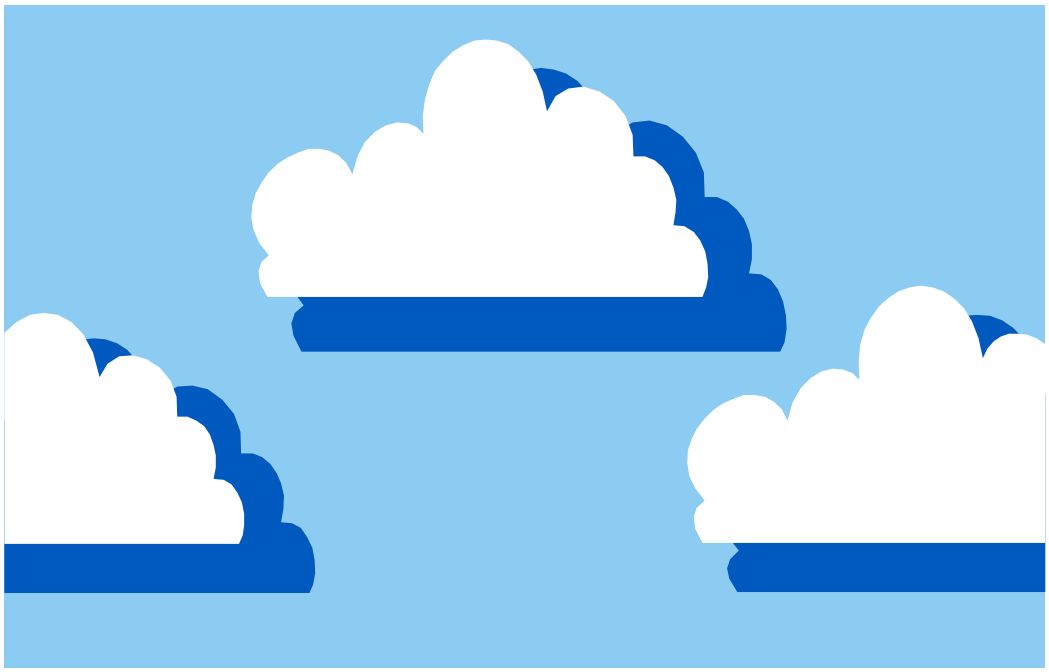
CARLISLE CITY COUNCIL

LOCAL AIR QUALITY MANAGEMENT

FIRST STAGE REVIEW AND ASSESSMENT



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FIRST STAGE AIR QUALITY REVIEW AND ASSESSMENT

1. INTRODUCTION

1.1 AIM AND OBJECTIVES

This document is the first stage review and assessment of local air quality in the Carlisle City Council area. As such, its aim is to undertake an examination of air pollution and the public's exposure to it in the authority area.

The review and assessment will address the following objectives:

- Identify significant sources of air pollution
- Review existing air quality monitoring data
- Assess exposure of the public to air pollution
- Determine the likelihood of achieving air quality objectives by 2005
- Identify future review and assessment work

1.2 LEGISLATION

The United Kingdom National Air Quality Strategy (NAQS) identified the need for a local air quality strategy, due to increased concerns about both sustainable development and the effects of air pollution on human health. This strategy is targeted at the management of ambient air, that is the outdoor air which the public breathes. It does not consider occupational or indoor air, nor is it aimed at ecological protection.

The Environment Act 1995 lays the foundations for a nationwide system of local air quality management. It requires local authorities to periodically review and assess the air in their areas against national pollution objectives. Where assessed levels are likely to exceed these objectives, an Air Quality Management Area (AQMA) must be declared and an action plan published.

The air quality objectives are defined in the Air Quality Regulations 1997. These identify the seven pollutants of concern and the levels which should be attained by the end of 2005. Further direction is provided to local authorities in DETR Circular 15/97 and eight accompanying volumes of guidance.

The whole review and assessment process is divided into three stages:

- First stage – Screening exercise examining all 7 pollutants
- Second stage – Measurement and initial modelling of local "hotspots"
- Third stage – Detailed monitoring, modelling and emission estimation

The second stage is only necessary for those pollutants which have failed the first stage assessment; likewise the third stage is only required for those failing the second stage.

DETR expects local authorities to have completed the first stage by December 1998 and the second and third stages by December 1999. Local authorities will also be expected to conduct a second review and assessment exercise before 2005.

1.3 AIR QUALITY STANDARDS

The government has identified seven pollutants that are the most prominent contributors to poor air quality in the UK. Each substance has had a concentration defined for it by an expert panel, below which they are not considered to be a significant risk to health. The intention is thus to render pollution harmless. The pollutants are:

TABLE 1: THE POLLUTANTS AND THEIR SOURCES

Pollutant	Main sources	Measured as	Air quality objective
Sulphur Dioxide (SO_2)	Fuel combustion in industry, transport and housing	15 minute mean	100 ppb measured as the 99.9th percentile.
Nitrogen Dioxide (NO_2)	Fuel combustion in industry, transport and housing	1 hour mean Annual mean	150 ppb 21 ppb
Fine particulates (PM_{10})	Fuel combustion in industry, transport and housing	Running 24-hour mean	50 ug/m^3 measured as the 99th percentile
Carbon Monoxide (CO)	Motor vehicles and combustion processes	Running 8-hour mean	10ppm
Benzene	Petrol combustion and evaporation	Running annual mean	5ppb
1,3 – Butadiene	Motor vehicles and industry	Running annual mean	1ppb
Lead (Pb)	Lead additives in petrol	Annual mean	0.5 ug/m^3

ppm = parts per million by volume ppb = parts per billion by volume ug/m^3 = micrograms per cubic metre

As the assessment is health-based, a key consideration is the length of time that the public is exposed to pollutants. For those with short averaging times, such as the 15-minute mean for SO_2, the assessment should consider near-ground level outdoor locations where the public may be found. This would include parks, bus stops and pavements. Pollutants with longer averaging periods, especially those of one year, must be assessed where people spend a reasonable portion of a year, for example schools and residential areas.

1.4 LOCAL AREA

The authority area administered by Carlisle City Council covers 103 km^2 of northern Cumbria. The urban area of Carlisle has a population of 71,000 within a diameter of approximately 6 kilometres. The surrounding area with a population of 32,000 is primarily agricultural and includes the towns of Brampton, Dalston and Longtown. Because 70% of the population lives in one urban area, most pollution is generated in this city and the majority of people's exposure is here. Although the surrounding towns and villages do experience the effects of pollution, these are modest and are assessed to be within national objectives. This review and assessment will therefore concentrate on pollution in Carlisle.

Carlisle is centred around the River Eden, with land rising towards the Pennines in the East and The Lake District in the South. The authority does not contain any land in a National Park.

Historically, Carlisle experienced elevated levels of smoke and sulphur dioxide pollution as a result of the burning of coal and other fossil fuels. The Clean Air Act 1956, which accelerated the change in fuel usage towards gas and electricity, has led to improved air quality.

Today, the majority of air pollution in the city is from road traffic. Individual vehicles have become cleaner through the use of low-sulphur and -lead fuels and, since 1993, catalytic converters on petrol vehicles. However, traffic levels have consistently risen and are currently growing by 2.2% per year. Emissions from industry are now broadly controlled by the authorisation regime introduced by the Environmental Protection Act 1990.

1.5 METROLOGY

Once pollution has been generated, the main effect on its duration is the weather. Most important is wind, which disperses pollutants depending on its speed. Rainfall cleanses the air by washing out particulates.

Short-term pollution incidents (hours to days) are primarily caused by weather conditions. Summer anticyclones produce long periods of sunlight and light winds, which may allow the production of photochemical smog. In winter, temperature inversions on calm days can trap pollutants at ground level as smog.

2. SOURCES OF POLLUTION

2.1 TRANSPORT

Road traffic is the single most significant producer of air pollution. The emissions from vehicles are the main sources of CO and NO_2 in ambient air, with significant contributions to airborne levels of lead, PM_{10}, benzene and 1,3-butadiene. Emissions from vehicles come from exhaust tailpipes, particularly after cold starts and are also associated with refuelling and tyre/brake wear.

Pollution depends mainly upon flow rates, with major roads carrying over 25,000 vehicles per day the most important. Seven roads in Carlisle fell into this category in 1997and are marked on the map in Annex A. Congestion also generates air pollution, as vehicles operate inefficiently during slow urban movement. Morning and afternoon rush-hour episodes last 60-90 minutes in Carlisle and cause pollution levels to peak during these times.

Transport activities, other than road traffic, are minor contributors of pollution. Rail locomotives are primarily electric-powered and aircraft activity at Carlisle Airport is modest.

2.2 INDUSTRY

Industrial activities are the second largest contributors to local air pollution and those over certain government-defined pollution limits are regulated under powers in the Environmental Protection Act 1990. These fall into two categories; regionally controlled by the Environment Agency ("Part A" processes) and locally controlled by the authority ("Part B" processes).

Part A processes are those activities which pollute air and also land or water. There are none in the authority's area. Part B processes are those activities which only pollute air and there are 59 of these in this area. Emissions depend upon the process undertaken, with common examples being:

TABLE 2: COMMON PART B PROCESS EMISSIONS

Process	Substances emitted
Petrol station	Benzene, 1,3-butadiene
Combustion	NO_2, SO_2, PM_{10}
Concrete batching	PM_{10}
Coatings	Solvents

2.3 OTHER SOURCES

Domestic properties generate pollution from the combustion processes in heating systems. The trend from burning coal and oil to natural gas over the last 20 years has markedly reduced emissions of SO_2, CO and particulates (in the form of soot).

Agricultural activities can create particulates, mainly through disturbing soil during ploughing, harvesting etc. However most local farming is livestock-based, which while generating methane (a greenhouse gas) does not produce much particulate matter.

Additional sources include salt particulates from coastal sites and pollen, which contribute towards background PM_{10} levels.

