Glasgow City Council

Local Air Quality Management

Progress Report

October 2005

List of Tables **Page No.**

List of Figures **Page No.**

Executive Summary

Progress Reports have been introduced into the Review and Assessment process to ensure continuity in the implementation of Local Air Quality Management. The main objective is to provide an annual review and update on air quality issues by reporting progress on implementing Local Air Quality Management in the local authority's area and progress in achieving, or maintaining concentrations below the air quality objectives.

This report provides a summary of all available monitoring data for the purpose of comparison with the relevant air quality objectives and details results for new monitoring sites, as well as highlighting any evidence of trends over recent years. In addition, progresses on measures that have been undertaken as part of the Air Quality Action Plan are summarised.

Industrial

There are a small number of industrial processes in Glasgow that have the potential to emit significant quantities of pollutants, but it is believed that no new industrial processes have commenced operation or have changed significantly since the last round of Review & Assessment.

Glasgow City Council proposes to introduce a monitoring programme to assess ambient concentrations of PM_{10} at relevant locations in the vicinity of specific industrial processes. The results from this monitoring programme and air-dispersion modelling from each location will be presented in future review and assessment documents.

Commercial/Residential

New Residential, Commercial and Public Developments that are considered in the report to warrant further assessment include:

- Queen's Dock 2 (QD2) Development (Scottish Exhibition and Conference Centre site)
- Pacific Quay, which is a 60 acre site on the south side of Glasgow and is already home to Glasgow Science Centre, an IMAX cinema and the city's innovative Glasgow Tower. As part of the Clyde Waterfront regeneration plan, it will be turned into a "digital media campus" and business park. Construction began on-site in 2004, the area will accommodate the new headquarters for BBC Scotland, the Scottish Media Group and Film City Glasgow.
- Glasgow Harbour is the name given to the redevelopment of 49 hectares of former ship yards, docks, warehouses and granaries fronting the River Clyde and the River Kelvin south of Clydeside Expressway, between the SECC and the Clyde Tunnel.

Transportation

New transportation developments that are considered in the report to warrant further assessment include:

- Finnieston Road Bridge.
- East End regeneration route
- M74 extension

These issues will require to be assessed in more detail by Glasgow City Council and careful consideration will be given to the air quality in the areas which are being or are due to be developed. All relevant information will be reported in more detail in the next full round of review and assessment.

1.0 BACKGROUND INFORMATION

1.1 Purpose and Role of the Progress Report

Progress Reports have been introduced into the Review and Assessment process to ensure continuity in the Local Air Quality Management (LAQM) process. It will allow air quality monitoring data and local development changes that may impact on air quality to be assessed on a regular basis and provide an early indication of whether measures are required to improve air quality.

The main objective is to provide an annual review and update on air quality issues by reporting progress on implementing Local Air Quality Management in the local authority's area and progress in achieving, or maintaining, concentrations below the air quality objectives.

The report will provide a summary of all available monitoring data for the purpose of comparison with the relevant air quality objectives (AQOs), detailing results for new monitoring sites and highlighting any evidence of trends over recent years. Data has also been collated for any local development changes that may affect air quality e.g. industry, traffic management schemes, developments granted (or applying for) planning permission and will provide an update for any existing developments where further information has become available. In addition, progress on any measures undertaken as part of the Air Quality Action Plan will be summarised and an update on any planning policies and Local Transport Plan (LTP) measures that may affect air quality will be reported.

1.2 Air Quality Strategy Objectives and Relevant Public Exposure

The National Air Quality Strategy, published in 1997, set target concentrations for 8 air pollutants: Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Particulate matter (PM_{10}), Carbon monoxide (CO), Benzene, 1,3-Butadiene, Lead (Pb) and Ozone (O_3). All of the listed pollutants are known to affect human health at sufficiently high concentrations and thus the aim of the publication is for pollutant concentrations to meet the objectives set for 2005 and 2010 (See Table 1.1). The Environment Act and subsequent legislation provided local authorities with new responsibilities to assess and manage air quality in their respective areas of jurisdiction. Following the latest evidence of the impacts of these pollutants on human health, the objectives for a number of these have been revised, with tighter objectives being introduced including separate objectives for Scotland.

The time period for each of the standards varies according to the pollutant. This is done in order to reflect the health effect of each pollutant. For example, a sufficiently high concentration of SO_2 could potentially impact on a person's health within a short time period (minutes). For benzene, however, the time required for the pollutant to be detrimental to health would be much longer (years). Therefore, the respective objectives are of appropriate periods of exposure to represent this.

In terms of public exposure, LAQM.TG(03) states that:

'the quality of the air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present. Reviews and assessments should thus be focussed on those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Authorities should not consider exceedences of the objectives at any location where relevant public exposure would not be realistic'.

Table 1.1 Examples of locations where the Air Quality Objectives (AQOs) should apply in terms of the set averaging period

Averaging Period	**Objectives should apply at:**
Annual mean **NO_2 and PM_{10}**	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, libraries etc.
24-hour mean **PM_{10} and SO_2**	All locations where the annual mean objective would apply. Gardens of residential properties.
1-hour mean **NO_2 and SO_2**	All locations where the annual mean and 24-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend 1-hour or more. Any outdoor locations to which the public might reasonably expected to spend 1-hour or longer.
15-min mean **SO_2**	All locations where members of the public might reasonably be exposed for a period of 15-minutes or longer.

Review and assessments should be focussed on those locations where members of public are likely to be regularly present and are likely to be exposed over the averaging period of the objective.

The air quality objectives set by the Air Quality Regulations are shown in Table 1.2 below. These objectives are to be achieved between 2003 and 2010.

Table 1.2 – The National Air Quality Strategy Objectives for the seven key pollutants in Scotland

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	3.25 µg m^{-3}	Running annual mean	31.12.2010
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	31.12.2003
Carbon Monoxide (CO)	10 mg m^{-3}	Running 8 h mean	31.12.2003
Lead (Pb)	0.5 µg m^{-3} 0.25 µg m^{-3}	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen Dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times per year 40 µgm-3	1 h mean Annual mean	31.12.2005 31.12.2005
Particulate Matter (PM_{10})	50 µg m^{-3} not to be exceeded more than 35 times per year 40 µg m^{-3} 50 µg m^{-3} not to be exceeded more than 7 times per year 18 µg m^{-3}	24 h mean Annual mean 24 h mean Annual mean	31.12.2004 31.12.2004 31.12.2010 31.12.2010
Sulphur dioxide (SO_2)	266 µg m^{-3} not to be exceeded more than 35 times per year 350 µg m^{-3} not to be exceeded more than 24 times per year 125 µg m^{-3} not to be exceeded more than 3 times per year	15 minute mean 1 h mean 24 h mean	31.12.2005 31.12.2004 31.12.2004

1.3 Sources of Air Pollution (Glasgow)

Air pollution is now a major environmental and public health concern and in urbanised areas in particular, where the level of emissions from industrial sources and road transport can create 'hot-spots' of poor air quality. As detailed above, the Government has set target concentrations for eight air pollutants to be met by the end of 2005. Local Authorities must undertake a review of seven of the key air pollutants in their area and assess whether the target levels set will be achieved by the specified objective date. Ozone is to be dealt with at a national level due to its transboundary nature.

Table 1.3 - Main air pollutants of concern

Pollutant	**Sources**
Particulates (PM_{10})	Fuel combustion for domestic heating, power stations, industrial boilers, transport (mainly diesel), waste incineration, road dust, pollen, mineral extraction, sea salt.
Carbon monoxide (CO)	Motor vehicles and combustion processes
Oxides of Nitrogen (NOx) • Nitric oxide (NO) • Nitrogen Dioxide (NO_2)	Transport (road, rail), fuel combustion (domestic heating), power stations, industrial boilers and chemical processes, waste incinerators.
Sulphur dioxide (SO_2)	Fuel combustion for domestic heating, power stations, industrial boilers and chemical processes, waste incinerators, diesel vehicles.
Lead (Pb)	Additive to petrol which makes the engine run smoother.
Volatile organic compounds (VOCs) VOCs include a large number of different compounds, two important ones are: Benzene & 1,3-Butadiene	Transport, oil based fuel combustion sources, chemical processes, paints and solvents, waste incinerators. Petrol combustion products, evaporation from petrol pumps and fuel tanks Petrol combustion products, fuel combustion for domestic heating
Ozone (O_3)	Pollutant generated from a chemical reaction involving strong sunlight and oxides of nitrogen and volatile compounds

Air Pollution is generated from a number of different every day activities, such as road traffic, domestic and commercial heating and industrial processes. Existing data shows that in Glasgow, traffic is the main source of emissions for the majority of the pollutants detailed in this report (*Glasgow City Council's Updating and Screening Assessment - 2003*). For example, road transport was found to account for 75%

of all NO_2 emissions, 51% of fine particulate matter, 86% of CO, 66% of Benzene, 95% of 1,3-butadiene, 21% of SO_2 and 8% of all Lead emissions.

1.4 Summary of Review and Assessment

This report has been prepared to fulfil Glasgow City Council's obligations under the Environment Act 1995 Part IV to regularly review and assess local air quality against the objectives set in Air Quality Regulations. These reviews are intended to compare current and future concentrations of air pollutants with the standards and objectives outlined in the National Air Quality Strategy (NAQS) and Air Quality (Scotland) Regulations 2002, as amended. The NAQS provides a framework for air quality control through local air quality management. In areas where objectives are not likely be met by the required date, Local Authorities are required to establish Air Quality Management Areas (AQMAs) and to produce an Air Quality Action Plan in order to improve air quality.

The first round of review and assessment took a three-stage approach, which assessed the sources of seven air pollutants of concern to health: nitrogen dioxide, particulate matter (PM_{10}), sulphur dioxide, carbon monoxide, lead, benzene and 1,3-butadiene. The Stage I report was completed in 1999, which highlighted a requirement for further investigation for carbon monoxide. The Stage II assessment, detailing both CO and sulphur dioxide, suggested that these pollutants would meet the objectives in 2003 and 2005 and thus would not require further assessment. In 2001 NO_2 and PM_{10} were identified as the key pollutants of concern for Glasgow and consequently, a Detailed Assessment (DA) was undertaken. Through the interpretation of monitoring data and advanced dispersion modelling, PM_{10} concentrations were found to comply with the objectives whereas the concentration of NO_2 was predicted to exceed the annual and 1-hour NO_2 objectives at certain locations within Glasgow. Thus, further assessment was required in the form of a Stage III report. Subsequently, Glasgow City Council declared the entire city centre an AQMA for NO_2 in 2002 and produced an Air Quality Action Plan in 2004.

Local Authorities are currently undertaking the second round of Review and Assessments. This is undertaken in two stages; initially an Updating and Screening Assessment (U&SA) is carried out for all pollutants identified in the Air Quality Regulations. If a significant risk of exceeding one or more of the air quality objectives is identified the Local Authority will be required to produce a Detailed Assessment on the pollutants of concern. The U&SA report illustrated that exceedences of the NAQS objectives were predicted for NO_2, PM_{10} and SO_2 and therefore a Detailed Assessment was carried out for these pollutants. The aim of the Detailed Assessment should be to identify with reasonable certainty whether or not a likely exceedence of standards set within the National Air Quality Strategy will occur at the locations identified in the Updating and Screening Assessment.

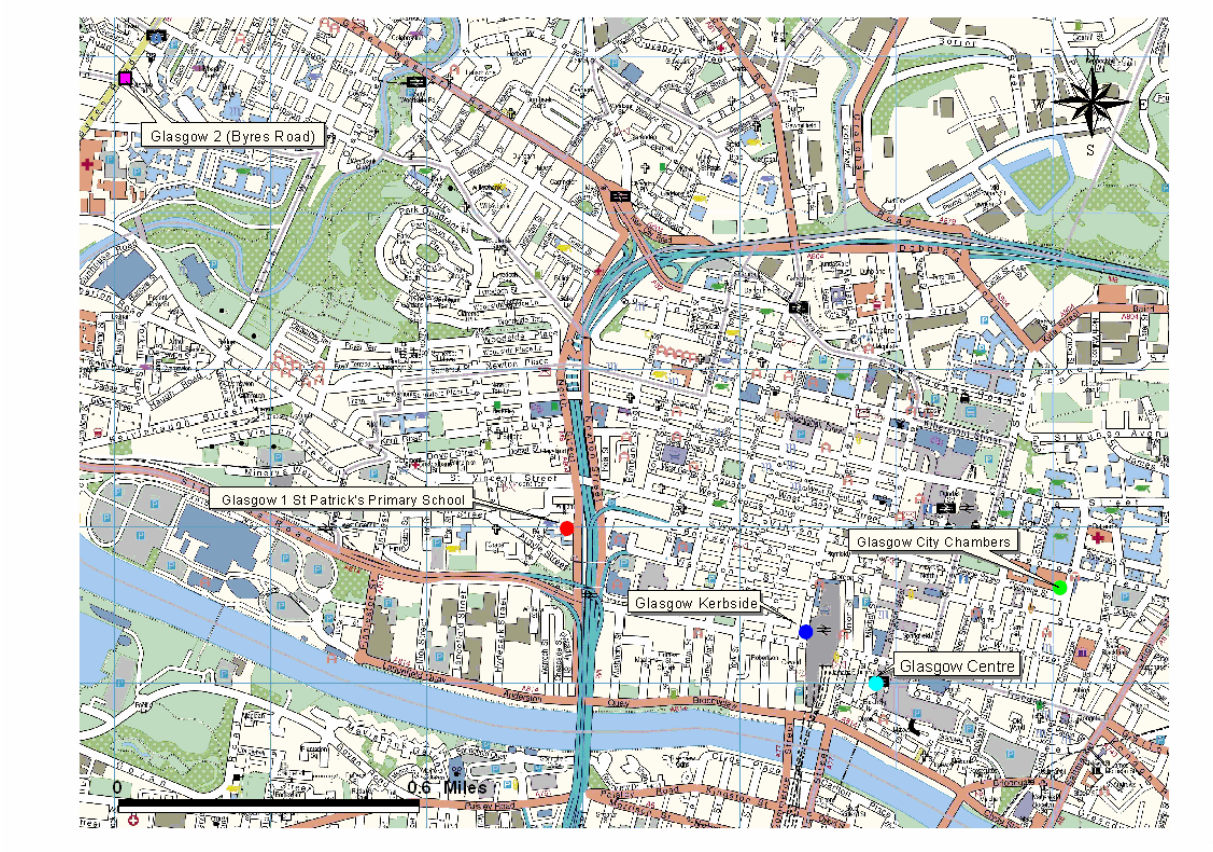
Glasgow City Council completed a Detailed Assessment in early 2005 which highlighted five additional locations that will require to be declared as Air Quality Management Areas for NO_2. It also concluded that there are sites within and out-with the current AQMA i.e. the city centre, which are predicted to exceed the 2010 annual mean air quality objective for particulates. However, the modelled results can only be classed as provisional due to a lack of monitored data. Therefore, the data requires to be verified through monitoring before the areas of exceedence can be declared as AQMA's. The Detailed Assessment (2005) highlights, through automatic monitoring and air dispersion modelling, that data from the 8-port SO_2 bubbler and automatic analyser (Glasgow Centre collocation study) differ significantly and suggests that SO_2 bubblers over-estimate ambient concentrations of SO_2. Therefore, it is believed that Glasgow will meet the AQOs for SO_2 and that no further action is required for this pollutant at the present time.

If it is not necessary to produce a Detailed Assessment then an annual Air Quality Progress Report is required instead. The Progress report has been prepared in accordance with the Government's published Progress Report Guidance (LAQM.PRG (03)).

2.0 SUMMARY OF MONITORING

Glasgow City Council monitors for a number of different pollutant species at a variety of locations across the city. This includes six automatic monitoring stations, three of which are part of the national Automatic Urban and Rural Network (AURN) run by the Scottish Executive and the Department for the Environment, Food and Rural Affairs (DEFRA). The remaining three automatic stations are independently operated by Glasgow City Council and are located in three mobile air quality units.

Figure 2.1 – Locations of all automatic monitoring sites, except Glasgow 3 (Waulkmillglen reservoir)



2.0.1 Automatic Monitoring Sites

Automatic analysers produce high resolution measurements at a single point. They utilise a different analytical technique dependent on the pollutant that is to be measured. For example, IR and UV absorption is used to determine the concentrations of CO and ozone respectively. PM_{10} concentrations are calculated by various filtration techniques and gas chromatography analysers can provide high resolution data on benzene, 1,3-butadiene and other speciated hydrocarbons.

Glasgow City Chambers (AURN)

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 urban background. This site forms part of Glasgow City Council's smoke, SO_2 and metal monitoring network in addition to automatic NOx and CO analysers that are currently in operation.

Glasgow Centre (AURN)

The unit at St Enoch Square is located in an open, pedestrianised area in the centre of Glasgow (258943 665027). It is approximately 20m from Argyle Street, which has a traffic flow of 20,000 vehicles per day (vpd) and is thus classified as an urban centre site. The site monitors concentrations of NOx, SO_2, CO, O_3, PM_{10} and $PM_{2.5}$.

Glasgow Kerbside (AURN)

This site is located at the southern end of Hope Street with close proximity to the corner of Argyle Street (2586969 665166). This location forms a street canyon and traffic flow is in excess of 25, 000 vpd. It is a kerbside site as its inlet less than 1m from the road. Monitoring at this site includes NOx, CO, PM_{10} and VOCs.

Glasgow 1 (Groundhog)

The 'Groundhog' has monitored pollutant concentrations at a variety of locations across the city since it was introduced in 1999. Its current location, since 2001, is at St Patrick's School in Anderston (257925 665487). It is approximately 50m from the M8 motorway and monitors for NOx, CO, SO_2 and PM_{10}.

Glasgow 2 (Rollalong)

Since April 2004 the 'Rollalong' unit has been located on the corner of University Avenue and Byres Road (256553 665487) which is a busy junction. It monitors concentrations of NOx, CO and PM_{10}.

Glasgow 3 (Background)

This mobile unit went into operation at Waulkmillglen reservoir (252520 658095), just outside the south-east boundary of the city in 2002. It is located several hundred metres from major roads and monitors background concentrations of NOx, CO, O_3 and PM_{10}.

2.0.2 Non-Automatic Monitoring Sites

In addition to both AURN and Glasgow City Council's real-time analysers, a number of other monitoring networks are in place:

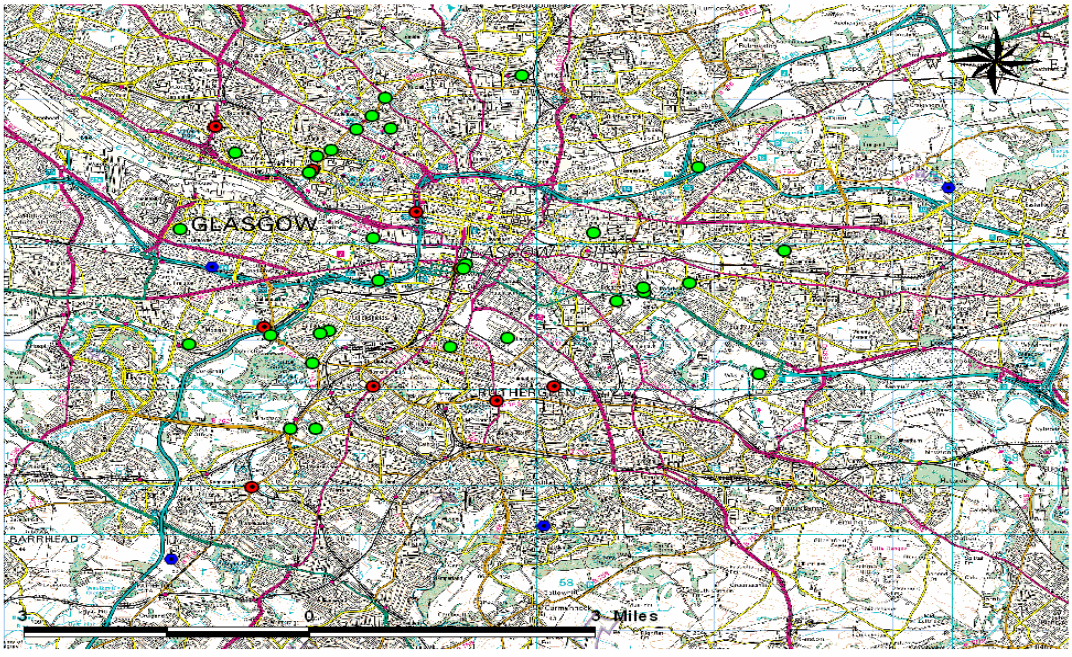
- NO_2 (diffusion tubes)
- Smoke and SO_2 (8-port bubblers)
- Heavy Metals e.g. Lead, Chromium, Arsenic, etc
- Benzene (diffusion tubes)

Nitrogen dioxide

Diffusion tubes are a simple and inexpensive technique of screening air quality to give a general indication of average pollution concentrations over a period of weeks or months. The large number of sampling points used can highlight 'hotspots' of poor air quality. For example, near major roads or industrial processes.

Glasgow City Council operates an extensive NO_2 diffusion tube network. This consists of more than one hundred diffusion tubes which are distributed throughout the city. The majority of these tubes are located within the AQMA (Glasgow city centre), which was declared in 2002 for NO_2.

