6: Detailed Assessment of PM_{10} Particulate Matter

The Government has adopted two air quality objectives for PM_{10} particulate matter.

These air quality objectives are;

- 40 ug/m^3 (Gravimetric)[1] as an annual average to be achieved by the end of 2004.

- 50 ug/m^3 (Gravimetric) as a 24 hour mean, to be exceeded no more than 35 times per year to be achieved by the end of 2004.

In addition to these objectives, the European Union has set air quality Limit Values for PM_{10} of;

- 20 ug/m^3 (Gravimetric) as an annual average to be achieved by the end of 2010.

- 50 ug/m^3 (Gravimetric) as a 24 hour mean, to be exceeded no more than 7 times per year to be achieved by the end of 2010.

The European Union Limit Values have not yet been transposed into UK legislation, but DEFRA have recommended that local authorities should consider these Limit Values as provisional air quality objectives, and that an assessment of compliance with the Limit Values should be included in air quality Review & Assessment reports.

The Phase One, Stage 3 Review & Assessment concluded that exceedences of the 24 hour, 2004 objective, were likely, in locations where public exposure would occur.

In July 2001 Manchester City Council declared an AQMA, based on exceedences of the annual average nitrogen dioxide objective. The AQMA covered the city centre, the north of the city, and locations near to busy roads in the south east of the city. Map 1.1 shows the extent of the AQMA. The areas of predicted exceedence of the PM_{10} objective were much smaller than the areas of predicted nitrogen dioxide exceedence, and were confined to roadside locations near the major road network. The areas of PM_{10} exceedences were all within the much larger area that was identified as being at risk of exceeding the annual average nitrogen dioxide objective. As such, the area of nitrogen dioxide exceedence was used as the basis of the AQMA, and no separate AQMA was declared for PM_{10}.

In May 2003 Manchester City Council published the Phase Two, Update & Screening Assessment. This assessment concluded that there was a risk of the 2004 24 hour objective being exceeded at locations close to the busiest roads, and junctions in the city. No exceedences of the 2004 annual average objective were predicted. This Detailed Assessment will define the location and extent of predicted exceedences of the PM_{10} objectives.

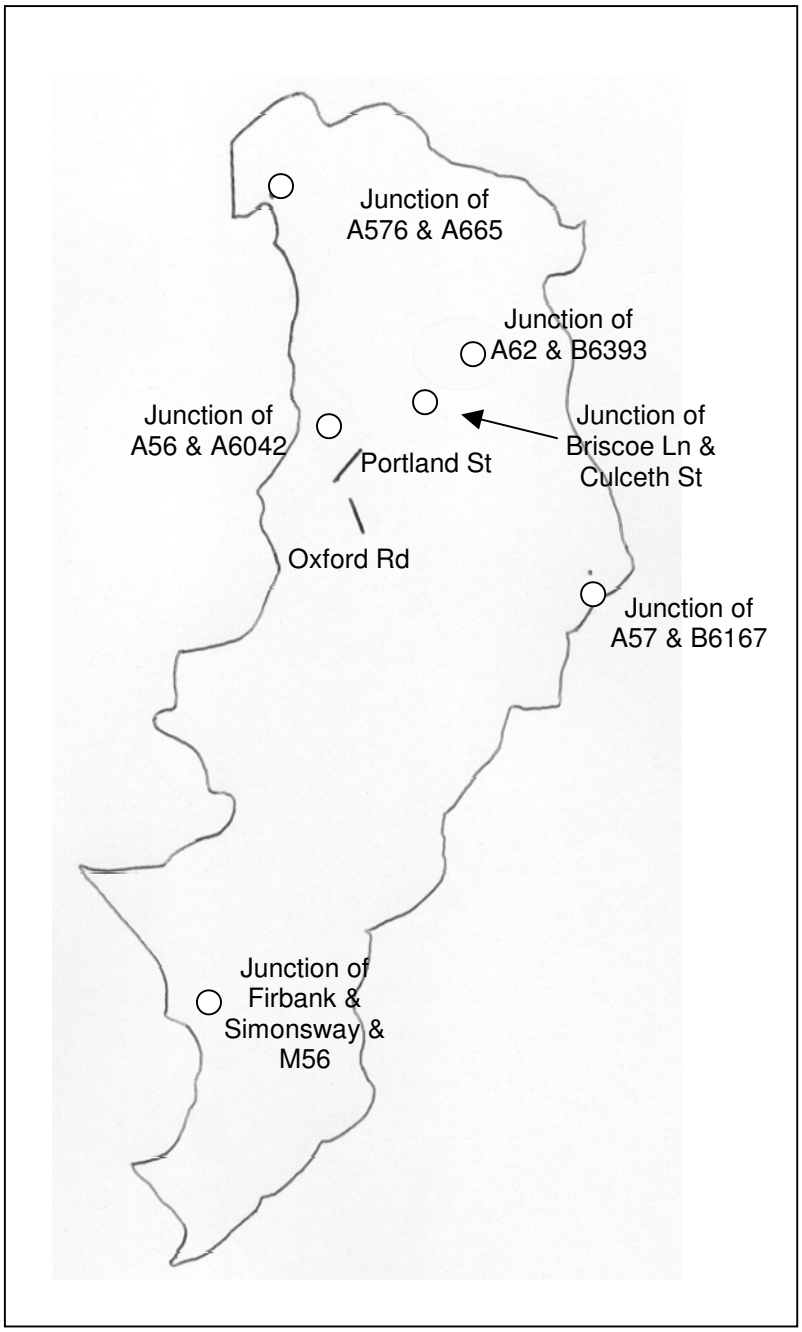
The locations identified in the Update & Screening Assessment were;

1. Oxford Road in Manchester city centre.
2. Portland Street in Manchester city centre.
3. The junction of the A57 Hyde Road and B6167 Reddish Lane.
4. The junction of the A56 Great Ducie Street and A6042 Trinity Way.
5. The junction of the A62 Oldham Road and B6393 Thorp Road.
6. The junction of Briscoe Lane and Culceth Street.
7. The junction of Firbank and Simonsway, and junction 4 of the M56
8. The junction of the A576 Middleton Road and A665 Cheetham Hill Road.

These locations are shown in figure 6.1 overleaf.

Technical Guidance note LAQM TG(03) sections 8.73 to 8.101 provide a methodology for carrying out a Detailed Assessment of PM_{10}. The Technical Guidance note stresses that the Detailed Assessment should focus on locations where maximum relevant public exposure is likely to occur, and to define the magnitude and geographic extent of any exceedences in these areas. The Detailed Assessment therefore involves two elements. Firstly, the results from the Manchester air quality monitoring programme will be used to determine whether or not exceedences of the objective are likely. Secondly, if likely exceedences are predicted, atmospheric dispersion modelling will be used to define the magnitude and geographic extent of the exceedence, with a particular focus on those areas identified by the analysis of the monitoring data.