2.4 TRANSBOUNDARY SOURCES

Air pollution is carried into the authority's area by wind blowing across boundaries. The prevailing wind is from the south-west, so the most significant sources will be in this sector. Pollutant levels in transboundary air will be low due to the rural nature of these surrounding areas. There are not thought to be significant point sources in these authorities that affect the Carlisle City Council area; however they will be considered during the stage two review and assessment.

3. CONSULTATION

Schedule II of the Environment Act 1995 requires local authorities to consult externally as part of their review and assessment exercises. This is to gather external information on pollution matters and publicise the exercise to non-governmental organisations that may wish to contribute. The following bodies have been contacted:

- 5 other Cumbrian district councils
- Tynedale District Council (Northumberland)
- Scottish Environmental Protection Agency (Borders and Dumfries & Galloway area offices)
- Environment Agency (Penrith office)
- Carlisle Business Forum
- Friends of the Earth (Carlisle branch)
- Carlisle Association of Parish Councils

A forum for air quality issues was established in 1998 within Carlisle City Council. This contains representatives from Development Control, Environmental Health and Highways, alongside Cumbria County Council representation. This group meets bimonthly to develop air quality policies authority-wide and integrate the subject into established council functions.

4. REVIEW & ASSESSMENT OF BENZENE

Objective: 5 ppb or less, when expressed as a running annual mean.

4.1 SOURCES

Benzene is a liquid organic compound at room temperature, but evaporates readily. There are no significant natural generators of benzene; the main source in the UK is petrol (where it is used as an anti-knock agent, comprising 2% by volume.) In 1995, 70% of emissions came from petrol vehicles and 10% from the refining, distribution and evaporation of petrol. There are no significant industrial sources of benzene in the Authority area.

4.2 HEALTH EFFECTS

Evidence from industrial workers exposed to high concentrations of benzene (over 25,000 ppb) have shown it to be associated with cancer. These effects are not detectable at the much lower concentrations evident in ambient air.

4.3 NATIONAL DATA

Benzene was monitored nationally in 1995 at 12 Automated Urban Network (AUN) sites, which are government-sponsored real-time monitors producing high quality data. The nearest is in Middlesbrough, a city of 150,000 containing large chemical plants. The maximum annual running means were 1.3 ppb in 1995 and 1.2 ppb in 1996.

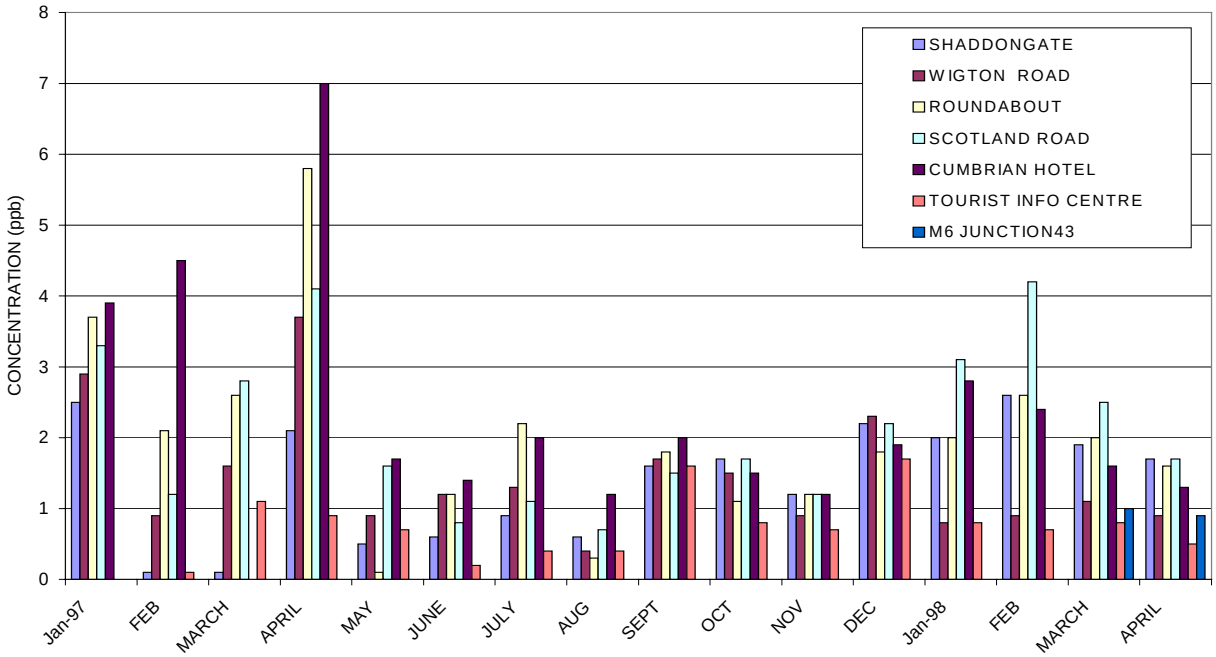
4.4 LOCAL MONITORING

Benzene is monitored using diffusion tubes; simple devices normally attached to lampposts where gas is adsorbed by a medium in a small plastic tube. These are changed monthly and analysed by laboratory. Six monitoring sites have been operated since January 1997 at the following city locations:

- 2 arterial roads (Wigton Road, Scotland Road)
- 3 inner city roads (Shaddongate, Hardwicke Circus, Botchergate)
- Tourist Information Office

The monthly results from the six benzene diffusion tubes are illustrated in graph 1:

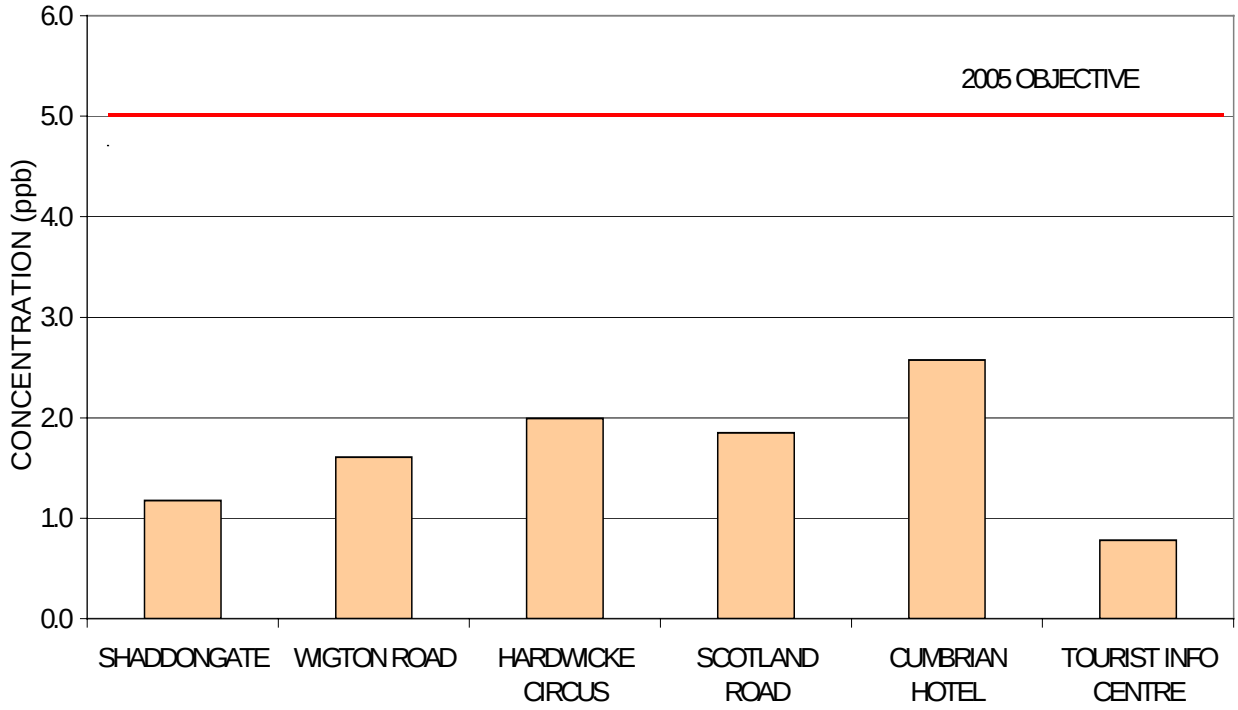
GRAPH 1: BENZENE MONTHLY LEVELS



The monthly data shows the consistent presence of benzene across the urban area. Levels are elevated during winter, probably because of the periodically stable atmospheric conditions that can trap pollutants.

As the air quality objective is expressed as an annual mean, the results for 1997 (the only full annual set of data) are in Graph 2:

GRAPH 2: BENZENE ANNUAL MEANS 1997



Most sites fall into the 1 to 2 ppb band, with the Cumbrian Hotel higher (probably because of canyon effects, when tall buildings shelter the street from pollution-dispersing winds). Levels are all well under to NAQS objective of 5 ppb.

4.5 PREDICTED LEVELS

Emissions of benzene can be expected to increase as road traffic levels rise. The traffic growth in Carlisle is 2.2% annually, therefore over the seven years to 2005 the total increase is predicted to be 16%. It is estimated that the 2005 annual mean for benzene will be approximately 2.0 ppb.

4.6 ASSESSMENT

The annual mean at the kerbside in Carlisle by 2005 is predicted to be 2.0 ppb. The pollution objective of an annual level requires it to be assessed where people are likely to be exposed for that year-long period, e.g. homes and schools. As these locations are generally separate from the major roads, their air will be less polluted. The roadside measurements are therefore relatively pessimistic and if kerbside readings are under the objective level, then homes and schools will experience even lower pollution levels.

It is assessed that benzene levels will fall under the NAQS objective. It will not be considered for a stage 2 review and assessment.

5. REVIEW & ASSESSMENT OF 1,3-BUTADIENE

Objective: 1 ppb or less, when expressed as a running annual mean.

5.1 SOURCES

1,3-butadiene is an organic chemical that exists as a gas at normal temperature. The two main sources are:

- Petrol combustion in vehicles, which generate 1,3-butadiene as a component of exhaust gases. 67% of UK emissions arose from vehicles in 1995 and this would be expected to be the dominant local source.

