City of Edinburgh Council

Review and Assessment of Air Quality

Stage 4

May 2002

CONTENTS

Executive Summary

This report, known as Stage 4, is supplemental to the City of Edinburgh Council's Stage 3 Review and Assessment of Air Quality. The Stage 3 report concluded that at various city centre locations, the annual average objective for nitrogen dioxide was not likely to be achieved by the end of 2005 and proposed the declaration of an Air Quality Management Area (AQMA). The AQMA was designated on 31st December 2000.

The key elements contained in this report focus on:

- additional nitrogen dioxide monitoring data and traffic data collected since the publication of the Stage 3 report and the designation of the AQMA
- the calculated level of reduction required in nitrogen oxide (NO_x) levels to achieve the annual average nitrogen dioxide (NO_2) objective within the AQMA.

The findings in this report conclude that the AQMA is still valid, taking account of proposed local development plans. The majority of exceedances within the AQMA are at or close to busy road junctions and are therefore shown to be more localised than was previously thought. The largest contribution of NO_x is derived from larger diesel engines. In the AQMA this is primarily buses. Substantial improvements in NO_x levels produced by traffic are required in order to attain the objective.

An Air Quality Action Plan is currently being developed which will detail measures to be considered in pursuit of achieving the annual average nitrogen dioxide objective.

Stage 4 is the final report with respect to the initial phase of Local Air Quality Management (LAQM), and has been produced in compliance with Section 84-(2) (a) of the Environment Act 1995. A further citywide review and assessment of air quality is due to be completed by the end of 2003. Additional monitoring of nitrogen dioxide has begun in the vicinity of proposed large-scale developments, and at other localities where traffic flows or congestion has notably increased.

Both stage 3 and stage 4 reports are available on the following web page:

www. edinburgh.gov.uk/airquality

Introduction

The Environment Act 1995 requires all Local Authorities to review and assess air quality in their areas with regard to prescribed air quality objectives set out in the Air Quality (Scotland) Regulations 2000 Appendix 1 (a).

Government guidance documents recommend that the air quality review and assessment should be a three stage process. All local authorities should complete the first stage, which comprises of a desk top study. The results of the first stage will indicate whether it is necessary to progress to a second and a third stage review. The third stage requires to provide a more accurate and detailed assessment of air quality.

Where a Local Authority has identified that an objective for a specific pollutant is unlikely to be achieved within the relevant time scale, it must designate an Air Quality Management Area (AQMA). After an AQMA has been declared the Local Authority must carry out a further assessment of the existing and likely future air quality in the designated area. This assessment is known as stage 4. This aims to supplement information which has already been gathered and confirm that the original designated area is still valid. According to guidance from Department for Environment, Food and Rural Affairs (DEFRA) this further assessment should also:

- show the calculated level of improvement in air quality which is needed to meet objectives and the extent to which different sources contribute to the problem;
- take account as far as possible of any local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into earlier calculations. These might include, for example, the implications of any new transport schemes that are likely to be implemented in the vicinity of the AQMA, or of any new major housing or commercial developments that are likely to be built by the relevant date
- take account of any national policy developments which may come to light after the AQMA declaration.

Under section 84 (2) of the Environment Act, Local Authorities must draw up an Action Plan detailing the measures which they intend to take in pursuit of achieving the air quality objectives**. Local authorities are not under a legal obligation to achieve the objectives.**

However, local authorities are required to be seen to be taking action to work towards the objectives. European Union Directives are being transposed into national legislation through the Air Quality Limit Values (Scotland) Regulations. The revised regulations will place an obligation on **Scottish Ministers to achieve the EU limit value** for nitrogen dioxide (annual average) by 2010.

2.0 The Edinburgh Perspective

Following a Stage 3 Review and Assessment of Air Quality the City of Edinburgh Council declared an AQMA, which was designated on 31st December 2000. This report concluded that at 8 city centre sites the annual average standard for nitrogen dioxide was not currently being met and was not likely to be achieved by the end of 2005.

Nitrogen dioxide objective:

	Concentration	Measured as	Date to be achieved by
Nitrogen dioxide	40 μg/m^3	Annual mean	2005

The Stage 1 and 2 Review and Assessment report determined that all the other pollutants would meet the required standards in the relevant time scale.
The eight locations which are likely to fail to meet the annual average objective for nitrogen dioxide are:

West Maitland Street	Princes Street	North Bridge	Gorgie Road
Roseburn Terrace	Queen Street	Leith Walk	George Street

The locations which are identified as having the highest concentrations of nitrogen dioxide, are adjacent to roads which carry high volumes of traffic i.e. the main radial routes into and through the city centre.
The emissions inventory for Edinburgh (detailed in the Stage 1 and 2 report and summarised in Stage 3) identified that road transport is the most significant source of nitrogen oxides. Mobile sources accounted for up to 96% of nitrogen oxide emissions, 8% of which was attributed to the airport and 88% to road traffic. The highest emissions of nitrogen oxides occur in and around the city centre. In order to facilitate an integrated Action Plan a single AQMA was declared for the city centre which includes the main link roads in to the city centre**.** (Map 1.1)

City of Edinburgh Council's Action Plan is being developed in conjunction with this Stage 4 report.

3.0 Nitrogen dioxide monitoring data

To ensure that the AQMA is still valid, nitrogen dioxide was measured using chemiluminescent real - time analysers at five locations within the AQMA together with a network of passive diffusion tubes located at the kerbside. Additional diffusion tubes were located close to the existing junction sites, to assess any spatial change in nitrogen dioxide levels.

The real - time analyser located at Cowgate for stage 3 was resited on Leith Walk at Shrubhill adjacent to the north bound carriageway. The locations of the other real - time monitors remained the same as did the passive diffusion tube sites.
Real - time analysers provide the most accurate and precise values. To correct for the discrepancy between the two methods of measurement, diffusion tubes were co - located in duplicate and latterly in triplicate at each of the sampling ports of the five analysers.

At the start of 2001, the exposure time for diffusion tubes was changed from weekly to monthly sampling periods as a result of the findings of a Best Value review of the Air Quality service. There is research evidence to suggest that monthly exposed diffusion tubes under read in comparison with weekly exposed tubes [1]. This was also found at the real - time sites in Edinburgh, where diffusion tubes were co-located. The percentage variation of passive diffusion tube over-read, compared with real-time measurements is summarised below for years 1999 to 2001 and the appropriate correction values have been used for the purpose of assessment of levels of nitrogen dioxide for each year. The individual average comparison values are tabulated in Appendix 1(b)

Year	**1999**	**2000**	**2001**
%Pdt variation	21.9 %	22.2 %	9.9%
	***17.2 %**		

Note * 17.2 % was used as the correction factor for the over-read associated with passive diffusion tube measurement following advice from the Scottish Executive and Scottish Environment Protection Agency (S.E.P.A)

[1] Heal M. R, O' Donoghue M.A and Cape J. N. Over estimation of urban nitrogen dioxide by passive diffusion tubes: a comparative exposure and model study. Atmospheric Environment pgs 514 - 524.