Figure 6.1 Locations identified in the Update & Screening Assessment as being at risk of suffering exceedences of the PM_{10} objectives.



6.1 Real time monitoring of PM_{10}

Technical Guidance note LAQM TG(03) box 8.6 provide a methodology for estimating future concentrations of PM_{10}, based on current monitoring results.

Manchester City Council operate both gravimetric and TEOM particulate matter analysers.

A Partisol Plus Gravimetric PM_{10} analyser is located at the Manchester Piccadilly AURN monitoring site, in Piccadilly Gardens, in central Manchester. This instrument is operated by Manchester City Council, under a contract issued by DEFRA. Regular calibration of this instrument, QA/QC checks, and data management, are all carried out by Casella Ltd, also under contract to DEFRA.

At the time of writing this Detailed Assessment, ratified results for this analyser were only available for the period 22nd March 2002 to 22nd May 2003. Results obtained from this analyser are shown in figure 6.2 below.

Figure 6.2 Gravimetric PM_{10} data

Annual average	Maximum 24 hour average	No. of 24 hour averages over 50 ug/m^3	Data capture
32.9	109.5	64	93%
			Results in ug/m^3 gravimetric

The results obtained from the gravimetric analyser indicate that over this monitoring period the 2004 annual average objective was achieved, but there was an exceedence of the 2004 24 hour objective. The provisional 2010 objectives were both exceeded.

In addition to the gravimetric analyser, Manchester City Council also operate a TEOM particulate matter analyser. This analyser is also located at the Manchester Piccadilly AURN site, and forms part of the suite of analysers affiliated to the national network. This TEOM analyser is calibrated, and is subject to QA/QC and data management checks, in accordance with AURN procedures. The results from the TEOM analyser are shown in table 6.3. Projected figures for 2004 were calculated using the equation shown in LAQM TG(03) Fig. 8.1.

TEOM analysers are considered to be less accurate than their gravimetric counterparts as the TEOM microbalance is held at 50°C, to prevent condensed water vapour from adding to the weight of the sample. Unfortunately this means that the volatile component of the particles, (such as sulphates, nitrates, and VOC), are likely to evaporate, and some of the mass will be lost. Technical Guidance Note LAQM TG(03) Box 8.2 recommends that a correction factor of x 1.3 should be applied to TEOM data, to account for the lost volatile material. TEOM results shown in this report have been multiplied by 1.3 to produce gravimetric equivalent results.

Figure 6.3 TEOM PM_{10} concentrations at the Manchester Piccadilly AURN site.

Year	Annual average	Maximum 24 hour average	No. of 24 hour averages > 50 ug	Data capture	Projected 2004 annual average	Projected 2004 no. of 24 hr >50 ug
1996	34.01	125.07	46	98%	25.61	46
1997	31.21	110.50	34	94%	25.21	34
1998	27.72	108.49	22	97%	24.48	22
1999	26.30	74.64	9	99%	24.14	9
2000	27.48	84.55	23	98%	26.68	23
2001	38.89	185.09	73	97%	36.90	73
2002	27.48	85.37	13	95%	26.66	13
2003	28.45	76.00	33	98%	27.99	33
Results in ug/m^3 gravimetric						

The results show that there have been exceedences of the 2004 24 hour objective during both 1996 and 2001. it should be noted that 1996 was a year of unusual meteorological conditions, when elevated PM_{10} concentrations were observed across the UK. 2001 was also unusual for this site, as major redevelopment work was taking place around this monitoring point. The redevelopment building work produced significant amounts of dust, which may have contributed to elevated local PM_{10} levels. The projected 2004 annual average and 24 hour concentrations do not exceed the objectives, with the exception of the 24 hour concentrations projected from 2001 data)

The TEOM results suggest that the 2004 annual average and 24 hour average objectives are unlikely to be exceeded at background locations. However, high concentrations of PM_{10} are often found at roadside locations, rather than the background sites where the real time monitoring was carried out. To overcome this situation, Manchester City Council also employ particulate matter monitors, at locations across the city. The results from these monitors are discussed in section 6.2.

6.2 PM_{10} monitoring using 'M' type sampling apparatus

As well as the automatic analysers installed in the city centre, Manchester City Council also operate a network of 'M' type total particulate matter samplers. These 'M' type samplers do not differentiate between PM_{10} particles and larger sizes which are not of interest, and so the results from the 'M' type sample cannot be directly compared to the objective. However, the 'M' type sampler does provide a cost effective means of measuring particulate matter concentrations at numerous locations across the city. Furthermore, the 'M' type samplers have a D50 cut off of 13.5 um, and so produce an approximation of PM_{10} concentrations in typical wind speed conditions.

In order to improve the usefulness of the 'M' type sampler results, a year specific correction factor was derived to estimate what proportion of the total particulate matter collected was likely to be PM_{10}. The correction factor was

obtained by co-locating an 'M' type sampler with the TEOM unit in Piccadilly Gardens, for a number of years. This allowed a comparison of the results between the two instruments, from which a bias correction factor for the 'M' type sampler could be calculated. The calculation used to derive this factor is shown in Appendix B.

Results from the 'M' type sampler network, adjusted to give a gravimetric equivalent result, are shown in figure 6.4 below.

Figure 6.4 Results from the 'M' type sampler network

Year	Clayton			St. Pauls School			M56 Junction 4		
	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture
1995	-	-	-	22.94	28.68	81%	31.45	39.31	85%
1996	24.04	33.18	100%	20.92	28.87	96%	29.42	40.60	100%
1997	23.59	29.02	100%	20.48	25.19	96%	29.45	36.22	96%
1998	18.69	24.86	96%	19.51	25.95	98%	26.46	35.19	96%
1999	19.83	27.37	98%	19.08	26.33	100%	27.34	37.73	98%
2000	16.37	32.41	98%	17.40	34.45	100%	25.97	51.42	100%
2001	19.75	18.37	81%	17.18	15.98	94%	27.46	25.54	90%
2002	17.97	19.59	86%	16.44	17.92	92%	24.00	26.16	96%
2003	22.38	28.20	88%	22.16	27.92	88%	32.27	40.66	88%
All results ug/m^3 TEOM equivalent									

The 'M' type samplers have an exposure period of seven days, and so are unsuitable for calculating compliance with the 24-hour objective. There are no clear trends in the concentration of PM_{10} measured at these sites. The results indicate that there may be exceedences of the 2004 annual average objective at locations close to the M56 motorway, and other hot spots.

6.3 Atmospheric dispersion modelling of PM_{10}

The results of PM_{10} monitoring in Manchester indicated that exceedences of the 2004 objectives were possible. Atmospheric dispersion modelling was carried out, in order to define the location, magnitude, and geographic extent of any areas of exceedence.