- Certain industrial processes handle 1,3-butadiene in bulk and have associated emissions. There are no such activities locally.

5.2 HEALTH EFFECTS

Exposure of industrial workers to 1,3-butadiene levels of 1000-10,000 ppb has identified a slightly elevated risk of cancer. This is not evident in the much lower levels present in ambient air.

5.3 NATIONAL DATA

1,3-butadiene is monitored nationally at 12 AUN locations. The nearest site is in Middlesbrough, which contains a major industrial source of 1,3-butadiene. Their annual mean in 1995 was 0.3 ppb.

5.4 LOCAL MONITORING

No monitoring has been conducted in the authority for 1,3-butadiene because it is not assessed to be a pollutant at risk of breaching national objectives.

5.5 PREDICTED LEVELS

Work done nationally has identified a broad relationship between ambient air concentrations of benzene and 1,3-butadiene in the ratio of 3:1. That is, 1,3-butadiene levels will generally be one third those of benzene. The 1996 annual mean for benzene in Carlisle was 1.7 ppb, so the surrogate statistic for 1,3-butadiene can be estimated as 0.6 ppb. Increasing this by the traffic growth of 16% suggests a level by 2005 of approximately 0.7 ppb.

5.6 ASSESSMENT

It is assessed that 1,3-butadiene will fall under the NAQS objective. It will not be considered for a stage 2 review and assessment.

6. REVIEW & ASSESSMENT OF CARBON MONOXIDE

Objective: 10 ppm or less, when expressed as a running 8-hour mean.

6.1 SOURCES

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of fuel. It is generated mainly by road traffic (90% nationally in 1992), along with contributions from industrial combustion and domestic boilers/heating. Improvements in vehicle technology (e.g. fuel injection) and particularly the introduction of exhaust catalysts have lead to a steady reduction in CO levels nationally.

6.2 HEALTH EFFECTS

The hazards associated with carbon monoxide are well documented. It binds strongly to the haemoglobin in red blood cells to produce carboxyhaemoglobin (COHb); this hinders oxygen being carried around the body from the lungs. Non-smokers exposed to environmental CO can have COHb levels ranging from 0.5-1.5%. Moderate exposure (around 10%) causes headaches and dizziness, with high levels leading to unconsciousness and death. Those most likely to feel effects are those with heart and lung disorders, as well as infants and the elderly.

6.3 NATIONAL DATA

Carbon monoxide was monitored nationally at 26 AUN sites in 1995. As an illustration of urban levels, the data from the central Newcastle-upon-Tyne site is as follows:

TABLE 3: CARBON MONOXIDE LEVELS IN NEWCASTLE-UPON-TYNE

Year	Annual mean (ppm)	Max. running 8-hour mean (ppm)
1992	0.8	4.0
1993	0.7	6.1
1994	0.6	3.2
1995	0.6	3.5
1996	0.5	4.3

This illustrates typical levels in the city centre of a large urban area. There were no breaches of the 10 ppm NAQS objective during this 5 year period.

6.4 LOCAL MONITORING

No monitoring is undertaken in the authority area for carbon monoxide because it is not assessed to be a pollutant at risk of breaching national objectives.

6.5 PREDICTED LEVELS

It is not known what the precise levels of CO are in Carlisle. Estimates, considering national data, would be an annual mean of 0.2-0.4 ppm and a maximum 8-hour mean of 2-4 ppm.

6.6 ASSESSMENT

Carbon monoxide concentrations in Carlisle are not thought to be problematic. Data for a major city like Newcastle (population 1 million) shows no exceedences of the NAQS objective. It is therefore assessed that Carlisle (population 70,000) will safely fall under the national limit. Carbon monoxide will not be considered for a stage 2 review and assessment.

7. REVIEW & ASSESSMENT OF LEAD

Objective: 0.5 ug/m^3 or less, when expressed as an annual mean

7.1 SOURCES

70% of lead in the UK originates from leaded petrol burnt in road vehicles, with other significant sources being industrial and waste operations. Airborne levels have steadily dropped due to the reduction in the tetraethyl lead content of fuel, most recently in 1986 from 0.4 g/l to 0.15 g/l. Catalyser-equipped cars must use unleaded fuel, thus as the proportion of these vehicles on the road increases the amount of leaded fuel sold declines. Leaded fuel will be withdrawn from national sale in 2000.

7.2 HEALTH EFFECTS

As a heavy metal, lead accumulates in the body and is known to produce neurological effects, including reduced IQ in children. It can be ingested in water (e.g. via lead pipes) or inhaled as particulates – the most common pathway.

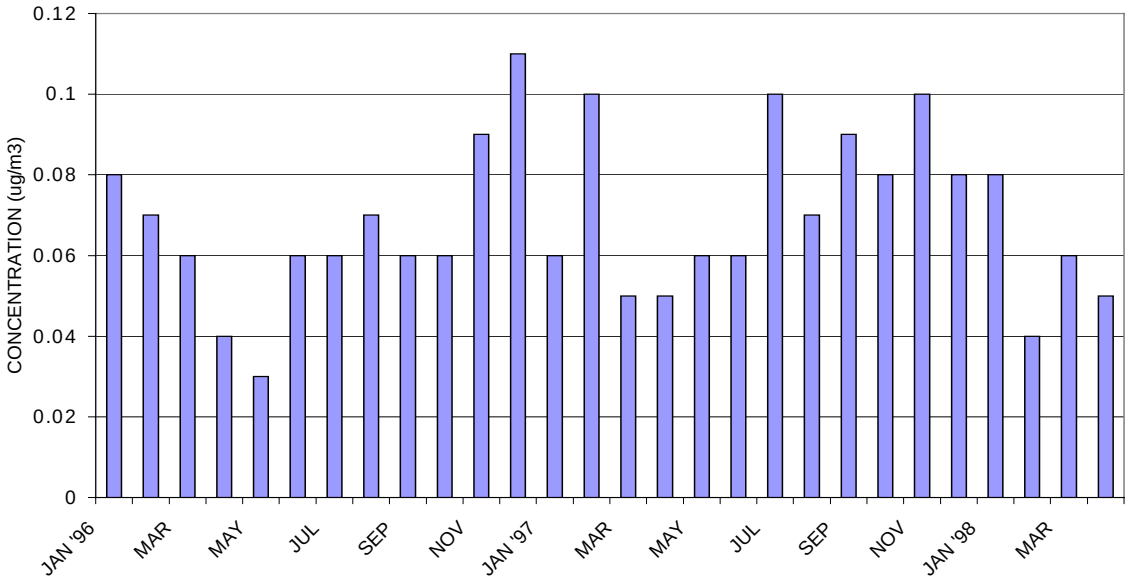
7.3 NATIONAL DATA

The urban background site in Leeds in 1996 had an annual mean of 0.6 μg/m^3.

7.4 LOCAL MONITORING

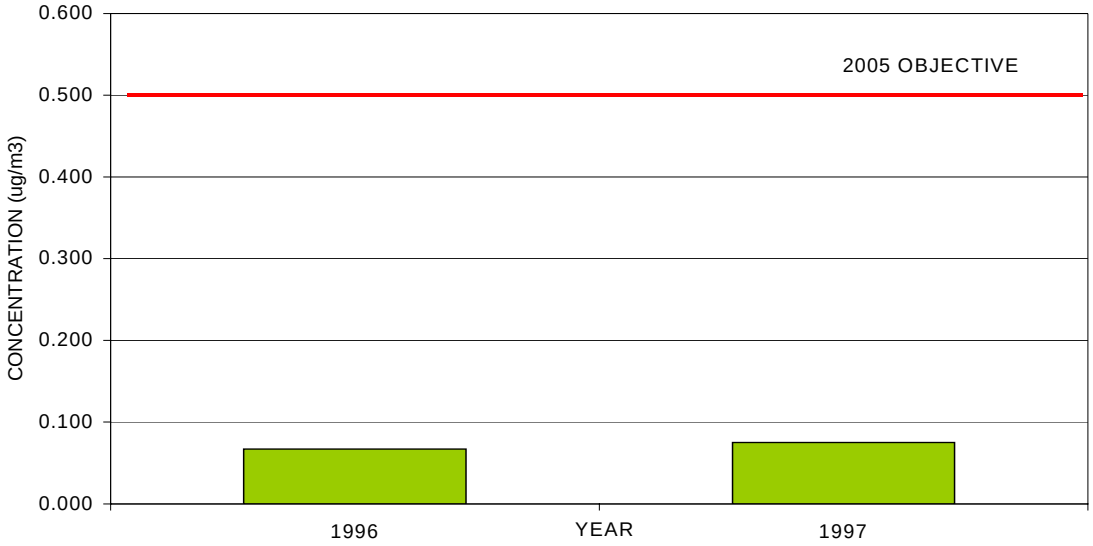
A lead monitoring site was established at Caldewgate in 1996. Air is drawn through a filter in an M-type sampler, which collects material over weekly periods. Used filters are analysed by laboratory for total suspended lead particulates, expressed as a monthly average as graph 3:

GRAPH 3: LEAD MONTHLY MEANS



Monitoring has identified the ongoing presence of airborne lead with seasonal variations, but at low levels. As the NAQS objective is expressed as an annual mean, the local data when averaged over periods of 12 months appears as in graph 4:

GRAPH 4: LEAD ANNUAL MEANS



Annual mean levels are therefore very low, with the 1997 mean of 0.075 μg/m^3 being well under the objective of 0.5 μg/m^3.

7.5 PREDICTED LEVELS

Leaded petrol burnt by road traffic is the majority producer of urban lead. The withdrawal from sale of leaded petrol in 2000 will eliminate this source and is expected to produce further reductions in airborne lead levels. In Carlisle, these should drop to below 0.05 μg/m^3 by 2005.

7.6 ASSESSMENT

Monitoring in Carlisle has confirmed the continuing presence of airborne lead. However levels in 1997 were only 15% of the NAQS objective and are expected to fall further. Lead will not be considered for a stage 2 review and assessment.