Figure 2.2 NO_2 diffusion tubes located out with Glasgow's AQMA



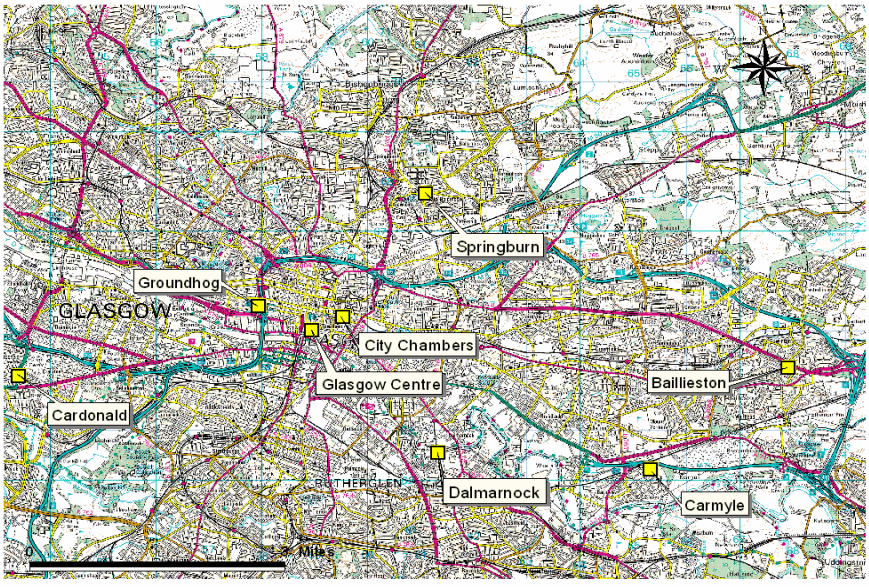
Smoke and Sulphur dioxide

Glasgow City Council's Air Quality Control (or Local Air Quality Management) has been functioning since the 1950's. Due to the extreme pollution episodes (smog) that affected Glasgow, which were a result of the widespread burning of coal in the early-mid 1900's, it previously operated a large network of smoke and SO_2 stations. Although these monitoring techniques are still utilised today, the number of smoke and SO_2 sites have declined with the introduction of automatic analysers delivering real-time data. These are accurate to a much higher degree and have more value in determining the principal air quality trends and short-term pollution episodes. However, 8-port SO_2 bubblers are still utilised in six locations across the city. The bubbler and SO_2 automatic analyser locations are shown below in Table 2.1 and Figure 2.3.

Table 2.1 Glasgow's SO_2 Monitoring Locations

Site Name	Grid Reference
Baillieston	267893 664289
Carmyle	265314 662223
Dalmarnock	261272 662497
Springburn	261085 667754 (discontinued in July 2005)
Glasgow City Chambers	259527 665297
Cardonald	253419 664092
Groundhog	257925 665487
Glasgow Centre	258943 665027 (discontinued in August 2005)

Figure 2.3 Glasgow's SO_2 Monitoring Locations



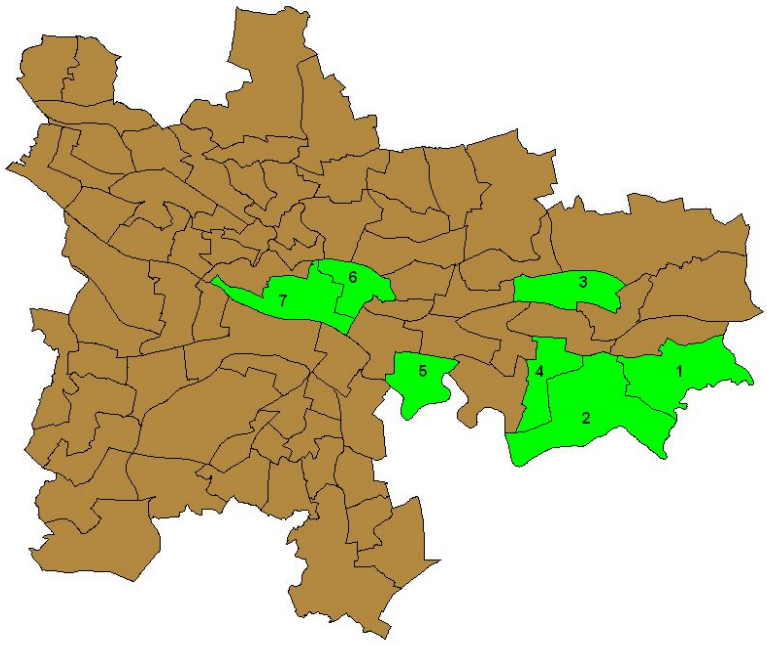
Atmospheric Lead

Monitoring of the concentration of atmospheric lead has been carried out in Glasgow since 1997 at a variety of locations. A number of heavy metals are monitored in addition to atmospheric Lead, namely: Chromium, Cadmium, Arsenic, Vanadium, Zinc, Aluminium, Copper, Iron and Nickel.

Name of Monitoring Site	Grid-reference	Status
1. Baillieston	2679 6642	
2. Carmyle	2653 6622	
3. Fastnet Street, Queenslie	2645 6659	
4. Shettleston	2632 6644	discontinued in 2002
5. Dalmarnock	2612 6627	
5. St Anne's Primary School*	2613 6644	
6. Glasgow City Chambers (Montrose Street)	2595 6653	
6. Glasgow Cross	2597 6649	
7. Charing Cross	2584 6666	discontinued in 2000

* Part of the UK National Network

Figure 2.4 Location of metal monitoring sites in Glasgow



1 Ward 47 (Baillieston)
2 Ward 46 (Mount Vernon) Carmyle
3 Ward 40 (Queenslie) Fastnet Street
4 Ward 43 (Shettleston)
5 Ward 35 (Bridgeton/Dalmarnock) Dalmarnock & St Anne's primary school
6 Ward 27 (Merchant City) City Chambers & Glasgow Cross
7 Ward 17 (Anderston) Charing Cross

Benzene

Since 1999, monitoring of benzene has taken place at four locations in the city centre. Concentrations of benzene in ambient air were first considered during Stage I of the Review and Assessment Process (Round 1) and again in the Update and Screening Assessment (Round 2). The air quality objective for benzene is at present set at 3.25 µg m^{-3} as a running annual mean to be achieved by 31st December 2010. Both of these reports concluded that Glasgow would comply with the air quality objective for benzene.

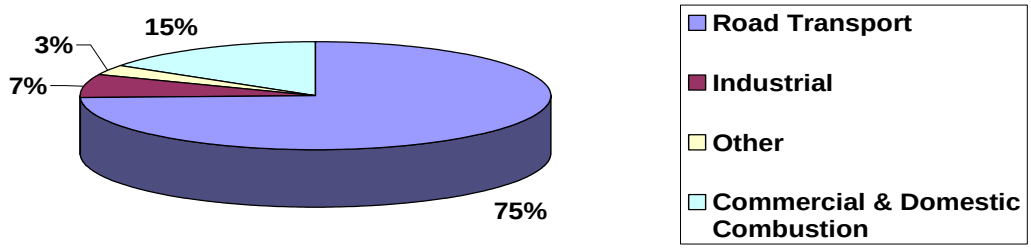
2.1 MONITORING METHODOLOGY AND DATA

2.1.1 Nitrogen Dioxide (NO_2)

Nitrogen oxides (NOx) are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. In the UK, the principal source of NOx - Nitric oxide (NO) and Nitrogen dioxide (NO_2), is road traffic, with most of the remainder arising from power stations and other industrial sources. Since power station and industrial emissions are usually from elevated sources (i.e. high chimneys), motor vehicles represent by far the largest source of low-level NOx emissions and therefore make the largest contribution (75% or greater) to long-term ground level concentrations in urban areas.

Glasgow City Council's Updating and Screening Assessment (2003) identified that emissions from motor vehicles represent the predominant source of NO_2 within Glasgow. It has been estimated by the National Atmospheric Emissions Inventory (NAEI) that road transport accounted for 78% of total NOx emissions in Glasgow in 2000. The contribution of road traffic to NOx emissions has declined significantly in recent years as a result of various policy measures, and further reductions are expected up until 2010 and beyond. Other sources of NOx emissions include residential, commercial and industrial combustion (see Figure 2.5 overleaf).

Figure 2.5 Sources of NOx in Glasgow, 2002 (NAEI)



There are two air quality objectives set for NO_2 in the Air Quality (Scotland) Regulations, an annual mean and a 1-hour mean. Details of these objectives are presented in Table 1.2. Nitric oxide is not generally considered to be harmful to health at the concentrations found in the ambient atmosphere. However, nitrogen dioxide has a variety of environmental and health impacts. Its direct health impact as a respiratory irritant may be significant.

In the presence of sunlight, it can react with volatile organic compounds (VOCs) to produce photochemical pollutants including ozone. Nitrogen dioxide can also be further oxidised in air to acid gases such as nitric acid, which contribute to the production of acid rain over regional scales. In addition to this, NOx plays a key role in secondary particulate formation.

The annual mean objective is currently widely exceeded at urban sites in the United Kingdom, with the highest concentrations generally being recorded at roadside locations. The number of exceedences of the 1-hour objective show considerable year-to-year variability and is driven by meteorological conditions, which give rise to both winter episodes of poor dispersion and summer oxidant episodes.

In 2002, Glasgow's City centre was declared an Air Quality Management Area (AQMA) for NO_2; actions being undertaken to address elevated concentrations within the area are outlined in the Air Quality Action Plan (2004). In the second round of Review and Assessment, Glasgow City Council's Updating and Screening Assessment identified numerous locations out-with the city centre where exceedences of the Objectives for NO_2 could potentially occur. The vast majority of these locations were in the vicinity of road sources and fell into three categories, namely (1) monitoring locations where exceedences had already been identified and busy roads (2) and junctions (3) where exceedences of the objectives were likely. Table 2.2 lists sites that the U&SA identified as requiring further assessment.

Table 2.2 Glasgow locations assessed for exceedences of the NAQS Objectives for NO_2 together with predicted background concentrations for 2005

Category	Location	Background [NO_2] 2005 ($\mu g\ m^{-3}$)
Monitoring locations	Byres Road	35.5
	Royston Road	37.4
	Bridge St/ Norfolk St.	39.4
	North St.	38.3
Busy Roads/ Junctions	Dumbarton Road at Partick	36.9
	Great Western Road at Kelvinbridge	34.2
	Paisley Road at Cessnock	36.9
	Parkhead Cross	34.4
	Calder St. / Aikenhead Rd	32.7

* Data and results have been taken from Glasgow City Council's Detailed Assessment 2004. Refer to this document for additional information.

Monitoring Methodology and Data:

Glasgow City Council monitors ambient concentrations of NO_2 at numerous locations across the city, through the application of both diffusion tubes and automatic analysers. Concentrations detected at all sites have been compared against the National Air Quality Strategy Objectives (Table 1.2) and are presented in Tables 2.4-2.10 and Figures 2.7-2.8.

Diffusion Tube Monitoring

NO_2 diffusion tubes represent a simple, effective and low cost method of monitoring ambient concentrations of nitrogen dioxide in a large number of locations, with Glasgow City Council's NO_2 diffusion tube network currently consisting of more than 100 tubes spread throughout the city. However, data of NO_2 concentrations provided by diffusion tubes is limited to fairly long-term exposure. Tubes are generally exposed for periods of a month, annual mean concentrations determined and compared with the annual mean objective. Furthermore, the accuracy of diffusion tubes can vary depending on the preparation methodology, handling procedures and the identity of the analysing laboratory.

Diffusion tubes utilised by Glasgow City Council are prepared and analysed by Glasgow City Council's Scientific Services. The tubes are stored in a cool location prior to use and end caps only removed as and when they are placed at the monitoring location.

In order to determine bias-correction factors for diffusion tube results, triplicate tubes are co-located with the automatic NO_2 analysers located at Glasgow Centre (Urban Background), Glasgow Kerbside (Kerbside) and Glasgow City Chambers (Urban Centre). Concentrations detected by these tubes were compared against those recorded through chemiluminescent detection over the same sampling period and a bias-correction factor determined using the guidance outlined in LAQM.TG (03). A summary of the bias-correction factor calculated for sites in Glasgow in 2004 is given in Table 2.3.

Table 2.3 Determination of Bias-correction factor for 2004

Site name	**NO_2 Diffusion Tube [Annual Mean] ($\mu g\ m^{-3}$)** DM	**NO_2 Chemiluminescent Detection [Annual Mean] ($\mu g\ m^{-3}$)** CM	**Bias correction Factor (CM/DM)**
Glasgow Centre	43.4	32.0	0.737
Glasgow Kerbside	90.8	68.0	0.749

Diffusion tube results presented in the following tables have been subject to adjustment with the relevant correction factor for each year and monitoring location.

Diffusion Tube Monitoring Data

Tables 2.4-2.9 present NO_2 levels detected by diffusion tubes within and out with the city centre AQMA. The monitoring sites include kerbside, roadside, urban centre and urban background locations. Data is presented for 2003 and 2004 and shows the projected annual mean NO_2 concentration for 2005.

Values presented in red indicate exceedences of NAQS objectives.

Table 2.4 NO_2 levels detected by diffusion tube at kerbside sites out with the city centre

Location	Grid ref.	Annual Mean NO_2 ($\mu g\ m^{-3}$)		Projected 2005 annual mean ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
Mosspark Boulevard	255392 663286	34	30	32	29
Thornliebank Road	255193 659969	27	25	26	24
Mosside Road	257235 662064	35	31	33	30
Royston Road	260278 666186	49	45	47	44
Bridge St./ Norfolk St.	258702 664480	45	36	43	35
Aikenhead Road	259323 661763	36	30	34	29
Balshagray Avenue	254566 667431	39	31	37	30
North Street	257971 665654	47	43	45	42
Dumbarton Road	256209 666525	43	34	40	33
Dougrie Road 1	259586 658996	-	19	-	18
Dougrie Road 2	259879 659059	-	18	-	18
Anniesland X	254646 668820	-	39	-	38
Lawrence St	256295 666816	-	23	-	23
Coburg St	258760 664473	-	29	-	28

Table 2.5 NO_2 levels detected by diffusion tube at roadside sites out with the city centre

Location	Grid ref.	Annual Mean NO_2 ($\mu g\ m^{-3}$)		Projected 2005 annual mean ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
Hillcrest Road (UK)	256485 663205	30	18	29	17
Hillcrest Road	256485 663205	22	17	21	17
Dumbreck Road	255497 663126	27	25	26	24
St Andrews Drive	256214 662536	25	20	23	20
Haggs Road	256263 661781	29	25	27	25
Pollokshaws Road	255839 661189	29	26	28	26
Dunn Street	261328 663817	41	32	39	31
Byres Road	256530 666939	50	42	48	41
Queen Margaret Drive	257440 668016	32	26	31	26
Westmuir Street	262559 664181	43	50	41	49
Finnieston Street	257235 665108	43	34	40	33
Napiershall Street	257774 666795	-	54	-	53
Dougrie Road 3	260204 659127	-	21	-	20
Queen Margaret Drive 2	257216 667639	-	30	-	29
Queen Margaret Drive 3	256941 667363	-	37	-	37
Cooperswell Street	256154 666478	-	23	-	23
Castle Street, Partick	256160 666452	-	25	-	25
Royston Road 2	260430 666263	-	39	-	39
Oxford Street	258731 664590	-	28	-	27

Table 2.6 NO_2 levels detected by diffusion tube at urban background sites out with the city centre

Location	Grid ref	Annual Mean NO_2 ($\mu g\ m^{-3}$)		Projected 2005 annual mean ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
Sutherland Ave. (UK)	256343 663153	24	15	23	14
Kinningpark (Stanley Street)	257335 664239	53	32	51	32
Ascaig Crescent	254119 662931	25	15	24	15
Belmont Street	257535 667378	38	24	36	23
Mallaig Place	253984 665299	32	23	31	22
Govanhill Street	258545 662882	39	23	37	22
Drumhead Road	263744 662327	27	17	26	17
Caledonia Road	259504 663055	32	21	31	20
Westercraigs	260943 665225	36	23	34	22
Inveresk Lane	264162 664854	30	21	29	20
Maxwellton Road	262705 666577	45	32	43	31
Kippen Street	259727 668476	27	17	26	17
Broomhill Road	254904 666873	37	21	35	21
Celtic Park 1	261799 663987	32	21	31	21
Celtic Park 2	261788 664091	31	19	30	19
Sacone SW	263920 664570	-	19	-	19
Castlemilk	260156 659189	26	15	25	14
Craigton Rd	254515 664510	48	28	46	27
Invergarrie Road	253824 658589	22	13	21	13
Easterhouse	266933 666154	36	23	34	22

Table 2.7 NO_2 levels detected by diffusion tube at kerbside sites within the city centre

Location	Grid ref	Annual Mean NO_2 ($\mu g\ m^{-3}$)		Projected 2005 annual mean ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
Hope Street (UK)	258730 665322	101	67	97	65
Argyle Street	258846 665088	85	70	81	69
George Square	259246 665442	65	49	62	47
Union Street	258833 665210	73	68	69	66
Glasgow Cross	259658 664868	44	43	42	42
Bath Street	258215 665864	53	45	51	44
Glassford Street	259361 665250	58	61	55	59
Briggait	259420 664703	46	37	43	36
St Vincent Street	258844 665446	84	75	80	73
N. Hanover Street	259375 665900	52	39	49	38
Castle Street	260100 665579	54	45	51	44
Hope Street 2 (mid)	258730 665405	68	64	65	62
Hope Street 3 (north)	258857 665913	61	49	58	48
Montrose Street	259543 665332	53	37	51	37
Cochrane Street (1)	259524 665294	46	43	43	42
Cochrane Street (2)	259430 665316	46	38	43	37
Ingram Street	259524 665253	41	37	39	36
Renfield Street	258954 665873	63	51	59	50
George Street	259551 665380	50	41	48	40
Broomielaw	258561 664931	55	45	52	44
Carrick Street	258319 665076	-	31	-	30
Dundasvale Street	258828 666289	-	32	-	31

Table 2.8 NO_2 levels detected by diffusion tube at roadside sites within the city centre

Location	Grid ref.	Annual Mean NO_2 ($\mu g\ m^{-3}$)		Projected 2005 annual mean ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
Hope Street 1 (south)	258730 665322	81	67	77	66
Gordon Street	258766 665347	87	64	82	63
Heilan'man's Umbrella north	258770 665117	80	73	76	71
Heilan'man's Umbrella south	258769 665106	84	73	79	72
Saltmarket	259545 664739	42	37	40	37
High Street	259732 664991	54	48	51	47
Dobbies loan	259302 666289	39	37	37	37

Table 2.9 NO_2 levels detected by diffusion tube at urban centre sites within the city centre

Location	Grid ref	Annual Mean [NO_2] ($\mu g\ m^{-3}$)		Projected 2005 annual mean [NO_2] ($\mu g\ m^{-3}$)	
Year/ Base Year		2003	2004	2003	2004
M^{c}Leod Street (UK)	260077 665481	50	33	48	32
M^{c}Leod Street	260077 665481	46	32	44	32

Automatic Monitoring

Glasgow City Council operates six chemiluminescent analysers for measuring NO_2 concentrations, the locations of these monitoring sites are shown in section 2.0.1. The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide.

Monitoring Data

The following table is taken from the Detailed Assessment (2005) and shows the measured annual mean and the projected annual mean for 2005. Data collection from Glasgow City Council's mobile units are unavailable during the period of study due to operational, communication and software problems and thus have not been included in this report.

Table 2.10 Annual mean NO_2 concentrations measured at AURN sites

Location	Measured Annual Mean (μgm^{-3})					Projected 2005 Annual Mean (μgm^{-3})		Projected 2010 Annual Mean (μgm^{-3})	
	2000	2001	2002	2003	2004	Base 2003	Base 2004	Base 2003	Base 2004
Glasgow Chambers	49	42	47	50	49	48	48	39	39
Glasgow Centre	37	33	32	38	36	37	35	32	30
Glasgow Kerbside	72	71	74	75	68	71	66	59	55

Values presented in red indicate exceedences of NAQS objectives (40 μgm^{-3}).

Figure 2.7 & 2.8 (below) present the concentrations of NO_2 measured at each AURN site. The NO_2 concentration is compared to the Air Quality objective (Figure 2.7) and the number of permitted exceedences (Figure 2.8).

