45	53
Hope Street (UK)	94.2	92	97	74	47	55	65	74	66	73	79
Hope Street 2 (mid)	91.7	-	-	76	67	62	69	63	49	48	80
Hope Street 3 (north)	89.6	-	-	62	44	44	49	42	33	43	48
Montrose Street	83.3	-	-	-	-	-	-	-	-	-	57
Cochrane Street 1	100	-	-	-	-	-	-	-	-	-	43
Cochrane Street 2	83.3	-	-	-	-	-	-	-	-	-	46
Ingram street	83.3	-	-	-	-	-	-	-	-	-	39
Renfield Street	91.6	-	-	-	-	-	-	-	-	-	62
George Street	91.6	-	-	-	-	-	-	-	-	-	44
Broomielaw	83.3	-	-	-	-	-	-	-	-	-	47

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.9 NO_2 concentrations at kerbside diffusion tube sites in Glasgow City centre

Results from monitoring levels of NO_2 at roadside diffusion tube sites in Glasgow City centre are:

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Hope Street (UK)	94.2	92	97	74	47	55	65	74	66	73	79
Hope Street 1 (south)	99.1	-	91	67	58	54	59	51	45	53	80
Gordon Street	88.0	-	72	75	69	59	60	54	44	49	73
Heilan'man's Umbrella North	96.3	-	79	70	56	48	54	40	40	54	114
Heilan'man's Umbrella South	74.1	-	94	73	55	56	57	56	35	55	46
Saltmarket	96.7	-	-	-	-	-	41	33	28	31	41
High Street	96.7	-	-	-	-	-	44	37	30	34	52
Buchanan Galleries North	69.6	-	-	-	-	-	57	38	-	-	-
Buchanan Galleries South	73.3	-	-	-	-	-	52	32	39	41	74
Dobbies Loan	100	-	-	-	-	-	-	-	-	-	39

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.10 NO_2 concentrations at roadside diffusion tube sites in Glasgow City centre

Results from monitoring NO_2 at urban centre diffusion tube sites in Glasgow City centre are:

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02 *
McLeod Street (UK)	95.0	45	52	47	35	35	36	37	27	34	34
McLeod Street	96.3	-	70	44	40	33	36	26	25	24	34
Buchanan Street	76.9	-	41	44	32	34	40	28	-	43	74

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.11 NO_2 concentrations at urban centre diffusion tube sites in Glasgow City centre

Results from monitoring NO_2 levels at kerbside diffusion tube sites outwith Glasgow City centre are presented in Table 4.12.

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Mosspark Boulevard	95.8	-	-	45	36	38	33	26	24	27	39
Thornliebank Road	90.3	-	-	39	29	28	26	22	18	22	25
Mossside Road	87.5	-	-	-	-	31	23	18	21	28	41
Royston Road	88.9	-	-	-	-	46	31	31	36	49	43
Bridge St/Norfolk St	95.8	-	-	-	-	-	-	-	-	33	47
Aikenhead Road	100	-	-	-	-	-	-	-	-	27	39
Balshagray Avenue	95.8	-	-	-	-	-	-	-	-	39	36
North Street	87.5	-	-	-	-	-	-	-	-	46	52
Dumbarton Road	91.6	-	-	-	-	-	-	-	-	-	50

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.12 NO_2 concentrations at kerbside diffusion tube sites outwith Glasgow City centre

Results from monitoring NO_2 levels at roadside diffusion tube sites outwith Glasgow City centre are:

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Hillcrest Road (UK)	91.7	18	32	27	18	18	18	16	19	19	22
Hillcrest Road	84.3	-	33	27	24	20	21	28	14	16	20
Dumbreck Road	92.7	-	-	38	32	25	28	20	18	25	21
St Andrews Drive	96.9	-	-	41	35	24	21	19	16	21	21
Haggs Road	96.9	-	-	49	39	29	27	26	19	25	20
Pollokshaws Road	95.8	-	-	58	38	33	31	25	20	26	28
Dunn Street	78.3	-	-	-	-	-	29	26	18	31	41
Byres Road	94.4	-	-	-	-	39	38	27	33	35	47
Queen Margaret Drive	90.3	-	-	-	-	38	24	18	22	25	41
Westmuir Street	62.5	-	-	-	-	44	43	28	24	25	38
Finnieston Street	91.6	-	-	-	-	-	-	-	-	-	36

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

***Table 4.13 NO_2* concentrations at roadside diffusion tube sites outwith Glasgow City centre**

Results from monitoring NO_2 levels at urban background diffusion tube sites outwith Glasgow City centre are presented in Table 4.14.

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Sutherland Avenue (UK)	90.8	21	32	26	24	17	16	18	13	15	18
Sutherland Avenue 1	75	-	28	21	21	20	20	13	9	12	16
Kinning Park	76.4	-	-	-	-	33	32	24	10	26	41
Ascaig Crescent	91.7	-	-	26	20	21	18	16	12	15	17
Belmont Street	87.5	-	-	-	-	51	21	18	24	21	25
Mallaig Place	97.2	-	-	-	-	32	18	13	17	18	24
Govanhill Street	90.3	-	-	-	-	34	19	17	21	17	27
Drumhead Road	84.7	-	-	-	-	21	12	34	26	14	20
Caledonia Avenue	93.1	-	-	-	-	31	18	15	19	21	23
Westercraigs	86.1	-	-	-	-	34	18	9	23	19	30
Inveresk Lane	88.9	-	-	-	-	27	17	16	19	18	20
Maxwellton Road	76.4	-	-	-	-	40	28	11	33	29	35
Kippen Street	75.0	-	-	-	-	31	20	11	16	16	18
Broomhill Road	87.5	-	-	-	-	-	-	-	-	21	32
Celtic Park 1	91.7	-	-	-	-	-	-	-	-	20	17
Celtic Park 2	90.9	-	-	-	-	-	-	-	-	25	21

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.14 NO_2 concentrations at urban background diffusion tube sites outwith Glasgow City centre

Results from monitoring NO_2 at suburban diffusion tube sites outwith Glasgow City centre are:

Location	Data Capture (%)	Annual Mean NO_2 ($\mu g/m^3$)									
		'93	'94	'95	'96	'97	'98	'99	'00	'01	'02*
Invergarry Road	84.4	-	-	21	18	17	18	12	9	14	12
Easterhouse Sports Centre	97.2	-	-	-	-	33	19	15	19	21	23
Castlemilk Sports Centre	76.7	-	-	-	-	-	13	7	17	17	20
Craigton Road	95.8	-	-	-	-	-	-	-	-	24	33

- - 2002 results have been adjusted for bias based on triplicate collocated tubes at AURN sites

Table 4.15 NO_2 concentrations at suburban diffusion tube sites outwith Glasgow City centre

4.5 Projected NO_2 levels in 2005

Monitored NO_2 can be used to estimate concentrations in 2005, the year that objectives are to be met. This is done by applying correction factors which take account of the expected changes in emissions from road traffic. For this reason, these factors can only be used for areas where traffic is the main source of NO_2. The correction factors given below are taken from the most recent guidance, *Review and Assessment: Technical Guidance LAQM.TG (03)*.