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

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

The methodology used to carry out the dispersion modelling was discussed at length in Section 4 of this report. Sections 4.3.1 to 4.3.8 provide details of the inputs used in the model, and the model validation. Section 4 deals specifically with the modelling of annual average concentrations of nitrogen dioxide, and the same approach was also used for the PM_{10} dispersion modelling. One area of difference, however, was the derivation of the background concentration used.

6.3.1 Model inputs - background concentrations

Technical Guidance Note LAQM TG(03) Section 8.05 states that PM_{10} should be thought of as being comprised of three separate types of particles. Primary particles are those particles directly emitted from combustion processes, including motor vehicle engines. They are comprised of soot, and unburned fuel material, and they are only thought to affect the local area close to the source. The modelling exercise focused on calculating the rate of dispersion of primary particles, and what contribution they would make to concentrations at locations near to busy roads.

The other two types of particle that make up PM_{10} are classified as secondary, and coarse particles. Secondary particles are crystalline molecules formed by chemical reactions in the atmosphere, typically from the condensation of gaseous pollutants such as sulphates. Although secondary particles will reduce in concentration with distance from their source, they are generally thought of as being more of a regional issue than primary particulate. It is considered appropriate to apply a single secondary particulate concentration to an entire modelled area.

Coarse particle are made up of re-suspended dust from road traffic, dust from construction work, sea salt, transboundary pollutants, and particles from a wide variety of other sources. Like secondary particulate, the concentration of coarse particles are similar across large geographical areas, and so a single background concentration is applicable.

An appropriate background concentration would therefore be a PM_{10} data set unaffected by local primary particulate sources, but with similar secondary and coarse particle loading to Manchester. It was decided that the most likely candidate for a PM_{10} data set without primary particulate contribution would be from a rural PM_{10} monitoring site. Unfortunately no PM_{10} measurements are undertaken at any rural site in Greater Manchester, and therefore a data set had to be sought from further afield. Nationally, only three rural sites were identified as having PM_{10} measurements. These were Rochester, Harwell, and Narberth. Data from the Harwell site was rejected, as insufficient data had been collected in 2001 to allow an adequate estimation of background to be made. Of the remaining two sites, Narberth was judged to be the most appropriate, as this South Wales site is located in the west of the UK, as is Greater Manchester, and is therefore likely to experience similar levels of transboundary particulates. Also, Narberth experiences a similar climate to Greater Manchester, with high rainfall and wind speed

The annual average PM_{10} measured at Narberth was 19.3 ug/m^3 gravimetric. This figure was taken to be comprised of both secondary and coarse particulate. The 1999 APEG[3] report indicated that both urban and rural locations would experience a similar coarse particle concentration, of 5 ug/m^3. The figure of 19.3 ug/m^3 (gravimetric) was therefore used as a background concentration for all of the PM_{10} dispersion modelling carried out for Greater Manchester.

6.3.2 Model verification

Before predictions of future concentrations were made, the model was run to calculate PM_{10} concentrations using 2001 emissions and meteorological data. The results from the modelling were compared to actual measured PM_{10} concentrations made in 2001.

Figure 6.5 Modelled and measured PM_{10} at TEOM analyser sites in Greater Manchester.

AURN site name	2001 measured annual average PM_{10} concentration	2001 modelling output for the site, annual average PM_{10}
Bolton	20.71	21.02
Bury Roadside	32.41	27.52
Manchester Piccadilly	39.01	21.12
Salford Eccles	24.15	21.31
Stockport	22.78	20.87
Wigan Leigh	24.20	20.66
Calibration Club sites below		
Oldham West End Hse.	24.94	21.38
Salford St Marks (M60)	24.44	24.49
Stockport Bredbury	21.63	20.55
Stockport Cheadle	19.92	20.28
Stockport Marple	18.87	19.98
Tameside Two Trees	23.52	20.51
Trafford Moss Park	23.71	20.89
Wigan Parsons Walk	29.98	20.69
		Results in annual average ug/m^3 TEOM

The results show that the model had not performed well. There was a significant underprediction of PM_{10} concentrations at most of the monitoring sites. The worst model performance was observed for the Manchester Piccadilly and Wigan Parsons' Walk monitoring sites. The poor model performance at these two locations was thought to be due to site specific local factors. As has been mentioned previously, the Manchester Piccadilly site was affected by nearby building work in 2001, which probably led to elevated local construction derived PM_{10} concentrations which could not be effectively used as a comparison in the emissions inventory. The Parsons Walk site is located very close to a six storey building, and is subject to an unusual airflow which may have lead to higher PM_{10} concentrations accumulating near the monitoring site. However, even with the exception of these two sites, the

model was still clearly underpredicting PM_{10} concentrations. This was a similar situation to the one observed for NO_X modelling results, as set out in Section 4 of this report. The underprediction of NO_X results was thought to be due to national traffic related emissions factors not adequately reflecting emissions from the local vehicle fleet. The vehicle fleet used in urban areas such as Greater Manchester may be older, poorly maintained, or may be comprised of high mileage vehicles. This problem was overcome by adjusting the road derived NO_X concentrations produced by the model. A similar procedure was therefore carried out to adjust the road contribution to PM_{10}.

6.3.3 Adjustment of modelled PM_{10} road contribution

For each of the TEOM analyser locations, the modelled and measured road traffic derived PM_{10} concentration was calculated. The modelled road derived PM_{10} concentration was obtained from the model, by subtracting background concentrations and the non-road derived PM_{10} contribution. Measured road derived PM_{10} was estimated by taking the total measured PM_{10}, and subtracting the background concentration of 19.3 ug/m^3, and also subtracting the non-road derived PM_{10} from the model. The comparison of measured and modelled road derived PM_{10} is shown in the table below.

Figure 6.6 Modelled and measured roadside PM_{10} at TEOM analyser sites in Greater Manchester