A further correction for passive diffusion tube data requires to be made for the distance between the sampling point and the nearest building façade as concentrations of nitrogen dioxide decrease sharply, with increasing distance from source. The assistance of the Government's review and assessment helpdesk was sought in relation to this and the following factors were adopted on the advice received:

0 to 2 metres x 0.95
2 to 5 metres x 0.90
> 5 metres x 0.75

Distances for sampling points and the nearest building façade are listed for all sites within the AQMA together with the raw (uncorrected) annual average data (Appendix 1(c)).
Predictions of concentrations for 2005 have been made using 1999, 2000 and 2001 data. However, for passive diffusion tube data for 2001, only 11 months of data was available. Due to changes in the exposure periods from weekly to monthly, the data sets were incompatible and therefore values from 2000 data sets could not be used to provide a full 12 month data set for 2000 – 2001.
The correction factors detailed in Pollutant Specific Guidance note TG4 were applied to provide the predicted nitrogen dioxide concentrations for 2005.(Table 3.1)

Table 3.1 Correction factors to estimate annual mean roadside/kerbside NO_2 concentrations for future years (Source TG4)

Year	1996	1997	1998	1999	2000	**2001**	2002	2003	2004	**2005**
Correction factor to be applied	1.00	0.97	0.94	0.92	0.90	**0.87**	0.85	0.83	0.81	**0.79**

Example:
To correct monitoring data to 2005. Assume the **2001** measured NO_2 concentration is 30 $\mu g/m^3$. The estimated 2005 concentration is then :
30 x (0.79/0.87) = 27.2 $\mu g/m^3$

Therefore correction factors for years 1999 to 2001 are detailed below
1999 = 0.8586
2000 = 0.8777
2001 = 0.9080

The corrected and predicted passive diffusion tube data is shown below for sites within the AQMA. Data is expressed in μg/m^3 (Table 3.2).

Table 3.2 Nitrogen dioxide passive diffusion tube data for years 1999 to 2001 and subsequent predictions for 2005.

Site	1999	2005	2000	2005	2001	2005
West Maitland St/Palm Pl jnct	61	53	67	58	72	65
West Maitland Street	-	-	56*	49*	59	54
Roseburn Terrace/ St jnct	62	53	60	53	57	52
Roseburn Terrace	-	-	39 *	34*	43	39
North Bridge 1	57	49	55	48	53	48
North Bridge 2	-	-	49*	43*	55	50
Princes Street	48	41	51	45	57	52
Gorgie Road/Ardmillan jnct	44	38	42	37	58	53
Ardmillan Terrace/Gorgie Rd	-	-	-	-	40	36
Leith Walk/McDonald Rd jnct	46	39	42	37	43	39
Leith Walk	-	-	-	-	33	30
Queen Street	50	43	45	40	43	39
York Place	38	33	36	32	38	35

Note * incomplete data sets for monitoring period.Site commenced July 2000
11 months of data available for year 2001.

Data from the real-time analysers is shown below. The data has been predicted for 2005 using the appropriate correction factors listed above. A correction factor for the distance of the sampling point to the nearest building façade has not being applied, as most of the sites are classified as roadside sites (barring Princes Street) and are positioned at or are set back from the nearest building façade.

Table 3.3 Comparison of annual average nitrogen dioxide data for years 1999 to 2001 using chemiluminescent analysers located within AQMA and subsequent predictions for 2005.

SITE	1999	2005	2000	2005	2001	2005
A.U.R.N Princes St Gdns	42	36	45	39	44	40
Cowgate (City Mortuary)	31	27	29*	25	-	-
Leith Walk (Shrubhill House)	-	-	36**	32	37	34
QueenSt/North Castle St	42	36	38	33	39	35
Haymarket Terr	38	32	37	32	42	38
Gorgie Rd (White Park)	42	36	38	33	40	36

***** **Incomplete annual data .Site changed to Leith Walk end of monitoring period 27.07.00**

****** **Incomplete annual data .Site commenced monitoring 03.08.00**

Note the 2001 data from the Automated Urban And Rural Network (A.U.R.N) site at Princes Street Gardens, funded by DEFRA requires to be ratified.

Chart 3.1

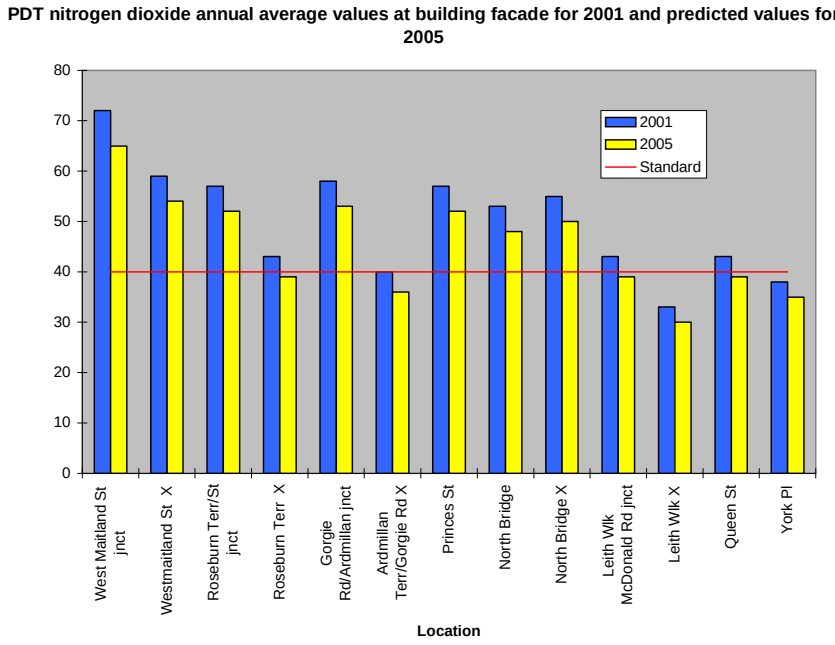
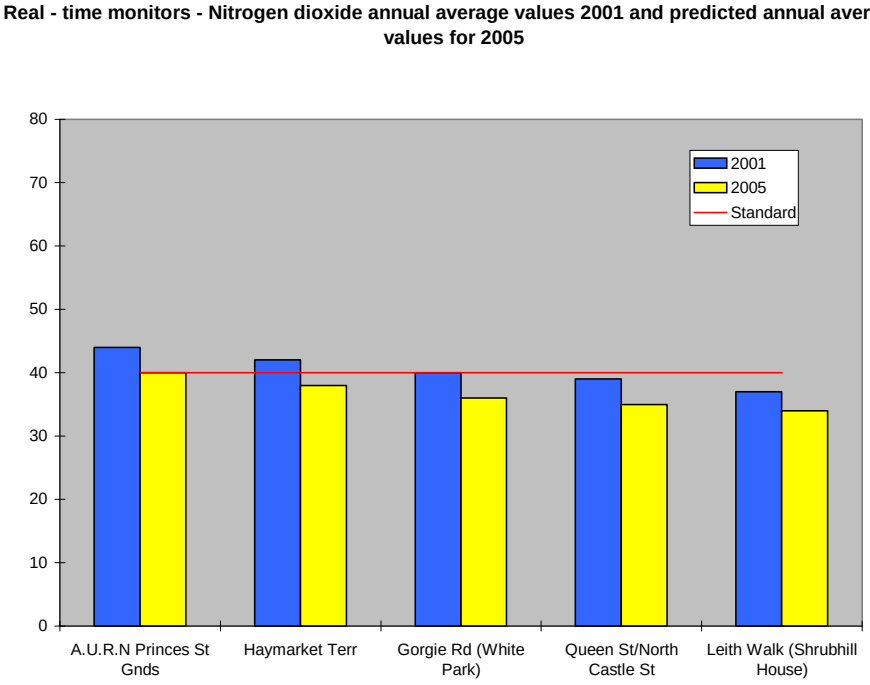


Chart 3.2



4.0 Data Assessment

Passive Diffusion Tube Sites

The 2001 data for the monitoring locations within the AQMA shows that the annual standard concentration of nitrogen dioxide is still not currently being met and is not likely to

be achieved by 2005 at the majority of the sites. The sites which are likely to achieve the objective are Queen Street and at the junction of Leith Walk/McDonald Road, although these sites could be considered to be borderline, each with a predicted concentration of **39 μg/m^3.**

The above data sets show a marked increase at the Gorgie Road /Ardmillan junction, this may have been due to road works which were being undertaken and an adjacent road closure during the monitoring period.