Estimation of the number of exceedences of the hourly objective can also be made. The most recent guidance does not contain any advice on this, so the older note, *Review and Assessment: Pollutant Specific Guidance LAQM.TG4 (00)* is used. This advice states that,

"for the purpose of a Stage Two assessment…(or as here to indicate where exceedences of the NO_2 objectives may occur)…it may be assumed that the 99.8th percentile of 1-hour mean concentrations…(i.e. the maximum hour after the 18 allowed exceedences per year)…will not exceed 5 times the predicted annual mean at background sites and 3.5 times the predicted annual mean at roadside or kerbside sites".'

Year	Correction Factor Background sites	Correction Factor Roadside sites
1999	1.066	1.075
2000	1.025	1.033
2001	1.000	1.000
2002	0.973	0.969
2003	0.948	0.941
2004	0.927	0.915
2005	0.908	0.892

Table 4.16 Correction factors for projecting future concentrations of NO_2

For the purposes of this review and assessment three base years have been used (2000 – 2001). Implied exceedences of one or other of the NO_2 objectives are given in red. Applying these factors to the data from automatic monitoring sites:

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean - 99.8th% ($\mu g/m^3$)		
	Base year 2000	Base year 2001	Base year 2002	Base year 2000	Base year 2001	Base year 2002
Glasgow City Chambers	44	38	43	218	192	217
Glasgow Centre	32	30	30	113	103	105
Glasgow Kerbside	61	62	68	215	215	238
Office World	--	38	40	--	132	140
St Patrick's Primary	--	28	13	--	140	63
Byres Road	49	--	--	172	--	--

Table 4.17 Projected future concentrations of NO_2 at automatic monitoring sites in Glasgow

For all kerbside NO_2 sites in Glasgow City centre:

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	Base Year 2001	Base Year 2002	Base Year 2000	Base Year 2001	Base Year 2002
Argyle Street	36	31	-	127	109	-
George Square	31	36	49	108	125	172
Union Street	42	47	64	147	165	223
Glasgow Cross	21	29	39	73	103	136
Bath Street	40	30	63	139	106	221
Glassford Street	34	38	51	118	134	180
Briggait	23	26	39	79	91	136
St Vincent Street	43	42	79	149	147	278
North Hanover Street	34	37	53	118	128	185
Castle Street	36	40	49	126	140	172
Hope Street (UK)	57	65	72	200	227	253
Hope Street 2 (mid)	42	43	74	149	150	259
Hope Street 3 (north)	29	38	44	100	134	155
Montrose Street	-	-	52	-	-	182
Cochrane Street 1	-	-	40	-	-	139
Cochrane Street 2	-	-	42	-	-	147
Ingram street	-	-	36	-	-	125
Renfield Street	-	-	57	-	-	199
George Street	-	-	40	-	-	142
Broomielaw	-	-	44	-	-	152

Table 4.18 Projected future concentrations of NO_2 at kerbside sites in Glasgow City centre

Similarly, projected concentrations for roadside sites in Glasgow City centre are presented in Table 4.19.

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	Base Year 2001	Base Year 2002	Base Year 2000	Base Year 2001	Base Year 2002
Hope Street 1 (south)	39	47	74	135	165	259
Gordon Street	38	44	67	133	153	234
Heilan'man's Umbrella North	34	48	105	120	169	368
Heilan'man's Umbrella South	31	49	42	107	172	147
Saltmarket	25	28	38	86	97	133
High Street	26	30	47	91	106	166
Buchanan Galleries South	34	37	68	118	128	240
Dobbies Loan	-	-	36	-	-	125

Table 4.19 Projected future concentrations of NO_2 at roadside sites in Glasgow City centre

For urban centre sites in Glasgow City centre:

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	Base Year 2001	Base Year 2002	Base Year 2000	Base Year 2001	Base Year 2002
McLeod Street (UK)	24	31	32	121	153	161
McLeod Street	22	22	32	112	109	161
Buchanan Street	-	39	69	-	195	344

Table 4.20 Projected future concentrations of NO_2 at urban centre sites in Glasgow City centre

For sites outwith the City centre projections can also be made. Thus, projected concentrations of NO_2 in 2005 for kerbside, roadside, urban background and suburban sites outwith the City centre are presented in Tables 4.21 to 4.24 respectively.

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	Base Year 2001	Base Year 2002	Base Year 2000	Base Year 2001	Base Year 2002
Mosspark Boulevard	20	24	36	71	84	125
Thornliebank Road	16	20	23	55	69	82
Mossside Road	18	25	38	63	87	133
Royston Road	31	44	40	108	153	139
Bridge St/Norfolk St	27	29	44	94	103	152
Aikenhead Road	-	24	36	-	84	125
Balshagray Avenue	-	27	33	-	94	117
North Street	-	41	48	-	144	169
Dumbarton Road	-	-	46	-	-	161

Table 4.21 Projected concentrations of NO_2 at kerbside sites out with the City centre

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	Base Year 2001	Base Year 2002	Base Year 2000	Base Year 2001	Base Year 2002
Hillcrest Road (UK)	16	17	20	57	60	70
Hillcrest Road	12	14	19	42	50	65
Dumbreck Road	16	22	19	55	78	68
St Andrews Drive	14	19	19	49	66	68
Haggs Road	16	22	19	57	78	65
Pollokshaws Road	18	23	26	61	81	90
Dunn Street	15	28	37	53	97	131
Byres Road	28	31	44	99	109	152
Queen Margaret Drive	19	22	38	67	78	133
Westmuir Street	21	22	35	74	78	123
Finnieston Street	-	-	33	-	-	117