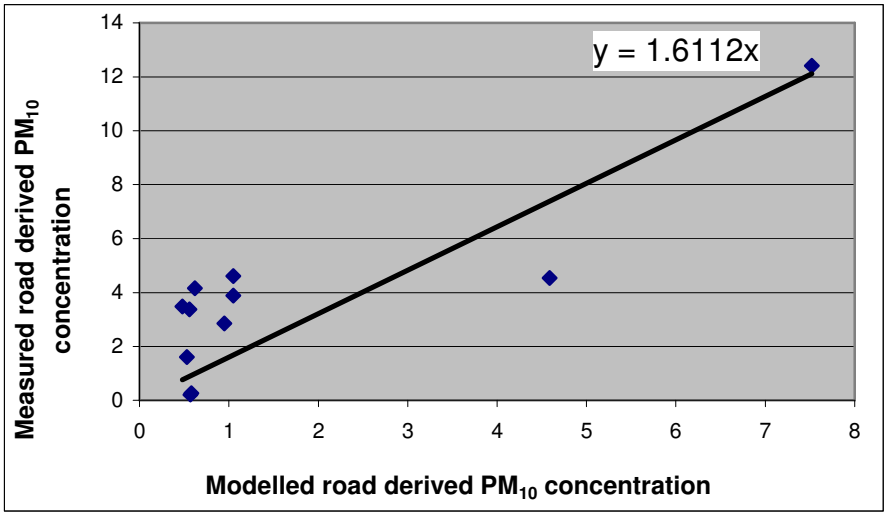
AURN site name	2001 measured annual average road derived PM_{10} concentration	2001 modelling output for the site, road derived annual average PM_{10}
Bolton	0.27	0.58
Bury Roadside	12.41	7.52
Manchester Piccadilly	18.82	0.93
Salford Eccles	3.89	1.05
Stockport	2.86	0.95
Wigan Leigh	4.16	0.62
Calibration Club sites below		
Oldham West End Hse.	4.61	1.05
Salford St Marks (M60)	4.54	4.59
Stockport Bredbury	1.61	0.53
Stockport Cheadle	0.21	0.57
Stockport Marple	0.00	0.20
Tameside Two Trees	3.49	0.48
Trafford Moss Park	3.38	0.56
Wigan Parsons Walk	9.77	0.48
		Results in annual average ug/m^3 TEOM

The results of this comparison show that the model was generally underpredicting PM_{10} concentrations at these sites, and that the model output would require adjustment.

The comparison between modelled and measured PM_{10} concentration was plotted on a graph, to identify an appropriate adjustment factor. The derived

adjustment factor showed the lowest error when the results for Manchester Piccadilly and Wigan Parsons' Walk were removed from the data set. The result for Stockport Marple was also removed from the data set, as using this methodology it appears that this site has no road derived PM_{10} contribution. The Marple site is located in a suburban, almost rural location, and is probably not affected by road derived PM_{10} emissions.

Figure 6.7 Plot of monitored and modelled PM_{10} at TEOM analyser sites in Manchester



This comparison produced a correction factor of 1.6112. This adjustment factor was applied to the road derived PM_{10} contribution produced during this modelling exercise.

The model adjustment correction factor of x 1.6112 was only applied to the road derived PM_{10} concentration, it was not applied to point source emissions, volume emissions, or background concentrations. The adjustment factor was applied during the post processing of the results. The impact of the application of the adjustment factor is shown in figure 6.8 overleaf.

Figure 6.8 Measured, unadjusted modelled, and adjusted modelled roadside PM_{10} at TEOM analyser sites in Greater Manchester

AURN site name	2001 measured annual average road derived PM_{10} concentration	2001 modelling output for the site, road derived annual average PM_{10}	Adjusted modelling output of road derived annual average PM_{10}
Bolton	0.27	0.58	0.93
Bury Roadside	12.41	7.52	12.12
Salford Eccles	3.89	1.05	1.69
Stockport	2.86	0.95	1.53
Tameside Two Trees	3.49	0.48	0.77
Wigan Leigh	4.16	0.62	1.00
Oldham West End House	4.61	1.05	1.69
Salford St Marks (M60)	4.54	4.59	7.40
Stockport Bredbury	1.61	0.53	0.85
Stockport Cheadle	0.21	0.57	0.92
Trafford Moss Park	3.38	0.56	0.90
			Results in ug/m^3 TEOM

These adjusted road derived PM_{10} concentrations were then added to the unadjusted PM_{10} levels derived from other sources, and the background concentrations. This allowed the total PM_{10} concentration to be re-calculated for each site, and an overall comparison of total measured and modelled, (adjusted), PM_{10} to be calculated.

The comparison between measured and adjusted modelled PM_{10} is shown in the figure 6.9 overleaf.

Figure 6.9 Modelled and measured total PM_{10} at TEOM analyser sites in Greater Manchester

AURN site name	2001 measured annual average total PM_{10} concentration	Adjusted PM_{10} modelling output for the site
Bolton	20.71	21.37
Bury Roadside	32.41	32.12
Manchester Piccadilly	39.01	21.69
Salford Eccles	24.15	21.95
Stockport	22.78	21.45
Wigan Leigh	24.20	21.04
Calibration Club sites below		
Oldham West End Hse.	24.94	22.02
Salford St Marks (M60)	24.44	27.30
Stockport Bredbury	21.63	20.87
Stockport Cheadle	19.92	20.63
Stockport Marple	18.87	20.10
Tameside Two Trees	23.52	20.80
Trafford Moss Park	23.71	21.23
Wigan Parsons' Walk	29.98	20.98
		Results in annual average ug/m^3 TEOM

The adjusted PM_{10} model results show a lower error, (a lower difference between modelled and measured concentrations), than was obtained using the original, pre-adjustment modelled concentrations.

By using the adjusted road contribution, the overall level of difference between total measured PM_{10} and modelled PM_{10} reduced from 12% to 8%. The level of improvement in model performance was highest for the urban sites, the very sites where there was the greatest likelihood of an exceedence of the objectives.

6.3.4 Model resolution

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

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

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

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

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

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

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

processing resources. The production of annual average contour plots for Greater Manchester took the equivalent of 15,120 PC hours.

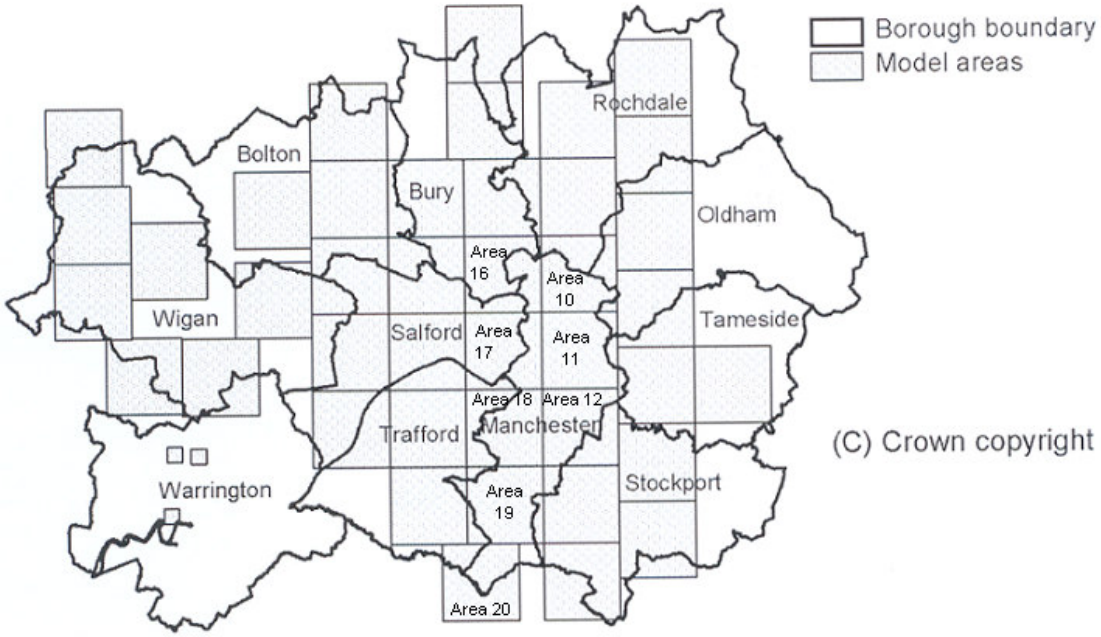
The results from the atmospheric dispersion modelling exercise are shown in the next section of this report.