Princes Street and West Maitland Street also show an increase in levels from 1999 to 2001. Queen Street demonstrates a decrease in nitrogen dioxide values. York Place is a continuation of Queen Street. The sampling site is located approximately 125 metres from the busy roundabout at Picardy Place, however this section of the main route is likely to meet with the annual objective.

The two North Bridge locations are at the same building façade approximately 20 metres apart, the data is comparable and indicates that this site is still likely to fail the annual objective.

The additional site at West Maitland Street is located further away from the busy junction site on the opposite side of the road. The predicted value here is less than that predicted at the site closer to the junction. A similar pattern occurs at Gorgie Road, Roseburn Terrace and Leith Walk, in each case passive diffusion tubes were located at opposite sides of the road where traffic queues were less obvious and traffic flowed more freely. The percentage differences at these sites are shown below:

Site	Nitrogen dioxide value 2005	% Increase at junction
West Maitland St/Palmerston Pl junction	65	
West Maitland St	54	20 %
Gorgie Rd/Ardmillan junction	53	
Ardmillan Terrace /Gorgie Rd	36	47%
Roseburn Terrace/Roseburn St junction	52	
Roseburn Terrace	39	33%
Leith Walk/McDonald Rd junction	39	
Leith Walk	30	30%

The location at Leith Walk adjacent to McDonald Road may have shown a reduced level in nitrogen dioxide, due to the closure of McDonald Road during 2000 and 2001 to through traffic.

Real - time monitoring data

The values obtained from the five real-time analyser sites indicate that these locations are likely to meet with the annual average objective, for nitrogen dioxide in the timescale proposed. However, at present Haymarket Terrace and the site at Princes Street Gardens do not meet the annual average objective. It is important to note that none of the real - time analyser sites are located close to road junctions. The Queen Street site is on a stretch of road, which has relatively free flowing traffic. Although the 24-hour average annual traffic flow is in excess of 35,516 vehicles, the road is open and wide with gardens on the north side. This topography inevitably facilitates the dispersal of pollutants. In addition, there is a much smaller percentage of buses which use this road.

The Air Quality (Scotland) Regulations 2000, state that the assessment of air quality requires to be determined at locations a) which are situated outside of buildings and b) where members of the public are regularly present. Statutory guidance also states that the local authorities should have regard to those locations where members of the public are likely to be exposed and regularly present over the averaging period of the pollutant, and that exceedances of the objectives should not be considered where relevant public exposure would not be realistic.

All monitoring sites within the AQMA are in close proximity to residential properties. Details of each site are described in the Stage 3 Report, together with a map showing the area of potential exceedance.

Assessment summary

From the additional monitoring data collected it would appear that the AQMA is still valid. The majority of exceedances are at or close to busy road junctions. Both Leith Walk and Queen Street show that they are now likely to meet with the objective, based on monitoring data for 2001. However, the values (**39μg/m^3**) are considered borderline. Also, traffic increases are likely along these routes, due in particular to the development at Greenside Place which is currently being constructed and will comprise multi screen cinema, office development, numerous retail outlets, restaurants and bars.

In addition to this development there are major traffic proposals for the centre of Edinburgh, which affect the majority of the AQMA. Whilst these proposals are predicted to improve air quality in George Street they are likely to have either a neutral or adverse effect at other locations within the AQMA.The main proposals are summarised below:

- Opening up of the junction at Queensferry Street and Princes Street thus directing buses along Princes Street and removing buses from Charlotte Square and George Street
- On Princes Street (westbound carriageway) permit only buses, taxis, emergency vehicles and cycles. This scheme is currently operational on the eastbound carriageway.

4.1 Planning, development and policy considerations

The role of the planning process and the implications of development plans for air quality management in Edinburgh are documented in the council's Action Plan. There are development proposals of major significance in terms of housing, schools and commercial properties for the southeast wedge, northeast and west of Edinburgh. At several locations development is already underway, although timescales for many developments are unknown at present. Such developments are likely to result in additional traffic volumes which may impact on the AQMA in particular at Leith Walk.

Where development has or is taking place, which is predicted to have a significant effect on traffic related NO_x emissions, additional monitoring using passive diffusion tubes has begun in preparation for the next round of reviews and assessments which have to be completed by 2003.

4.2 Changes in National policies

Detailed below is a list of national policy matters which have come to light since Edinburgh's 3rd Stage Review and Assessment of Air Quality was published and the AQMA declared. These are issues which could have an influence on future air quality matters.

National Emissions Factor Data Base

The draft revised emission factors, (currently the subject of consultation) are more pessimistic than those previously applied. It is now suggested by Central Government, that emissions of nitrogen oxides could be up to 36% higher in 2005 than originally predicted. In Edinburgh, our policy throughout the review and assessment process has been to monitor the levels of nitrogen dioxide as opposed to making assessments derived from the modelling of traffic emissions. Edinburgh has always considered modelling to be a delicate issue, due to the complex changes associated with urban – drive cycles.

Revised National Air Quality Strategy

The government and the devolved administrations are currently consulting upon proposed changes to The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Of particular significance for Local Air Quality Management (LAQM) are proposals in respect of new objectives for pollutants and for these to be included in the LAQM regime. The consultation document is seeking views on proposals for more stringent particle (PM_{10}) objectives and the establishment of different objectives for different parts of the UK. For example London could have a more relaxed objective than the rest of England; whilst an even more stringent objective for Scotland could be established. Table 4.1

Table 4.1 Current and proposed PM_{10} objectives for Scotland

	Current- to be achieved by 2004	**Proposed- to be achieved by 2010**
24-hour mean	**50** μg/m3 not to be exceeded more than **35** times a year	**50** $\mu g/m^3$ not to be exceeded more than **7** times a year
Annual mean	**40** $\mu g/m^3$	**18** $\mu g/m^3$

None of the proposed changes affect the current status within the AQMA nor the development of the associated Action Plan. However, the proposals for PM_{10}, if adopted, would have a significant impact for Edinburgh, as the proposed objectives are unlikely to be achieved within the framework of LAQM.