Figure 2.7 Annual mean NO_2 concentrations measured at AURN sites

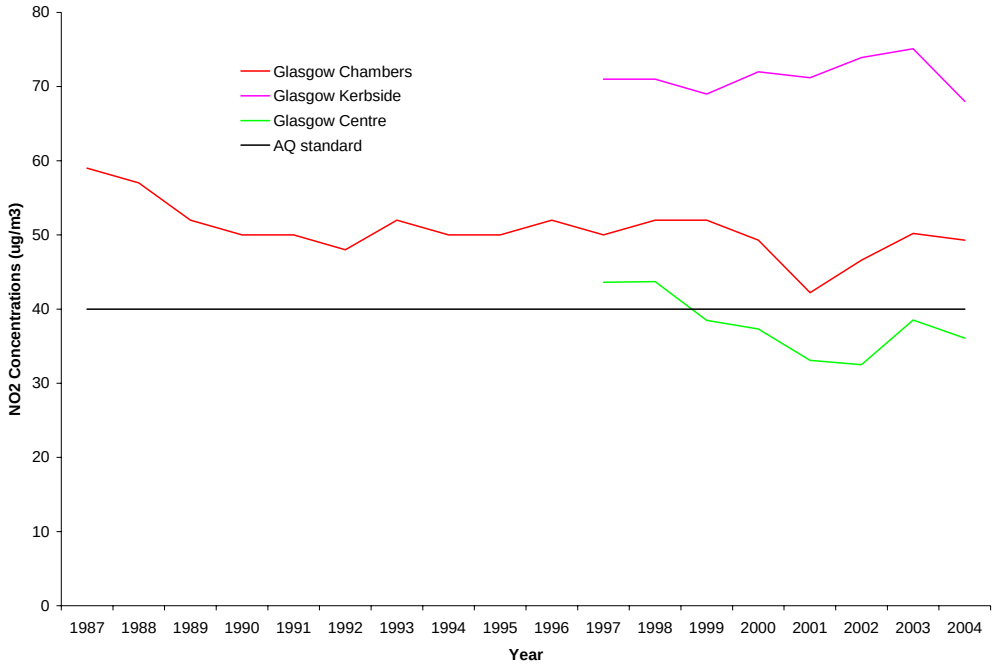
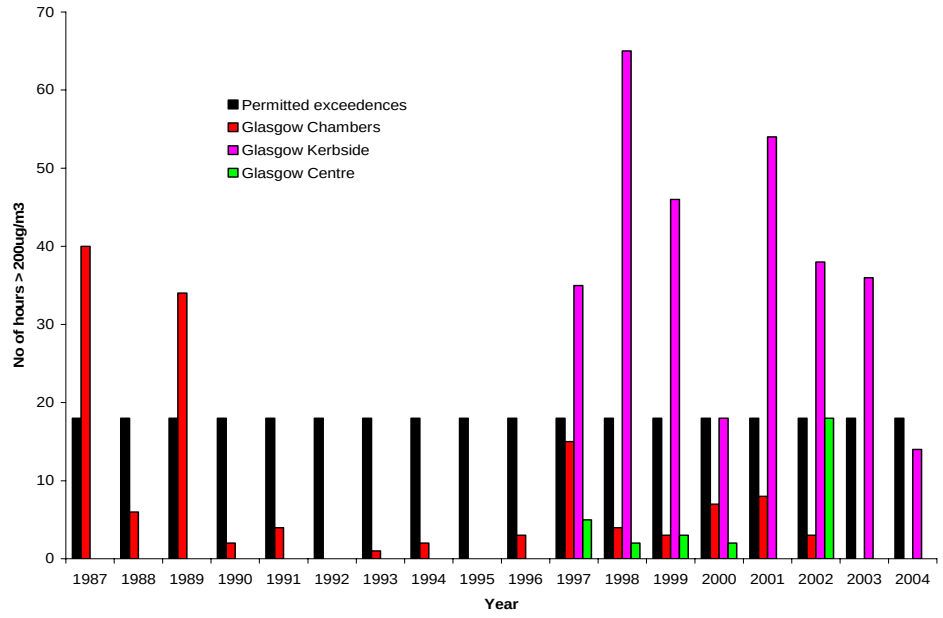


Figure 2.7 highlights that both Glasgow Kerbside and Glasgow City Chambers are recording concentrations which are continually breaching the annual mean objective for NO_2. Whereas, Glasgow Centre located at St Enoch's square, has maintained concentrations below or in line with the annual mean objective of 40 µg m^{-3} since 1999. The excursions seen at Glasgow Chambers and Glasgow Kerbside are also reflected in Figure 2.8; Kerbside has breached the limit of permitted exceedences virtually every year since it began operation in 1997. A contributory factor to this may be due to the high number of buses and taxis, which are present on this street during the majority of the day. Hope Street also exhibits a canyoning effect which could potentially enhance these conditions due to poor dispersal of pollutants. Glasgow Chambers is also classified as a street canyon (see previous reports) and thus pollution dispersal is rather limited.

Figure 2.8 Number of exceedences of 1-hour mean objective for NO_2, Glasgow AURN stations



NO_2 Conclusions

The results of the Detailed Assessment indicate that numerous locations out with the present AQMA are likely to fail the annual mean objective in 2005. Results from air dispersion modelling at busy roads/ junctions indicate that exceedences of the annual mean objective are likely to occur at Royston Road, Byres Road, Bridge Street/Norfolk Street, North Street/ Glasgow 1, Dumbarton Road and Parkhead Cross.

In comparison, the results from NO_2 diffusion tubes located at Royston Road (2004) reported annual mean concentrations ranging from 39-45 µg m^{-3}, supporting the findings of the model at this location. Similarly, results from NO_2 diffusion tubes located at Byres Road (42 µg m^{-3}), North Street (43 µg m^{-3}) and Westmuir Street (Parkhead Cross) (50 µg m^{-3}) also support the findings of the model in that these locations are likely to fail the annual mean objective for NO_2 in 2005. In contrast, the results from the NO_2 diffusion tube located at Bridge Street/ Norfolk Street from 2004 do not agree with the results of the model. In 2004, the diffusion tube located at Bridge Street/ Norfolk Street recorded an annual mean concentration of 36 µg m^{-3}. As this site represents a kerbside location, this result indicates that the NAQS annual mean objective for NO_2 is unlikely to be exceeded at Bridge Street/ Norfolk Street in 2005.

In addition, monitoring results from the NO_2 diffusion tube located at Napiershall Street in 2004 recorded an annual mean concentration of 54 µg m^{-3}. This tube was only introduced at the end of 2003 and indicates that this location is likely to fail the annual mean objective for NO_2 in 2005 and thus requires further assessment.

Furthermore, this study has recognised that there are gaps in Glasgow City Council's diffusion tube network including areas around Paisley Road and Great Western Road, whilst a high number of tubes are located at Kerbside and Roadside locations and are thus not representative of human exposure. Consequently, it is recommended that where possible, Glasgow's current NO_2 diffusion tube network is extended to those areas where gaps have been identified and that some reassessment of diffusion tube locations is conducted.

In relation to potential exceedences of the NAQS objectives from the proposed M74 extension and industrial sites within Glasgow, it is concluded that further monitoring and assessment is required in the vicinity of these sites before conclusions can be drawn.

2.1.2 Particulate Matter (PM_{10})

PM_{10} is composed of a wide range of materials and several different sources contribute to it's concentrations in the UK. These can be split into three distinct categories.

- Primary particles are those which are blown or emitted directly into the air e.g. produced directly through combustion. Sources include road transport, power generation and industrial processes.
- Secondary particles are formed through chemical reaction in the atmosphere. These mainly comprise sulphates and nitrates and can travel considerable distances from their source.
- Coarse particles have a variety of sources and include re-suspended soils and dusts from road traffic and construction works, biological particles and sea salt.

Reductions in emissions of the three types of particles will be controlled independently from each other. Primary particles will be governed by legislation on such areas as vehicle emission standards and combustion processes, secondary particles will largely be governed by controls on power generation, SO_2 and NO_X emissions from industry and transport, while coarse particles are uncontrolled, and would not be expected to decline.

During the 1990's, research provided evidence that fine particles can damage human health even at concentrations previously thought to be insignificant. Particles with a diameter of 10 microns or less, termed PM_{10} are the most hazardous. Therefore, a PM_{10} standard was designed to identify those particles likely to be inhaled by humans. Larger particles are filtered out by the body's natural defence system, but tiny particles that can reach deep into the lung can be absorbed into the blood stream or can cause lung problems. Both the size and composition of particulate matter determine any potential health effect. As well as creating dirt, odour and visibility problems, PM_{10} particles may carry surface-absorbed

carcinogenic compounds into the lungs. This is likely to be because diesel vehicles are now the major source of urban particulates; some hydrocarbons (in fuel) are linked to cancer and metal particles (e.g. lead) can cause poisoning.

In the UK mean PM_{10} concentrations have been decreasing steadily since they were first monitored in 1992, although maximum levels have remained relatively constant. Since 1970, domestic emissions have decreased considerably, which is largely due to a reduction in coal use. Domestic emissions in 1970 totalled 222 kilotonnes (41% of total emissions) and in 2002 this had been reduced to 28 kilotonnes, constituting 17% of total emissions. Existing PM_{10} data show that daily average concentrations are usually highest in the winter months and lowest in the summer. During the spring and summer, the photochemical oxidation of SO_2 and NOx to particulate sulphate and nitrate is an important source.

The Air Quality Objectives for PM_{10} in Scotland have been tightened considerably in recent years. The new objectives and target dates for compliance are given in Table 2.11 below.

Table 2.11 PM_{10} air quality objectives

Averaging period	Air Quality objective ($\mu g\ m^{-3}$)	Number of permitted exceedences	Compliance date
24 hour mean	50	7	31 Dec 2010
Annual mean	18	n/a	31 Dec 2010

In Glasgow, the main source of PM_{10} emissions is road traffic, with the National Atmospheric Emissions Inventory (NAEI) estimating that this source accounts for just over half of all emissions. Other sources include residential and commercial combustion, industrial combustion and other industrial processes.

Figure 2.9 Sources of PM_{10} in Glasgow, 2002 (NAEI)

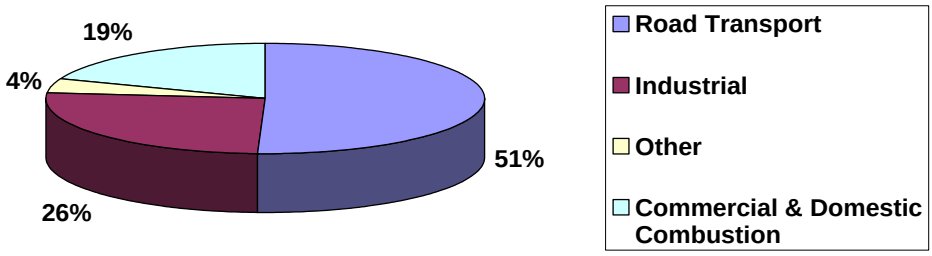


Figure 2.9 gives a breakdown of emissions from within the Glasgow boundary. However, a significant contribution to PM_{10} levels in Glasgow will come from sources out with the City boundary. Long distance transport from regional sources, and sources in Europe, make up a large portion of background concentrations, which are outside of the control of local authorities.

Background concentrations of PM_{10} are available on the national air quality archive website: (http://www.airquality.co.uk/archive/laqm/tools.php?tool=background). Some typical background concentrations are given in Table 2.12.

Table 2.12 Background PM_{10} concentrations

Grid reference		Location	Background PM_{10} 2001 ($\mu g\ m^{-3}$)
Easting	Northing		
258890	665540	City Centre	20.3
259360	669520	North	17.5
257600	660560	South	18.0
264360	664041	East	18.7
252200	669640	West	17.0

Monitoring Methodology

In Glasgow, there are currently five sites which measure PM_{10} using Tapered Element Oscillating Microbalance (TEOM) analysers. However, results from these instruments are not directly comparable to the air quality standards, which are based on measurements made with gravimetric samplers. Measurements from TEOM samplers are found to underestimate gravimetric samplers by between 15-30% and so a correction factor must be applied to TEOM results. This factor of 1.3 has been applied to all monitored PM_{10} data in Glasgow. The guidance advice on what this factor should be is,

"Measurements of PM_{10} concentrations carried out using a TEOM or β-attenuation instrument, operated with a heated manifold, should be adjusted by multiplying the data by 1.3 to estimate gravimetric equivalent concentrations."

Glasgow City Council's Updating and Screening Assessment (2003) identified that potential exceedences of the National Air Quality Strategy Objectives for PM_{10} (2010) were likely to occur at numerous busy roads and junctions across the city. Thus, the report concluded that concentrations of PM_{10} should be assessed at the busy roads/junctions listed in Table 2.13 (overleaf) and at monitoring locations where elevated concentrations of PM_{10} had been recorded.

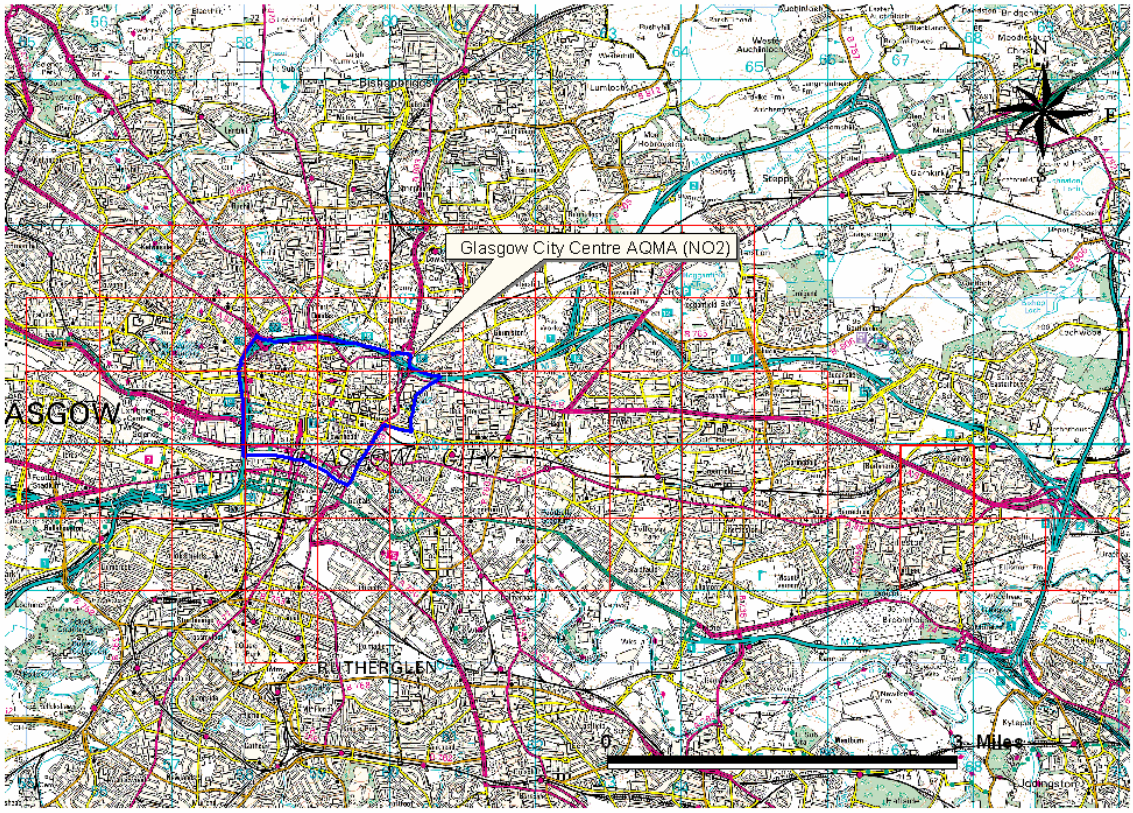
Table 2.13 Glasgow locations assessed for exceedences of the NAQS Objectives for PM_{10} together with predicted background concentrations for 2005 and 2010

Category	Location	Background [PM_{10}] ($\mu g\ m^{-3}$)	
		2005	2010
Monitoring locations	Glasgow Kerbside (Hope Street)	19.5	17.9
	Glasgow Centre (St Enoch Sq.)	19.5	17.9
	Glasgow 1 (Anderston)	19.5	17.9
	Glasgow 2 (Byres Road)	18.8	17.3
Busy Roads / Junctions	Paisley Road	18.1	16.7
	Calder Street/ Aikenhead Road	18.4	17.1
	Bridgeton Cross	19.1	17.7
	Battlefield	17.7	16.5
	Victoria Infirmary	17.7	16.5
	Pollokshaws Road/Minard Road	18.2	16.8
	Crow Road	17.4	16.1
	Victoria Park Drive South at Whiteinch	17.8	16.5
	Dumbarton Road at Partick	18.4	16.9
	Shieldhall Rd at Cardonald	17.4	16.2
	Maryhill Road at Kelvindale	17.5	16.2
	Union St	19.5	17.9
	Cathedral Street	19.6	18.0
	M8 Charing Cross	19.2	17.9
	Argyle Street	19.8	18.2
	Renfield Street	19.5	17.9
	M8 at Scotland Street	18.5	17.1
	Balshagray Avenue	17.4	16.1
	Parkhead Cross	18.2	16.9

In 2005 new NAQS objectives for PM_{10} came into force in Scotland. These new objectives saw the annual mean objective reduced from 40 μg m^{-3} to 18 g μm^{-3}, and a reduction in the number of permitted exceedences of the 24-hour mean objective (50 μg m^{-3}) from 35 to 7.

As demonstrated in Figure 2.10, examination of the predicted background concentrations of PM_{10} across Glasgow for 2005, suggests that most of the city is currently failing the NAQS annual mean objective.

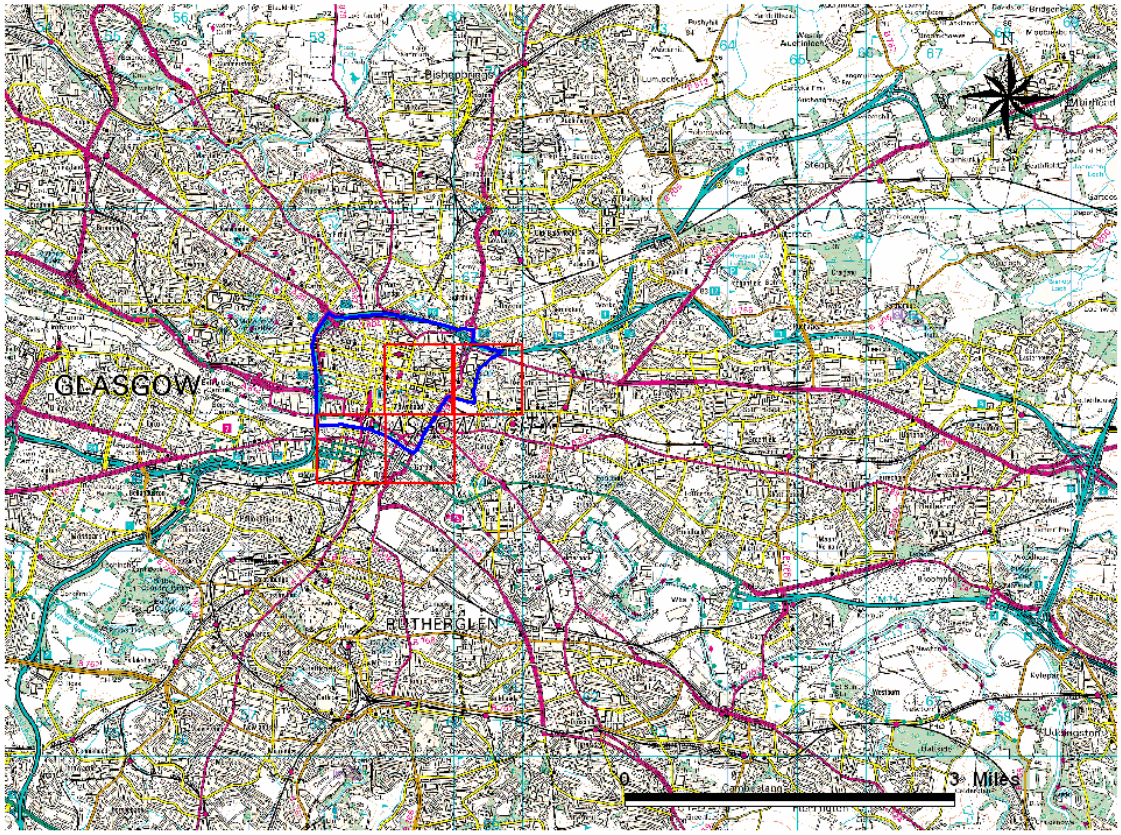
Figure 2.10 Areas of Glasgow (2005) where the annual mean background concentration of PM_{10} is predicted to exceed 18 μg m^{-3}.



□ - 1 km grid square where annual mean concentration of PM_{10} is predicted to be ≥ 18 μg m^{-3}

By 2010 background concentrations of PM_{10} are predicted to decline to the extent that a much smaller area of Glasgow is predicted to fail the basis of background concentrations. Areas of Glasgow where the background concentration of PM_{10} is predicted to exceed the NAQS annual mean objective of 18 μg m^{-3} are presented in Figure 2.11. However, in addition to the areas where background annual mean concentrations of PM_{10} are predicted to be ≥ 18 μg m^{-3}, background concentrations in many other areas of the City are predicted to be only slightly under 18 μg m^{-3}.

Figure 2.11 Areas of Glasgow (2010) where the annual mean background concentration of PM_{10} is predicted to exceed 18 μg m^{-3}.



□ - 1 km grid square where annual mean concentration of PM_{10} is predicted to be ≥ 18 μg m^{-3}

Monitoring Data

At present, data from monitoring of ambient concentrations of PM_{10} in Glasgow are available from two sites, (1) Glasgow Kerbside and (2) Glasgow Centre which constitute part of the Automatic Urban and Rural Network. Both of these sites are discussed in section 2.0.1 and results from PM_{10} monitoring in recent years presented in Tables 2.14 and 2.15. Projected annual mean concentrations of PM_{10} for Glasgow Kerbside and Glasgow Centre for 2010 are presented in Table 2.16.

N.B. Values presented in red indicate exceedences of NAQS objectives

Table 2.14 Results of monitoring for PM_{10} at Glasgow Kerbside

Year	Data capture (%)	Annual mean PM_{10} ($\mu g\ m^{-3}$)	Maximum 24-hour mean ($\mu g\ m^{-3}$)	No. of days >50$\mu g\ m^{-3}$
1997	72	40	125	80
1998	97	35	147	68
1999	97	27	105	44
2000	97	27	75	23
2001	98	31	147	36
2002	96	30	132	42
2003	93	32	146	53
2004	95	27	71	35

All values of [PM_{10}] are presented as gravimetric equivalent concentrations

Table 2.15 Results of monitoring for PM_{10} at Glasgow Centre (Gravimetric concentrations)

Year	Data capture (%)	Annual mean PM_{10} ($\mu g\ m^{-3}$)	Maximum 24-hour mean ($\mu g\ m^{-3}$)	No. of days >50$\mu g\ m^{-3}$
1997	95	27	113	19
1998	98	26	70	11
1999	98	23	87	9
2000	97	28	111	27
2001	99	22	130	12
2002	97	20	114	8
2003	96	21	68	13
2004	67	19	50	0

All values of [PM_{10}] are presented as gravimetric equivalent concentrations

Table 2.16 Estimated PM_{10} Annual Mean Concentrations (Gravimetric concentrations)

Location	Estimated 2010 PM_{10} annual mean concentration ($\mu g\ m^{-3}$)				
	Base year 2000	Base year 2001	Base year 2002	Base year 2003	Base year 2004
Glasgow Centre	25	20	19	20	18
Glasgow Kerbside	24	27	27	28	25

All values of [PM_{10}] are presented as gravimetric equivalent concentrations

In summary, the results from the air quality monitoring of PM_{10} in Glasgow indicated that the NAQS annual mean objective for PM_{10} was exceeded at both Glasgow Kerbside and Glasgow Centre in 2004 and is also likely to be exceeded at both in 2010. In addition, the monitoring results from 2004 indicated that the 24-hour mean objective for PM_{10} was also exceeded at Glasgow Kerbside, with daily mean concentrations in excess of 50 µg m^{-3} being recorded on 35 occasions.