8. REVIEW & ASSESSMENT OF NITROGEN DIOXIDE

Objectives: 21 ppb or less when expressed as an annual mean
150 ppb or less when expressed as an hourly mean

8.1 SOURCES

Nitrogen dioxide (NO_2) is a red-brown gas produced by the reaction between nitrogen and oxygen during high temperature combustion. The reaction usually takes place in two stages; one atom each of nitrogen and oxygen combine during combustion to form nitric oxide (NO) which then oxidises at a later stage in the atmosphere to produce NO_2. The combination of NO and NO_2 is collectively known as oxides of nitrogen (NO_x). In the UK, 46% of NO_2 is produced by motor vehicles and 22% by power stations. As there are no large power stations in Carlisle, it can be assumed that the majority of local NO_2 comes from traffic.

8.2 HEALTH EFFECTS

Nitrogen dioxide is an irritant of the airways and exposure to concentrations of 300 ppb for 30 minutes can produce a small change to lung function in asthmatic individuals. In non-asthmatics exposure to 1000 ppb is necessary to produce a similar response. Exposure to NO_2 at these levels may also increase the response of sensitive individuals to allergens. Young children and those with chronic respiratory diseases (e.g. bronchitis or emphysema) will also be sensitive to NO_2 exposure. These acute (short-term) health effects are addressed by the 150 ppb objective. As NO_2 may also have a cumulative impact on the population, the Expert Panel on Air Quality Standards (EPAQS) also defined a 21 ppb annual average to protect against any possible chronic (long-term) health effects.

8.3 NATIONAL DATA

NO_2 is extensively monitored in the UK. One of the smallest cities with an AUN site is Leicester (population 280,000). In 1995 the NO_2 levels were as follows:

TABLE 4: NO_2 MONITORING DATA, LEICESTER 1995

Statistic	Concentration (ppb)
Annual mean	23
Maximum hourly mean	106

Of the 28 AUN sites nationally, 7 had breaches during 1995 of the one hour objective. These were all in major cities.

8.4 LOCAL MONITORING

NO_2 levels are monitored using passive diffusion tubes. These are mounted on lampposts and changed monthly to be analysed by laboratory. As an economical

technique, these are useful for identifying local hotspots and trends in NO_2 pollution and 11 sites have therefore been established since October 1995. The locations are grouped as follows

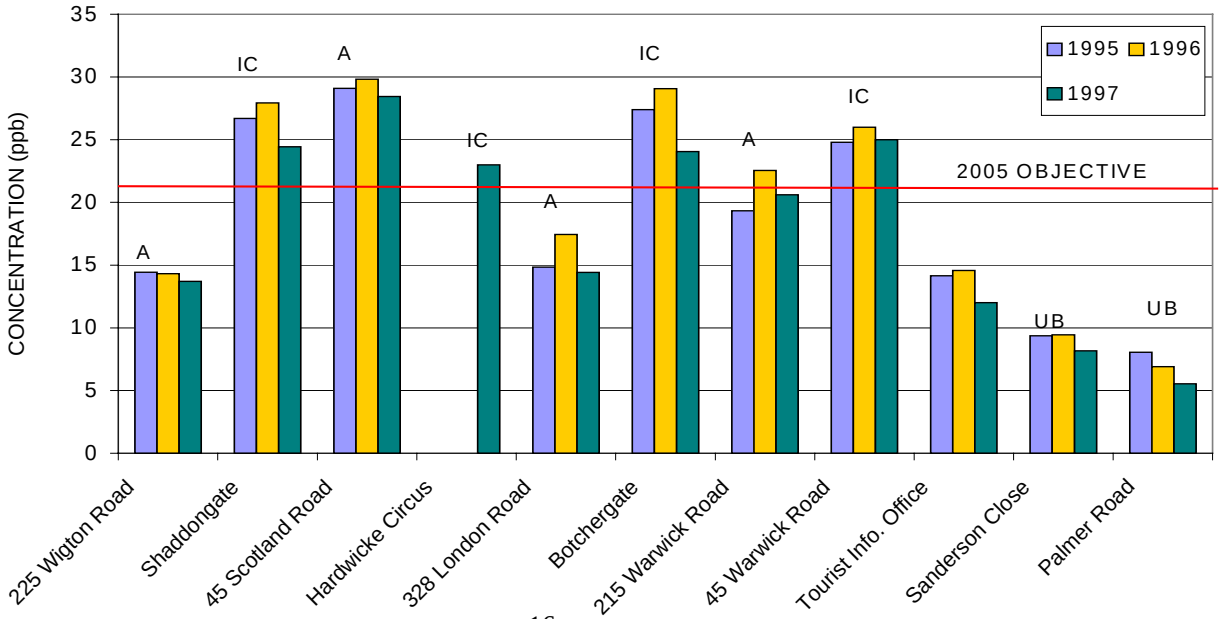
- 4 arterial roads:
  - 225 Wigton Road, (opposite BP petrol station) [western – outer]
  - 45 Scotland Road, (near Spar shop) [northern – outer]
  - 328 London Road, (near Cavaghan & Grey) [southern – outer]
  - 215 Warwick Road, (opposite Beehive pub) [eastern –outer]
- 4 inner city roads:
  - Shaddongate, (near The Maltsters pub) [western – inner]
  - Hardwicke Circus [northern – inner]
  - 8 Botchergate, (near The Cumbrian Hotel) [southern – inner]
  - 45 Warwick Road, (near Vantage Chemists) [eastern – inner]
- 1 city centre site: Tourist Information Centre
- 2 background sites:
  - Sanderson Close, Lowry Hill [northern – suburban]
  - Palmer Road, Belle Vue [western – suburban]

Their locations are marked on the map at Annex B.

Measurement accuracy for diffusion tubes has been calculated as ±35% for one tube and ±17% for 12 tubes (i.e. an annual average). In side-by-side comparisons with real-time monitoring stations in the AUN, their accuracy was within 10%.

The NAQS firstly defines an annual mean of 21 ppb. Monitoring results from these sites can be averaged to produce annual mean figures as illustrated in graph 5:

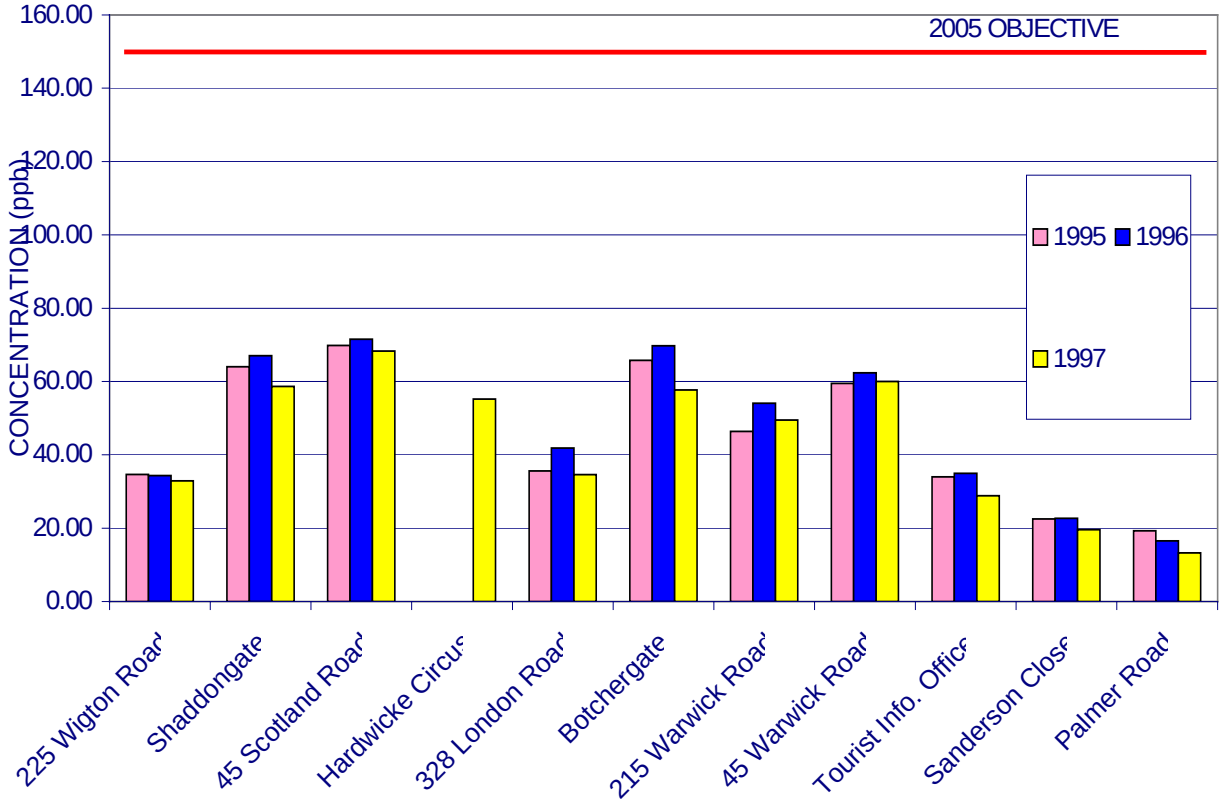
GRAPH 5: NO_2 ANNUAL MEANS



This shows the presence of NO_2 city-wide. Levels are generally highest on the inner city roads (marked "IC" on graph) and exceed the 2005 objective. Arterial roads ("A" on graph) have lower levels, with the exception of Scotland Road. The city centre, where the largest numbers of people are exposed, is located within the pedestrianised area and has levels less than roadside ones (because pollution concentrations fall as separation from the road increases). Urban background levels ("UB" on graph) are relatively low and less than half the objective; these are typical residential locations were people experience most long-term exposure.

The NAQS also defines an hourly standard for NO_2 of 150 ppb. Measuring at hourly intervals requires expensive real-time monitoring equipment that the authority does not possess. It is possible to estimate hourly means by the use of surrogate statistics, using the relationship established by the Environment Agency where peak hourly NO_2 levels are typically 2.4 times greater than the annual mean level. Applying this factor to the annual data would predict hourly means as in graph 6:

GRAPH 6: NO_2 MAXIMUM HOURLY MEANS (SURROGATE STATISTICS)



This suggests that short-term NO_2 levels at monitoring sites are under the NAQS objective by a factor of two. This estimate has not been validated by monitoring.