6.4 Results of atmospheric dispersion modelling

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

For the purposes of this atmospheric dispersion modelling Greater Manchester was split up into 44 separate 5x5 km modelling areas. The areas relevant to the Manchester City Council area were numbered 10 to 12, 16 to 19, and 20. The location of the modelling areas are shown in figure 5.1.

Figure 5.1 Location of modelling areas.



These modelling areas cover almost all of the Manchester City Council area. All of the locations identified in the Update & Screening Assessment, (as requiring inclusion in the Detailed Assessment), were located within the modelled areas. A full description of the results for each modelling area can be found in junction 6.5 of this report.

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

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

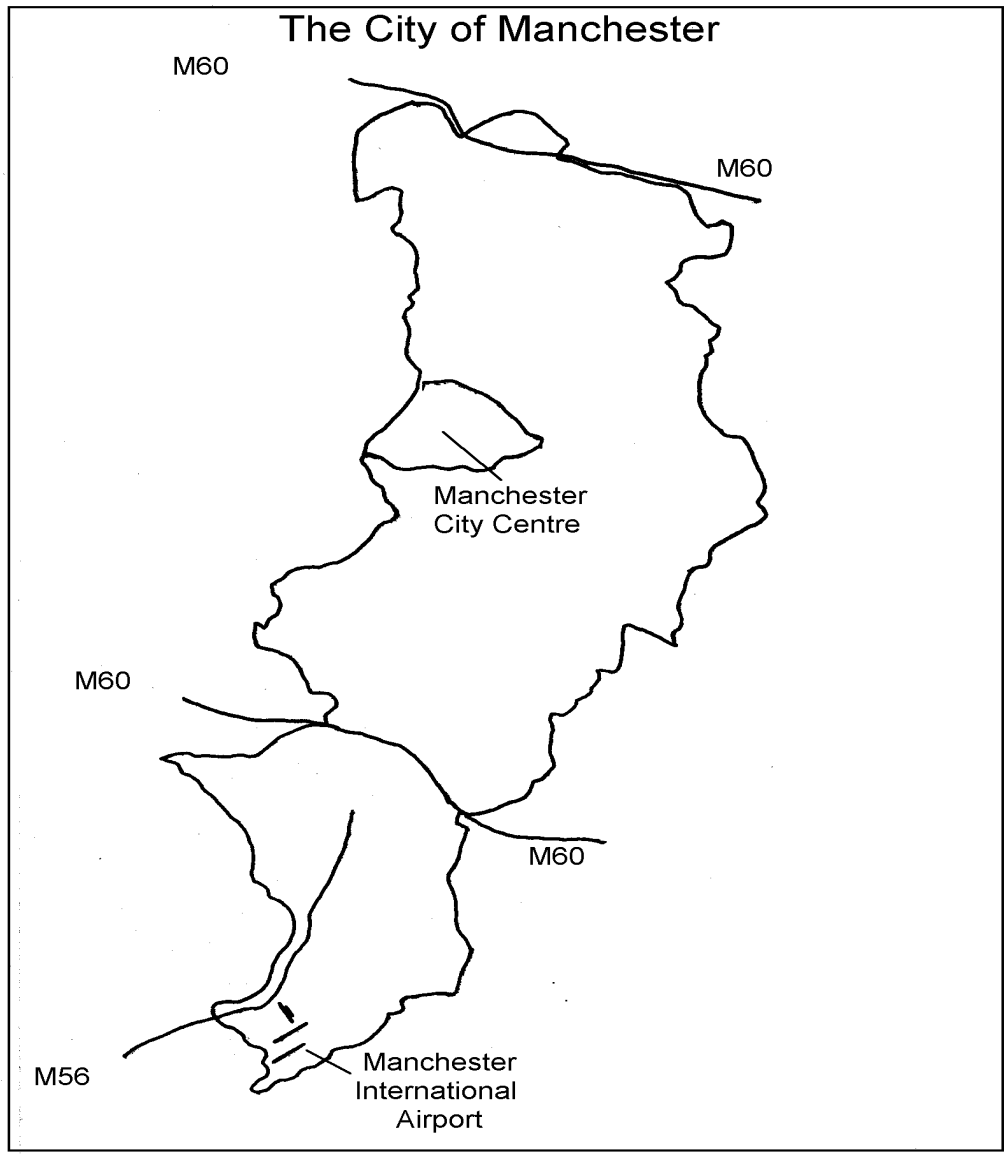
Manchester Airport has been treated separately, as the airport has a unique combination of emission sources, including aircraft, mobile and fixed ground equipment, and traffic.

Each of these three geographic areas is described in section 4.6.1 of this report. A description of the geography of Manchester is also provided in this section.

6.4.1 The geography of Manchester

The city of Manchester is located in the centre of Greater Manchester, in the north west of England. The city is bounded by Rochdale Metropolitan Borough Council (MBC), Oldham MBC, Tameside MBC, Stockport MBC, Macclesfield Borough Council, Trafford MBC, the City of Salford, and Bury MBC. Map 5.2, showing a selection of important locations in Manchester, is reproduced below.