PM_{10} Conclusions

The results from air quality monitoring and air-dispersion modelling of PM_{10} in Glasgow indicate that sections of the City Centre including Hope Street, Renfield Street, Union Street, Cathedral Street and Charing Cross are considered highly likely to fail the annual mean objective set for 2010, whilst further exceedences of the objective are predicted out with the City Centre at Dumbarton Road, Bridgeton Cross, Crow Road and at Glasgow 1 (Air Quality monitoring Unit at St Patrick's Primary School).

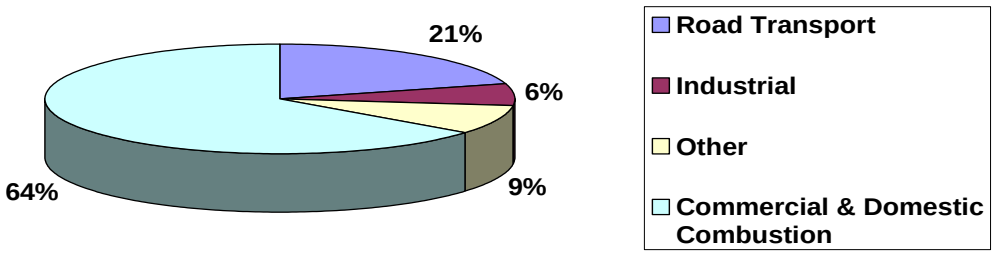
It must be stated however, that the modelling results for PM_{10} have not been verified, due to the limited availability of suitable monitoring data. As such, the findings of the modelling studies and the preliminary declaration of Air Quality Management Areas must be treated with caution until further monitoring and verification can be conducted.

In relation to emissions of PM_{10} and potential exceedences of the NAQS objectives from the proposed M74 extension and industrial sites within Glasgow, it is concluded that further monitoring and assessment is required at these locations in future years.

2.1.3 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is a colourless gas, about 2.5 times as heavy as air. It naturally occurs in volcanic gases but is also produced from various metallurgical and chemical processes. Other sources of SO_2 emissions are due to the oxidation of sulphur impurities in fuels during combustion processes. Power stations are generally the main source of SO_2 in the UK but smaller sources may combine to produce hot spots. However, the NAEI for Glasgow contrasts this in that domestic and commercial combustion accounts for almost two thirds of total SO_2 emissions, with road transport the next most important source.

Figure 2.12 Sources of SO_2 in Glasgow, 2002 (NAEI)



Residential and commercial combustion sources that are likely to be significant will include small (>5MW) combustion plants and boilers from places including schools, hospitals and universities. These could lead to exceedence of the 15-minute objective in the immediate area. While road transport accounts for a large amount of total SO_2 emissions in Glasgow, it is not considered likely that it will result in exceedences of any air quality standards.

The greatest impact to human health from SO_2 comes from short-term exposure to large doses of this gas. There are three air quality objectives for SO_2; the 24 hour objective, 1 hour objective and 15-minute objective, details of these objectives are presented in Table 1.2. In the UK as a whole there has been a steady and substantial decline in the concentrations of both sulphur dioxide and associated black smoke since 1962. This decrease was initially achieved through controls on burning coal, introducing cleaner solid fuels and taller power station stacks. In recent years further decreases have been achieved through generating more electricity from gas and nuclear power, using low sulphur fuels and fitting flue gas desulphurisation equipment to certain power stations. SO_2 emissions contribute to various types of

air pollution; acidification and eutrophication, secondary particulate formation, and both toxic and transboundary air pollution.

Monitoring methodology

Glasgow City Council undertakes two methods of monitoring SO_2 concentrations; using UV fluorescence analysers (automatic analysis) and by utilising 8-port smoke and SO_2 bubblers (active sampling).

Two automatic SO_2 analysers, located at Glasgow Centre and St Patrick's Primary School, Anderston, work on the principle of UV fluorescence. SO_2 molecules are excited to energy states by UV radiation. These energy states decay causing an emission of secondary fluorescent radiation with an intensity that is proportional to the concentration of SO_2 in the sample. This method is more accurate than the bubbler technique, and also has the advantage of being able to make direct comparisons against all three air quality objectives. (Data from the St Patrick's Primary school site is currently unavailable but will be included in future reports).

Active sampling has been operational in Glasgow since the 1950s with 6 sites currently part of the National network. 8-port smoke and SO_2 bubblers measure two factors; the concentration of particulate matter in the sampled air (black smoke) and the concentration of sulphur dioxide in the air. Black smoke is classified as strongly light absorbing particulate material suspended in the ambient atmosphere. Monitoring involves drawing air at a constant, measured flow rate through a paper filter, forming a dark stain. The darkness of the stain is measured by a reflectometer and used to calculate the concentration of particulate matter in the sampled air based on standard calibrations.

To determine the concentration of sulphur dioxide in the air the same measured sample of filtered air is passed through a dilute, acidified solution of hydrogen peroxide over a 24 hour period. The solution is analysed by net acidity titration, and a daily concentration of SO_2 is derived. Consequently, SO_2 bubblers do not provide a direct measurement of SO_2 concentrations in relation to the 1hour or 15-minute mean. Instead, these values are estimated from the 24 hour mean using guidance contained within LAQM.TG (03). In order to take account of the uncertainty in these procedures the guidance states that;

" ....it may be assumed that the 15-minute mean objective is unlikely to be exceeded if the maximum daily mean concentration is <80 µg m^{-3} , and the 1 hour mean objective is unlikely to be exceeded if the maximum daily mean concentration is <200 µg m^{-3}.

Monitoring Data:

Active Sampling

The following six graphs compare the maximum 15-minute, 1 hour and 24 hour SO_2 concentrations recorded by each 8-port SO_2 bubbler, against their respective air quality objective. Data is from 1997-2004. For bubbler data, a correction factor (1.25) has been applied to the 24 hour mean and empirical relationships have been used to estimate the 15-minute and 1 hour percentiles.

Figure 2.13 – Baillieston

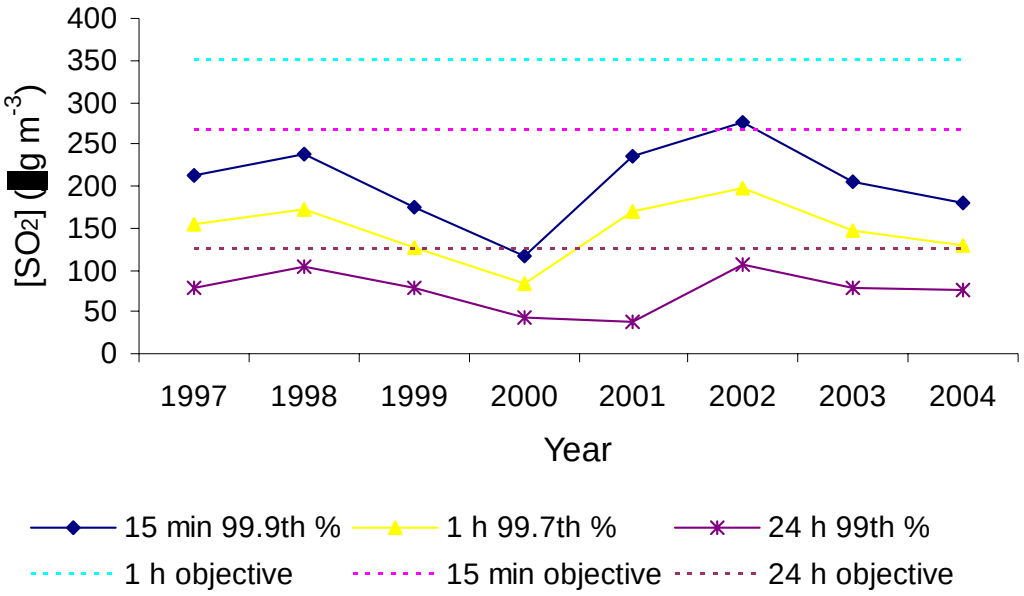


Figure 2.14 - Dalmarnock

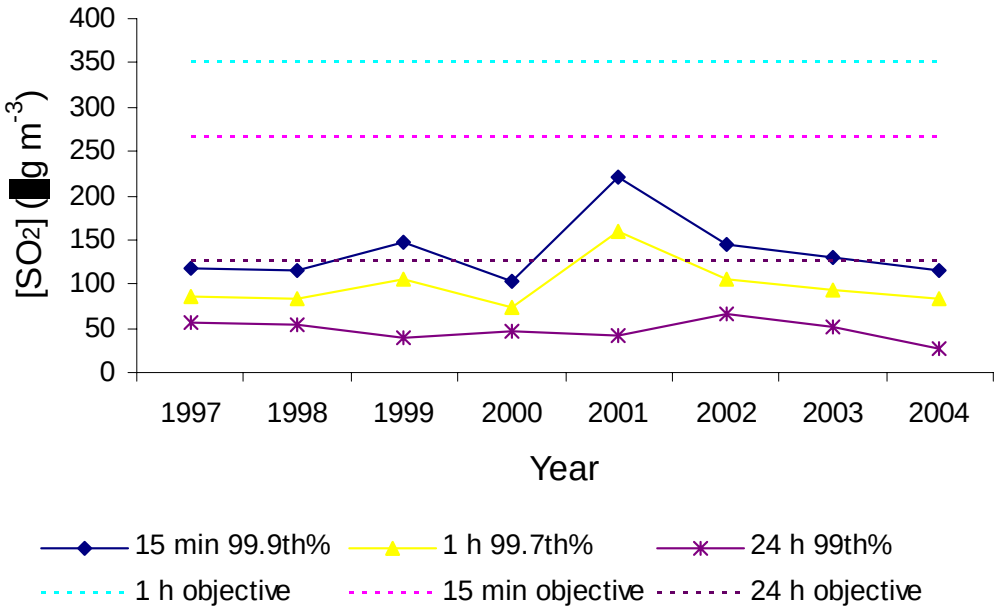


Figure 2.15 Springburn

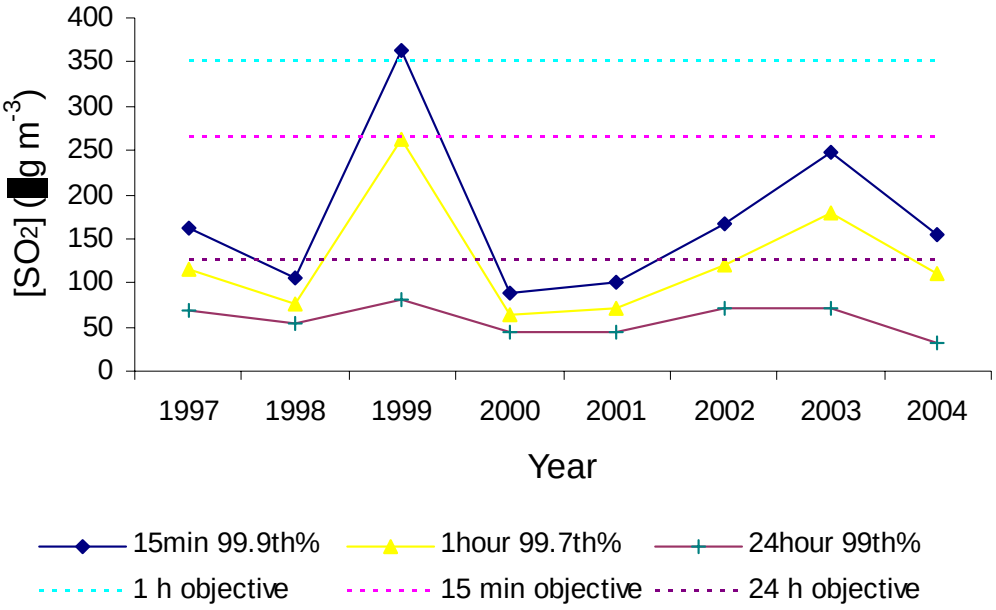


Figure 2.16 Montrose Street

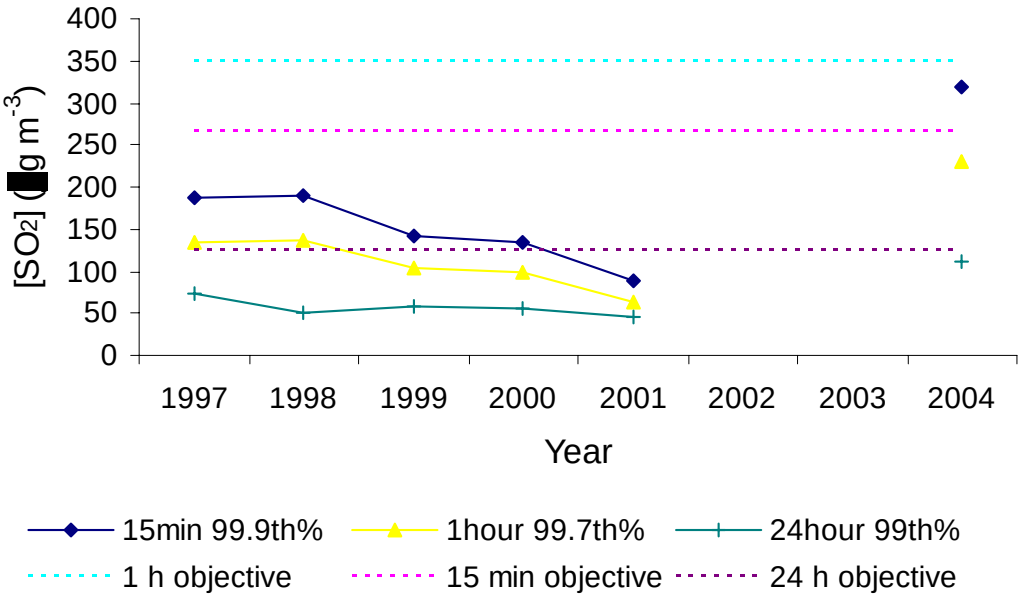


Figure 2.17 – Cardonald

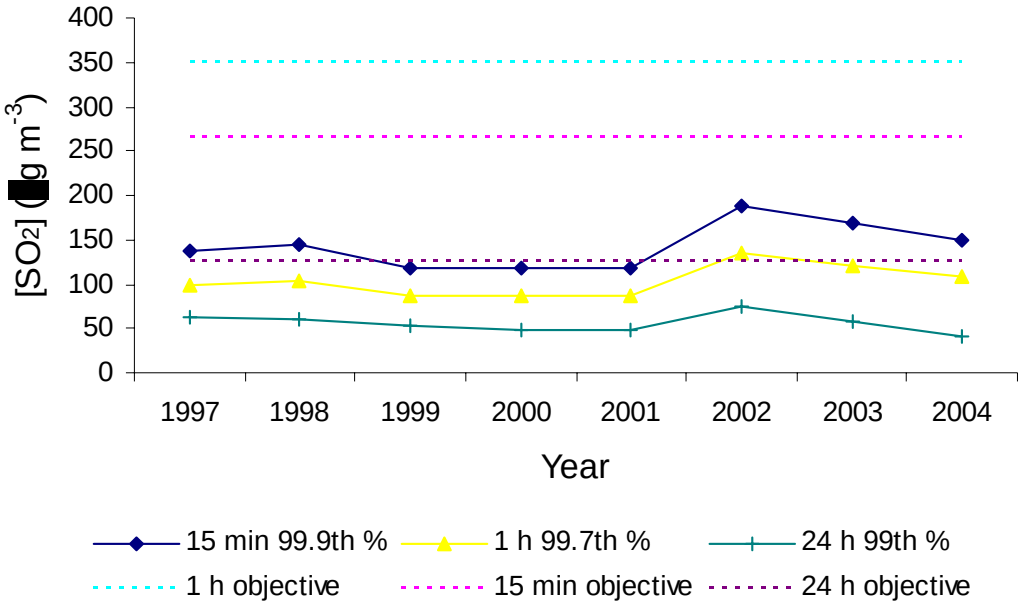


Figure 2.18 – Carmyle

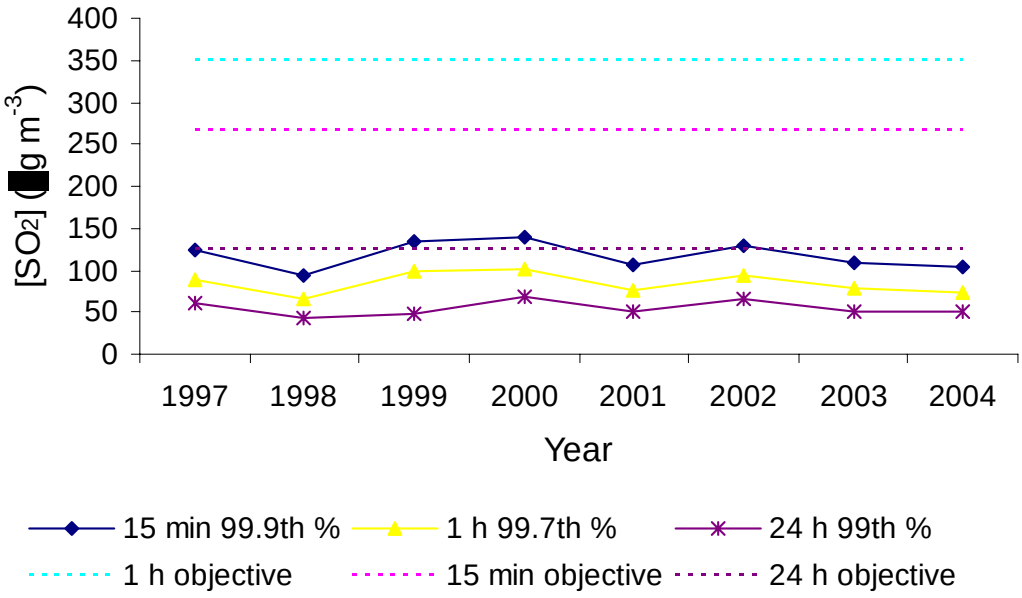


Table 2.17 shows the maximum daily mean SO_2 concentration determined by each 8-port bubbler from 1997 until 2004. The highest concentration recorded (191 µg m^{-3}) was at Wellfield Nursery School, Springburn in 1999; this may be explained by adverse weather conditions during a pollution episode. However, the site in Baillieston has been consistently recording concentrations >80 µgm^{-3} (except year

2000), which suggests that the 15 minute objective is likely to be exceeded at this location. As the maximum daily mean concentration has never exceeded 200 µg m^{-3}, at any site, then it can be assumed that the 1-hour objective will not be breached.

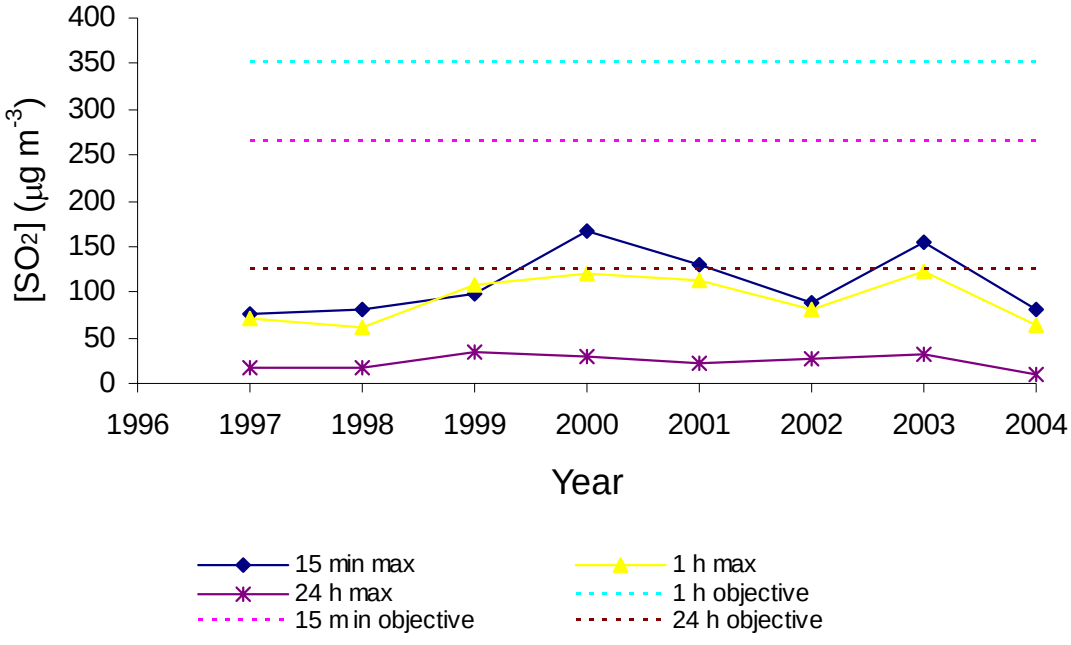
Table 2.17 Maximum daily mean SO_2 concentration (µg m^{-3}) determined by 8-port bubblers

Year	Baillieston	Carmyle	Dalmarnock	Springburn	Montrose St.	Kelvinhall Art Galleries	Cardonald
1997	113	65	63	85	79	140	73
1998	125	49	61	56	80	80	76
1999	93	71	78	191	75	N.A.	63
2000	61	74	54	58	71	N.A.	63
2001	124	56	116	53	47	68	63
2002	145	68	76	88	-	126	99
2003	107	57	69	131	-	-	89
2004	95	54	61	81	169	-	79

Automatic analysis

DATA is presented from 1997-2004 (information taken from the Detailed Assessment). The following graph shows the maximum SO_2 concentrations recorded by the automatic analyser located at Glasgow Centre and compares them to the three air quality objectives set. Data from Glasgow 1 (St Patrick's Primary School) is currently unavailable. However, this will soon be rectified and this data will be included in future reports.