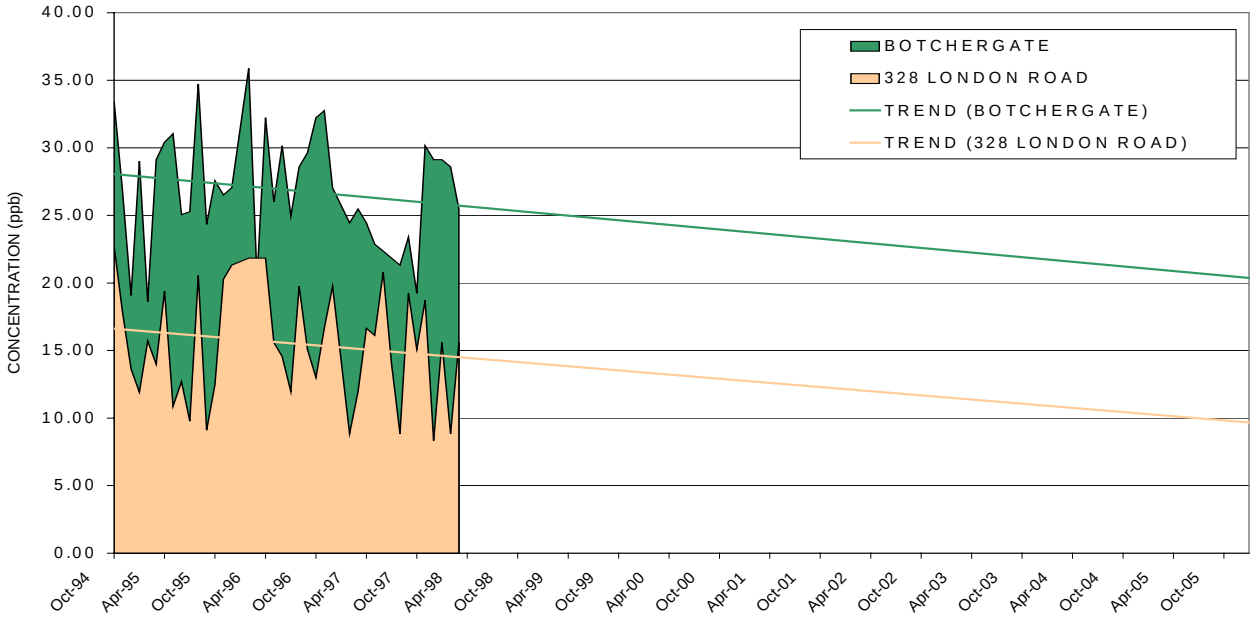
8.5 PREDICTED LEVELS

The national perspective for NO_2 is that levels are expected to fall by 2005, with current policies expected to deliver reductions of about 38%. This will be achieved mainly by increasing proportions of vehicles having catalysts and the availability of lower-sulphur fuels, both measures reducing NOx emissions. Applying this

correction to the worst site – Scotland Road – predicts a change of annual mean from 29 ppb (1996) to 18 ppb (2005).

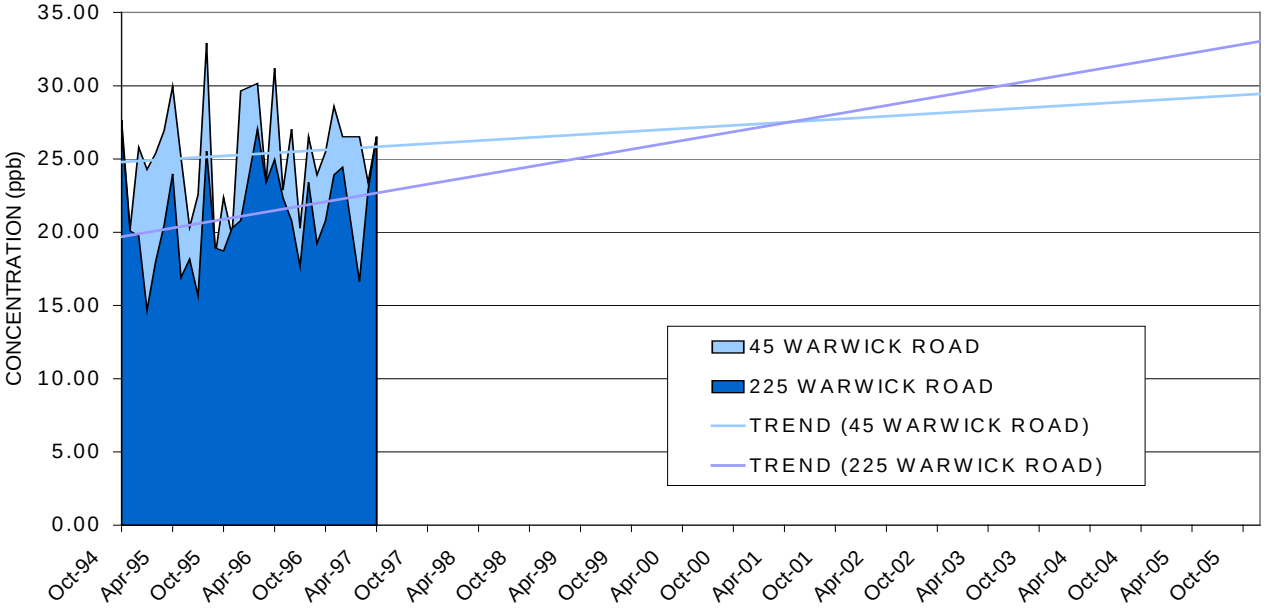
To examine the issue of trends in more detail, the situation in Carlisle during 1995-98 shows an increase in NO_2 levels on some roads. The following graphs illustrate current rates of change and extrapolations to 2005 *were these rates to be maintained*. However this is rather pessimistic because of anticipated increases in vehicle efficiency; it could be considered a worst-case scenario. As most NO_2 comes from traffic, the following predictions have been grouped by the geographical sectors of the city where the pairs of NO_x monitoring sites are located. Graph 7 for the southern sector shows declining levels on both roads:

GRAPH 7: NO_2 TREND TO 2005 (SOUTH)



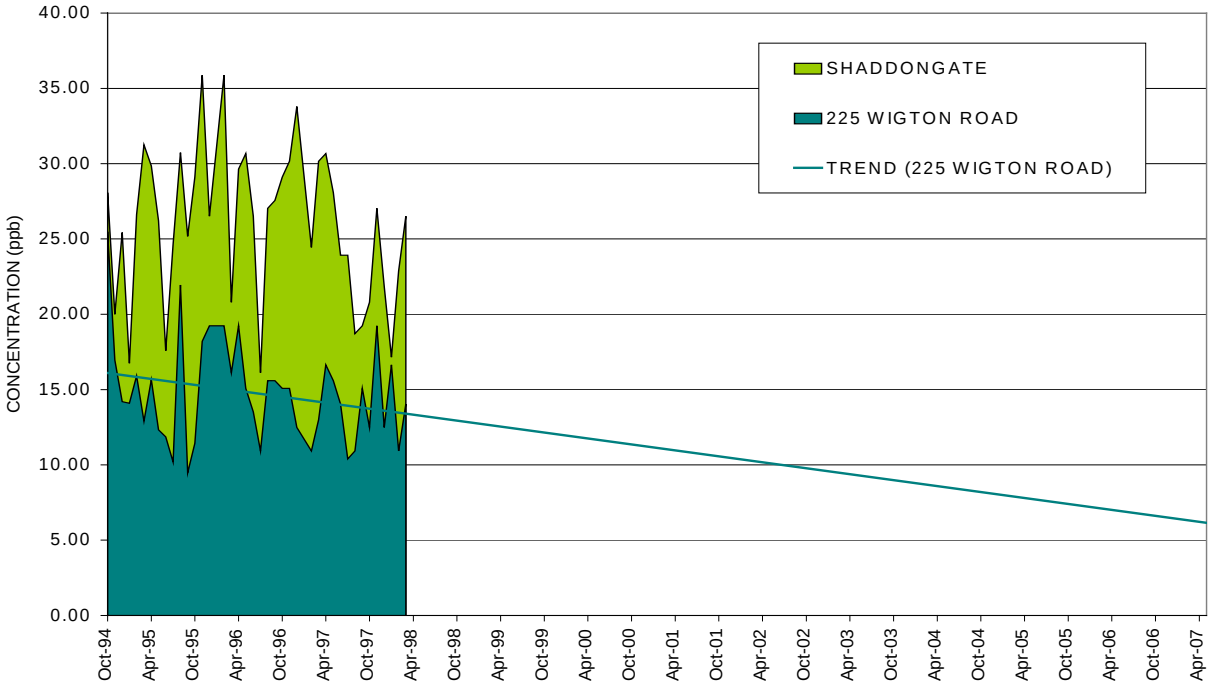
Graph 8 for the eastern sector shows increasing levels, particularly on the outer length of Warwick Road:

GRAPH 8: NO_2 TREND TO 2005 (EAST)