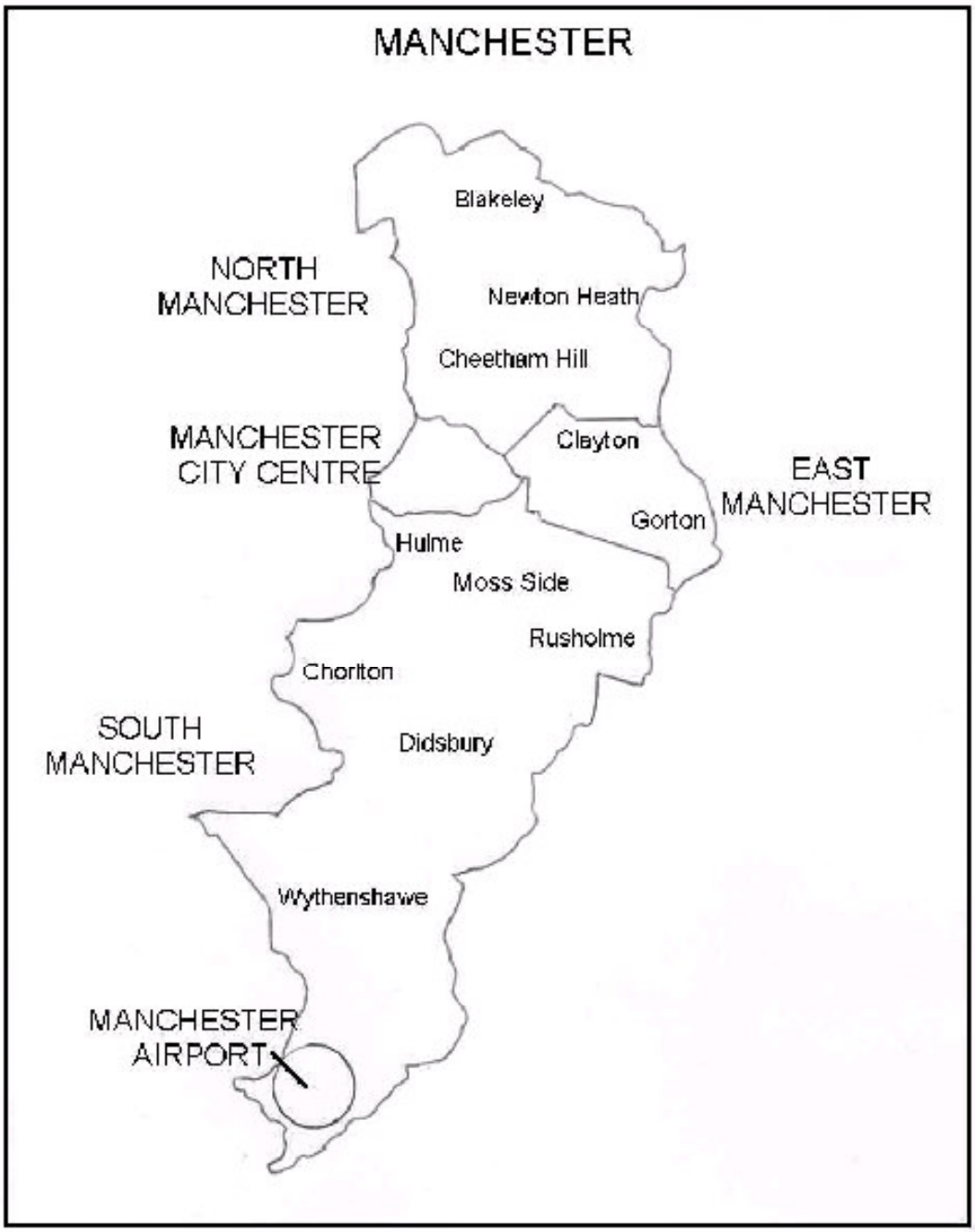
Figure 5.2 Location of Manchester city centre, motorways, and Manchester International Airport



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

As was described in section 5.1, the city of Manchester, was divided into three types of area, (city centre, airport, and rest of city), for the purpose of presenting the results of the atmospheric dispersion modelling. The map below shows selected districts in Manchester, and also shows the location of the airport and city centre.

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



6.5 PM_{10} dispersion modelling results for Manchester city centre

PM_{10} monitoring carried out in Manchester city centre indicated that there had been exceedences of the 2004 24 hour average concentration in 1996 and 2001. These years were considered to be atypical, due to unusual meteorological conditions in 1996, and due to building work occurring close to the monitoring site in 2001, leading to artificially elevated concentrations being recorded in that year.

Projections of future PM_{10} concentrations, based on existing monitoring data, indicated that there would not be any exceedences of the 2004 objectives.

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

Atmospheric dispersion modelling was carried out, for PM_{10} in 2004. The dispersion modelling results indicated that all locations in Manchester would achieve the 2004 PM_{10} objectives.

6.5 PM_{10} dispersion modelling results for Manchester city centre

The location of Manchester city centre is shown in figures 5.5 and 5.6. The city centre area described here is the area which falls within the Manchester Inner Ring Road. The city centre entirely falls within the Central council ward, although it should be noted that this council ward also extends outside of the city centre area described here.

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

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

Monitoring of PM_{10} is undertaken in Manchester City Centre, at the Manchester Piccadilly AURN site. Both gravimetric and TEOM analysers are installed at this location. However, there was not a complete calendar year of ratified gravimetric results available at the time of writing this report. The results from the TEOM instrument was shown in figures 6.3 of this report. This table is reproduced below.

Figure 6.3 TEOM PM_{10} concentrations at the Manchester Piccadilly AURN site.

Year	Annual average	Maximum 24 hour average	No. of 24 hour averages > 50 ug	Data capture	Projected 2004 annual average	Projected 2004 no. of 24 hr >50 ug
1996	34.01	125.07	46	98%	25.61	46
1997	31.21	110.50	34	94%	25.21	34
1998	27.72	108.49	22	97%	24.48	22
1999	26.30	74.64	9	99%	24.14	9
2000	27.48	84.55	23	98%	26.68	23
2001	38.89	185.09	73	97%	36.90	73
2002	27.48	85.37	13	95%	26.66	13
2003	28.45	76.00	33	98%	27.99	33
Results in ug/m^3 gravimetric						

As was discussed in Section 6.1, the results from the years 1996 and 2001 were considered unusual, and do not necessarily provide an accurate baseline from which to calculate future concentrations of PM_{10}. The projected results therefore indicate that the 2004 air quality objectives are likely to be achieved at urban central locations in Manchester city centre. However, roadside locations may experience higher concentrations than urban central locations.

Atmospheric dispersion modelling was carried out, to determine the location, and magnitude, of areas of exceedence across the city centre. As was discussed earlier, dispersion models can produce results as both contour plots and as tables of receptor point results. Contour plots can only readily be produced for long term averaging periods, such as annual averages. For the 2004 PM_{10} objectives, the 24-hour objective was more difficult to achieve than the annual average objective. As such, the tabular results, (which included an assessment against the 24 hour objective), formed the basis of the 2004 assessment.

Receptor points were selected, at the nearest residential locations to the three city centre locations, identified in the USA as being at risk of exceeding the objectives. Results obtained for these receptor points are shown in figure 6.10 below.

Figure 6.10 PM_{10} Receptor point results from Manchester city centre

Location of Area of Potential Exceedence	Receptor Location	2004 90.4%ile of 24 hour averages	No of 24 hour averages > 50 ug/m^3	2004 annual average
Oxford Road	Residential locations on Oxford Road	29.94	0	22.16
Portland Street	Piccadilly Gardens adjacent Portland Street	28.45	0	20.92
Junction of A56 & A6042	Flats facing onto A6042 Trinity Way at Ducie Bridge	33.94	1	24.72

Results in ug/m^3 (gravimetric)

These receptor points were located at the nearest exposure locations, to the junctions and roads expected to have the highest PM_{10} concentrations in the city centre. As such, these results represent the worst case, roadside scenario of PM_{10} concentrations.