Figure 2.19 Maximum SO_2 Concentrations at Glasgow Centre (AURN)

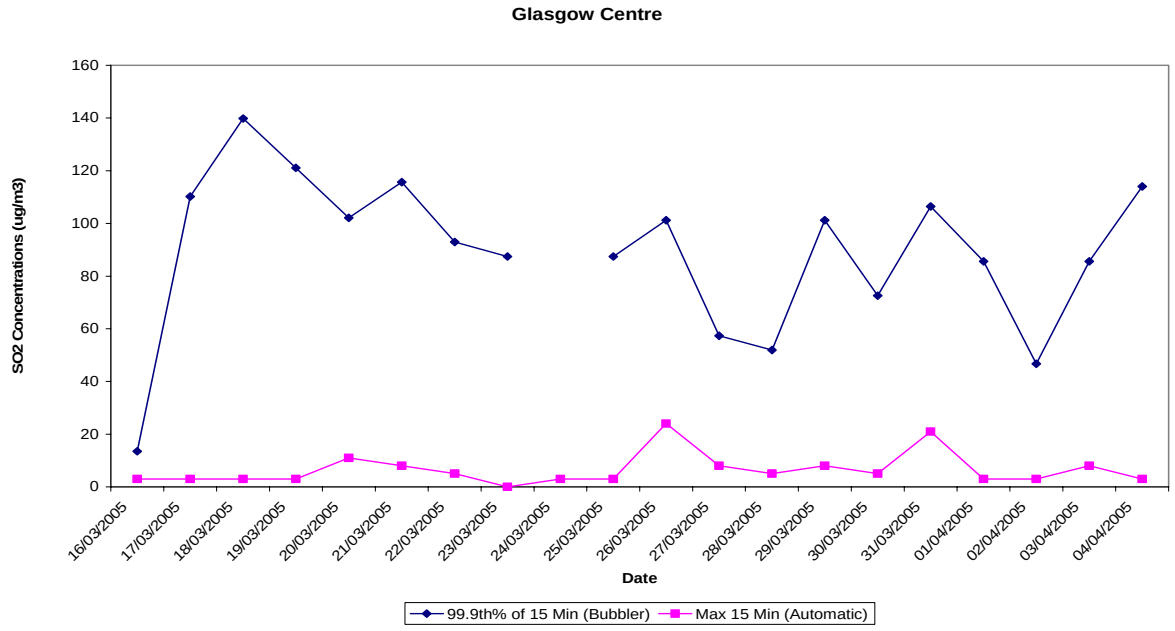


SO_2 Conclusions

The results from the monitoring of SO_2 indicated that no exceedences of the 24 hour mean or 1 hour mean objective were observed at any of Glasgow's monitoring sites in 2003 or 2004. However, assessment of the maximum 24 hour mean SO_2 concentrations reported at all 8-port bubbler locations (Table 2.17) demonstrated that daily means equal to or in excess of 80µg m^{-3} have been observed at Baillieston, Dalmarnock, Springburn, Montrose Street and Cardonald in recent years.

In light of these indicated exceedences of the 15 min objectives at multiple 8-port bubbler locations and the recognition that SO_2 bubblers do not provide a direct measurement of SO_2 concentration in relation to the 15 min mean the decision was taken to co-locate an 8-port bubbler with the automatic analyser at Glasgow Centre in order to assess bubbler performance. The results of this short term co-location study are presented in Figure 2.20.

Figure 2.20 Automatic analyser – 8-port bubbler comparison



The results demonstrated that the concentrations of SO_2 measured by the 8-port SO_2 bubbler and the more accurate automatic SO_2 analyser differed significantly over the study period. These results appear to indicate that 8-port SO_2 bubblers overestimate ambient concentrations of SO_2 and do not represent an accurate method of estimating 15 min maximum concentrations. In order to assess the validity of these findings Glasgow City Council intends to continue this co-location experiment over a longer time period in order to establish a long term relationship between the two monitoring methods. However, current evidence suggests that it is unlikely that Glasgow will be in breach of the SO_2 objectives.

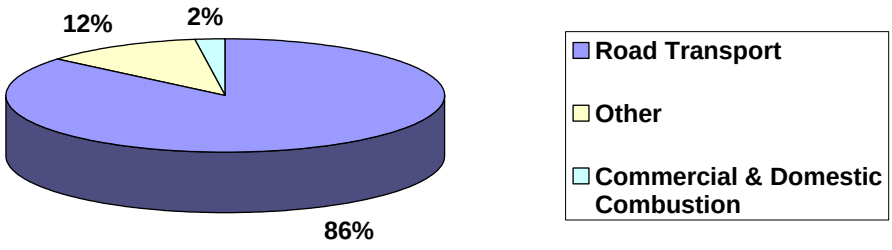
Recently, the co-location experiment has moved location and is now conducted at St Patrick's school (Groundhog site).

2.1.4 Carbon Monoxide (CO)

Carbon monoxide (CO) is a toxic gas that is produced by the incomplete combustion of solid, liquid and gaseous fuels. Emissions are dominated by road transport activities, especially prevalent when vehicles are idling or traffic is slow moving. Therefore, concentrations are found to be highest close to busy roads, particularly during rush hour periods. CO contributes to a number of air pollution problems e.g. toxic air pollution, ground level ozone formation and transboundary air pollution.

The National Atmospheric Emissions Inventory estimated that for Glasgow 86% of total emissions of CO in 2002 were due to road traffic, with commercial and domestic combustion accounting for only 2% of emissions. The remaining 12% is largely made up of emissions from other transport sources, with industrial processes constituting <1% of total emissions. The sources of CO emissions in Glasgow are shown below.

Figure 2.21 Sources of CO in Glasgow, 2002 (NAEI)



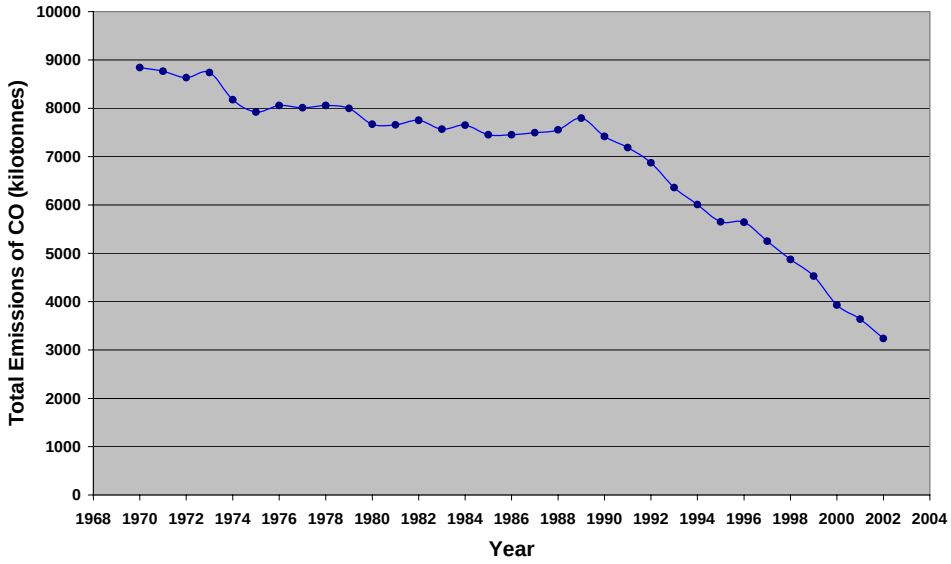
CO is one of eight NAQS Pollutants because of the potentially detrimental effects that it can have on human health. At worst case ambient levels e.g. in congested streets, car parks or tunnels exposure may reduce the oxygen-carrying capacity of the blood and impair oxygen delivery to the brain and other organs, particularly affecting those suffering from cardiovascular disease. Since traffic is by far the most important source of CO, its spatial distribution will follow that of traffic. This will generally result in the highest levels being observed in the city centre, where most congested areas tend to be found. Periods of cold, still atmospheric conditions during winter can further elevate levels by restricting the dispersion of CO gases.

The Update and Screening Assessment of CO carried out by Glasgow City Council in 2003 concluded that there were no exceedences of this objective at any site where sufficient data was available. In addition, no exceedences of the CO objective were expected at heavily trafficked sites in Glasgow. The highest background CO concentration recorded in the city is 0.488 mgm-3 (2001) and the average level is expected to be 0.375 mgm-3 (2001). The U&SA stated that a number of roads within Glasgow's boundary meet the criteria in terms of traffic flow but as the background concentration is so low it was not necessary to carry out screening at any roads or junctions, and therefore it can be assumed that there are no potential exceedences of the CO objective. At present there are no available data for background CO post-2001. Estimated annual mean background CO concentrations for 2001 are provided on the Air Quality website, www.airquality.co.uk/archive/laqm/tools.

The air quality objective for CO is 10 mg m^{-3} (8.6ppm) as a running 8-hour mean. Details of these objectives are presented in Table 1.2. Locations where this should be considered include all background and roadside locations up to the building façade 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 will be short.

Figures that have been taken from the NAEI website show that total UK emissions of CO from 1973 to 2002 have decreased by 63%. In 1973 CO emissions totalled 8740 kilo tonnes whereas in 2002 total CO emissions amounted to, a substantially lower, 3238 kilo tonnes.

Figure 2.22 Total UK Emissions of Carbon monoxide (1973-2002)



The pronounced decrease evident from the early 1990's is likely to be due to the introduction of catalytic converters, in conjunction with the development and improvement in engine and fuel technology. This decrease is also reflected in average CO concentrations in Glasgow (Figure 2.24).

Monitoring Methodology

Glasgow City Council measures ambient concentrations of carbon monoxide through the application of automatic analysers at six locations across the city (see section 2.0.1). Carbon monoxide concentrations are determined by the absorption of Infra-Red Radiation at a wavelength of 4.5-4.9µm. An Infra-red detector and amplification system produce an output voltage that is proportional to the CO concentration. Concentrations at all sites have been compared against the National Air Quality Strategy objectives (Table 1.2) and they are presented in Tables 2.18 – 2.20.

Monitoring Data

Table 2.18 Carbon monoxide results from Glasgow City Chambers

Year	Air Quality Objective (mg m^{-3})	Data Capture Rate (%)	Average annual CO concentration (mg m^{-3})	Maximum 8hr running mean (mg m^{-3})	Number of days exceeding standard
1999	11.6	99.96	0.69	4.2	0
2000	11.6	97.76	0.61	3.9	0
2001	11.6	97.74	0.62	7.3	0
2002	10	96.19	0.57	5.7	0
2003	10	97.52	0.58	2.6	0
2004	10	99.2	0.44	1.6	0

Table 2.19 Carbon monoxide data for Glasgow Centre

Year	Air Quality Objective (mg m^{-3})	Data Capture Rate (%)	Average annual CO concentration (mg m^{-3})	Maximum 8hr running mean (mg m^{-3})	Number of days exceeding standard
1999	11.6	97.61	0.46	4.5	0
2000	11.6	97.61	0.40	4.2	0
2001	11.6	96.56	0.45	8.6	0
2002	10	94.84	0.32	4.8	0
2003	10	80.53	0.33	2.3	0
2004	10	92.02	0.43	2.5	0

Table 2.20 Carbon monoxide data for Glasgow Kerbside

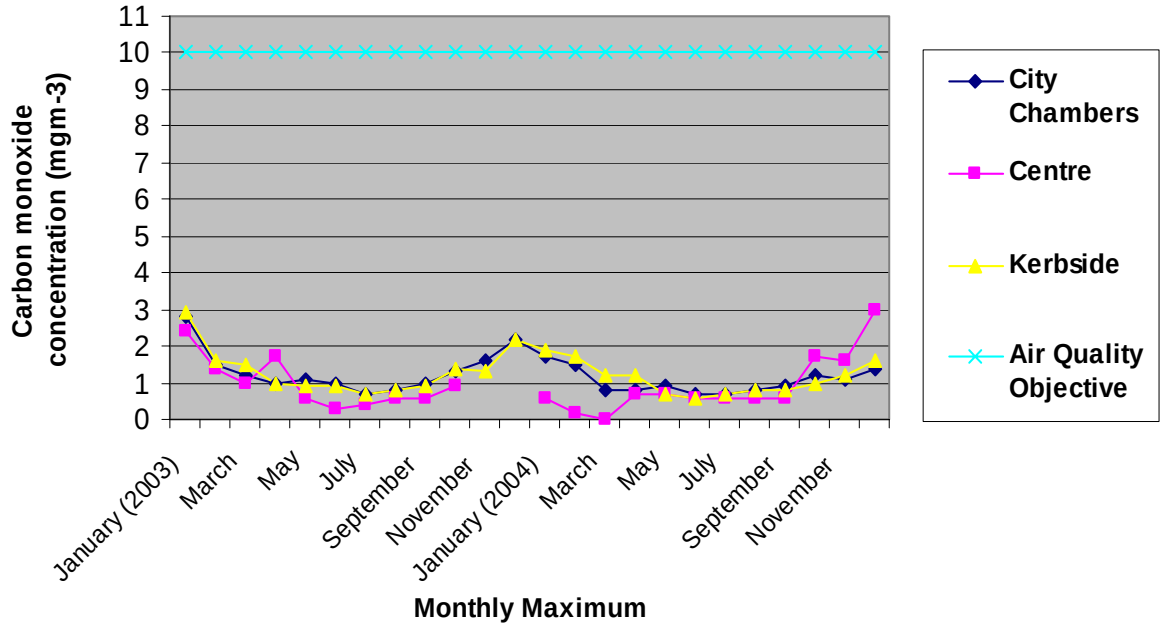
Year	Air Quality Objective (mg m^{-3})	Data Capture Rate (%)	Average annual CO concentration (mg m^{-3})	Maximum 8hr running mean (mg m^{-3})	Number of days exceeding standard
1999	11.6	97.17	0.82	4.4	0
2000	11.6	98.15	0.70	5.0	0
2001	11.6	98.81	0.66	6.7	0
2002	10	98.04	0.57	5.5	0
2003	10	96.38	0.51	2.7	0
2004	10	98.51	0.45	1.8	0

Data is presented for 2003, 2004 as results from 1999-2002 were covered in the U&SA and data from 2005 has yet to be ratified. This data will be updated and detailed in subsequent reports. The data

capture rate has been calculated for each site; both City Chambers and Glasgow Centre were above 90% whereas Kerbside has a capture rate of 80.53% for 2003. If data capture is <90% the results would usually be presented as percentiles. However, no exceedence of the objective has occurred since 1992 and all concentrations are very low. Therefore, the results have been presented in the standard form.

The following graph demonstrates the maximum 8hr mean CO concentrations from each AURN site as a monthly maximum (January 2003-December 2004).

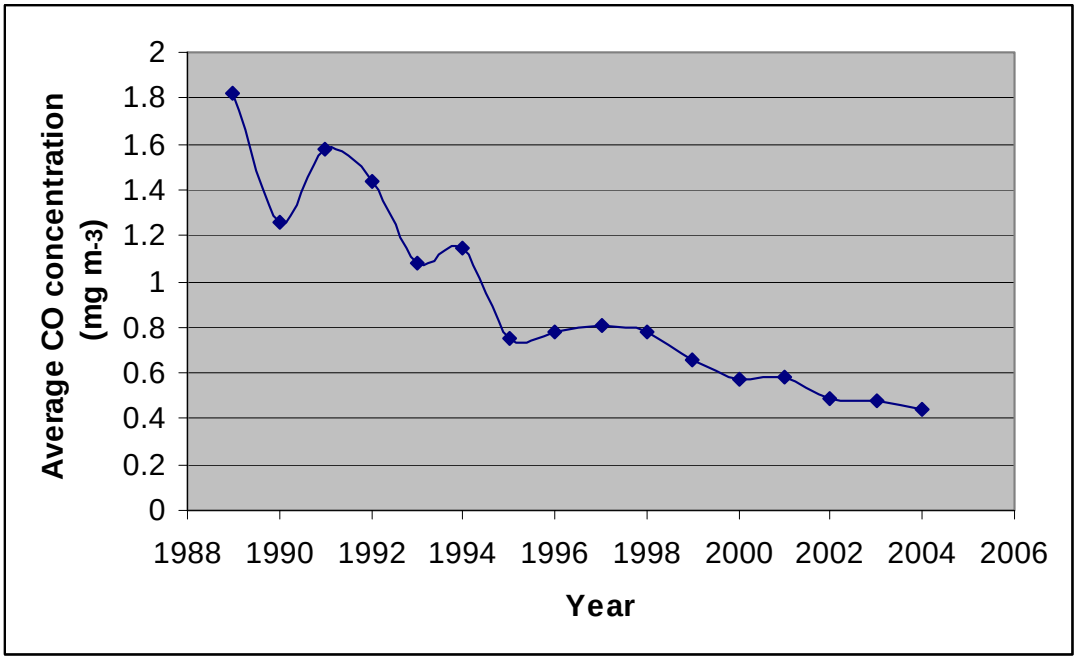
Figure 2.23 Maximum 8 hour means at AURN sites



Monitoring has shown that there were no exceedences of the CO objective at any AURN site in Glasgow. Generally, the recorded levels are very low; the highest CO concentration recorded was at Kerbside, measuring 2.9 mgm^{-3} on the 11th January 2003 (this is substantially less than the peak 8hr mean of 2001 (7.4 mgm^{-3} – 12/12/01)). Both of these occurred during a pollution episode, when meteorological conditions caused pollutants to accumulate and concentrations to increase considerably. The three AURN sites give a good indication of typical CO levels expected across the City as they range from an urban background site, giving typical exposure levels, to the kerbside site, which would be expected to show the worst-case results due to its proximity to traffic.

It is noticeable that average carbon monoxide levels have shown a downward trend in Glasgow since the early 1990's (see Figure 2.24), which can be attributed to improvements in engine technology and the introduction of catalytic converters. However, this may be offset in the future due to increasing numbers of vehicular traffic.

Figure 2.24 Average CO concentrations in Glasgow, 1989-2004



The presence of low average levels of CO in Glasgow is supported by the DEFRA estimates for urban background levels in Glasgow City Centre. However, the maximum 8-hour mean for CO, as specified in the National Air Quality Strategy, is poorly correlated with the annual average and it is evident that there have been occasional excursions to concentrations approaching that specified in the National Air Quality Strategy standard.

Areas of elevated concentrations of CO will exist, particularly on the roads which travel below bridges such as at Buchanan Galleries and the Heilan'man's Umbrella. However, it is questionable whether these sites represent areas of relevant exposure as individuals are unlikely to be exposed over the averaging period of the objective (8 hours). In terms of breaching the NAQS objective for CO, areas of more concern are those that are out-with the City Centre and are adjacent to heavily trafficked roads and/or contain housing. For example, the M8 corridor carries a traffic volume of over 50,000 vehicles per day, is subject to periods of traffic congestion, and is overlooked, in places, by housing. A short-term study was carried out in 1999 at two different locations; however, the results were inconclusive as a longer monitoring period would be required to make positive and accurate conclusions.

The more detailed analysis of CO in Stages II and III of the review assessment process imply that breaches of the National Air Quality Strategy objective for CO would not occur in 2005 at such locations. Combustion from domestic and commercial coal fires also needs to be considered. However, with the move away from coal burning as a means of heating, emissions of CO from this source have seen a massive reduction over the second half of the 20th Century. In fact, Glasgow is now completely covered

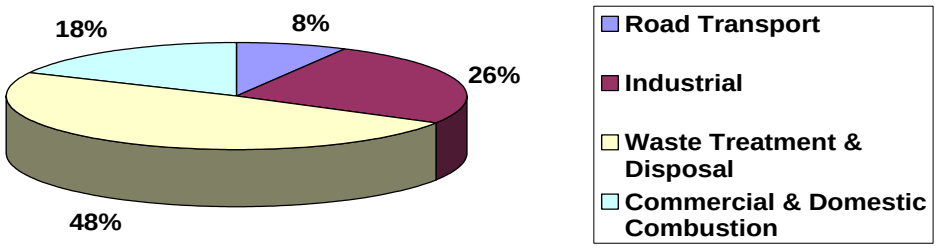
by Smoke Control Area Orders which restrict the circumstances under which certain types of combustion may take place. This is illustrated in Figure 2.21, which shows that domestic and commercial combustion only makes up 2% of all CO emissions in Glasgow. There are now no significant emitters of CO from industrial processes. From information obtained from SEPA there would appear to be no large single emitter of air pollutants outside of Glasgow that would have a significant impact on levels of CO within the city. Most of the gross emitters, such as fossil fuel-fired power generating plants, are some distance from Glasgow or are not situated in the direction of the prevailing wind.

It is therefore expected that CO levels will not breach the National Air Quality Strategy objective in 2005 throughout all of the city and during periods of adverse meteorological and traffic conditions.

2.1.5 Lead (Pb)

Lead is a naturally occurring element and is released by a variety of biogeochemical processes. However, anthropogenic activities represent the major sources of atmospheric lead; including processes such as ore mining and smelting, the manufacture, utilisation and disposal of lead-containing products and the combustion of fossil fuels. In recent decades road traffic emissions were the major source of atmospheric lead but since the sale of leaded petrol was banned in January 2000 emissions are now largely restricted to the industrial sector. It is thought that emissions have also declined due to the reduction in domestic coal burning. Therefore, lead has become a local rather than national problem.

Figure 2.25 Sources of Lead in Glasgow, 2002 (NAEI)



Lead is a heavy metal and exposure to which can have potentially serious effects on human health. Lead may enter the body via ingestion or through inhalation of lead-containing particles; after which it accumulates in various body tissues, such as bone, muscle and blood. The toxic effects of lead on humans vary depending on the extent of exposure; effects can include anaemia, osteoporosis and damage to the kidneys, liver and central nervous system.

The Air Quality objective was set at 0.5 µg m^{-3} to be met by 31 Dec 2004 but has since been tightened to 0.25 µg m^{-3}; as an annual mean, which has to be met by 31st December 2008.