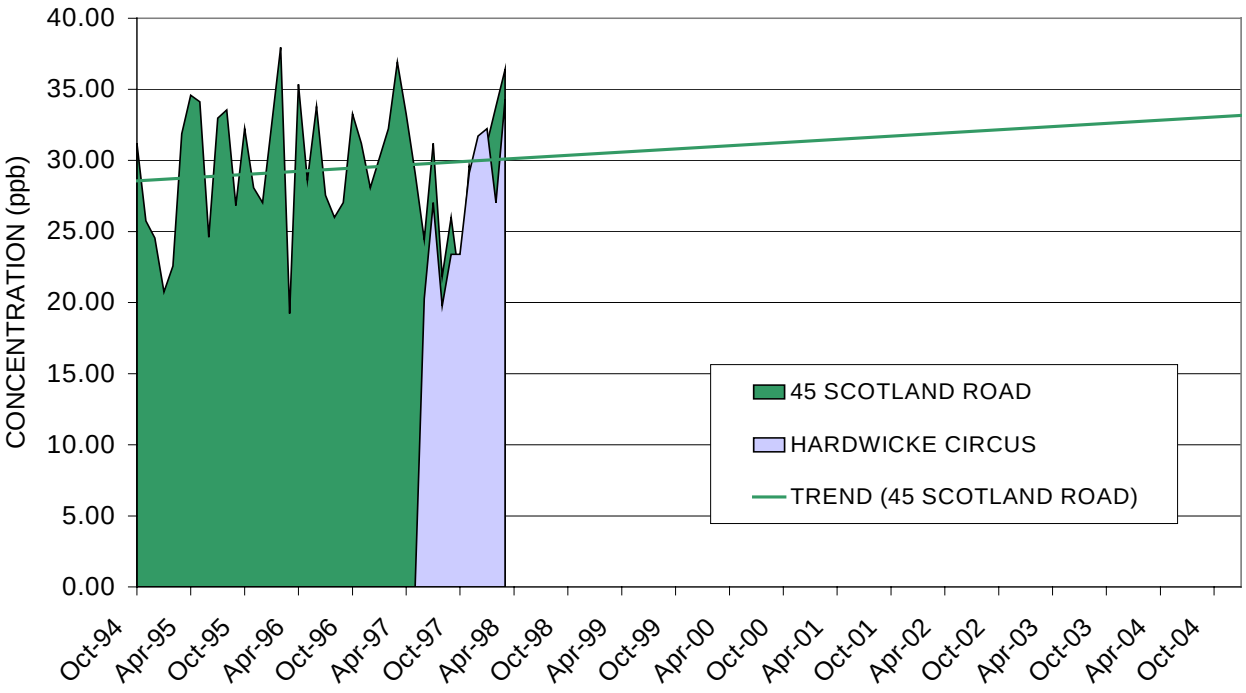
Graph 9 for the western sector shows declining levels on these routes. (The Shaddongate monitoring site had previously been vandalised, necessitating its temporary relocation 200m westwards, but giving some disruption to the data set):

GRAPH 9: $N0_2$ TREND TO 2005 (WEST)



Graph 10 for the northern sector shows increasing levels along Scotland Road. (Hardwicke Circus has not been established sufficiently long to identify a trend):

GRAPH 10: NO_2 TREND TO 2005 (NORTH)



8.6 ASSESSMENT

The Pollutant-Specific Guidance from DETR states that authorities should consider existing or proposed activities which have the potential, singly or together, to emit significant quantities of NO_2. For stage one, these factors include:

- Annual mean urban background NO_2 in 1996 over 30 ppb

  -this condition is virtually met on Scotland Road.

- One or more existing or planned roads with annual average daily traffic flows over 25000 by the year 2005

  -14 roads in Carlisle are predicted to meet this condition

The guidance then states that if the risk of exceeding the air quality objective is not negligible, further review and assessment work should be undertaken. The current highest kerbside NO_2 levels of 30 ppb are over the 21ppb objective and these are predicted to fall to 18 ppb by 2005. This is only a projection and is subject to uncertainties over future traffic growth, congestion and legislative changes. The risk of exceedence is therefore not negligible and justifies further study.

Nitrogen dioxide will be considered for a stage 2 review and assessment.

9. REVIEW & ASSESSMENT OF PARTICULATES

Objective: 50 μg/m^3 PM_{10} or less, when expressed as the 99th percentile of daily maximum running 24-hour means

9.1 SOURCES

Particulates are fundamentally different from the five gaseous pollutants as they consist of solid matter. There are two forms:

- Primary particles, which are emitted directly to the atmosphere. These come mainly from factories, power stations and vehicles. Natural sources include pollen and sea salt. About two thirds of PM_{10} are primary ones.

- Secondary particles, which are mostly sulphates or nitrates formed by natural processes in the air from other pollutants such as SO_2 or NO_2. Their production is not locally controllable. About one third of PM_{10} are secondary particles.

All Particulate Matter (PM) is grouped according to its size, with the maximum diameter of a class stated as a subscript. The NAQS refers to PM_{10}; these are particles which are 10 microns or less in diameter [one micron = 1 μg = one millionth of a metre]. This very fine dust is minute enough to be inhaled into the lungs. Most man-made particles are smaller than 10 microns, with naturally-generated particles tending to be larger.

Particles are a complex mix of substances and a number of sources can be identified. National figures in 1995 considered these as:

- Industry (including quarrying and construction): 47%
- Motor vehicles (2/3 from diesels): 26%
- Power stations: 15%
- Domestic: 11%

There are no fossil-fuel power stations or large industrial sources of particulates in the authority area. Local conditions would therefore suggest a higher proportion of PM_{10} from traffic; possibly up to 50%. National studies have determined that winter pollution episodes (i.e. exceedences of 50 μg/m^3 objective) are 80% generated by traffic emissions. Summer episodes are less common, but are mainly caused by transboundary secondary particles.

The NAQS objective is expressed as the "99th percentile of daily maximum running 24-hour mean." This necessitates measuring particulate levels every hour; the daily running average is then calculated from the 24 readings over the immediately preceding period. This produces 24 averages for each day, the largest one of which is taken as the "daily maximum running 24-hour mean". The 99th percentile represents the reading that would be 99th highest out of an ascending series of 100 readings. Over a period of 365 days, this would represent 4 days' measurements. Using a percentile allows for occasional breaches of the objective, as routinely happens for example around Bonfire Night.

9.2 HEALTH EFFECTS

Fine particles can prejudice health, mainly of respiratory functions, at levels over 1000 $\mu g/m^3$ such as were evident during the smog episodes in 1950s. These concentrations do not occur now, but short-term elevations may cause discernable effects in people with poor respiratory health. A recent study in Birmingham (with a population of one million), showed that a rise in 24-hour average PM_{10} concentration from 25 to 50 $\mu g/m^3$ would typically produce one more admission to hospital for treatment of respiratory diseases. A study in the USA calculated that a 10 $\mu g/m^3$ rise in PM_{10} may be associated with an increase in daily mortality of about 1%, manifested as additional acute effects in older people already suffering from serious heart or lung illnesses. 50 $\mu g/m^3$ was therefore set by EPAQS as a level below which there should be no noticeable effects on public health.

9.3 NATIONAL DATA

Widespread particulate monitoring is a relatively recent activity in the UK. 19 AUN sites were operating in 1995, with Leicester (the smallest city) recording the following data:

TABLE 5: PM_{10} MONITORING DATA, LEICESTER 1995

Measurement	Statistic
Annual average	20 $\mu g/m^3$
99^{th} percentile of running 24-hour mean	50 $\mu g/m^3$
Number of exceedences of NAQS objective	8

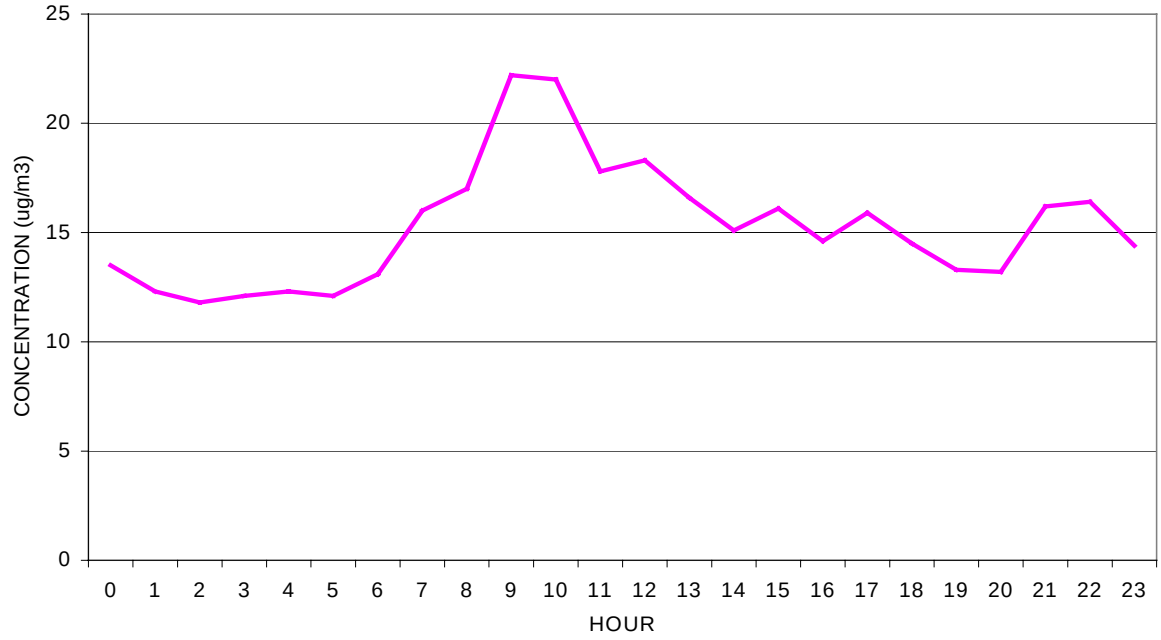
Annual mean concentrations of PM_{10} at urban background AUN sites in the UK were 20-34 $\mu g/m^3$, but with substantial daily and seasonal variations. The NAQS objective was exceeded on average 30 times at each of these locations.

9.4 LOCAL MONITORING

Particulate monitoring is an involved exercise because of the complexity of airborne physical matter. No measurement is presently carried out for particulates because the authority does not have any real-time monitoring equipment for that purpose.