Table 4.22 Projected concentrations of NO_2 at roadside sites out with the City centre

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	**Base Year 2001**	**Base Year 2002**	**Base Year 2000**	**Base Year 2001**	**Base Year 2002**
Sutherland Avenue (UK)	12	14	17	58	69	86
Sutherland Avenue 1	8	11	15	42	54	76
Kinning Park	9	24	38	44	118	191
Ascaig Crescent	11	14	16	55	68	80
Belmont Street	22	19	24	108	95	118
Mallaig Place	15	16	22	73	82	111
Govanhill Street	19	15	25	94	77	126
Drumhead Road	23	13	18	113	64	92
Caledonia Avenue	17	19	21	84	95	107
Westercraigs	21	17	28	103	86	141
Inveresk Lane	16	16	18	82	82	92
Maxwellton Road	29	26	33	144	132	164
Kippen Street	14	15	17	72	73	84
Broomhill Road	-	19	30	-	95	149
Celtic Park 1	-	18	16	-	91	80
Celtic Park 2	-	23	20	-	114	99

Table 4.23 Projected concentrations of NO_2 at urban background sites out with the City centre

Location	Projected 2005 annual mean ($\mu g/m^3$)			Projected 2005 1-hour mean – 99.8th% ($\mu g/m^3$)		
	Base Year 2000	**Base Year 2001**	**Base Year 2002**	**Base Year 2000**	**Base Year 2001**	**Base Year 2002**
Invergarry Road	8	13	11	39	64	57
Easterhouse Sports Centre	17	19	21	85	95	107
Castlemilk Sports Centre	15	15	18	74	77	92
Craigton Road	-	22	31	-	109	153

Table 4.24 Projected concentrations of NO_2 at suburban sites out with the City centre

4.6 Public exposure

It is clear in the Technical Guidance LAQM.TG (03) that objectives should be assessed in relation to,

'the quality of air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present'.

For the annual mean objective this means considering all background and roadside locations up to the building facade of properties such as residencies, schools, hospitals and other buildings where the public may visit or remain for long periods. The objective would not apply at building facades of offices or other places of work where members of the public do not have regular access or at kerbside locations where public exposure is likely to be short.

The hourly NO_2 objective is applicable at any outdoor location where the public might reasonably be expected to have access and will include all background, roadside and kerbside sites.

For automatic monitoring sites in use in Glasgow, this means that Glasgow City Chambers and Glasgow Centre will be compared to both the annual and hourly means while Glasgow Kerbside will be compared to the hourly mean only. Groundhog data from Byres Road and St Patrick's Primary School will also be compared to both objectives.

While the Office World site is not itself positioned in an area where public exposure is likely, it can still be compared to both objectives since it is probable that other locations in the AQMA where exposure is relevant will be subject to similar NO_2 concentrations.

The diffusion tubes can be treated in a similar manner. Roadside, background and suburban sites can be measured against both the hourly and annual NO_2 objectives, while kerbside sites will be compared to the hourly mean only.

4.7 Results of automatic data and projections to 2005

The results from monitoring data between 2000 and 2002 are used to assess if the decision made on the AQMA in Glasgow is still valid. The Stage Three report concluded that projections of the annual and the hourly mean objectives for NO_2 in 2005 would be exceeded at locations across the City centre. These locations included the Glasgow City Chambers and Glasgow Kerbside AURN sites.
Projections of 2005 NO_2 annual means using the most recent monitored data confirmed that the NO_2 objective will still be exceeded at these sites.

Projections of the 99.8^{th} percentile of the 2005 hourly mean has also shown exceedences at Glasgow City Chambers and Glasgow Kerbside from new monitored data. The only exception to this is projections made using 2001 data at Glasgow City Chambers.

As in Stage Three, projections of NO_2 concentrations at Glasgow Centre do not show any exceedences of either objective. Indeed, at this location, there has not been an exceedence of either objective since 1998.

This report is the first time that data from mobile units can be used. This data has indicated an exceedence of the annual mean objective in 2005 at Office World when using monitored data from 2002.

Estimation of the 2005 annual mean at Byres Road has also indicated that the objective will be exceeded. This is a significant finding as this location is situated outwith the declared AQMA. This site will be addressed fully below.

4.8 Results of diffusion tube data and projections to 2005

As with data from chemiluminescent monitoring, diffusion tube data are used to assess if decision made on the AQMA in Glasgow is still valid. As predicted in the Stage Three report, annual and hourly mean objectives for NO_2 in 2005 are expected to be exceeded at multiple locations across the city centre.

Projections based on diffusion tube data have predicted exceedences of the annual mean standard at five locations outwith the City centre. No exceedences of the hourly mean are predicted. Since these sites are outside the AQMA they represent significant findings. The five locations are as follows:

Royston Road
Bridge Street
North Street
Dumbarton Road
Byres Road

As has been previously stated, due to public exposure, the kerbside sites will be compared to the hourly mean only. Royston Road, Bridge Street, North Street and Dumbarton Road are kerbside sites and as such can be disregarded. Byres Road, on the other hand, is a roadside site and the annual mean therefore applies.

These findings agree with the predictions from chemiluminescent monitoring regarding Byres Road.

4.9 Assessment of results

The results of NO_2 monitoring carried out since the Stage Three Review and Assessment shows that the declaration of the AQMA in Glasgow city centre is still a valid one.

Data from the AURN site at Glasgow Kerbside still projects exceedences of the hourly objective in 2005, as well as exceedences of the annual mean objective.

At Glasgow City Chambers, projections of NO_2 in 2005 indicate that both the annual and the hourly objectives will be exceeded. The only exception is the projection of the annual mean when using 2001 data as the base year, although this projection is for concentrations to be just below the objective. This site is particularly important because there are many residential properties in the City centre in a similar position to this site.

At Glasgow Centre, projections forward to 2005 show no exceedences of either the annual or hourly objective of NO_2.

When 2002 monitoring data at Office World is projected to 2005, the annual mean concentration is exactly that of the objective. There is no exceedence of the hourly objective anticipated.