Monitoring Methodology

Glasgow operates six metals monitoring sites (includes lead monitoring), one of which is a national network site. The principle of operation is similar to that of the smoke monitor, in that a measured constant volume of air is pulled through a filter. The particulate material is gathered on the filter and analysed using wet chemical techniques to determine the concentrations of: Aluminium, Cadmium, Chromium, Copper, Iron, Nickel, Vanadium, Zinc and Lead.

A standard protocol was used to determine atmospheric lead concentrations. Air is sampled by drawing air through a cellulose filter at a rate of 5 Lmin-1 for periods of 7 days, with lead concentrations determined by atomic absorption spectroscopy.

Monitoring Data

Table 2.21 Lead levels measured at various Glasgow locations

	Year							
Location	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
City Chambers	0.045	0.026	0.023	0.041	0.023	0.031	0.027	0.003
Glasgow Cross	0.039	0.025	0.019	0.024	0.041	0.033	0.028	0,003
Carmyle	0.027	0.009	0.043	0.015	0.013	0.026	0.031	0.003
Dalmarnock	0.029	0.012	0.014	0.041	0.026	0.026	0.027	0.010
Shettleston	0.060	0.039	0.027	0.031	0.043	-	-	-
Charing Cross	0.044	0.030	0.020	-	-	-	-	-
Fastnet Street	-	-	-	-	-	0.027	0.021	0.031
St. Anne's Primary	0.044	0.029	0.020	0.017	0.025	0.015	0.015	0.014
Baillieston	-	-	-	-	-	-	0.038	0.020

All units are expressed in µg m^{-3}

Annual averages recorded at all sites within Glasgow are significantly below the Air Quality Strategy Objective (0.25 µgm^{-3}). It is therefore unlikely that there will be any breaches of the objectives for lead at any of the Glasgow locations.

2.1.6 Benzene

Benzene is a Volatile Organic Compound (VOC) and is an additive to vehicle fuel. In their 1994 report, EPAQS recommended an air quality standard of 16.25 μgm^{-3} as a running annual mean; a level which they concluded represents an exceedingly small risk to health. The longer-term aim of policy was to reduce concentrations of benzene as far as practicable to a level of 3.25μgm^{-3} by 2005. The objective for Benzene is currently 3.25μgm^{-3} measured as a running annual mean to be met by 1 January 2010.

In the UK, the main atmospheric source is the combustion and distribution of petrol, of which it is a minor constituent. Benzene is also formed during the combustion process from aromatics in the petrol and also from stack and fugitive emissions. Diesel fuel is a relatively small source. The amount of benzene in petrol is below 1%. The main outdoor sources of benzene remaining beyond 2005 are expected to be:

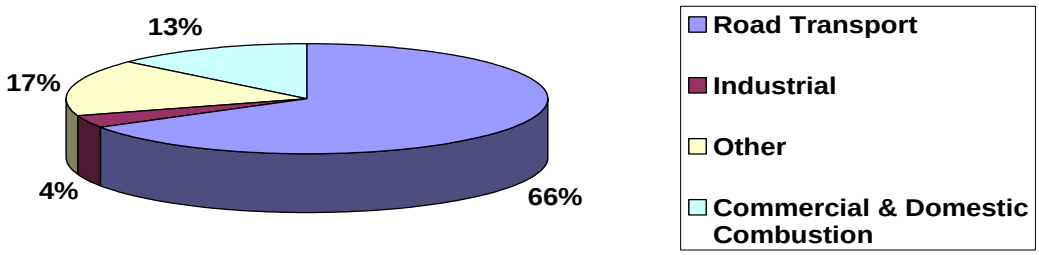
- Petrol-engine vehicle exhausts;
- Petrol refining and distribution;
- Uncontrolled emissions from petrol station forecourts without petrol vapour recovery systems.

A number of significant policy developments since 1997 will contribute to reducing concentrations of benzene in ambient air. The Auto-Oil programme has brought agreement to:

- Reduce further the emission limits for cars, light vans and heavy duty vehicles sold from 2001 and 2006;
- Reduce the amount of benzene (to 1%) and aromatics in petrol from 1 January 2000; and
- Reduce the sulphur content of fuels from 2000 and again from 2005.

It is also expected that emissions of benzene from petrol station forecourts will be reduced with new controls to supplement existing legislation controlling petrol vapour emissions during storage and distribution.

Figure 2.26 Sources of benzene in Glasgow, 2002 (NAEI)



In Glasgow, emissions are dominated by the road transport sector; this constituted 66% of total emissions in 2002. Benzene emissions also arise from commercial, domestic and industrial combustion in addition to other transport sectors i.e. air, rail and shipping. UK emissions have been steadily decreasing since 1990, which is primarily due to the introduction of catalytic converters. In addition, EU legislation, effective since January 2000, stated that the maximum benzene content of petrol is to be 1% (previously 5%). Decreases in emissions due to improvements in vehicle engines have also been seen and emissions from domestic and industrial sectors are also falling. However, these reductions could be offset by the increase in traffic volume on the roads.

During the Stage I report for benzene, no major industrial processes were identified as a significant emitter of benzene. There have been no new industrial processes, or changes to existing processes, that would have lead to an increase in benzene emissions in Glasgow since then.

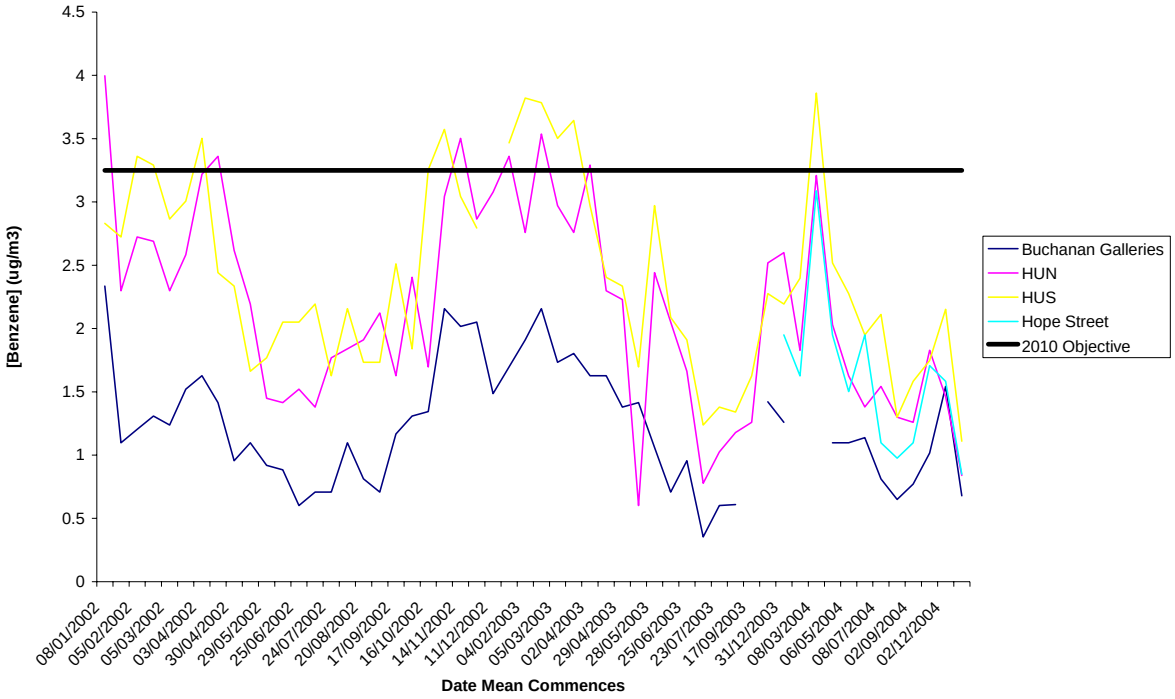
Glasgow City Council currently operates a relatively small Benzene tube network; four tubes are located within the city centre. Three diffusion tubes are roadside sites and are also situated underneath a canopy. Two of the monitoring sites are on opposite sides of Argyle Street under the Heilan'man's Umbrella, the railway bridge that carries rail traffic over the river Clyde and into Central Station. The third site is on the enclosed roadway under Buchanan Galleries, on Cathedral Street. The fourth is co-located at the Glasgow Kerbside AURN site. Therefore, these diffusion tube sites represent the 'worst case' benzene concentrations in ambient air. For this reason, dispersion will be very low and measured benzene concentrations will be higher than normally expected.

Monitoring methodology

The diffusion tubes contain a stainless steel mesh disc (closed end) which has been coated with chromasorb absorbent. The tubes work on the principle of molecular diffusion; with molecules of benzene gas diffusing from a high-concentration area (open end) to a low-concentration area (closed end) where ambient benzene accumulates. A mass spectrometer is used to analyse the sample tubes and to determine the concentration of benzene at each location. Tubes were initially exposed for a period of two weeks but in late-2004 the sampling period changed to monthly exposure.

These tubes are prepared and analysed by Glasgow's Scientific Services which holds UKAS accreditation.

Figure 2.27 Benzene diffusion tube results



On occasions the monthly results at both Heilan'man's Umbrella sites have occurred. However, due to the generally lower values observed at this site, breaches of the annual running mean are unlikely. Since these sites are no longer failing the 2010 objective, it is extremely unlikely that there would be any other sites that might fail the objective.

In addition to the diffusion tubes, there is an automatic hydrocarbon analyser located within Hope Street (Glasgow Kerbside AURN). This analyser works through gas chromatography and monitors a number of

different hydrocarbon species, including both Benzene and 1, 3-Butadiene. The results from this method also indicate that Glasgow is unlikely to fail the objective for these pollutants (see Table 2.22 overleaf).

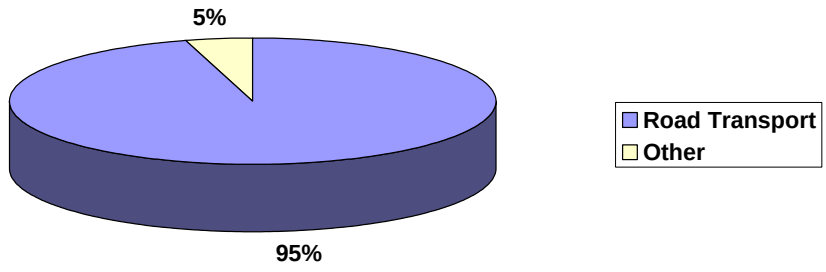
Table 2.22 Annual Means of Measured Benzene Concentrations (µg m^{-3})

	2002	2003	2004	Maximum Annual Running Mean (2004)
Glasgow Hope St	2.33	1.82	1.40	1.82

2.1.7 1, 3-Butadiene

1, 3-Butadiene is a gas at normal temperatures and pressures and trace amounts are present in the atmosphere, deriving mainly from the combustion of petrol and of other materials. It is also an important chemical in certain industrial processes, mainly the manufacture of synthetic rubber for tyres, and is used in bulk in these procedures. However, there are no industrial sources like this in or around Glasgow; therefore motor vehicles are the dominant source of 1, 3-butadiene.

Figure 2.28 Sources of 1, 3-Butadiene in Glasgow, 2002 (NAEI)



The emission limits agreed for cars, light vans and heavy-duty vehicles sold from 2001 and 2006 and fuel quality standards agreed for 2000 and 2005 as part of the Auto-Oil programme will both contribute to reduced emissions of 1,3-Butadiene. The Air Quality Strategy states that "maximum recorded concentrations at roadside locations are expected to be about 1.13µgm^{-3} (0.05ppb) by 2005".

The objective for 1, 3-Butadiene is 2.25 µgm-3 (1ppb), measured as a running annual mean. In view of the health effects of 1, 3-Butadiene and advice from EPAQS, the objective of national policy should be to reduce concentrations to as low a level as is reasonably practicable such that they represent an exceedingly small risk to human health. The health effect that is of most concern is the induction of cancers of the lymphoid system and blood-forming tissues, lymphomas and leukaemia. Like benzene, 1,3-butadiene is a genotoxic carcinogen, and so no absolutely safe level can be defined.

The measures introduced or adopted by the Government have led to dramatic falls in 1, 3-Butadiene levels and will continue to do so. These will deliver significant improvements in air quality and it is believed that the 1997 objective will be achieved well before the end of 2005. EPAQS considered that its recommended standard for this pollutant should be reviewed after a period of five years, in the light of additional data on human health and the experience of improved pollution control.

Monitoring Methodology

Currently GCC does not operate a monitoring network for 1,3-butadiene. However, we can compare benzene levels to levels of 1,3-butadiene as they are closely correlated. An automatic VOC monitoring station was installed at Glasgow Kerbside on August 1st 2002; data has been downloaded from www.airquality.co.uk/archive and is presented below.

Monitoring Data

Table 2.23 Annual means of measured 1,3-Butadiene (µg m^{-3})

	2002	2003	2004	Maximum Annual Running Mean (2004)
Glasgow Hope St	0.36	0.42	0.28	0.45

The data from the automatic analyser shows that measured values of 1,3-Butadiene at this location are significantly below the National Air Quality Strategy Objective (2.25 µgm^{-3}).

2.2 NEW AIR QUALITY MONITORING SITES

Glasgow's extensive network of air quality monitoring equipment is continuing to provide data on pollution levels within the City and the AQMA. A new roadside monitoring station, which has NO_2 and PM_{10} analysers, was installed in spring 2005 in the Battlefield area of the City (258421, 661384). This site

was chosen due to a gap in the spatial distribution of monitoring sites on the south-side of Glasgow. Ideally, the AQ monitoring station would have been positioned at the busy cross-junction at Victoria Infirmary but unfortunately there was no suitable location in this particular area and therefore the 'next-best' alternative site of Battlefield Road was chosen. Air quality data is only available from this site for a small number of months and thus definitive conclusions and evidence of trends cannot be shown at this point in time.

In addition, it is planned to install a compact monitoring station at one of Glasgow City Centre's busy train stations to monitor levels of SO_2 and PM_{10} by early next year.

It is also planned to review the deployment of NO_2 diffusion tubes within the City to ensure that the actions above can be monitored to show improvements to air quality resulting from their implementation.

2.3 UNREGULATED POLLUTANT MONITORING

In addition to monitoring NAQS pollutants Glasgow City Council also undertake monitoring of unregulated pollutants such as Ozone. Details of their respective monitoring methodologies and results are presented below.

2.3.1 Ozone monitoring

Ground level ozone is not emitted directly to the air; it is formed by a complex series of chemical reactions involving precursor pollutants – NOx and hydrocarbons – together with oxygen. Ultraviolet radiation drives these reactions and, as a result, ozone production rates are highest in hot, sunny weather. Ozone formation can occur over a timescale of a few hours to several days. As a result, concentrations are decoupled temporally and spatially from precursor sources and ambient concentrations are strongly dependent on meteorological conditions, together with scavenging and deposition rates. Ozone tends to be higher during hot summers, when higher temperatures and bright sunlight speed up chemical reactions between nitrogen oxides, carbon monoxide and volatile organic compounds (VOCs) to form ozone. Concentrations in busy urban areas are often lower than in the surrounding countryside. This is because road transport emissions react very quickly with ozone to remove it from the atmosphere. Because ozone is very reactive, it is also readily deposited onto the ground or adsorbed onto vegetation.

A natural background ozone concentration exists in the atmosphere due to mixing of ozone from the stratosphere and its generation in the troposphere. The background concentration depends on latitude

and time of year; in the UK measurements show the resulting annual average background concentration to be about 70 µg m^{-3}.

The Air Quality Strategy has only set a provisional objective for ozone (100 µgm^{-3}) not to be exceeded more than 10 times per year and which has to be met by 31st December 2005. This has not been included in the regulations because of the transboundary nature of ozone and the need to deal with the pollutant on a European scale. Ozone is a highly reactive oxidising agent with a wide range of material, vegetation and human health impacts. Acute health effects of ozone may include eye/nose irritation, respiratory problems and airway inflammation.

Monitoring Methodology

Measurement of ozone is based on the absorption of UV light by ozone. The absorption by an air path with no ozone present is measured to give a reference intensity. The absorption of the ozone containing sample is then measured. The ozone concentration is calculated using the Beer Lamberts absorption equation.

Monitoring Data

Table 2.24 Monthly maximum ozone concentrations at Glasgow Centre

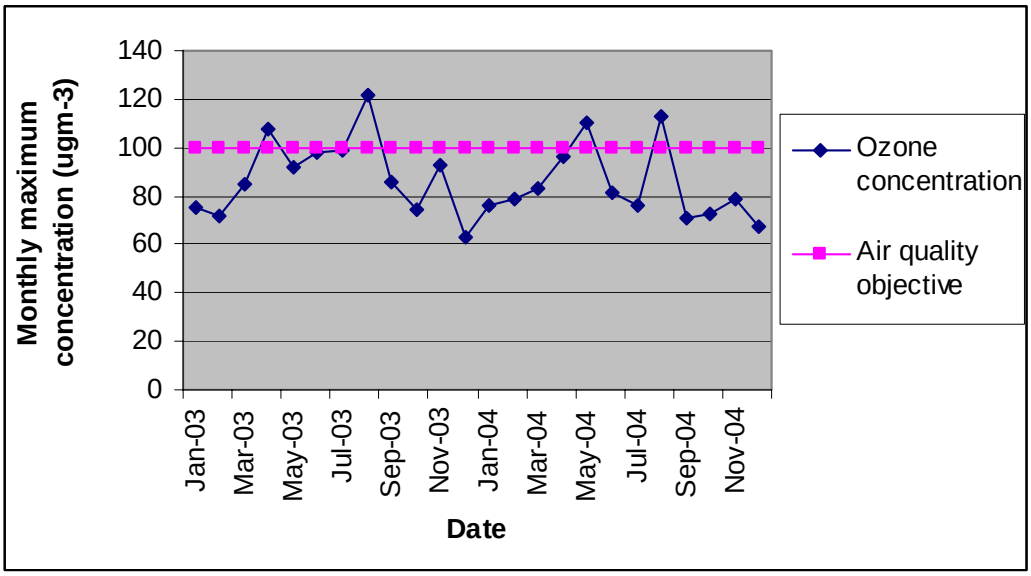
	Monthly maximum concentration (µgm-3)	Air Quality Objective (µgm-3)
January (2003)	75	100
February	72	100
March	85	100
April	108	100
May	92	100
June	98	100
July	99	100
August	122	100
September	86	100
October	74	100
November	93	100
December	63	100
January (2004)	76	100
February	79	100
March	83	100
April	96	100
May	110	100
June	81	100
July	76	100
August	113	100
September	71	100

October	73	100
November	79	100
December	67	100

Table 2.25 Summary of Ozone data

	2003	**2004**
Annual mean concentration (µgm^{-3})	34	37
No. of exceedences of 100 gm-3 (maximum rolling 8hr mean)	3	2
Data capture rate	96%	98%

Figure 2.29 Maximum 8hr mean ozone concentration



It can be seen that there have been a small number of excursions above the air quality objective of 100 ugm-3. Figure 2.29 shows that these breaches occurred in April and August in 2003 and in May and August 2004. A likely explanation for these breaches is summer oxidant episodes, during which low atmospheric dispersion can cause ozone levels to dramatically increase.

3.0 NEW DEVELOPMENTS

Since the completion of the GCC Detailed Assessment 2004, there have been a number of developments in Glasgow that may have implications for local air quality. These range from small industrial processes through to major commercial/residential and road network development projects.

New developments which may have an effect on air quality are to be considered in the Progress Report. Following the guidance LAQM.PRG (03), these developments are noted for possible further assessment in the next round of review and assessment.

There are a wide range of developments which can have an effect on air quality, both positively and negatively. These could be such things as the building of a new industrial process or a change to the road network. Other developments which may impact on air quality include developments such as supermarkets with large car parks, airport expansions or residential developments within air quality management areas.

The impact of these developments on exposure must also be considered.

3.1 Industrial Processes and Developments

The Scottish Environment Protection Agency (SEPA) has responsibility over prescribed processes in Scotland. SEPA authorise Part A and B processes and set conditions to limit emissions from them, which places them under an obligation to use 'the best available techniques' to prevent or minimise pollution. The SEPA public register was examined and enquiries made to SEPA staff in order to determine if there were any new regulated processes or if any regulated processes had varied emissions significantly since the last round of review and assessment.

3.1.1 Part A installations

Industrial developments may result in the emission of a number of pollutants to the air. Such developments are detailed below. There are a small number of industrial processes in Glasgow that have the potential to emit significant quantities of NAQS pollutants (see Table 3.1) but it is believed that no

new industrial processes commenced operation or changed significantly since the last round of R & A. However, it should be noted that there is at least one industrial development which is likely to come into operation in 2005; Tennent Caledonian Brewery Ltd has applied for a new PPC permit, which is currently under consideration by SEPA. At present, the brewery has three gas fired boilers and capacity for burning fuel oil. It is situated within close proximity to the AQMA so therefore has the potential to significantly impact on the local air quality. Emissions data is unavailable at the present time but will be accessible from SEPA public registers within subsequent months. If a significant impact is predicted then GCC may study the air quality in the vicinity of Tennent Caledonian Brewery Ltd more closely.

Table 3.1 Existing industrial processes (Part A) which have a high potential to emit NAQS pollutants

Name	Type	Potential to emit	Process	Location
Allied Distillers	A	PM_{10}	Combustion	259832, 663996
Sacone Environmental	A	NO_2, PM_{10}, SO_2, CO	Incineration	263821, 664591
SMW Daldowie Ltd	A	NOx, CO	Sewage sludge derived fuel plant	267201, 661997
Tennent Caledonian Brewery Ltd	A	NO_2, CO, SO_2	Brewing process	260495, 665258
Patersons of Greenoakhill Ltd	A	PM_{10}	Landfill site	267140, 662523

These industrial processes were addressed during Stage III and looked at briefly during the U&SA. The conclusion reached in these reports was that these processes would not result in any exceedences of the air quality objectives.