5.0 Reduction in nitrogen oxides (NO_X) which are required

Nitrogen dioxide (NO_2) is a secondary pollutant formed by atmospheric reactions between nitric oxide (NO) and ozone (O_3). Nitrogen dioxide and nitric oxide are both oxides of nitrogen and are collectively referred to as NO_X.The chemistry of the formation of nitrogen dioxide is complex and the relationship between atmospheric concentrations of NO_2 and NO_X is not linear. Therefore an increase in NO_X emissions from vehicles, which comprise largely of nitric oxide, does not necessarily bring about a proportionate increase in NO_2. However, an empirical relationship between annual mean NO_x and NO_2 has been derived from data gathered from national air quality sites for kerbside locations, which is shown below and featured in Pollutant Specific Guidance document TG4

$$x = 3.3931y^{0.5275}$$

where $x = NO_2$ and $y = NO_X$

Therefore, to calculate the levels of reduction in NO_2 which are required to achieve the annual average objective, it will be necessary to look at the NO_X levels (largely NO). This methodology was confirmed as appropriate from the Government helpdesk. The calculated reductions in NO_x for current data (2001) and predicted values for 2005 are shown in tables 5.1 and 5.2. An example of the calculation is detailed in appendix 2.

Table 5.1 Level of reduction necessary of NO_X concentrations from vehicular traffic to bring about required reduction in NO_2 based on current data for 2001
Note 88% of NO_X is attributed to road traffic

Site	NO_2 2001 Measured	Total NO_X Modelled	RoadTraffic NO_X Modelled	% NO_X reduction from traffic
West Maitland St/Palmerston Pl jnct	72	326	287	76 %
West Maitland St	59	224	197	59 %
Roseburn Terrace/ St jnct	57	210	185	56 %
Roseburn Terrace	43	123	108	15 %
North Bridge 1	53	183	161	47 %
North Bridge 2	55	196	172	52 %
Princes Street	57	210	185	56 %
Gorgie Rd/Ardmillan jnct	58	217	190	58 %
Ardmillan Terrace /Gorgie Rd	40	107	94	0
Leith Walk/McDonald Rd jnct	43	123	108	15 %
Leith Walk	33	74	65	0
Queen Street	43	123	108	15 %
TARGET			NO_2 = 40 $\mu g/m^3$ NO_X = 107 $\mu g/m^3$	

Table 5.2 Level of reduction necessary of NO_X concentrations from vehicular traffic to bring about required reduction in NO_2 based on predicted 2005 data

Site	NO_2 2005 Predicted	Total NO_X Modelled	Road Traffic NO_X Modelled	% NO_X reduction From traffic
West Maitland St/Palm Pl jnct	65	269	237	68 %
West Maitland St	54	189	166	49 %
Roseburn Terrace/ St jnct	52	176	155	45 %
Roseburn Terrace	39	102	90	0
North Bridge 1	48	151	133	33 %
North Bridge 2	50	164	144	39 %
Princes St	52	176	155	45 %
Gorgie Road/Ardmillan jnct	53	183	161	47 %
Ardmillan Terrace/Gorgie Rd	36	88	77	0
Leith Walk/McDonald Rd jnct	39	102	90	0
Leith Walk	30	62	55	0
Queen St	39	102	90	0
TARGET			NO_2 = 40 $\mu g/m^3$ NO_X = 107 $\mu g/m^3$	

The reduction in NO_x concentrations required from traffic related sources are substantial at five of the seven locations. These are summarised below:

Site	Required reductions in NO_x using 2001 data	Required reductions in NO_x using 2005 predicted data
West Maitland St /Palm Pl jnct	76 %	68 %
West Maitland St	59 %	49 %
Gorgie Rd/Ardmillan jnct	58 %	47 %
Roseburn Terr/ St jnct	56 %	45 %
Princes St	56 %	45 %
North Bridge 1	52 %	39 %
North Bridge 2	47 %	33 %
Roseburn Terr	15 %	0
Leith Wlk/Mc Donald Rd jnct	15 %	0
Queen Street	15 %	0
Leith Wlk	0	0
Ardmillian Terr/Gorgie Rd	0	0

Guidance recommends that the worst case scenario should be taken with respect to the level of reduction in NO_x required where there are two sites in close proximity.

Caution must be exercised in relation to the 2001 monitoring data Gorgie Road / Ardmillan junction as this may not be representative, due to road works etc being undertaken in the vicinity. Based on the predicted values for 2005, this site would require a substantial improvement in traffic related NO_x. However, previous data indicated that this site was likely to achieve the objective. Monitoring is still being undertaken at this site and this assessment will be reviewed, as more data becomes available.

6.0 Traffic Data

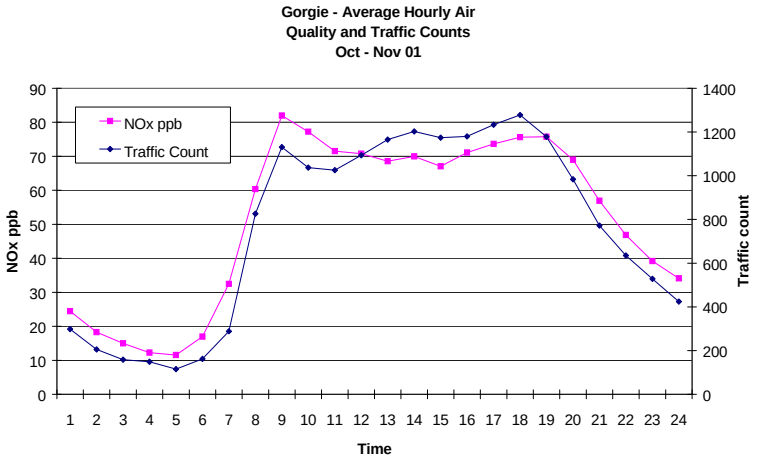
Enhanced traffic counters (Golden River automatic traffic counter classifiers Marksmen M660 series) have been installed at eight sites within the AQMA in close proximity to where real - time air quality monitoring equipment is located. The counters measure the total volume of traffic and the axle length of each vehicle. From the axle length the type of vehicle can be estimated as shown below:

Band Size (cm)	**Vehicle Type**	**Assumed predominant Vehicle type for calculations ***
0 – 300	Bikes,Motorcycles, Small cars	Cars - Petrol & Diesel
300 – 450	Cars, Taxis	Cars - Petrol & Diesel
450 – 600	Cars, LGV	Light goods vehicles
600 – 900	Rigid HGV	Rigid Heavy Goods vehicles
900 – 9999	Buses & Articulated HGVs	Buses

*** Assumed vehicle classes were based on local knowledge.**
Band size 900 – 9999 buses were considered to be the predominant group as articulated HGV s within the AQMA were less than 1% of total manual traffic counts at all sites.

The Golden River Marksman Target data analysis package was used for this purpose. Gathering both traffic data and air quality data allows their relationship to be established for a particular site and the contribution of a vehicle class to total NO_x emissions to be estimated. The real - time analysers are located at sites which are predicted to meet the standards. However, the hourly data collected has been used to demonstrate the relationship between traffic flows and air quality, within the AQMA. Chart 6.1

Chart 6.1



The above chart confirms that traffic is the major source of NO_x in Edinburgh. Further charts for the remaining sites, which illustrate a similar pattern are detailed in the Action Plan.

To estimate the contribution, which each type of vehicle makes to the overall NOx emissions, the emissions factors for 2001 (urban) were used. The factors are detailed in the emissions database from the NETCEN website (January 2002). The results are summarised below for the following site locations:

Haymarket	Queen Street	Gorgie Road
Leith Walk	West Maitland Street	

The calculation used to estimate the NO_x emissions from the vehicle classes is detailed in appendix 3. The proposed new emissions factors were not considered by the Government helpdesk to be in a suitable format to use for this exercise.

Detailed information regarding Edinburgh's bus fleet was not available at the time of compiling this report. Therefore 2001 urban fleet weighted emissions factors for buses were used.