Projections of 2005 NO_2 concentrations at Saint Patrick's Primary School in Anderston using 2001 and 2002 monitoring data has indicated that there will be no exceedences of either of the two objectives. This result is important as it is located just outside the AQMA, is adjacent to the busy M8 motorway and represents the nearest residential area.

Projections of 2005 NO_2 concentrations at Byres Road raise the most concern, as an exceedence of the annual mean objective is predicted for this location, which is outside the AQMA. Projections made in Stage Three from monitored data and from a modelling study did not predict any exceedences in 2005. While it is noted that the annual monitored mean in 2000 at Byres Road was an estimation due to the lack of a complete data set, the method used to derive an annual mean is recommended in the guidance. This data is also important since it is the only data available gathered from an automatic analyser, which is more accurate than diffusion tube measurements used previously.
Projections from diffusion tube measurements show similar trends within and outwith the AQMA.

4.10 Conclusions from Monitoring

Monitoring of NO_2 has been carried out between 2000 and 2002, and the data has been used to supplement that used for the Stage Three Review and Assessment report which contained data up to the year 1999.

Analysis of data from three AURN sites in Glasgow City centre has shown that exceedences of the annual and hourly objectives are predicted to occur in 2005 at Glasgow City Chambers and Glasgow Kerbside. Diffusion tube data confirms these findings throughout the City centre. This is consistent with conclusions reached in the Stage Three report. Conclusions reached regarding the AQMA are therefore still valid.

Analysis of monitoring data at Byres Road from the Groundhog mobile unit and NO_2 diffusion tubes have predicted an exceedence of the annual mean objective in 2005. This is a site outside of the declared AQMA. This site will be fully investigated as part of the Detailed Assessment required in the second round of reviews and assessments and due by April 2004.

There are no other predictions of exceedences from mobile data at other locations in the City.

5. Emissions Inventory

As part of the work to update and refine the data presented in Stage Three, it was acknowledged that the emissions inventory for Glasgow required to be updated.

The emissions inventory that was used in Stage Three was based on work undertaken in 1995 by the London Research Council. This data required to be reviewed and updated. The aim was to provide more information on the source apportionment of pollution and to provide more accurate grid emission data for inclusion in the air quality modelling.

Glasgow City Council appointed BMT Cordah Limited in January 2003 to undertake an assessment of pollutant emission sources, focusing on sources within the AQMA, in order to create an inventory of emissions within Glasgow.

Two emission inventories were produced, one for 2002 and one projected forward to 2005.

This chapter will discuss the data that was used to create the emissions inventory and the final results of the inventory.

5.1 Compilation of emissions inventory

The emissions inventory was compiled using the EMIT package produced by Cambridge Environmental Research Consultants (CERC). The package allows the creation of a database of emission sources, from which emissions can be aggregated to produce a net square kilometre emission. The EMIT package most importantly is compatible with the dispersion model ADMS-Urban also produced by CERC. This allows emissions sources data to be exported directly from EMIT to ADMS-Urban.

Four sources of emissions were included in the emissions inventory. These were:

- road traffic;
- industrial;
- commercial and domestic; and
- collectively ‘other’ emission sources.

The individual sources are discussed below.

5.2 AQMA Road Traffic Emissions

Emissions from road traffic were calculated on the basis of a standard emission rate per vehicle. Emissions per vehicle are calculated on the basis of vehicle type, age and speed. Total emissions per road segment are therefore based on total traffic flow and percentage of each vehicle category on the road.

Road traffic flow data was supplied by Glasgow City Council’s Land Services department, from the Saturn road traffic model. The traffic flow data has been validated against City centre traffic counts.

The vehicle flow in passenger carrying units (pcus) and average speeds of traffic were provided for monitoring nodes within the City centre. The monitoring nodes were

sections of road on which the traffic flows and speeds were measured. The nodes generally represented sections of road within junctions.

The road traffic monitoring nodes were provided on a map encompassing the AQMA. Street names and junction numbers were correlated to the node numbers and traffic flows to create a list of traffic flow information for AQMA roads.

The road segments included in the study were those provided on the maps excluding lanes and entrances to car parks etc. All main roads within the AQMA were included.

Roads outwith the AQMA explicitly included in the study were the M8, M80 and M77 motorways as well as the main trunk roads into the City centre. The trunk roads were:

- Springburn Road;
- Alexandra Parade;
- Duke Street;
- Eglington Street;
- Clydeside Expressway;
- Sauchiehall Street;
- Great Western Road; and
- Garscube Road.

Traffic flow data was provided for three monitoring periods AM, PM and INT. AM was monitored between 8-9am, PM between 5-6pm and INT between 2-3pm. The traffic flows for these periods were also projected forward to 2005. The projections, undertaken by MVA Consultants, encompassed predicted traffic growth and changes to traffic flow speeds and patterns as a result of planned changes to the City centre road network.

In order to use the traffic flow information provided by MVA the flows had to be converted from pcus into an annual average daily traffic flow (AADT). The AADT is broken down into three categories; motorcycles, light vehicles (cars and light goods vehicles) and heavy vehicles (buses and heavy goods vehicles).

The process to convert from pcus to AADT is described in four stages:

- The pcu traffic flow was broken down into vehicle categories provided by Glasgow City Council, i.e. 0.53% motorcycles, 91.25% light vehicles and 8.55% heavy vehicles.

- The pcu flow was converted to vehicle flow using conversion factors provided by Glasgow City Council, i.e. 0.4 motorcycles, 1.0 light vehicles and between 1.5 and 2.0 for heavy vehicles. The factors reflected the number of passengers equivalent that each vehicle type carries.

- The vehicle flow for the monitoring period (AM, PM or INT) is converted to a 12-hour flow. This is calculated using figures provided by Glasgow City Council that found that on average during a 12-hour (7 am to 7pm) monitoring period the AM (8-9am) was 9.642% of the total 12-hour traffic flow. Likewise the INT (2-3pm) was 8.585% and PM (5-6pm) was 11.05% of the total 12-hour traffic flow.

- Finally, the 12-hour traffic flow counts were converted to an AADT flow. Monitoring data of traffic flows at 28 junctions throughout the city showed that on average the

AADT flow is 26% higher than the 12-hour flow. Technical guidance LAQM.TG(03) states that on average the AADT flow is 15% higher than the 12-hour flow outwith London. Given that Glasgow City Centre is a bustling location in the evenings then the 26% conversion is more accurate. The 12-hour flows were therefore factored by 1.26 to convert to AADT flow.