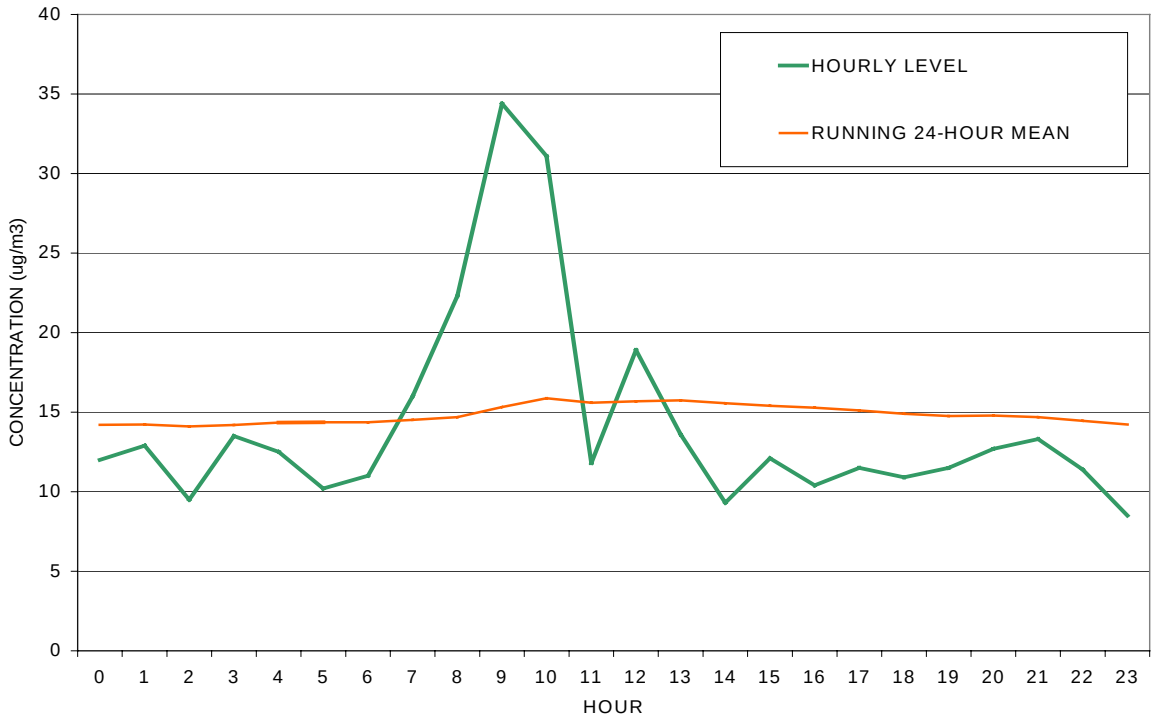
A brief period of PM_{10} measurement was conducted in 1994 as part of an academic study, with a monitoring station located on the roof of the council chamber. This is 9m above road level and too high up to give measurements equal to those experienced by the public on the pavement; readings are therefore an underestimation. However the data does give useful indications of trends. Graph 11 shows how levels varied by the hour over 11-17 August 1994:

GRAPH 11: PM_{10} HOURLY MEANS



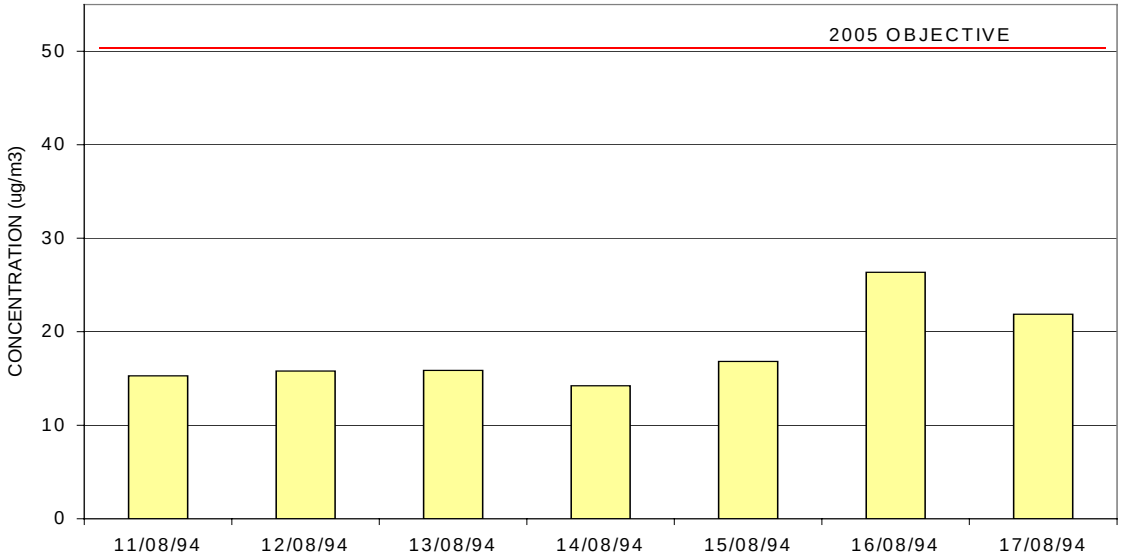
It can be seen from graph 11 that PM_{10} particulate levels are lowest at night, peak after the morning rush hour and then fluctuate during the afternoon and evening. As the NAQS requires a running 24-hour mean, this produces a flat curve that damps out short-term peaks. Graph 12 illustrates the results for one day (13 August 1994) as an example:

GRAPH 12: PM_{10} HOURLY LEVELS AND RUNNING 24-HOUR MEAN



The maximum daily running 24-hour mean occurred at 10 AM when the concentration reached 15.89 $\mu g/m^3$. Graph 13 shows the daily maximum running 24-hour means measured over the period 11-17 August 1994:

GRAPH 13: PM_{10} DAILY MAXIMUM RUNNING 24-HOUR MEANS

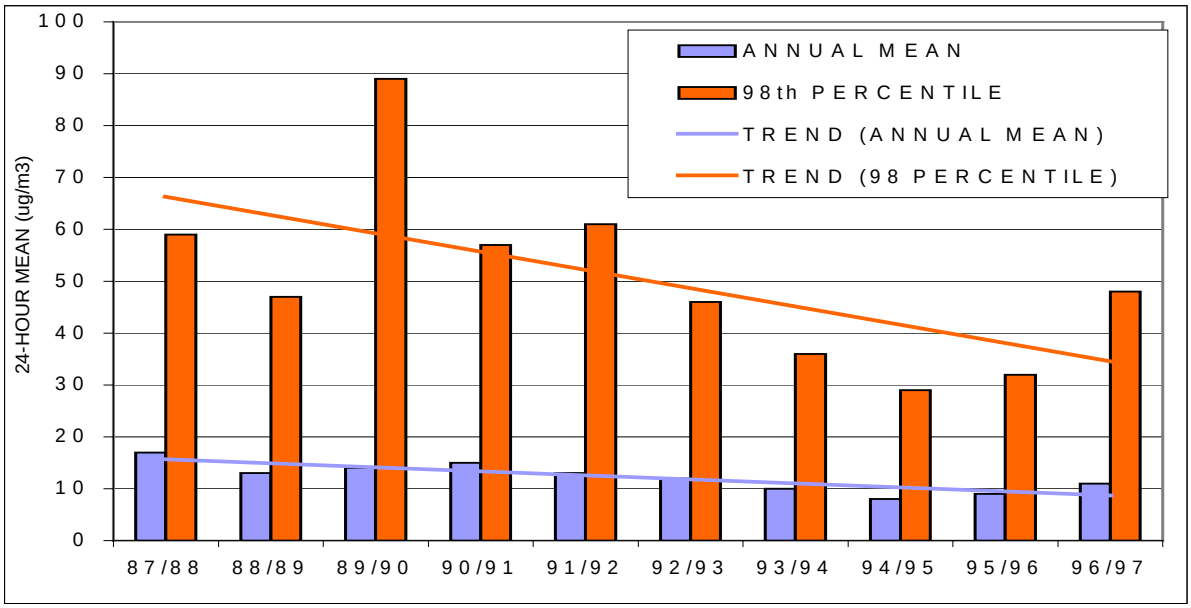


This shows levels under the 2005 objective, but is an underestimation. DETR advice is that national data indicates that every local authority in Great Britain will be at risk of exceeding the objective (and therefore need to progress to a stage 2 review and assessment for PM_{10}).

"Black smoke" is a polluting substance that is component of PM_{10} and has been monitored since the 1960s at the SO_2 and smoke-monitoring site at Denton Street. The air passes through a filter paper, which collects smoke to be analysed by a reflectometer. This data is also passed to AEA Technology who co-ordinate the European Union Directive Network.

This methodology was established following the Clean Air Act of 1956, when concern focussed on soot from coal-burning. These particles are black-coloured and are drawn through white filter paper, leaving a black stain. Black smoke levels have declined dramatically since then (down nationally over 1960-1995 by 93 %). Annual averages in Carlisle over the last 10 years are illustrated in graph 14:

GRAPH 14: BLACK SMOKE 1987-97



The annual mean shows a continuing decline, mostly attributable to the reduction in coal-burning in industrial and domestic properties. The 98th percentile represents peak occurrences and is markedly declining.

The NAQS objective for PM_{10} is 50 $\mu g/m^3$ at the 99th percentile, but this is not comparable with black smoke readings because the latter does not consider particle size. Black smoke measurements mainly record primary particles from local combustion activities. Significantly, secondary particles are mostly transparent and do not show up on the white filter paper. They do not therefore record on the black smoke readings. National studies indicate a concentration of secondary PM_{10} in North Cumbria of 7.5 ppb.

In summary, there is limited local data on particulates. Monitoring has identified moderate levels of PM_{10}, but this data is aged.

9.5 PREDICTED LEVELS

The UK Government estimates that PM_{10} emissions should fall due to current and planned legislation. These include reducing particulate emissions from diesel vehicles and international pollution agreements affecting secondary particle production. Accurate future trends are not calculable.

9.6 ASSESSMENT

The local picture regarding particulates is unclear as no substantial real-time monitoring has been done. The national picture is one of country-wide exceedences of the NAQS annual objective. In order to accurately quantify the levels of PM_{10} in the district, it is recommended that further monitoring be undertaken.

PM_{10} will be considered for a stage 2 review and assessment.