All traffic counter locations (including proposed locations) and air quality monitoring sites are detailed in map 1.2.

Table 6.1 The percentage of vehicle class types within the fleet profile at the given locations and their associated percentage contribution to NO_x emissions.

Haymarket : Total 24 hour average traffic count = **26,568**

Vehicle Class	Petrol Cars	Diesel Cars	Petrol LGV	Diesel LGV	Rigid HGV	Bus	Total %
% Vehicle class	49	7	6	21	4	11	100
% NO_x contribution	14	1	2	6	12	63	100

Leith Walk : Total 24 hour average traffic count = **26,091**

Vehicle Class	Petrol Cars	Diesel Cars	Petrol LGV	Diesel LGV	Rigid HGV	Bus	Total %
% Vehicle class	57	9	4	17	4	8	100
% NO_x contribution	19	2	3	6	15	56	100

Queen Street: Total 24 hour average traffic count = **37,356**

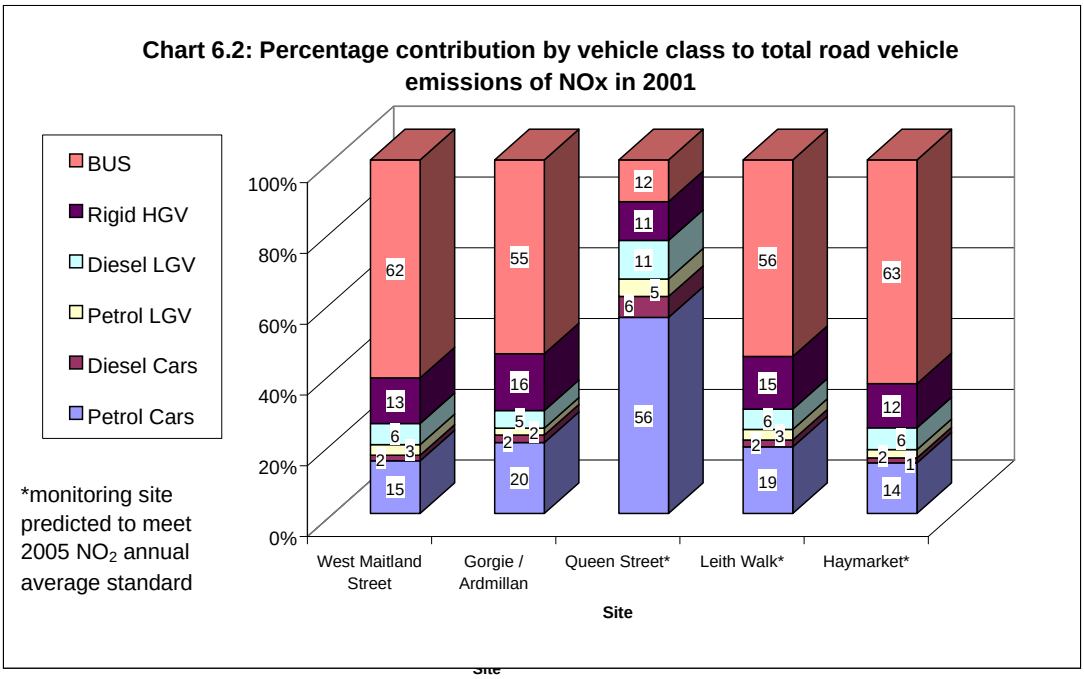
Vehicle Class	Petrol Cars	Diesel Cars	Petrol LGV	Diesel LGV	Rigid HGV	Bus	Total %
% Vehicle class	71	11	3	12	1	1	100
% NO_x contribution	56	6	5	11	11	12	100

West Maitland Street: Total 24 hour average traffic count = **22,330**

Vehicle Class	Petrol Cars	Diesel Cars	Petrol LGV	Diesel LGV	Rigid HGV	Bus	Total %
% Vehicle class	52	8	5	20	4	10	100
% NO_x contribution	15	2	3	6	13	62	100

Gorgie Road : Total 24 hour average traffic count = **18,235**

Class of vehicle	Petrol Cars	Diesel Cars	Petrol LGV	Diesel LGV	Rigid HGV	Bus	Total %
%Vehicle class	59	9	4	14	5	8	100
% NO_x Contribution	20	2	2	5	16	55	100



The above chart and tables show that buses are the largest contributors to NO_x levels within the AQMA at the following locations Haymarket, West Maitland Street, Gorgie Road and Leith Walk / Mc Donald Road junction. It is likely that the majority of NO_x on Princes Street will be attributed to buses since buses are predominant on this road. However, traffic counters were not installed at this location and therefore traffic data is not available for assessment. Queen Street has the highest estimated proportion of cars in its total vehicle fleet and consequently cars are responsible for the majority of NO_x emissions on this road. Traffic data from Roseburn and North Bridge is in the process of being gathered. The traffic data has been verified by performing manual counts for a period of 12 hours at each of the locations where traffic counters have been installed. A summary of the traffic counts and the manual count verification of the traffic data are shown in appendix 4a and 4b respectively.

7.0 Conclusions

This Stage 4 report concludes that the AQMA is still valid, from the assessment of additional monitoring data gathered during 2000 and 2001 and taking account of local development proposals and the proposed traffic management scheme for the city centre. However, the majority of exceedances of the annual average nitrogen dioxide objective are at or close to busy junctions and are therefore shown to be more localised than previously thought.

The traffic data collected has demonstrated a strong relationship with ambient NO_x concentrations, monitored from nearby real – time analysers, thereby directly confirming traffic emissions as the major source of NO_x, and hence nitrogen dioxide, in Edinburgh.

The estimated contribution of NO_x from the various vehicle categories has identified that a considerable portion of NO_x is derived from buses. Substantial reductions in NO_x are required (33% to 68%) at the majority of locations, in order to meet with the annual average nitrogen dioxide objective. NO_x can be reduced from individual vehicles by:

- Using vehicles with new engine technology;
- Using alternative cleaner fuels;
- Smoother running with reduced idling and stop/starts.

The Council's Action Plan is currently being developed which will detail measures to be considered in pursuit of achieving the annual average nitrogen dioxide objective.

8.0 Quality Assurance/Quality Control

QA/QC procedures for Edinburgh's monitoring regime were in accordance with the government guidance document LAQM.TG1 (00).

Automatic analysers real – time

The monitoring station located in Princes Street Gardens is part of the Automated Urban and Rural Network, (AURN). All AURN sites are subject to an independent audit and stringent QA/QC procedures which are undertaken by Casella Stanger and A.E.A Technology on behalf of DEFRA.

Site details and type of equipment used for the remaining four automated analysers located within the AQMA are shown in table 8.1

Table 8.1 Site location and type of automated monitoring equipment used.

Site	**NO_x analyser Model**	**Software**	**Supplier**	**Site Description**
Castle St / Queen St	ML 9841B Rollalong	Enview Data collected daily via modem	E.M.C	Urban roadside, location which has the highest volume of traffic within the AQMA.Residential property is in the vicinity. In line with building façade.
Haymarket Terrace	ML 9841B Rollalong	Enview Data collected daily via modem	E.M.C	Urban roadside.Located in a railway station car park adjacent to kerb.There are tenement buildings on the opposite side of road, with a high number of dwelling houses.Building façades 2.5m from kerb
Leith Walk	ET M200A Mobile trailer	Enview Data collected daily via modem	E.T	Urban roadside. Located in parking bay - in line with building facades of residential tenement blocks
Gorgie Road (White Park)	Model 42 Housing Police Box	ESC E-Das Ambient Data downloaded weekly via lab top	Thermo Onix	Urban roadside. Located at the pavement within children's play area. Adjacent buildings are all residential tenement blocks which are 2.5 metres from the kerb.