The results obtained at these receptor points indicate that there are not expected to be any exceedences of the 2004 objectives in Manchester city centre.

6.6 2010 PM_{10} dispersion modelling results for Manchester city centre

The Detailed Assessment of PM_{10} against the 2004 objectives, described in full in section 6.5 of this report, indicated that all locations in Manchester city centre would achieve the PM_{10} objectives.

A provisional PM_{10} objective for 2010 has been proposed. The new 2010 objectives are more challenging than the 2004 objectives.

PM_{10} concentrations are expected to decrease over time. Despite this decrease, projected future 2010 concentrations of PM_{10} measured in Manchester city centre are above the more stringent 2010 annual average objective level.

Atmospheric dispersion modelling was carried out. The results from this dispersion modelling indicated that exceedences of the 2010 annual average objective will occur at roadside locations in the city centre.

6.6 2010 PM_{10} dispersion modelling results for Manchester city centre

In addition to the existing UK air quality objectives for PM_{10}, the European Union has set air quality Limit Values for PM_{10} of;

- 20 ug/m^3 (Gravimetric) as an annual average to be achieved by the end of 2010.

- 50 ug/m^3 (Gravimetric) as a 24 hour mean, to be exceeded no more than 7 times per year to be achieved by the end of 2010.

The European Union Limit Values have not yet been transposed into UK legislation, but DEFRA have recommended that local authorities should consider these Limit Values as provisional air quality objectives, and that an assessment of compliance with the Limit Values should be included in air quality Review & Assessment reports.

PM10 is measured in Manchester city centre, at the Manchester Piccadilly AURN site. Results from the TEOM instrument at the AURN site were projected to 2010, using the equation in technical guidance note LAQM TG(03) Figure 8.1. The results are shown in figure 6.11 below.

Figure 6.11 Projected 2010 PM_{10} concentrations in Manchester city centre

Year	Annual average (gravimetric)	No. of 24 hour averages > 50ug/m^3	Projected 2004 annual average	Projected 2004 no. of 24 hr >50 ug	Projected 2010 annual average	Projected 2010 no. of 24 hr >50 ug
1996	34.01	46	25.61	14	23.62	9
1997	31.21	34	25.21	13	23.26	9
1998	27.72	22	24.48	11	22.62	7
1999	26.30	9	24.14	10	22.33	7
2000	27.48	23	26.68	17	24.55	11
2001	38.89	73	36.90	60	33.51	42
2002	27.48	13	26.66	17	24.54	11
2003	28.45	33	27.99	21	25.70	14
Annual average results in ug/m^3 (gravimetric)						

These results indicate that both the annual average and 24 hour objective are likely to be exceeded in 2010. It is important to note that the concentration of PM_{10} is actually expected to decrease between 2004 and 2010, and that the exceedences have arisen in 2010 due to the introduction of the more challenging objectives for this year.

Atmospheric dispersion modelling was carried out to determine the location, and magnitude of the area of exceedence. The receptor points used in the 2004 modelling were also assessed for 2010. However, in 2010 the annual average is considered the more challenging objective, (compared to the 2010 24 hour objective), and so it was appropriate to produce annual average contour plots in addition to the tabulated results from the receptor points.

The results obtained from these receptor points, for 2010, are shown in figure 6.12 below.

Figure 6.12 PM_{10} Receptor point results from Manchester city centre

Location of Area of Potential Exceedence	Receptor Location	2010 Annual average (ug/m^3)	98.08%ile 24 hour (ug/m^3)	No. of 24 hour periods > 50 ug/m^3
Junction of A6042 & A56	Flats facing onto A6042 Trinity Way at Ducie Bridge	22.05	34.71	0
Oxford Road	Residential locations on Oxford Road	20.05	33.11	0
Portland Street	Piccadilly Gardens adjacent Portland Street	19.23	31.00	0

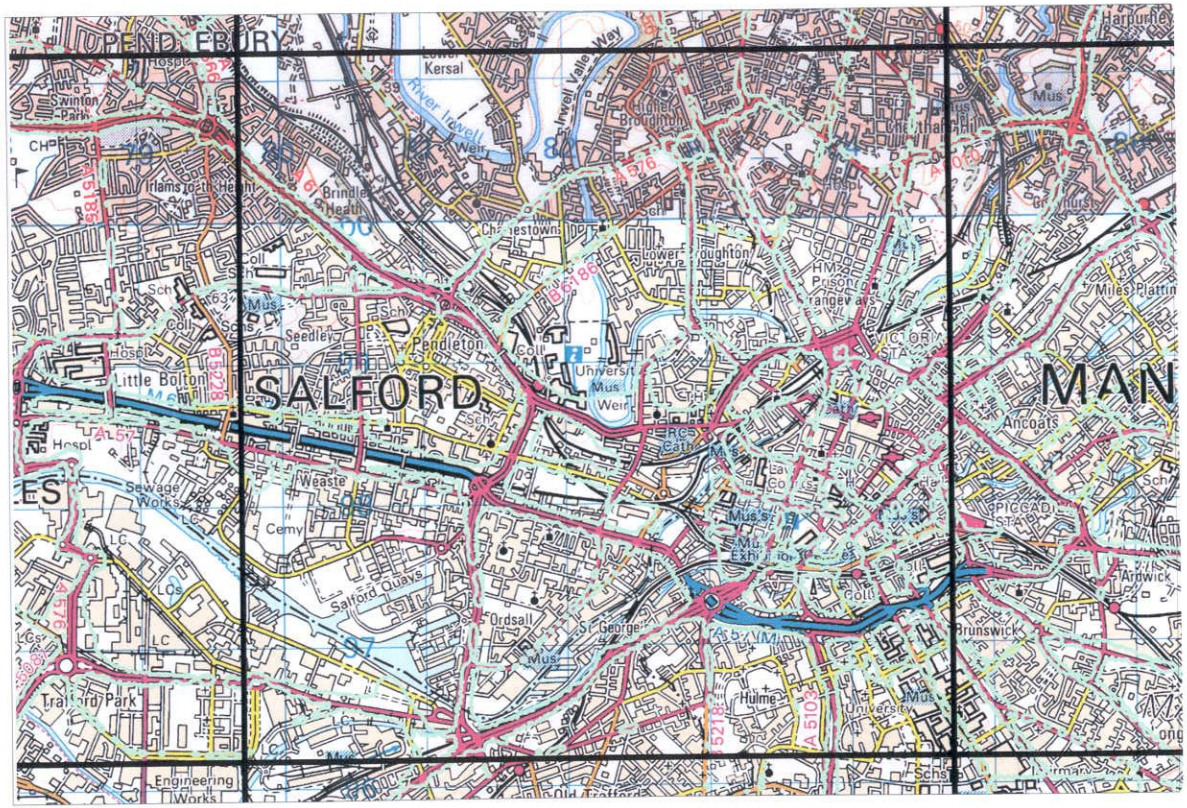
Results in ug/m^3 (gravimetric)

The results show that the annual average objective will be exceeded, or approached, at all of these locations. This shows that the exceedences of the annual average objective are going to impact on areas where exposure occurs. There were no predicted exceedences of the 24-hour objective.