In relation to industrial emissions of PM_{10}, Glasgow City Council's Updating and Screening Assessment (2003) concluded that as there were no new or existing industrial sources with significantly increased emissions of PM_{10} a detailed assessment was not required. However, due to the more stringent objectives introduced for PM_{10} in relation to 2010, the report also recommended that emissions from existing industrial sources in Glasgow be reassessed against the new objectives.

In response to this recommendation, Glasgow City Council proposed to introduce a monitoring programme to assess ambient concentrations of PM_{10} at relevant locations in the vicinity of A. Cohen and Co. and United Distillers. The results from this monitoring programme and air-dispersion modelling from each location will be presented in future review and assessment documents.

Glasgow City Council will continue to liaise with SEPA to collect information on the progression of such projects and any potential air quality impacts that could occur. This information will be presented, if appropriate, in future air quality review and assessment reports.

3.1.2 Part B installations

A number of Part B processes have been authorised in Glasgow since the U&SA. The following installations were previously defined as Part A processes but as of June 2005 they have been re-classified as Part B.

Table 3.2 Part B processes (previously Part A)

Name	Type	Potential to emit	Process	Location
A Cohen & Co	B	NO_2, PM_{10}	Non-ferrous metals	254298, 664460
United Distillers	B	PM_{10}	Grain drying	259155, 666710
British Bakeries Ltd	B	NOx, CO, VOCs	Treatment of vegetable raw materials for the food industry	261763, 665051

3.2 New Transport Developments

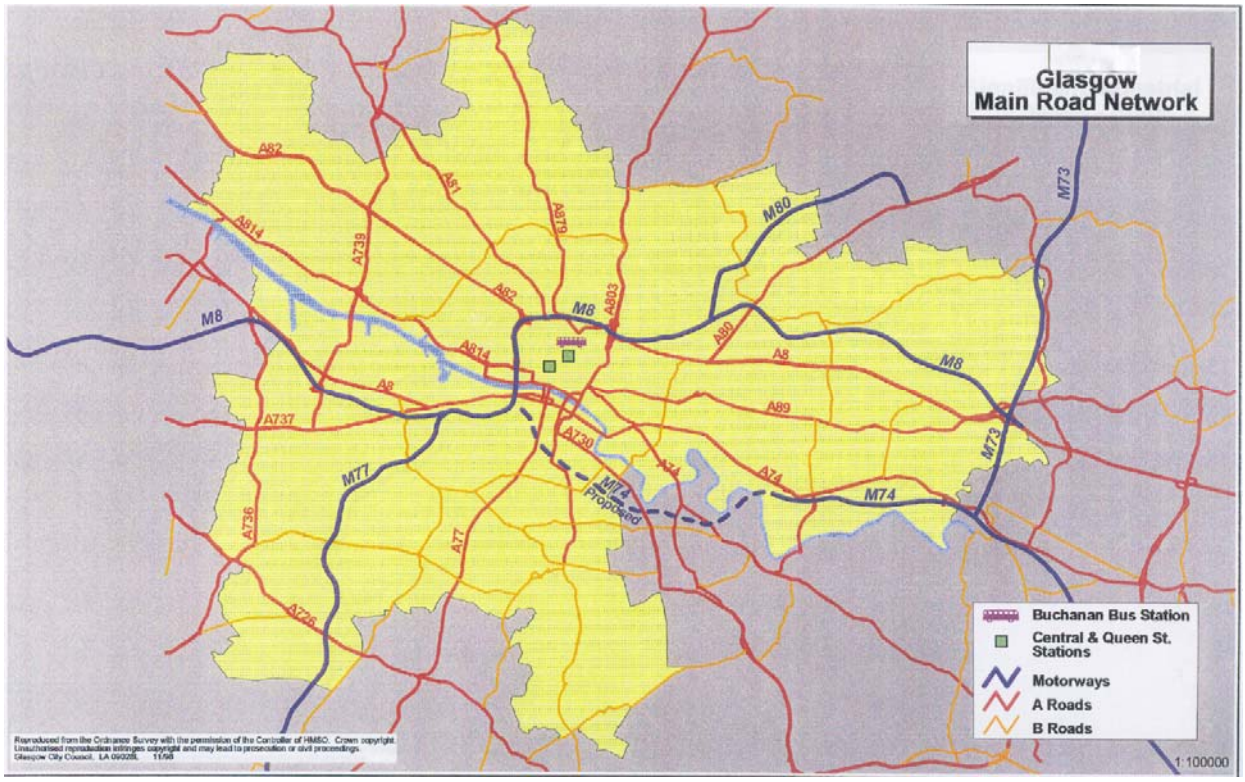
Glasgow has developed as a major nodal point of the Scottish transport system. It has an extensive road network which is outlined on the map below. There are currently 40km of motorway and 1700km of other public roads.

The backbone of the road system is the M8 motorway which runs through the City and continues to Edinburgh (A8/M8). At the Baillieston Interchange the M8 links, via the M73, with the M74/A74 route to Carlisle and the south, and with the M73/A80 route to Stirling and the north. The M77 (Ayr road route) was completed in November 1996 and runs through the south west of the City. It has also been

proposed to extend the M74 motorway through the east of Glasgow to converge with the M8 to the south of the City centre. This is discussed further later in this report.

Several other major routes radiate from the city. These include the Clydeside Expressway, Great Western Road, Springburn Road, Cumbernauld Road, Edinburgh Road, London Road, Paisley Road West and the M80 Stepps bypass.

Figure 3.1 – Glasgow's main road network



A large proportion of journeys along these routes are by private cars commuting to the City often from areas outwith the City boundary. As a result there is frequent overloading of routes leading to the City during peak periods.

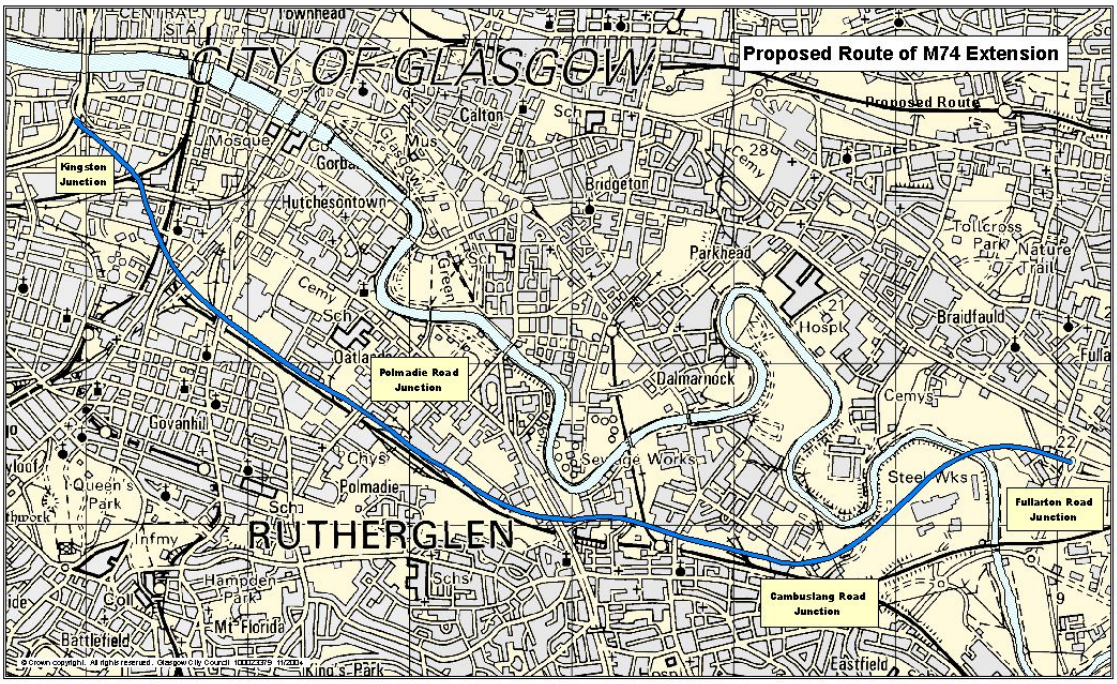
3.2.1 New / Proposed Roads

Glasgow City Council's Updating and Screening Assessment 2003 outlined the need to assess the impact of new or proposed roads on local air quality. In relation to this a detailed assessment was carried out regarding the proposed M74 extension, details of which are presented below. The East End Regeneration Route (EERR) is another major road that is currently at the planning stage. Although the EERR is being introduced primarily to aid in the successful regeneration of the east end of Glasgow, it will have the benefit of improving congestion and will have some benefits for air quality.

3.2.1.1 Proposed M74 extension

The existing M74 terminates at Fullarton Road in the south east of Glasgow, with a 'missing link' between here and the Kingston Bridge. Work is currently still in development, however, it is planned to complete the 5 mile link from the Fullarton Road Junction to the M8 just west of the Kingston Bridge, and have this section of road open to traffic by 2008. Obviously, such a major road may have implications for local air quality. The proposed line of the route is shown in Figure 4.1.

Figure 3.2 Proposed route of M74 extension



A full assessment of the likely air quality impacts of the M74 completion was undertaken as part of the E.I.A for the scheme and reported in the Environmental Statement. Environmental Resources Management Ltd (ERM) conducted this on behalf of Glasgow City Council to inform the public, the Scottish Ministers and organizations with statutory and non-statutory interests in the environment of the likely environmental effects of the works. The findings of the assessment, including the measures that will be taken to avoid, reduce or remedy adverse impacts are reported in the ES.

In terms of the predicted impact on NO_2 concentrations in Glasgow, the ES concluded that although a long term overall improvement in air quality is predicted with some 96 % of residential properties in the wider study area expected to experience a reduction in NO_2 concentrations; detailed modelling identified some increases in NO_2 concentrations close to the road corridor which could potentially result in exceedences of the air quality objectives.

Subsequent discussions between the appointed agents Environmental Resources Management and the Scottish Executive resulted in the recommendation that additional information on air quality in the vicinity of the proposed route prior to, during, and after construction of the scheme would be of benefit. This would allow an assessment of the direct impacts of the M74 completion in the route corridor and on background air quality.

Following further discussions between the appointed agents with representatives of Glasgow City Council (Land Services Design), the report M74 Completion: Air Quality Proposed Monitoring Study (2002) was prepared, and recommended the pollutants and locations to be monitored together with appropriate methodology. The study recommended monitoring of PM_{10} particulate matter twice every year (2 weeks during both summer and winter periods) by Glasgow City Council Environmental Protection Services at relevant sites near to the proposed M74 extension. In addition, Land Services are undertaking diffusion tube monitoring of NO_2 at 56 sites and benzene at 4 sites along the proposed route. Once the construction of the road is complete and it is open to traffic, monitoring results can be analysed to determine the impact of the road on local air quality.

In terms of the predicted impact on PM_{10} concentrations in Glasgow, the ES concluded that although a long term overall improvement in air quality is predicted with some 56 % of residential properties in the wider study area expected to experience a reduction in particulate matter (PM_{10}) whilst 1% will experience no change; detailed modelling identified some increases in PM_{10} concentrations close to the road corridor which could potentially result in exceedences of the air quality objectives. The study recommended monitoring of PM_{10} twice every year (2 weeks during both summer and winter periods) by Glasgow City Council Environmental Protection Services at relevant sites near to the proposed M74 extension.

The programme for construction of the scheme is currently subject to delay as a result of an appeal being lodged against the making of the road orders for the scheme. Consequently, the programmed date for opening of the road by 2008 will not now be achieved. In view of the legal challenge it is currently estimated that the completion date for the M74 will be delayed by 18 to 24 months to 2010, subject to the appeal being dismissed.

3.2.1.2 East End Regeneration Route (EERR)

The first element of what is now the EERR, the Parkhead Bypass, was opened in 1988 and runs from the Gallowgate roundabout to the forge roundabout. The development is currently at planning stage and has the potential to be completed in 2008.

A road, such as the EERR, was first proposed in the *Highway Plan for Glasgow, 1965*. Various bids for funding of the route have been made over the years. However, in 1996 the then Scottish Office announced an urban regeneration policy framework under the Programme for Partnership Initiative (PfP). Glasgow's east end was one of twelve new Priority Partnership Areas (PPAs) designated in Scotland.

The main benefits that a new road, such as the EERR would bring to the area are:

- Relief of traffic congestion on existing roads in the area, leading to reduced NOx emissions and improvements to NO_2 levels within the AQMA, especially at its eastern boundary
- Improved access for construction traffic to facilitate development
- Improved distribution of traffic from existing and new developments, including Celtic Park

The provision of an intermediate junction on the M74 at Polmadie provided the opportunity to connect the EERR to the strategic road network at both terminal points, i.e. M74 at the southern end and the M8/M80 at the northern end. This enables the EERR to provide improved access and the opportunity to regenerate the large tracts of vacant and derelict land located at the heart of the east end. Transport Assessment Reports have been carried out for the proposed EERR by consultants MVA, using the Saturn model.

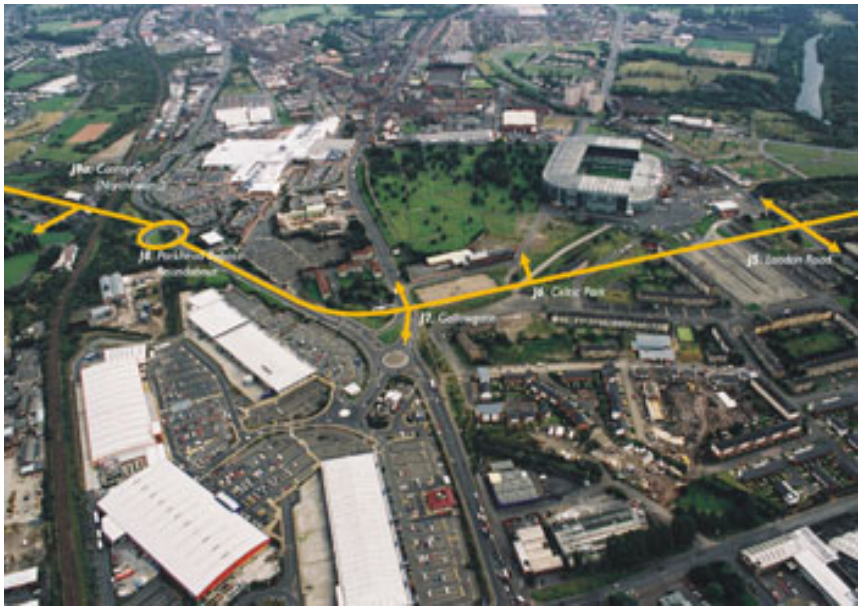
The proposed route will also have direct links to a number of rail and bus networks, this in itself will support and encourage the sustainability of integrated public transport. Near Dalmarnock Station, a new park and ride car park (400+ spaces) is proposed with direct access to the EERR, in addition to the Parkhead park and ride site. However, these are not part of the EERR proposal but provision has been made in the design for their future specification by others.

In addition to rail services, there are proposals for Quality Bus Corridors (QBCs) in the vicinity of the EERR. QBC1, which runs from Faifley to Baillieston, has now been completed with works at Glasgow Road in Baillieston completed in August 2005 and works in Partick completed in May 2005. Three other QBCs have also received funding; QBC5 (Dalmarnock Road/London Road), QBC6 (Edinburgh Road/Alexandra Parade) and QBC8 (Duke Street). All three corridors cross the EERR, providing opportunities to link new bus services on the QBCs with the EERR.

The development is predicted to have a neutral effect on emissions of NAQS Pollutants including NOx within the AQMA. However, some localised improvements in air quality are predicted due to reduced traffic congestion and the provision of improved public transport facilities.

Figure 3.3 – Aerial view of the proposed route of the EERR

Figure 3.4 – Aerial photograph of the proposed route of the EERR



3.2.1.3 The Finnieston Street Road Bridge

Funded by Glasgow City Council and Scottish Enterprise Glasgow, the Finnieston Street Road Bridge was granted planning permission in May 2003. Work is currently underway to construct the bridge which will arch 17ft above the Clyde and will link the north and south banks of the river between Finnieston Street and Govan Road. It will accommodate four lanes; two lanes dedicated to public transport and two for private and commercial traffic, with additional pedestrian and cyclist paths. One of the key features of the 140m span is a capability to cope with the addition of a light transport system, such as a tram, in the future. The bridge is expected to be open to traffic by July 2006.

Figure 3.5 – View of the proposed Finnieston Bridge

Glasgow City Council, as the Planning Authority, required an assessment of the impact on air quality from or associated with the completed development to be carried out. It was suggested that a screening model such as DMRB (Design Manual for Roads and Bridges) was used to carry out the initial air quality assessment. It was recommended that if exceedences were predicted then a further study should be undertaken using a detailed model such as ADMS-Roads.

The local AQ assessment considered the pollutants NO_2, PM_{10}, CO, Benzene and 1,3-Butadiene. It has shown that for the latter three pollutants all predicted levels are well below their respective objectives for the situations in 2005 and 2020, both with and without the bridge. Although exceedences of both the NO_2 and PM_{10} objectives (2005, 2010, 2020) are predicted in certain locations improvements in air quality are also expected. To this end, the report suggests that any negative air quality impacts will be balanced out by the positive impacts on air quality and thus, the construction of the Finnieston St Road Bridge will not have a significant effect on the air quality of the local area. Also, due to the conservative nature of the DMRB model it states that a further air quality study using a detailed model such as ADMS-Roads is not required. In addition, it concludes that "a significant proportion of airborne particles are secondary from large-scale atmospheric processes, adding therefore to the general regional pollution background".

3.2.2 Significant changes to existing roads

3.2.2.1 Pre-LRT Project

This project will build on the work of the recently completed Clyde Corridor Transport Study 2004, which identified a need for a Pre-LRT strategy to address the unique regeneration opportunities and development pressures on the north bank of the Clyde. SPT are now intending to seek funding to carry out a study into the LRT needs of the wider city conurbation which would include the recommendation

for a core network serving the north bank (city centre to Glasgow Harbour); south bank (city centre to the Southern General Hospital); and the city centre.

State-of-the-art monorails and conventional tram-on-rails (LRT) were considered as the most likely modes of transport for this project and it was concluded that although the monorail could provide benefits to certain parts of the network it did not offer the same level of benefits as the LRT. However, it is believed that the timescale to implement the LRT system would be in excess of ten years. Therefore, although LRT may ultimately provide the best solution, it would not meet the shorter term needs of this corridor. To address the regeneration pressures, which are particularly prevalent on the north bank, the City Council and SPT wish to bring forward a project which will be delivered by December 2007 when the majority of the regeneration developments in this corridor would be complete or in the latter stages of completion. It would provide an ultra modern bus based system operating a six minute service frequency between Glasgow City Centre and Glasgow Harbour. It is the intention that in the longer term the dedicated corridor can be modified to accommodate a full LRT system, assuming the design criteria for the 'Pre-LRT' route did not preclude its future design and implementation.

The introduction of this high quality bus based system is intended to provide an alternative to public transport associated with commuters and visitors along the corridor. It is expected that the Pre-LRT system will improve accessibility to the areas of recent, ongoing and proposed regeneration on the north of the River Clyde between the city centre and Whiteinch. It would provide a major element of the core network and aid in establishing the early patronage and economic case for the wider conurbation LRT system.

The scoping report for this study corridor has identified aspects of the route and its operation where there are potential environmental impacts. In terms of air quality, it is believed that the scheme will improve air quality, particularly if queuing traffic on the Clydeside Expressway can be reduced.

3.3 New Residential, Commercial and Public Developments

3.3.1 Queen's Dock 2 (QD2) Development

Occupying the site of the former Queen's Dock, the SECC is Scotland's national venue for indoor public events and is also the UK's largest integrated exhibition and conference centre. Along with the iconic Clyde Auditorium, the complex includes major exhibition and performance spaces.

A Master plan was presented to the City Council in February 2004. The architects Foster and Partners along with Arup Engineering Support have been appointed to develop the arena and infrastructure proposals. The masterplan is comprised of a series of components to create a complex that will meet the anticipated growth of the exhibition, conference and events markets in the 21st century and integrate with the City's vision for the regeneration of the River Clyde. These principal components are:

- the reconfiguration of the operational and service requirements of the current facilities, including multi-storey car parks;
- the development of a 'sustainable residential village' looking towards the river to the west of the SECC (comprising up to 1570 residential units, 2500m^3 of retail and commercial space, nursery school and doctor/dentist facilities);
- the development of an 'east end' to extend the SECC's facilities comprising a 12,500 seat indoor arena, service area, and multi-storey car park;
- the formation of new public spaces overlooking the river including a civic square fronting the 'east end' and Clyde Auditorium;
- new pedestrian and public corridor to meet the City's aspiration for a Pre-LRT and a light rapid transport through the developments connecting to:
    - river pontoons at the river edge;
    - new 'arrival building' linking the Finnieston Station pedestrian bridge and the existing exhibition halls and
    - upgraded connection to Clydeside Expressway.

The impact of the proposed development on air quality has been assessed and the E.S, prepared by Arup Scotland, aimed to identify potential sources of air pollutant emissions and consider their impact on local AQ in the vicinity of the site. The construction effects were assessed through a qualitative assessment of potential sources of emissions from construction activities (2006-2012) and through the formulation of appropriate mitigation and control measures. Operational traffic effects were assessed using a detailed air quality model – CALINE 4 and predicted pollutant concentrations were then compared with the relevant AQOs. Operational plant emissions were also considered in the E.S.

In the absence of mitigation, the potential effect on air quality during demolition and construction phases is considered to be minor adverse. These adverse effects should be greatly reduced by the effective implementation of dust control measures.

The main potential sources of emissions during operation will be from traffic travelling to and from the proposed development. There will be some additional emissions from extraction systems and general utility plant associated with the buildings on site but this information was unavailable when the E.S was

undertaken. The local impacts associated with this type of source are generally small and not considered significant. Pollutant concentrations have been forecast at selected properties (receptors) where exposure of residents to traffic emissions from vehicles travelling to/from the development site is potentially the greatest.