Calibration procedures

Two officers are trained to local site operator level in relation to the AURN site and undertake the necessary calibrations and basic maintenance at all automated sites.

The two ML 9841 B NO_x analysers perform an autocalibration each day with zero air and NO gas. Warning limits are set at +/- 5 % on the software program, the chemiluminesence detector model 42 and ETM200A perform an autocalibration for NO_2 using permeation tubes and a zero air check using an automatic zero air generator.

All sites are visited weekly, apart from the AURN site, (which is visited fortnightly) and manual calibration checks are carried out using certified NO gas at approximately 500pbb plus a zero check. All cylinders are replaced at 12 - 18 month intervals.

Servicing

All instruments are serviced and recalibrated every six months by the appropriate supplier The service contracts include a support package for software and replacement parts, plus any necessary call outs to the sites.

Data processing

All data, including calibration data is scrutinised on a daily basis (Monday to Friday), apart from the NO_x Model 42 which is checked weekly. However, to ensure that any drift on the Model 42 is minimised, the site is visited twice per week to check the two point autocalibration data. Should a problem be identified, then a further manual calibration with NO gas is undertaken, as it is recognised that autocalibration using permeation tubes are not as reliable as using a certified gas cylinder. All power failures, instrument breakdowns, and activities adjacent to the site are recorded. Any data which is considered to be erroneous is deleted.

Passive Diffusion tubes

Passive diffusion tubes were supplied and analysed by Analytical and Scientific Services, City of Edinburgh Council. The laboratory is UKAS accredited for this task and participates in the Workshop Analysis Scheme for Proficiency (WASP) inter laboratory QC/QA.The laboratories performance was considered to be satisfactory over the monitoring periods 1999, 2000 and 2001.

The laboratory uses 50% v/v Triethanolanine (TEA) in acetone for the adsorbent; the grids are dipped into this solution and allowed to dry before insertion into the tube. The method has remained unchanged during the monitoring periods. Acrylic diffusion tubes were used for the exposure periods.

NO_2 diffusion tube monitoring has been conducted in accordance with the quality requirements contained in the UK NO_2 Survey Instruction Manual for local/unitary authorities and government guidance document LAQM.TG1 (00). All diffusion tubes are located within 1 metre of the edge of the kerb, attached to sign posts/lampposts, at a height of 2.0m above ground level. All exposure times and dates are recorded and retained as paper documents. Copies of which are sent with the exposed diffusion tubes to the laboratory.
Three unexposed diffusion tubes (blanks) are also submitted with each batch of exposed tubes to check that contamination did not occur during tube preparation.

Details of calibration checks, data capture, precision and accuracy of instruments are available on request either in electronic or paper format.

APPENDIX 1 (a)

Current Objectives as detailed in The Air Quality (Scotland) Regulations 2000

Pollutant	Concentration	Measured as	Date to be achieved by
Benzene	16.25 μgm^{-3}	Running annual mean	31 December 2003
1,3 Butadiene	2.25 μgm^{-3}	Running annual	31 December 2003
Carbon Monoxide	11.6 mgm^{-3}	Running 8- hour mean	31 December 2003
Lead	0.5 μgm^{-3}	Annual mean	31 December 2004
	0.25 μgm^{-3}	Annual mean	31 December 2008
Nitrogen Dioxide [1]	200 μgm^{-3} not to be exceeded more than 18 times a year	1- hour mean	31 December 2005
	40 μgm^{-3}	Annual mean	31 December 2005
Particles(PM10) [2]	50 μgm^{-3} not to be exceeded more than 35 times a year	24- hour mean	31 December 2004
	40 μgm^{-3}	Annual mean	31 December 2004
Sulphur Dioxide	350 μgm^{-3} not to be exceeded more than 24 times a year	1- hour mean	31 December 2004
	125 μgm^{-3} not to be exceeded more than 3 times a year	24- hour mean	31 December 2004
	266 μgm^{-3} not to be exceed more than 35 times a year	15- minute mean	31 December 2004

Note changes to standards SE

1 The objectives for nitrogen dioxide are provisional

2 The Scottish Executive sees this new objective for particles as a staging post, not a final outcome. Work has begun on assessing the proposals for strengthening the new objective and the SE expects to make an announcement by the end of 2000.

APPENDIX 1 (b)

Correction Factors for the over-read of Passive Diffusion Tubes compared with real – time measurements

Co-Located NO_2 Analyser compared with PDT values ($\mu g/m^3$)

Correction factors for 1999 data

12 months of data

Site	Analyser	Pdt 1	Pdt 2	Mean Pdt	%Pdt variation
Queen Street /Castle St	40.3	53.2	53.4	53.3	32.2
Cowgate	30.6	39.1	39.1	39.1	27.7
Gorgie Road	41.8	46.6	47.7	47.1	12.7
Haymarket Terrace	37.6	43.7	42.8	43.3	15.1
AURN Princes Street	43.2	42.7	42.1	42.4	-1.9

Mean % Pdt variation all sites = **17.2 %**
Mean % Pdt variation excluding AURN **= 21.9 %**

The correction factor 17.2 % was used upon advice from the Scottish Executive and the University of West England

Correction factors for 2000 data

12 months of data

Site	Analyser	Pdt 1	Pdt 2	Pdt 3	Mean Pdt	%Pdt variation
Queen Street /Castle St	37.8	48.7	50.7	-	49.7	31.6
Gorgie Road	37.8	49.4	45.5	-	47.4	25.5
Haymarket Terrace	37.1	45.0	44.8	-	44.9	21.0
AURN Princes Street	44.6	50.1	47.6	50.3	49.3	10.5

Mean % Pdt variation all sites **= 22.15 %**

Correction factors for 2001 data

11 months of data only (Comparison dates 03/01/01 to 4/12/01)

Site	Analyser	Pdt 1	Pdt 2	Pdt 3	Mean Pdt	% Pdt variation
Queen Street/Castle St	38.2	42.0	42.4	-	42.2	10.5
Leith Walk	34.7	38.7	39.4	-	39.1	12.7
Haymarket Terrace	40.5	43.6	42.8	-	43.2	6.7
AURN Princes Street *	42.1	43.9	41.7	47.5	44.3	5.4

*** Data sets require to be ratified**

Mean % variation all sites = 8.9 %

Mean % variation excluding AURN site = 9.9 %

Note 9.9% was the correction factor used due to the AURN site's data still requiring ratification

APPENDIX 1 (c)

Building façade to sampling point correction factors and the raw (uncorrected) annual average nitrogen dioxide data for 1999, 2000 and 2001

SITE	1999	2000	2001**	Kerb to façade correction factor
West Maitland St/Palmerston Pl jnct	82	95	89.3	x 0.90
West Maitland St	-	76*	69.3	x 0.95
Roseburn Terrace /St jnct	78	81	67.1	x 0.95
Roseburn Terrace	-	53*	50.4	x 0.95
North Bridge 1	76	74	61.4	x 0.95
North Bridge 2	-	66*	63.8	x 0.95
Princes St	76	87	84.7	x 0.75
Gorgie Rd /Ardmillan jnct	59	60	72.0	x 0.90
Ardmillan Terrace/Gorgie	-	-	49.3	x 0.90
Leith Walk /McDonald Rd jnct	61	60	53.0	x 0.90
Leith Walk	-	-	41.2	x 0.90
Queen Street	67	65	53.5	x 0.90
York Place	52	52	46.9	x 0.90