The AADT was calculated for the three monitoring periods AM, PM and INT. The AADT calculated varied depending on the respective starting point. Of the three AADT calculated, the flow was generally higher when calculated for a starting base of AM pcu flow. The AADT calculated based on AM pcu flow was therefore used in the creation of the emissions inventory as it represented the worst-case scenario for the City centre roads.

The emissions per road were calculated using the default emission factors contained within the EMIT database. The emissions factors are reported for a number of vehicle sub-categories of engine emissions standards and are known as EURO emission factors. The emissions factors are regularly reviewed and updated. The latest dataset was released in February 2002 by the Department of Food, Environment and Rural Affairs (DEFRA).

The emissions factors are calculated as grams of pollutant emitted per vehicle per kilometre travelled. The emissions factors are sensitive to the average speed of the vehicles and the vehicle engine type.

The vehicle engine type is assumed from default vehicle fleet compositions assessed by Stanger Science and Environment. The composition corresponds to the percentage vehicles of each fleet corresponding to default European engine classifications. The composition of each vehicle type is built into the EMIT database for each year i.e. in 2005 the vehicle fleet in Glasgow will contain a higher percentage of ‘cleaner’ engines than in 2002 as new vehicles adopt cleaner technology.

The total emissions to air from motor vehicles were therefore calculated by EMIT as a product of the emissions factor at given speed for each vehicle category, assumed number of vehicles in each engine category and the distance travelled per vehicle.

5.3 Emissions from Non-specified Roads

Emissions from roads within and outwith the AQMA not specified in the inventory were included on a kilometre grid square basis. The emissions for these roads were taken from the National Atmospheric Emissions Inventory Database (NAEI). The emissions were calculated on the basis of total kilometres of roads in a grid square and total traffic flow in that area. The emissions from the specified roads within the inventory were dis-aggregated from the total grid square emissions in the NAEI so that they were not counted twice.

5.4 Industrial Processor Emissions

A list of industrial processes regulated by the Scottish Environment Protection Agency (SEPA) within Glasgow was obtained from the public register.

There are a total of five Part A IPC, one hundred and twenty-two Part B IPC and three PPC regulated processes within Glasgow. Of these processes, only two were predicted to have any impact on air quality within the AQMA, namely, United Distillers and Vintners (UDV) of Port Dundas and Allied Distillers of the Gorbals.

Specific emissions data from these two processes was obtained from the SEPA public register and incorporated within the emissions inventory.

Emissions from the remaining industrial processors were included in the emissions inventory on a kilometre grid-square basis. The industrial emissions also included emissions from non-regulated processes such as small combustion processes.

Emissions of particulates include estimates of emissions of dust from construction, road working and abrasive cleaning processes. These activities are prevalent within the City centre and therefore the AQMA.

Incorporating emissions from industrial processes on a grid square basis meant that more industrial emissions were included and greater spatial coverage of emissions was given. As the focus of the inventory was on the AQMA the industrial emissions are of lesser importance to road traffic emissions and did not require to be specified on a detailed individual basis.

Emissions from industrial processors were assumed to remain constant between 2002 and 2005 and therefore the same emission sources were included in both inventories.

5.5 Commercial and Domestic Emissions

Emissions for commercial and domestic premises based on heating and other combustion sources were assumed from the NAEI database and included in the inventory on a grid square basis.

Commercial and domestic emissions were assumed to remain constant between 2002 and 2005.

5.6 Other Emissions Sources

Other emission sources were included from the NAEI database on a grid square basis. These included non-road transport sources i.e. rail and air transport emissions, emissions from waste treatment and disposal and energy generating sources.

5.7 Summary of Emissions Inventory results for Nitrogen Dioxide

The emissions from the inventory were aggregated for each source type. The total emissions of Nitrogen Dioxide by each type for the whole of Glasgow are presented in Table 5.1. The AQMA encompasses four 1km by 1km grid squares. The emissions breakdown for the grid squares encompassing the AQMA are also shown.

Emissions of NO_2 have been assumed to be total oxides of nitrogen (NO_x).

The kilometre grid square output for Nitrogen Dioxide is shown in Appendix 3.

Emission Source	Emission Tonnes/annum	
	Oxides of Nitrogen Emissions for all Glasgow	Oxides of Nitrogen Emissions for AQMA
Road Traffic Emissions	5172	452
Industrial Emissions	356	47
Commercial and Domestic Emissions	903	95
Other emissions	285	31
Total	6716	625

Table 5.1 Total emissions of NO_2 attributed to each source type in Glasgow

The figures therefore show that the main source of NO_2 both within the AQMA and Glasgow-wide is from road traffic emissions. Road traffic emissions account for approximately 77% of total NO_x emissions Glasgow-wide and approximately 72% within the AQMA.

The contribution of each source to total NO_2 emissions Glasgow-wide can be viewed in Figure 5.1 and within the AQMA in Figure 5.2.