10. REVIEW & ASSESSMENT OF SULPHUR DIOXIDE

Objective: 100 ppb or less, when expressed as the 99.9th percentile of 15-minute means

10.1 SOURCES

Sulphur dioxide (SO_2) is a gas that is mainly produced by the combustion of sulphur-containing fossil fuels. Historical large-scale coal burning produced high urban levels of SO_2 in the UK that combined with soot to form smog. The Clean Air Act 1956 introduced Smoke Control Areas, with restrictions on the use of unauthorised (high sulphur-content) fuels. Subsequent changes in fuel usage lead to increased burning of oil and, more recently, gas. SO_2 levels dropped by 50% from 1970-93 and are now low. 66% of present day SO_2 comes from non-nuclear power stations (mainly coal-burning) and 2% from vehicles.

A common cause of localised SO_2 pollution episodes is where smoke plumes from industrial chimneys are brought down to ground level by atmospheric inversions or wind. This effect can be identified up to 75km from large coal-fired power stations. Carlisle has no such transboundary sources.

The NAQS refers to a 99.9th percentile to allow for occasional exceedences of the objective. Over a year, this would permit up to 35 periods of 15 minutes when SO_2 levels were over 100 ppb.

10.2 HEALTH EFFECTS

Sulpher dioxide is an irritant when inhaled because of its acidic nature. This can cause coughs, irritation and chest tightness. Concentrations over 1000 ppb can narrow the airways in asthmatics, with childrens' lung functions suffering reversible changes at 100-150 ppb. Because health effects may be noticeable after only a few minutes, the objective is set over the very short period of 15 minutes.

10.3 NATIONAL DATA

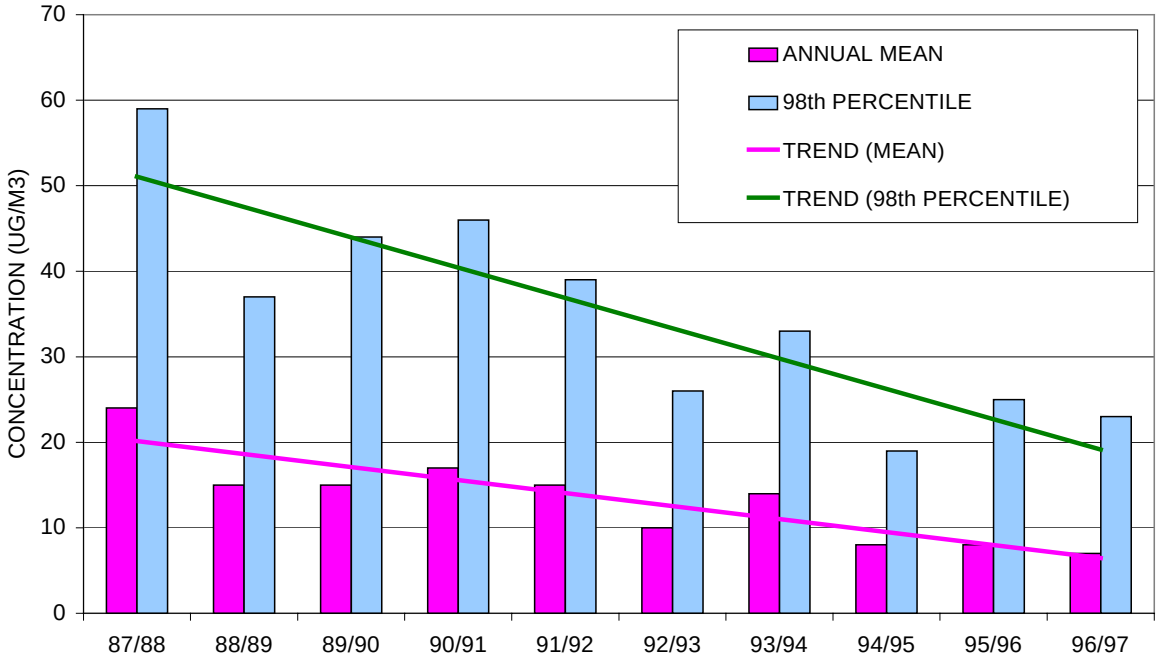
Sulphur dioxide is monitored nationally at 28 AUN sites. In 1995, the Middlesborough station recorded two exceedences of 100 ppb for over 15 minutes. Both episodes peaked at less than 125 ppb.

10.4 LOCAL MONITORING

The authority maintains a SO_2 and smoke-monitoring site at Denton Street, Carlisle. This uses an eight-port sampler to bubble air through a peroxide solution to remove SO_2. The resultant solutions are analysed weekly to determine airborne concentrations as daily averages.

The data is collated by AEA to produce annual means and 98th percentiles of daily levels (concentration exceeded on four days in the year). These figures for the period 1987-97 are shown in graph 15:

GRAPH 15: SO_2 ANNUAL MEANS AND DAILY LEVEL 98TH PERCENTILES



This indicates steadily declining trends in both annual mean and 98th percentile. (The 15-minute NAQS objective of 100 ppb is equivalent to 267 µg/m^3, the y-axis units used on the graph). It is not possible to infer any 15-minute means from this data because the measuring period is very short and exceedences are primarily determined by local atmospheric conditions.

10.5 PREDICTED LEVELS

SO_2 levels have declined nationally for 40 years and this trend is expected to continue. The UK Government is committed to reducing emissions of SO_2 by large combustion plants by 75% by 2005. Airborne concentrations should therefore continue to fall.

10.6 ASSESSMENT

Long-term monitoring in the city has established declining SO_2 levels. Although no short-time monitoring has been undertaken, the annual mean in 1997 was only 2 ppb (NAQS 15-minute objective: 100 ppb).

SO_2 will not be considered for a stage 2 review and assessment.

11. SUMMARY OF FINDINGS

This stage one review and assessment of local air quality in the Carlisle City Council area has examined seven pollutants as required in the Air Quality Regulations 1997.

Levels of benzene, 1,3-butadiene, carbon monoxide, lead and sulphur dioxide are expected to meet the National Air Quality Strategy objectives by December 2005. There is a significant risk that the objectives will not be met for nitrogen dioxide and particulates.

The annual mean for nitrogen dioxide is currently at the 2005 limit and traffic levels in Carlisle are reasonably high, and predicted to rise further. It is therefore necessary to examine the impact of this pollutant in more detail.

Particulate levels have not been accurately measured in the city, but there are significant local sources in the forms of traffic and industry. The UK perspective is of elevated PM_{10} levels nationwide and DETR anticipates that every local authority in Britain will need to proceed to stage 2.

It is recommended that a stage 2 review and assessment is undertaken for nitrogen dioxide and particulates.

12. SECOND STAGE REVIEW AND ASSESSMENT

The second stage review and assessment will focus on nitrogen dioxide and particulates. DETR Guidance Note 1 "Framework for review and assessment of air quality" states that a second stage review and assessment should include the:

> "estimation, modelling or measurement of levels of pollutants in areas influenced by road transport, industrial, or other significant sources."

The Government's intention is that a more detailed examination be conducted to assess pollution concentrations in locations where people are likely to be exposed. For long-term objectives (i.e. NO_2 : one year, PM_{10} : 24 hours) this would typically be near schools, houses and hospitals. Short-term objectives (i.e. NO_2 : one hour) would also include pavements and parks.

DETR recommends that the second stage is based on monitoring and modelling.

12.1 MONITORING

Monitoring is necessary to gather data on the existing levels of pollution to which the public are exposed. At present, the only monitoring undertaken for the two pollutants of concern is for NO_2 with 12 diffusion tubes. As these are changed monthly, they provide valid data for annual means, but nothing precise for short-term figures. No PM_{10} monitoring is undertaken. More detailed monitoring data is therefore necessary for the second stage.

DETR Technical Guidance Note 1, “Monitoring for air quality reviews and assessments” recommends the following procedures:

NO_2	Stage 2:	widely-distributed diffusion tubes
	Stage 3:	continuous automatic monitoring (1-hour resolution)
PM_{10}	Stage 2:	gravimetric or non-automatic/automatic sampling
	Stage 3:	gravimetric sampling (24-hr resolution), or preferably continuous automatic monitoring (1-hour resolution)

Monitoring should be conducted over at least a six-month period and should include a winter season, as most pollution episodes occur then. The Government expects the whole review and assessment process to be completed by local authorities by December 1999, so stage two monitoring should begin during autumn 1998. In order to gain the fullest picture of the nitrogen dioxide and particulate situation in Carlisle, it is recommended that the more sophisticated equipment required for stage three monitoring is started at the same time. This would provide the data required for any stage three review and assessment work during 1998.

12.2 MODELLING

(bit missing)

13. ANNEXES

13.1 Roads exceeding 25,000 vehicles per day

13.2 Locations of NO_2 diffusion tube sites

14. REFERENCES

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8. Department of the Environment, Transport and the Regions, internet site http://www.environment.detr.gov.uk/airq/aqinfo.htm

9. "Air pollution in the UK: 1995", AEA Technology, January 1997.

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11. "Monitoring for air quality reviews and assessments", Department of the Environment, Transport and the Regions, March 1998.

15. GLOSSARY

Accuracy	A statistical definition for defining how well measured data fits the true values
AEA	Atomic Energy Authority
AQMA	Air Quality Management Area
AUN	Automated Urban Network
BS	British Standard
CO	Carbon Monoxide
DETR	Department of the Environment, Transport and the Regions (formerly Department of the Environment)
EA	Environment Agency
EPAQS	Expert Panel on Air Quality Standards
Mean	The average value of a data set
mg/m^3	Milligrams per metre cubed
NAEI	National Atmospheric Emissions Inventory
NAQS	National Air Quality Strategy
NETCEN	National Environmental Technology Centre
NO_2	Nitrogen Dioxide
PM_{10}	Particulate Matter of 10 microns or less in diameter
ppb	Parts per billion
ppm	Parts per million
Precision	A statistical definition of how closely a set of repeated measurements taken independently are to one another
SO_2	Sulpher Dioxide
µg	microgram (one millionth of a metre)
$\mu g\ m^3$	microgram per cubic metre