*** Site started July 2000**

**** 11 months of data**

APPENDIX 2: ESTIMATED NO_x CALCULATIONS FROM MEASURED NO_2 DATA

Example of calculation to determine level of improvement required in NO_X derived from traffic to achieve the annual objective for NO_2 (West Maitland Street Junction)

Using the following formula for kerbside measurements the equivalent NO_X values were modelled for all the corrected passive diffusion tube measurements

$x = 3.3931y^{0.5275}$ where $x = NO_2$ and $y = NO_X$

NO_2 $\mu g/m^3$		**NO_X $\mu g/m^3$ equivalent**	
65	**measured**	**269**	**modelled**
40	**target**	**107**	**target**
25	**difference**	**162**	**difference**

Percentage of NO_X reduction needed of total NO_X

$$= 1 - \frac{(269 - 162)}{269}$$

= 61%

Traffic contributes to **88 %** of total NO_X

= 0.88 x 269 = 237 $\mu g/m^3$

Percentage reduction of NO_X related to road traffic needed

Require a **162 $\mu g/m^3$** reduction in NO_X

Traffic contribution requires to reduced by

237 $\mu g/m^3$ – 162 $\mu g/m^3$ = 75 $\mu g/m^3$ NO_X

$$\text{\% Reduction in } NO_X = \frac{237 - 75}{237} \times 100 = 68\ \%$$

APPENDIX 3: FLEET APPORTIONMENT CALCULATIONS

Example: Leith Walk Oct - Nov 2001

Class Size*	Type of vehicle	% of total traffic counted at junction	% petrol **	% diesel **	% of total by fuel type	Urban fleet weighted emission factors (2001)***	Relative NOx contributed	% NOx contribution
0-300 cm	Petrol Cars	5.30	86		4.56	0.56	2.55	1.51
0-300 cm	Diesel Cars	5.30		13	0.69	0.37	0.25	0.15
300-450 cm	Petrol Cars	61.07	86		52.52	0.56	29.41	17.41
300-450 cm	Diesel Cars	61.07		13	7.94	0.37	2.94	1.74
450-600 cm	LGV	21.26	21		4.46	0.97	4.33	2.56
450-600 cm	LGV	21.26		78	16.58	0.62	10.28	6.08
600-900 cm	Rigid HGV	4.16		100	4.16	5.9	24.54	14.53
900-9999 cm	Bus	8.19		100	8.19	11.56	94.66	56.02
					99.10	**Total**	168.97	

* Vehicle classes sizes as counted by traffic counting equipment - Oct to Nov 2001
** % of diesel or petrol calculated from Transport Statistics Great Britain: 2001 Edition

*** Emissions factors from The UK emissions factors data base - NETCEN website
these are based on:
20% diesel car sales with Euro III reductions into effect in 2001/2002 for all vehicles;
for cars & LGVs only with new fuel standards reducing emissions from pre 2000 cars in effect in 2000;
further reductions in 2005.
5% catalyst failure rate.
Original Source of Data: TRL 1998 and COPERT II for emission factors. Vehicle Licensing Data 1997. NETCEN road
Insufficient data available for disaggregating emission factors for petrol vehicles by road type or speed

Type of vehicle	**Assumed class sizes**	**Proportion of vehicle class within total fleet**	**% NOx contribution**
Petrol Cars	0-300 cm, 300-450 cm	57.08	18.92
Diesel Cars	0-300 cm, 300-450 cm	8.63	1.89
Petrol LGV	450-600 cm,	4.46	2.56
Diesel LGV	450-600 cm,	16.58	6.08
Rigid HGV	600 - 900 cm	4.16	14.53
Bus	900 - 9999 cm	8.19	56.02
		99.10	100.00

Calculation:

1. Percentage of vehicles registered in class size 0-300 cm from traffic counts = 5.3%
2. Percentage of this group of vehicles which are petrol = 86%
3. Total % of fleet which is petrol within these size group: 5.3 * 86% = 5
4. Weighted emission factor for petrol cars = 0.56
5. Relative NOx contributions of petrol cars: 0.56 * 4.56 = 2.55
6. Total relative fleet contributions of NOx = 168.97
7. Percentage contributions of petrol cars (0-300): (2.55/168.97)*100 = 1.51
8. Total petrol car contribution = petrol cars 0-300 + petrol cars 300-450 = 1.51 + 17.41 = 19%

APPENDIX 4a : SUMMARY OF TRAFFIC DATA COUNTS

Summary of traffic data expressed as a 24 hour average for the following collection periods

Location	Collection Period
Leith Walk	12/10/2001 to 08/11/2001
Gorgie Road	04/09/2001 to 11/10/2001 and 23/10/2001 to 22/11/2001
Queen Street	07/10/2001 to 14/12/2001
Haymarket	11/10/2001 to 31/10/2001
West Maitland St	12/09/2001 to 18/10/2001 and 24/10/2001 to 04/12/2001

Vehicle band width cm	Leith Walk	Gorgie Road	Queen Street	Haymarket Terrace	West Maitland St
0 - 300	1,384	610	3,163	2,409	1,864
300 - 450	15,935	12,001	27,556	12,750	11,620
450 - 600	5,548	3,361	5.920	7,268	5,654
600 - 900	1,086	823	717*	1,188	907
900 - 9999	2,138	1,440		2,953	2,285
Total	**26,091**	**18,235**	**37,356**	**26,568**	**22,330**

Note * Counters installed at the Queen Street location were unable to differentiate between 600 – 900 and 900 – 9999 band width settings and therefore the traffic data relates to an overall band width of 600 to 9999. For a consistant approach in the fleet apportionment calculations and based on the manual verification of traffic counts it was assumed that the split in the vehicle class group was 1:1