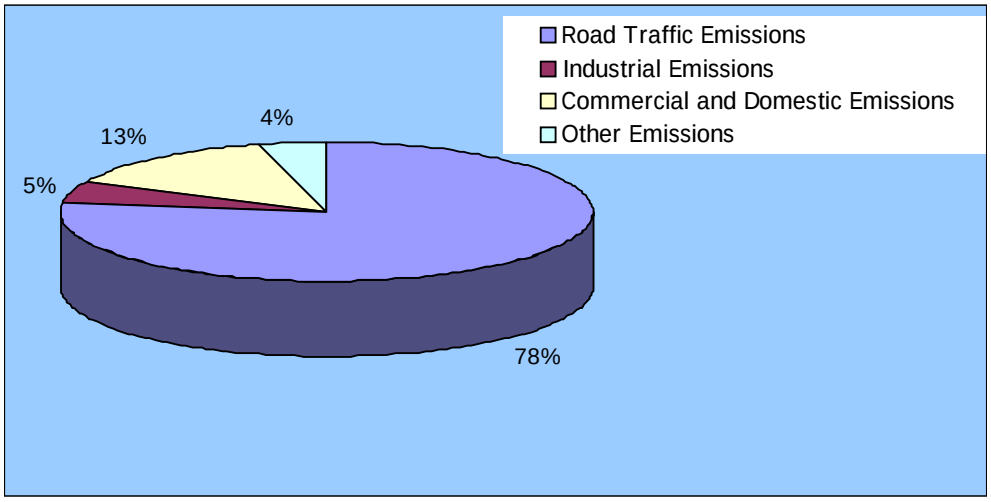


Figure 5.1 Contribution of Each Source to Total NO_x Emissions Glasgow-wide 2002

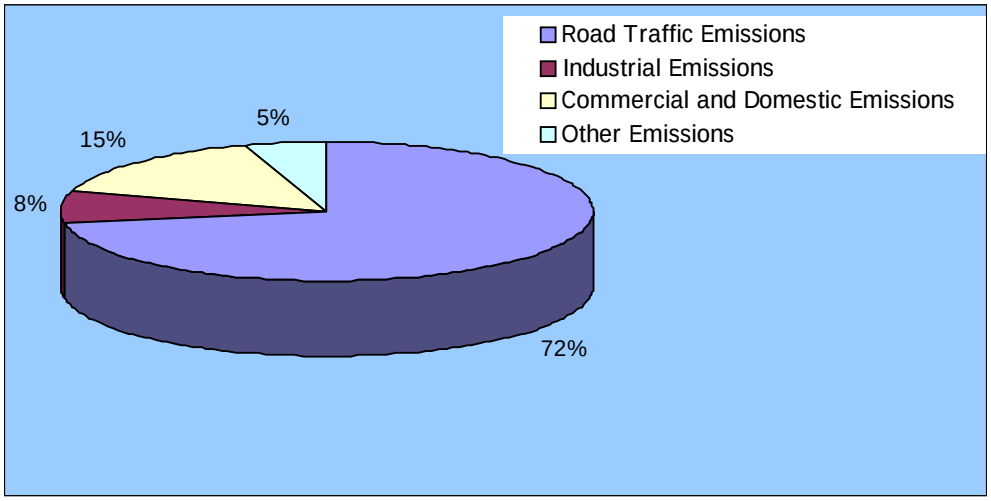


Figure 5.2 Contribution of Each Source to Total NO_x Emissions within AQMA 2002

The emissions inventory has therefore confirmed that the principal source of emissions of NO_2 within the AQMA is from road traffic. Industrial emissions form less than 10% of the total NO_x emissions. Commercial and domestic emissions form a significant proportion of the total emissions (15%) but remain roughly one third of the total.

Road traffic emissions account for 72% of total NO_x emissions within the AQMA. Cars and light goods vehicles account for approximately 48% of the total NO_x emissions from road sources within the AQMA, whilst buses and heavy goods vehicles make up the remaining 52%. Motorcycles account for a negligible amount of the total NO_x emissions within the AQMA.

6. Dispersion Modelling

The dispersion modelling was undertaken using the data from the updated emissions inventory.

The Emit-ADMS-Urban link allows each road traffic source database record to be exported as a line source including traffic flow, percentage of LGV's and HGV's, and geo-referenced road vertices. Likewise the link allows all specified industrial source records to be exported to ADMS-Urban as point sources.

The grid square emissions sources, including minor roads, non-specified industrial sources and commercial and domestic sources were exported to the model as a grid square background source.

6.1 Modelling Set-up

As the aims of the Stage Four were to further refine the data available for the Stage Three a few changes were made to the set up of the modelling runs. As a result of the validation procedure and the requirements of the latest version of the model (version 2) changes were made to grid height and surface roughness

As well as utilising the updated roads data the modelling study incorporated background concentration files for 2002 for validation purposes.

The modelling study utilised the Derwent-Middleton chemistry scheme and canyon effect modules contained within ADMS-Urban.

6.2 Model Validation

Dispersion modelling studies include a number of uncertainties not withstanding model input data. The ADMS Urban model has been extensively validated by the developers CERC over a number of scenarios. These validation studies are discussed and referenced in the ADMS-Urban manual and CERC website.

The main uncertainty in modelling studies is often the model input data. In this study the road traffic flow and subsequent emissions will have significant effect on the predicted ground level pollutant concentrations.

In order to validate the ground level pollutant concentrations predicted by the model comparison was made at a number of locations within the AQMA between the modelled predictions and actual NO_2 monitoring data provided by Glasgow City Council.

Predictions of NO_2 ground level concentration were made at fifteen points within Glasgow City centre. Each point corresponded to a monitoring location, eleven of which were passive diffusion tube sites and four automatic monitoring sites. Of these sites four of the passive diffusion tube sites and three of the automatic monitoring sites had data capture rates of less than 90%, and were therefore declared invalid. The monitoring locations and the respective monitored and modelled concentrations at the sites with sufficient data capture rates are presented in Table 6.1. The diffusion tube

monitoring results have been adjusted for field performance and laboratory bias by the methodology set out in the technical guidance document LAQM.TG(03).

All diffusion tube monitoring sites and the automatic site used in the validation study are classified as kerbside monitoring sites.

Site	Site Type	Annual Average Concentration Monitoring ($\mu g/m^3$)	Annual Average Concentration Modelling ($\mu g/m^3$)	Modelling Deviations
George Square	Kerbside	53	49.51	-6.58
Glassford St	Kerbside	56	50.44	-9.93
Briggait	Kerbside	42	49.39	17.61
St Vincent St	Kerbside	86	53.62	-37.65
Hope St 1	Kerbside	80	51.17	-36.04
Hope St 2	Kerbside	80	53.31	-33.36
Saltmarket	Kerbside	41	46.63	13.74
Hope St AURN	Kerbside	74	51.96	-29.79

Table 6.1 Monitoring / Modelling Results Comparison

The data presented in Table 6.1 demonstrates that some variation is observed between modelled concentrations of NO_2 and those actually detected at monitoring sites. At some sites the model under predicts and at some it over predicts, however in the majority of cases it under predicts by an average figure of 15%.

The apparent tendency of the model to under predict may be due to a number of reasons, such as: under-estimation of road traffic emissions, or under-estimation of emissions per vehicle or number of vehicles. Similarly street canyon dimensions will influence the predicted pollutant concentrations and may be a reason that results vary.