With suitable mitigation measures in place, minor adverse to neutral effects on local air quality are expected as a result of the construction of the proposed development. These effects would be relatively short-term and temporary and no long-term residual effects are expected as a result of the development construction. It has been determined that operation of the proposed development will have a neutral, minor adverse or moderate adverse effect on NO_2 concentrations and neutral or minor adverse effect on PM_{10} concentrations.

At the majority of receptors in most years, the proposed development does not lead to a breach of the EC NO_2 limit value as the 2010 limit values are already exceeded in the 'do-minimum' case. However, the proposed development does lead to a worsening of these breaches at receptors 2, 3 and 4 in 2010, 2010 and 2008 respectively. In addition, the proposed development leads to a worsening of the PM_{10} objective breach for both scenarios, in all years. Therefore, it is considered by the assessment that in the case of the proposed development air quality would be an overriding consideration.

3.3.2 Pacific Quay

Pacific Quay is a 60 acre site on the south side of Glasgow, which is already home to Glasgow Science Centre, an IMAX cinema and the city's innovative Glasgow Tower. As part of the Clyde Waterfront regeneration plan, it will be turned into a "digital media campus" and business park, costing £100 million. Construction began on-site in 2004, the area will accommodate the new headquarters for BBC Scotland, the Scottish Media Group and Film City Glasgow, both SMG and the BBC are looking to complete works in 2006.

A planning application for the site to the south of Pacific Drive was submitted to Glasgow City Council in January 2005. This 28 hectare site is to be transformed by the Pacific Quay partners to create a high quality mixed use development with associated access infrastructure, landscaping and public realm works. In adopting a development framework prepared by Gareth Hoskins Architects, the stakeholders at Pacific Quay propose to create the aforementioned digital media quarter and business park with associated infrastructure to reconnect the north and south banks of the City.

Scottish Enterprise propose to develop an area extending to 3.5 hectares as a centre of excellence for the Creative Industries in Glasgow and Scotland, which will compliment the existing portfolio of high profile projects at Pacific Quay. This media quarter will focus on the waterfront edge of the Canting Basin (formerly Princes Dock) and envisions a maritime facility for visiting boasts and events together with a

public square to the south of the Science Centre enhancing access to the area and the River Clyde. A multi-storey car park is also proposed.

To the east, between Pacific Drive and Festival Park, Parr Architects have submitted on behalf of Pacific Quay Developments, a planning application for the erection of mixed business, housing, hotel and retail plus associated landscaping, car parking, ground engineering and infrastructure works.

Original plans included:

- a new rail link – like the Docklands Light Railway
- new waterborne transport and
- a new bridge between Graving Docks in Govan and neighbouring Pacific Quay.

Information regarding the impact on air quality in conjunction with this development is currently unavailable but if necessary will be detailed in future reports.

3.3.3 Glasgow Harbour Project

Glasgow Harbour is the name given to the redevelopment of 49 hectares of former ship yards, docks, warehouses and granaries fronting the River Clyde and the River Kelvin south of Clydeside Expressway, between the SECC and the Clyde Tunnel. Planning consent was granted in 2001 for the development of the site consisting of:

- Residential: The first phase, comprising 649 houses, started in January 2003. The second phase for 770 units received planning consent in February 2005. A total of 2,500 units will be built in the area between the Clyde Tunnel and Partick Station.
- Business: The project's business district will be developed between the residential area and the River Kelvin.
- Retail and leisure: The Yorkhill Quay area will be developed for retail and leisure use, including a new Museum of Transport.
- Open space and public realm: Approximately 42% of the site area will be developed as new parks with river walkways and cycle ways. Following the opening in September 2004 of the first phase of the Clyde Walkway. The first phase of the linear park and public realm is expected be completed in 2005.
- Roads and transport: Planning consent was granted in 2002 for work to ensure that Glasgow Harbour will be connected to the West End of the city. A revised approach for the infrastructure

was subsequently approved in April 2005. Advanced infrastructure work commenced March 2005. There will be major investment to create new internal roads, lower the Clydeside Expressway at Partick, upgrade pedestrian connections from Partick to Glasgow Harbour and provide new transport links to the City Centre.

Phase 1 of the redevelopment (construction of 649 units) began in 2002 with the expected completion date of 2006 with Phase 2 residential commencing between 2005 and 2008; early action infrastructure work associated with lowering the Clydeside Expressway has also started. In addition, pre-application discussions are also currently in progress by the City Council with regard to a Pre-LRT route from the City Centre to Glasgow Harbour (this is discussed in more detail in Section 3.2.2).

An assessment of the impact on air quality at this location may be required, which will be included in a later air quality review and assessment if appropriate.

4.0 ADDITIONAL INFORMATION

4.1 Update on Air Quality Action Plan

Glasgow's Air Quality Action Plan was published in 2002. The plan focuses on reducing NOx (and PM_{10}) emissions, primarily through measures to reduce traffic flow and vehicle emissions that are consistent with council wide policies. Other actions focus on reducing emissions from buildings and industry as well as measures to raise public awareness on air pollution and greener travel. A copy of the full action plan and the Detailed Assessment is available on the website at www.glasgow.gov.uk using the residents link.

Quality Bus Corridors:

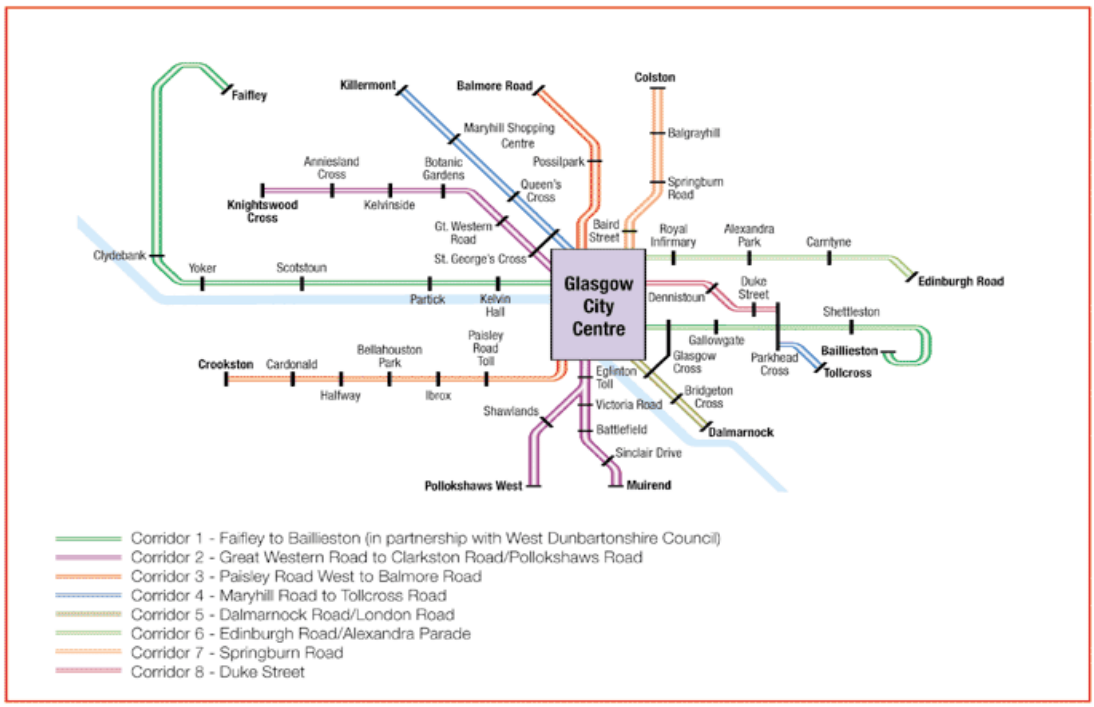
Eight new Quality Bus Corridors are being introduced across Glasgow. The first of these corridors, from Faifley in West Dunbartonshire to Baillieston in Glasgow, was launched in September 2005. This was launched under the name 'Streamline'. Improvements in traffic management allow all Streamline buses - equipped to communicate with information and traffic signalling systems – to provide the public with higher quality and faster journey times on 120 kilometres of Glasgow's Quality Bus Corridors.

Quality bus shelters with real-time passenger information displays have been provided at stops along the Faifley-to-Baillieston corridor and on-board CCTV security cameras will improve passenger safety. First Glasgow's £4.1 million contribution to the initiative includes electronic equipment on 460 of its 1,000-bus fleet enabling the Council's central traffic control system to track their movement, give late-running vehicles priority at traffic signals, and transmit predicted bus stop arrival times.

The launch is part of a series of weeklong events organised by Glasgow City Council as part of this year's European Mobility Week to promote alternative forms of travel, such as public transport and cycling to and from schools and workplaces.

Streamline will be rolled out to the following corridors over the next 12 months:

Corridor 1: Faifley to Baillieston
Corridor 2: Great Western Road to Clarkston Road
Corridor 3: Paisley Road West to Balmore Road
Corridor 4: Maryhill Road to Tollcross Road
Corridor 5: Dalmarnock Road
Corridor 6: Edinburgh Road/London Road
Corridor 7: Springburn Road
Corridor 8: Duke Street



Bus Information and Signalling System:

As part of the Quality Bus Corridor programme, the Bus Information and Signalling System (BIAS) is being introduced along bus corridors. The BIAS system is being implemented through two main contracts programmed for completion in the summer of 2006 for the Urban Traffic Control (UTC) system and the summer of 2005 for the Automatic Vehicle Location (AVL) system.

The first 10 UTC sites are now successfully operating under SCOOT control on Argyle Street/St Vincent Street between Blantyre Street and Elmbank Street. This means the traffic signals at these locations are not only operating on a fixed time plan, but also react to actual vehicle flows.

The AVL basic system software has been installed providing basic system functionality. There are 12 buses currently running on this version of the system, which use the new radio system and collect data that will enable First Glasgow to review their timetables more efficiently prior to the launch of the system. The main programme will provide an initial 337 buses installed with the BIAS equipment by the end of June 2005, when deployment of the signs displaying real-time information on bus arrival times at the 100 stops for which funding is available will also be completed. The remaining 123 buses in the overground fleet will be installed as First Glasgow upgrades their fleet over the next year.

Variable Message Signs:

Land Services within the Council has written to National Car Parks Ltd to ascertain whether the company would be interested in becoming involved in this scheme in order to push it forward.

Expansion of Shields Road Park and Ride:

A contract has been let to increase the capacity of the existing Shields Road Subway Station Park & Ride site from 500 to 800 spaces by constructing a multi-storey car park over part of the site. The new facility is scheduled for completion by June 2006. The project will also include improvements to the cycle routes connecting Paisley Road West and Pollokshields to the subway station and the erection of a variable message sign on the nearby M77 to advise commuters of the free capacity in the new car park.

Larkhall to Milngavie Rail Link:

The latest stage in the ongoing development of the Larkhall to Milngavie Rail Link was unveiled on 28 September 2005 with the official opening of the new Kelvindale railway station in Glasgow's west end.

The opening of Kelvindale is the first stage of a £35 million improvement programme under the Larkhall to Milngavie project, which in addition to the extension of the Northern Suburban Line, will see Larkhall restored to the rail network later this year. Sited at the junction of Temple Road and Dalsholm Road, the new station will allow passengers to travel between Kelvindale and Glasgow city centre in just 16 minutes. In addition, a mile of new track has also been laid to connect the station to Anniesland, allowing passengers to change to the north electric line and rail services to the west. Work began on-site in February 2004, with a half-hourly service between Hamilton and Anderston due to start in 2005, and the full link operational by late 2005.

Vehicle Emissions Testing:

Work on this issue is ongoing and enforcement work is carried out on a weekly basis. Glasgow City Council has applied for further funding to continue with the scheme for the year 2006-07. The Council is also set to carry out vehicle emissions testing work on behalf of neighbouring local authorities who have problems with air pollution from road transport in their own areas.

Idling Vehicles:

A further publicity campaign is to be undertaken over the winter of 2005-06 to reiterate the message to the public of the need to switch the engine of their vehicle off when stationary at the roadside and that failure to do so could result in the issuing of a Fixed Penalty Notice. The Council is also looking at the possibility of issuing Fixed Penalty Notices to persistent offenders.

Cycling and Walking Strategies:

£200,000 is being spent on enhancing and upgrading footpaths and cycle ways. Television adverts have been broadcast that publicise the network of pathways to encourage people to use them.

Proposals for the development of the Glasgow Cycle Network that are currently at design stage include cycle lanes along the A77 and the White Cart Cycle Route. Cycle links have also been provided through Glasgow Green. Resurfacing work is currently underway on a selection of paths within Bellahouston Park as part of the City Council's support for Scottish Cycling's Regional Cycling Academy.

School Travel Plans:

In order to raise awareness of travel issues of school journeys and to gain meaningful data on children's travel habits, all primary and secondary schools throughout the City were invited to participate in the inaugural 'Hands up for Glasgow' Travel Tally in September 2004. In total, 42,401 pupils from 165 schools completed the survey, representing an extremely favourable response rate for the first year. All participating schools have been supplied with their individual results together with a School Travel Plan Leaflet and a Hands Up for Glasgow Travel Tally 2004.

Some of the key results from the survey are:

- 59% of Glasgow's Primary School children currently walk to school.
- Almost half (49%) of pupils in Secondary schools walk to school with just over a quarter (26%) travelling by public bus.
- Over half (59%) of pupils in Independent schools travel to school by car with just under a quarter (21%) walking.

It is planned to undertake the 'Hands Up for Glasgow' School Travel Tally on an annual basis. This should provide a measure of the effectiveness of local initiatives aimed at encouraging the uptake of more active and sustainable modes of travel to school. It is also planned to undertake air quality monitoring at some schools in order to determine the effectiveness of these initiatives.

Air Quality Enforcement:

The Council is continuing to enforce the provisions of the Clean Air Act 1993 and the Environmental Protection Act 1990 in relation to air pollution. Recent talks were held with the Scottish Environment Protection Agency (SEPA) to find a more effective way of dealing with the emission of smoke from fires

on construction and demolition sites that potentially impact on air quality. A Fixed Penalty Notice was also recently served on a scrap dealer who was disposing of waste through burning. The aim of enforcement is to reduce the number of fires being lit that can contribute to air quality problems.

Commercial & Domestic Sources:

Work in this area is ongoing, as detailed in the Air Quality Action Plan. Glasgow has also launched a Fuel Poverty Strategy that has the aim of eradicating fuel poverty through for example, increasing insulation and installing energy efficient heating systems in domestic properties. Although this is driven by social and housing issues, the strategy may result in reductions in emissions from domestic properties. No figures are available at present as to whether strategies relating to energy efficiency have resulted in improvements to air quality in the AQMA.

Industrial Sources:

Glasgow City Council is continuing to actively enforce legislation relating to the control of emissions from industrial sources in terms of the Clean Air Act 1993 and the Environmental Protection Act 1990. However, due to the limited number of industrial type premises within Glasgow, it is still predicted that this is an action that will have a low impact in terms of improving air quality within the City Centre AQMA.

Glasgow City Council Leading by Example:

Vehicle Replacement Programme **-** As part of the 2005 vehicle replacement programme Land Services has been able to secure a grant from the Energy Savings Trust (EST) of £88,500, to equip 30 new vehicles with a selective catalytic reduction system (SCR). This will enable an extension of the current trial which ensures that the tailpipe emission standards of internal fleet vehicles significantly exceed the current EURO emission standards for vehicles.

This grant represented 75% of the total cost of installation and maintenance, leaving a cost of approximately £29,500, which is being met by the Policy & Resources (Environmental Sustainability) Sub-committee Special Projects Budget and Land Services.

The benefits that will be derived from this EST approved system will be a 70 – 90% reduction in oxides of nitrogen emissions as well as a reduction in diesel particulate matter. Monitoring results from the 4 vehicles currently fitted with these systems has shown, in addition to the emissions reduction, an improvement in fuel consumption of between 5 - 10%.

The fitting of 30 new fleet vehicles with SCR systems will assist the Council in its drive for cleaner air and demonstrate a commitment to lead by example.

Education and Awareness Raising:

In Town Without My Car Day **-** Last year, Glasgow was one of only 7 cities in the U.K. to fully participate in both European Mobility Week and 'In Town Without My Car Day' through the support of events on each day of the week and through the closure of North Frederick Street in front of the City Chambers on 'In Town Without My Car Day' itself.

In 2005 European Mobility Week ran from 16-22 September and aimed to promote alternative transport modes such as cycling, walking, public transport and car pooling to schools and workplaces. Various events took place throughout this week. Different events took place every day of the week which focussed on different aspects of alternative travel modes as described below:

Friday 16 September is Bike to Work Day**.** Employees of major organisations in Glasgow, including the City Council are encouraged to ride their bike to work on that day. Also, Land Services is offering free cycle training to the 1st 100 people who contact their phone line 0141 287 9483 on that day, provided they live or work in Glasgow.

Monday 19 September sees the launch of Streamline, a brand new bus priority system designed to Keep Glasgow Moving. That morning, the Kelvin Hall plays host to the launch which will showcase the technology behind the scenes and premiere the new Streamline service.

Tuesday 20 September is the formal launch of 'Free Bikes for Schools Scheme' at St. Mungo's Academy during the afternoon. This pilot project if successful could be extended to other schools.

Wednesday 21 September is the 'Hands up for Glasgow' School Travel Tally. This repeats last year's activity, where pupils of all mainstream primary, secondary and independent schools are asked how they travelled to school that day. It is hoped there is a reduction in the number of children being driven to school from last year.

Thursday 22 September is In Town Without My Car. This European-wide initiative sees the City Chambers being 'joined' to George Square in a traffic-free environment. The road in front of the City Chambers between Cochrane Street and George Street will be closed to all motor traffic, except emergency vehicles between 7.00am and 6.00pm on that day. The Company of Cyclists will provide a free try-out show,

where the public can try riding an array of usual and unusual bikes from 10am until 5pm. Tollcross Park sees the launch of Glasgow City Health Walks by Ex-Scotland International Rugby Player and BBC Radio Scotland Presenter John Beattie from 10.00am until 2.00pm.

4.2 New Monitoring Equipment

Glasgow City Council purchased an OSIRIS direct reading, airborne particle sampler which has yet to be located at an air quality monitoring site. The OSIRIS is a general purpose instrument that will continuously indicate the concentration on TSP, PM10, PM2.5 and PM1 particles with a resolution of 0.1micrographmes per cubic metre.

4.3 Planning Applications and Policies

Local authorities should integrate air quality considerations within the planning process at the earliest stage possible. Although the land use planning system does not offer any quick-fix solutions to areas of poor air quality, it can do much to improve local air quality in the longer term, in terms of strategic and development control planning.

Currently all planning applications are seen by an Environmental Health Officer who is responsible for air quality issues. If there are any concerns regarding air quality the application will be looked at in more detail and comments sent back to planning. This may be simply recommending that an air quality assessment be carried out prior to a planning decision being made.

4.4 Local Transport Plans and Strategies

The current Local Transport Strategy was release in 2001, its main aim was to make Glasgow a more pleasant, safe and healthy city to live, work and visit. The strategy details the need to move away from the use of the private car to utilise other modes of transport such as train, bus, bicycle and walking.

The implementation plans were to introduce Quality Bus Corridors, provide cycling facilities (for example cycle lanes) and consider pedestrians needs for new developments in and around the city. In addition to this, the aim was to further develop the bus services, park & ride facilities, underground and railway networks.

Targets set for 2005/2006 are to:

- Achieve a 10% reduction in rate of traffic growth in private car traffic by 2005 (based on 1998 levels of 2.2%). This was achieved in 2004 where the rate of traffic growth was reduced to 0.26%.
- Carry out a trial of acoustic traffic monitoring equipment at three sites. Since 2004 a further two sites have been identified for trials.
- Commence the review and updating of the Local Transport Strategy.
- Prepare a programme for its completion.

If all of the above is achieved there would be improved air quality, reduced noise pollution and the city would be more aesthetically pleasing to the general public.

In Scotland there is no definitive requirement to take air quality issues into account but this may change in the future as it is in England and Wales where it is now standard practice. At present the Local Transport Strategy is being reviewed and new documentation is due to be released in September 2006.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This Air Quality Progress Report has provided the most up-to-date information available that Glasgow City Council has on local air quality. This allows the Council to maintain continuity in its review and assessment process. Findings in the report show that although pollution emissions continue to decline, there have been no significant changes to air quality since the 2003 Update and Screening Assessment. Glasgow still has an air quality problem with respect to Nitrogen dioxide and fine particles that needs further investigation and resources to solve.

The next review and assessment progress report is not due until April 2007, as the council is required to conduct a second U&SA in 2006. This report will follow a similar format to the previous report in 2003 but will focus on 2010 objectives in more detail. This will include an update of monitoring data from 2005 and in preparation for this report GCC will consider whether the current action plan needs to be revised in light of the fact that the 2005 NO_2 objective will not be met.

Various issues have been highlighted within this report that currently have no data available or are under development, including:

- Monitoring data from GCC's mobile air quality stations;
- Air quality information regarding QD2 development, Pacific Quay and Glasgow Harbour Project.

New transportation developments that are considered in the report to warrant further assessment include:

- Finnieston Road Bridge;
- East End regeneration route;
- M74 extension.

These issues will be closely monitored by GCC and careful consideration will be given to the air quality in the areas which are being or are due to be developed. Any relevant information will be reported in more detail in the next full round of review and assessment, if deemed appropriate.

6.0 REFERENCES & USEFUL WEB SITE ADDRESSES

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National Atmospheric Emissions Inventory	www.naei.org.uk
Scottish Environment Protection Agency	www.sepa.org.uk
Scottish Executive	www.scotland.gov.uk
Scottish Natural Heritage	www.snh.org.uk
The Department of the Environment, Food and Rural Affairs	www.defra.gov.uk
The National Society for Clean Air	www.nsca.org.uk
The UK National Air Quality Information Archive	www.airquality.co.uk/archive

7.0 FURTHER INFORMATION

Further information on air quality and greener travel is available on the council's website at www.glasgow.gov.uk. Alternatively, please contact:

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