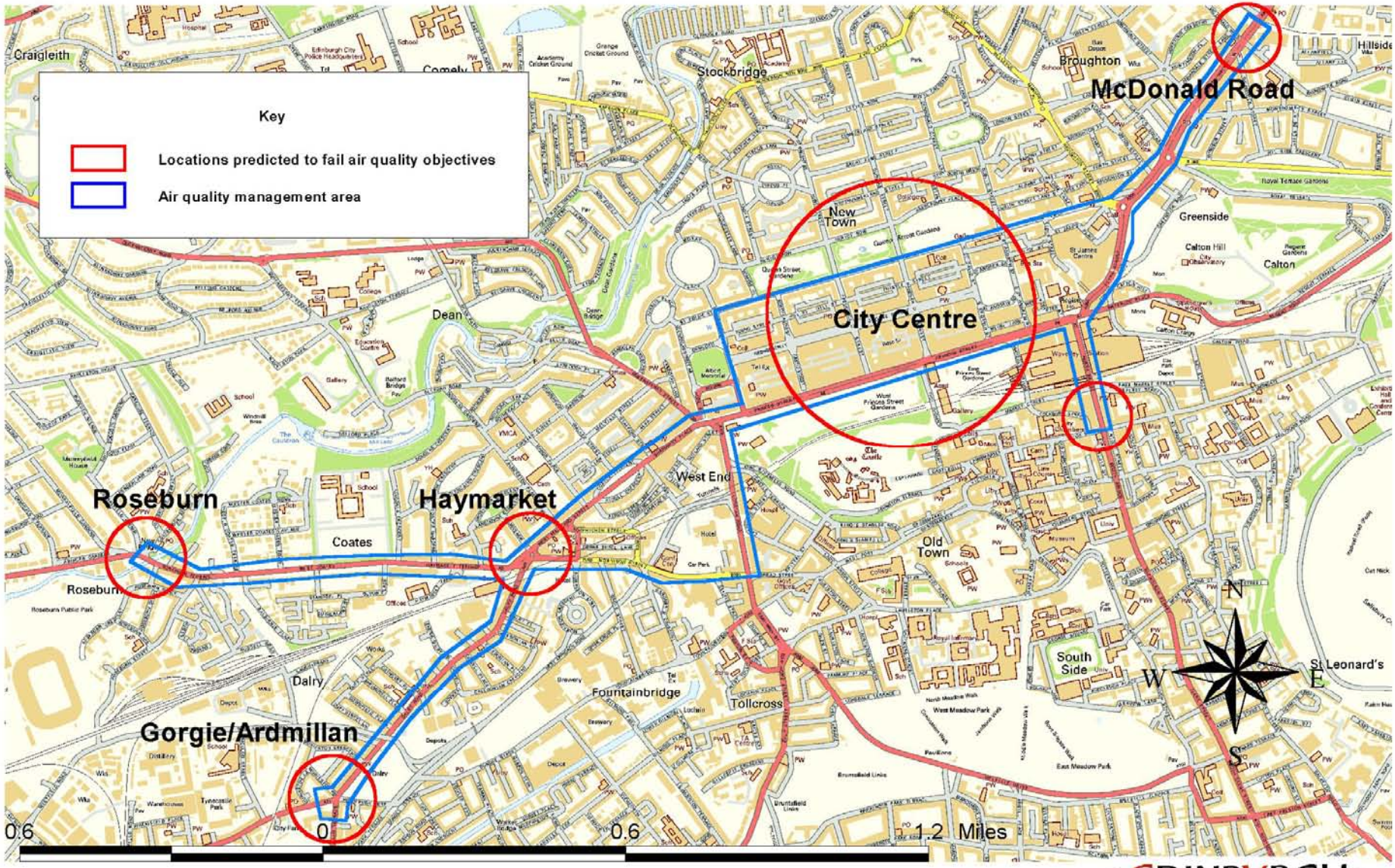
APPENDIX 4b: MANUAL TRAFFIC COUNT VERIFICATION

The counts are represented as a precentage of total counts for each of the three main fleet groups detailed in the table below.

	Cars, taxis, LGV's			**Rigid HGV's**			**Buses**		
	Man	**Aut**	**Aut***	**Man**	**Aut**	**Aut***	**Man**	**Aut**	**Aut***
Gorgie	89	88	86	3	5	5	7	7	8
Leith Walk	85	69	87	4	16	4	10	15	10
Haymarket	89	84	83	3	5	4	8	11	11
West Maitland St	87	84	85	4	5	4	9	10	10
Queen St	97	97	97	2	2	2	1	1	1

Automatic counts (Aut)
Manual (Man) counts were carried out from 07.00hrs to 19.00hrs
Comparison of manual and automatic counts were over the same time period and on the same day
Aut* represents automatic counts over the longer time period as specified in appendix 4a.

MAP 1.1: AIR QUALITY MANAGEMENT AREA



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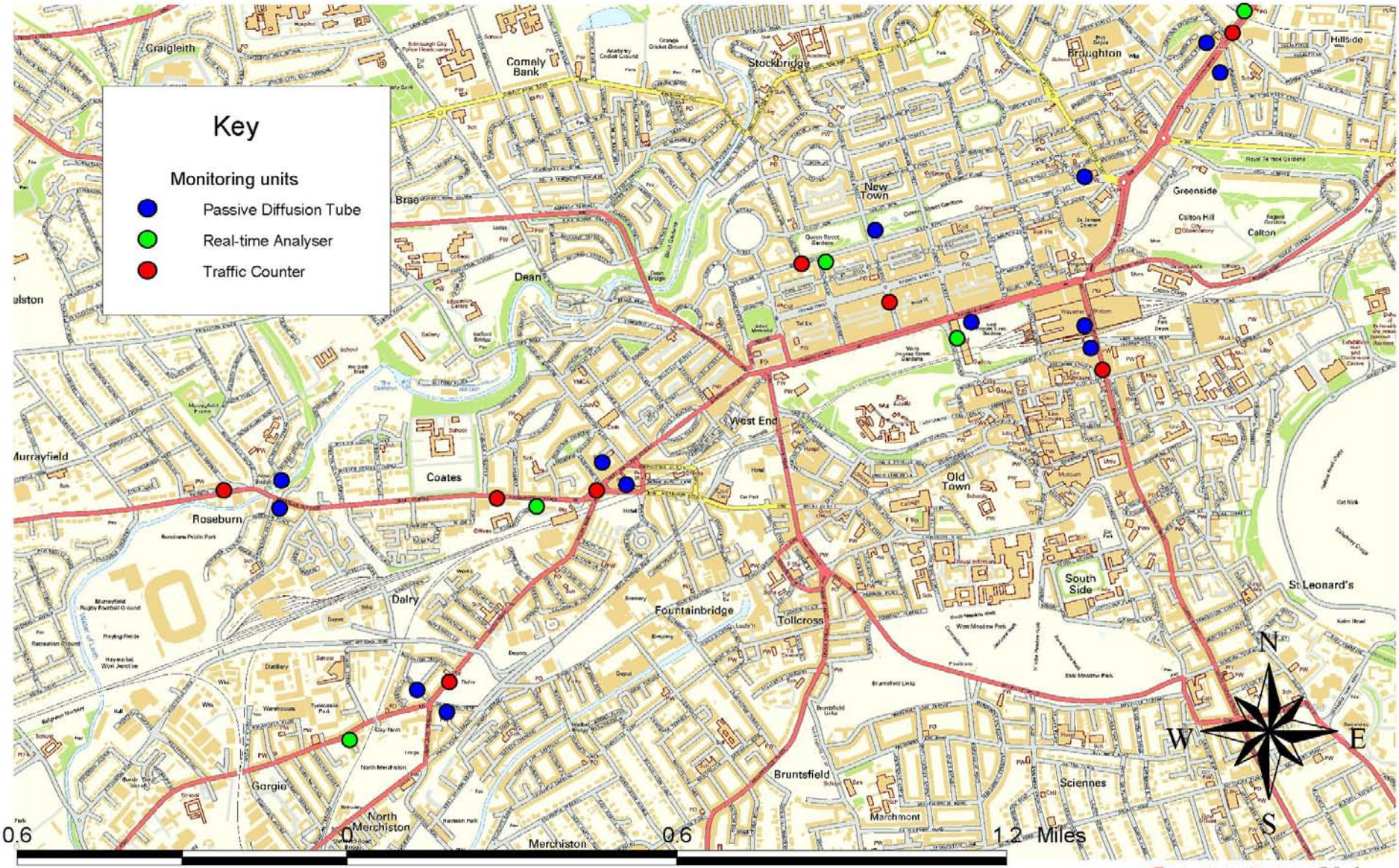
MAP 2.1: MONITORING UNITS IN CITY CENTRE



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