A methodology of a validation process to ascertain the standard deviation of the model is provided in the NSCA Guidance “Air Quality Management Areas: Turning Reviews into Action”.

The annual average concentrations predicted by the model and those measured at the monitoring sites were plotted on a scatter graph, as shown in Figure 6.1. The line of best fit was plotted on the graph.

The deviation of the modelling data was calculated for each monitoring location using the formula calculated for the line of best fit. The calculated modelling deviations are presented in Table 6.1. The calculation of model deviation was only applied to the kerbside monitoring sites.

The standard deviation (SD) of the modelling deviations was calculated to be 0.97. This value was used to calculate the standard deviation of the model (SDM) for this study, based on the uncertainty of the results. The standard deviation of the model was found to be 0.015 $\mu g/m^3$.

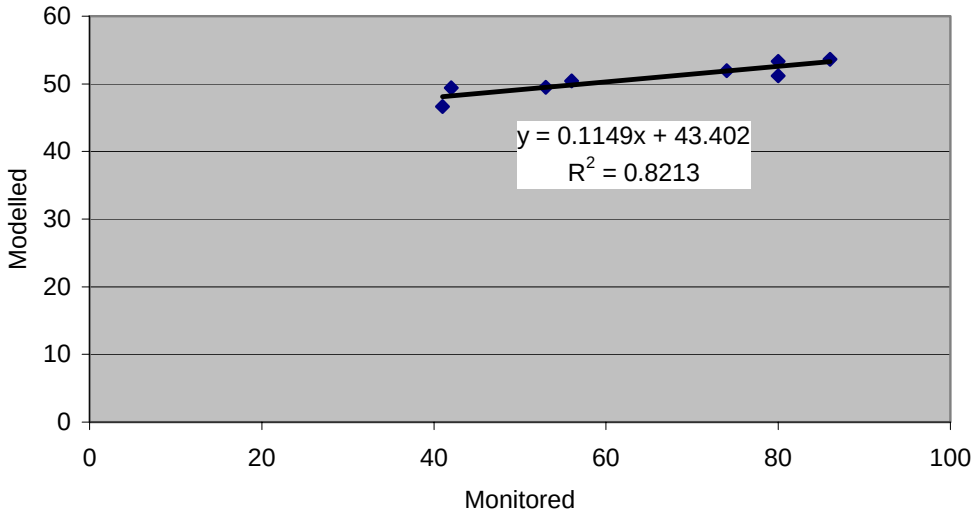


Figure 6.1 NO_2 Model Validation Monitored vs. Modelled

Therefore, although the model has under-read at kerbside locations, it has performed consistently with the standard deviation of modelling predictions being only 0.015µg/m^3.

The modelling predictions should therefore be adjusted for under-read at kerbside locations and a deviation of ± 0.015 µg/m^3 allowed for when comparing the predicted concentrations with the AQMA annual mean objectives for NO_2.

No verification or adjustment has been calculated for hourly NO_2 concentrations, as the only two monitoring sites with available monitoring data were urban centre sites, one of which is not considered reliable. The annual mean is the strictest standard of the two and in Glasgow City centre the one that is likely to be breached on the widest scale. Any areas of exceedence for the hourly objective are therefore likely to be encompassed within any areas of exceedence of the annual mean.

6.3 Results of Modelling Study

The modelling study has indicated that all areas within the AQMA will exceed the NO_2 annual mean objective as indicated in the contour plot in Appendix 4.

This differs from the conclusions of the Stage Three Review and Assessment, which indicated that only parts of the City centre would not comply with the objective. However it indicates that it was appropriate to consider the City centre as a whole.

The modelling study also indicates that the area of exceedence may be wider than the current boundary of the AQMA.

7. Conclusions

Since the publication of the Stage Three report, further work has been undertaken to update monitoring data and to refine the emissions inventory and modelling work undertaken by Glasgow City Council.

The monitoring of NO_2 carried out between 2000 and 2002 using both automatic and passive methods indicates that exceedences of the annual mean and hourly objective are predicted to occur within the City centre, consistent with the conclusions of Stage Three.

The further modelling work undertaken since Stage Three indicates that the area of exceedence may be wider than the current boundary of the AQMA.

Considering the two sources of information together it is considered appropriate that at this stage the boundary remains unchanged and the AQMA continues to be valid for the City centre area.

Compliance with the air quality objectives for areas outwith the current AQMA will continue to be assessed as part of the second round of review and assessment, which is currently ongoing.

APPENDICES

1. The City of Glasgow Air Quality Management Area Order 2001

2. Annex to the City of Glasgow Air Quality Management Area Order 2001

3. Glasgow City Council Emissions Inventory 2005: Total NO_x Emissions (kg/year)

4. Glasgow City Centre 2005: NO_2 Concentration Profile ($\mu g/m^3$)

APPENDIX 1

GLASGOW CITY COUNCIL

ENVIRONMENT ACT 1995 SECTION 83

THE CITY OF GLASGOW AIR QUALITY MANAGEMENT AREA ORDER 2001

Glasgow City Council ("the Council"), in exercise of the powers conferred upon it by Section 83 of the Environment Act 1995, hereby make the following Order.

1. This Order may be cited as the City of Glasgow Air Quality Management Area Order 2001 and shall come into operation on the 1st January 2002.

2. The area outlined in red shown on the plan annexed to this Order and sealed with the Common seal of the Council is declared to be an Air Quality Management Area ("the designated area"). The map can be viewed at Council Offices, Nye Bevan House, 20 India Street.

3. This Order may be varied or revoked by a subsequent Order.

4. When this Order comes into operation the Council will cause an assessment to be made of existing air quality and likely future air quality within the designated area.

5. Within 12 months of this Order coming into operation the Council shall prepare a report of the results of the air quality assessment.

6. A written action plan will be prepared in order to pursue the achievement of air quality standards and objectives in the designated area. The written action plan shall include a timetable for the Council's implementation of each of the proposed measures in the action plan.

7. The Council may revise the action plan from time to time.

Sealed with the Common Seal of the said Council and signed by

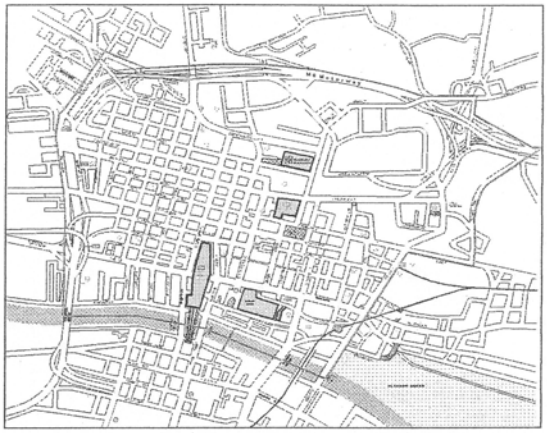
.....

on behalf of the said Council this ~~day of~~ Twenty fourth

day of December 2001

APPENDIX 2

Annex to the City of Glasgow Air Quality Management Area Order 2001



The Air Quality Management Area comprises the area within the City of Glasgow which is bounded by (and including the full widths of) the following roads and by the centreline of the River Clyde.

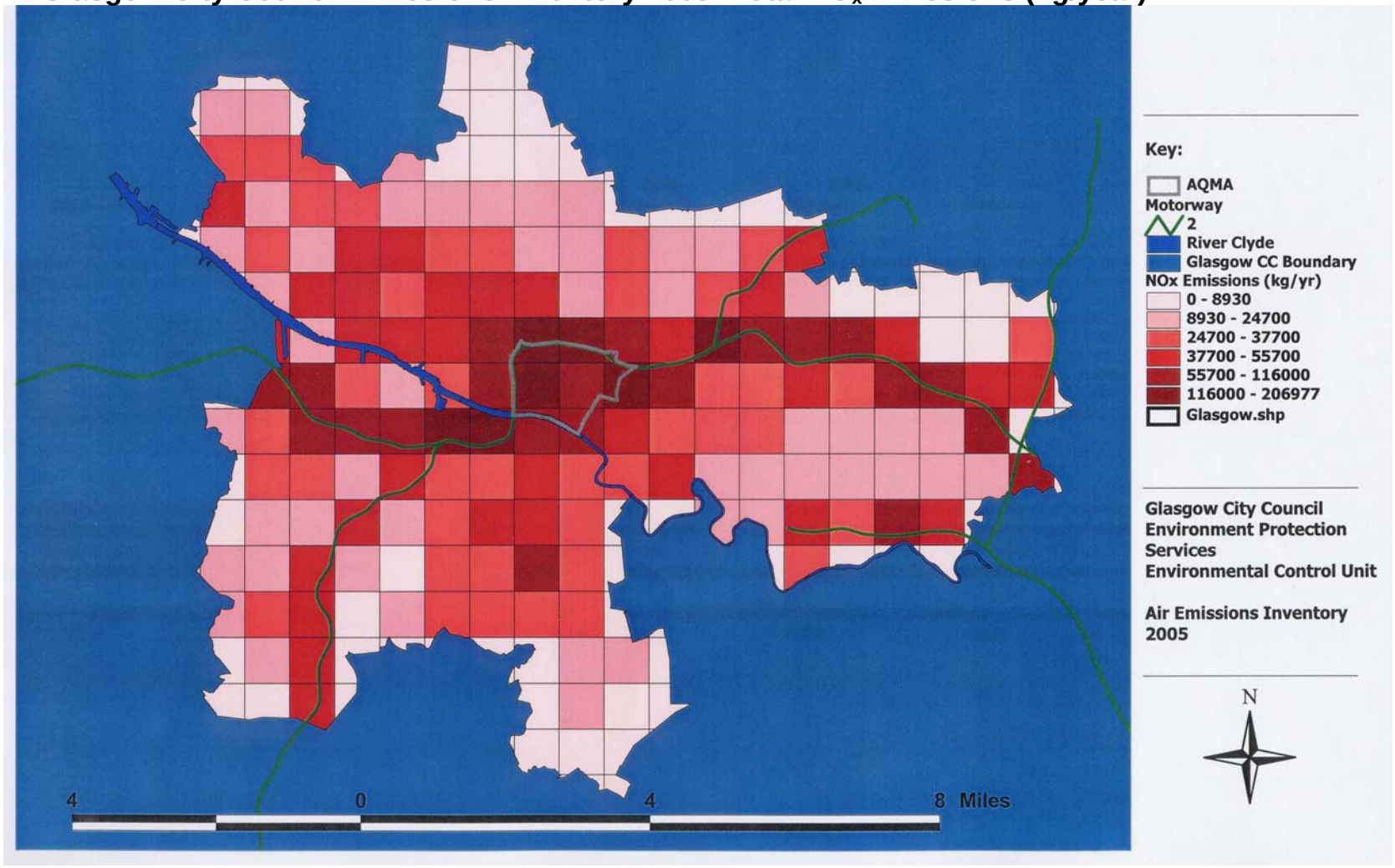
Kingston Bridge / M8 Motorway, from the centreline of the River Clyde to the junction of Piccadilly Street and North Street;
North Street, from the Junction with Piccadilly Street to Woodlands Road;
Saint George's Road, from Woodlands Road to Phoenix Road;
Phoenix Road, from Saint George's Road to the M8 Motorway;
M8 Motorway, from Phoenix Road to Baird Street;
Baird Street, from M8 Motorway to Castle Street;
Castle Street, from Baird Street to M8 on-ramp;
M8 Motorway (including on-ramp), from Castle Street to the projected line of the southeast side of Wishart Street;
The projected line of the southeast side of Wishart Street, from the M8 Motorway to Alexandra Parade;
Wishart Street, from Alexandra Parade to Ladywell Street;
John Knox Street, from Ladywell Street to Duke Street;
Duke Street, from John Knox Street to High Street;
High Street, from Duke Street to Trongate;
Saltmarket, from Trongate to Clyde Street;
Albert Bridge, from Clyde Street to the Centreline of the River Clyde;
The centreline of the River Clyde from Albert Bridge to the Kingston Bridge / M8 Motorway.

Sealed with the Common Seal of the said Council and signed by

..... on behalf of the said

Council this ~~day of~~ Twenty fourth day of December 2001

Appendix 3
Glasgow City Council Emissions Inventory 2005: Total NO_x Emissions (kg/year)



Appendix 4

Glasgow City Centre 2005: NO_2 Concentration Profile ($\mu g/m^3$)