The contour plots on the following pages show the locations and extent of the exceedences of the annual average objective.

The results indicate that there are numerous roads in the city centre, along which roadside exceedences of the 2010 annual average objective may occur.

Area 17 - 2010 annual average



ARIC, December 2003

Area 11 - 2010 annual average

Model area

PM10 (ug/m³)

20.0

30.0

36.8

40.0

43.2

N

(C) Crown Copyright

2 0 2 4 Kilometers

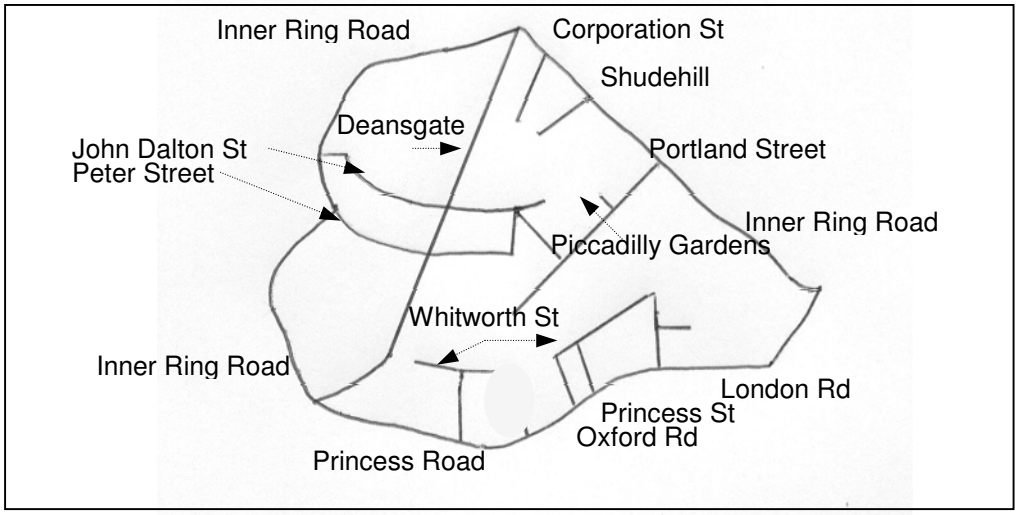
ARIC, December 2003

The results indicate that there are numerous roads in the city centre, along which roadside exceedences of the 2010 annual average objective may occur.

The results are confined to roadside locations close to the busiest roads in the city centre.

Figure 6.13 below shows the names of the roads, along which roadside exceedences have been predicted. Exceedences shown here are almost identical to those predicted for the 2005 annual average nitrogen objective.

Figure 6.13 Exceedences of the 2010 annual average PM_{10} objectives



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

The results will be used to inform the Manchester Air Quality Action Plan.

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

6.7 PM_{10} dispersion modelling results for Manchester Airport

The Manchester City Council Phase Two Update & Screening Assessment recommended that residential locations close to Manchester Airport should be included in the Detailed Assessment. This recommendation was based on technical guidance from DEFRA, which stated that airports with a throughput of 5 million passengers, or more, per annum, should be subject to Detailed Assessment. Manchester Airport is used by almost 20 million passengers per annum, and therefore qualified for inclusion in the Detailed Assessment.

Future concentrations of PM_{10} at Manchester Airport were calculated by projecting existing monitoring data to 2004. These projected concentrations indicated that the area around Manchester Airport would achieve the 2004 PM_{10} objectives.

Atmospheric dispersion modelling was carried out for the residential locations closest to Manchester Airport. The results of this dispersion modelling indicated that these residential locations would achieve the 2004 objectives.

6.7 2004 PM_{10} dispersion modelling results for Manchester International Airport

The location of Manchester International Airport is shown in map 4.11. The airport is located in the extreme south of the city. Manchester Airport Plc have committed to working in partnership with Manchester City Council on a variety of environmental protection programmes. Details of these programmes were provided in Section 5.4 of this report.

Particulate matter monitoring is carried out at the Manchester South AURN site, near Manchester Airport, using an 'M' type sampler unit. Results from this sampling programme are shown in figure 6.14 below.

Figure 6.14 Bias adjusted particulate matter concentrations measured at Manchester South AURN site

Year	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave. 2004	Annual Ave. 2010
1997	17.10	21.03	100%	27.57	26.51
1998	16.45	21.88	86%	26.85	25.66
1999	16.14	22.27	96%	26.72	25.48
2000	14.89	29.48	82%	32.99	30.91
2001	15.28	14.21	96%	19.38	19.07
2002	12.26	13.36	84%	18.46	18.25
2003	19.55	24.63	77%	28.83	27.31
All results ug/m^3 TEOM equivalent					

The results indicate that there are unlikely to be exceedences of the 2004 annual average objective at this location. However, the 'M' type sampler does not produce results which can be compared to the 24 hour objective.

Atmospheric dispersion modelling was carried out for locations around Manchester Airport, in order to assess the 2004 24 hour concentrations that can be expected in this area.

A number of receptor points were selected at residential locations close to the airport. The receptor points were close to different areas of the airport, where different types of activities occur. The results modelled at each of these receptor points are shown in figure 6.15 overleaf.

The residential locations selected were the closest points to the airport boundary, where public exposure was likely to occur.

Figure 6.15 2004 PM_{10} results at receptor points in Area 20.

Location of Area of Potential Exceedence	Receptor Location	2004 Annual average (ug/m^3)	98.08%ile 24 hour (ug/m^3)	No. of 24 hour periods > 50 ug/m^3
Runway & taxiway	Ravenscar Crescent	20.07	34.13	0
Airport car park	Hilary Road	20.28	34.33	0
Airport approach road	Oak Farm	20.16	34.05	0
Directly under flightpath	Manchester South AURN	19.58	33.90	0

Results in ug/m^3 (gravimetric)

The results demonstrate that there are unlikely to be any exceedences of the 2004 objectives at these locations. The locations chosen are the closest locations to the airport, where public exposure was likely to occur. As such, they are representative of worst case exposure. If these locations are expected to achieve the objective, then exceedences are unlikely at other locations where public exposure would occur.

Manchester Airport Plc have committed to working in partnership with Manchester City Council on a variety of environmental protection programmes. In 2003 the City Council and Airport authority jointly purchased a Partisol Plus gravimetric particulate matter analyser, for installation at the Manchester South AURN site. Results from this analyser will be used to inform future air quality management decisions at the airport.

6.8 2010 PM_{10} dispersion modelling results for Manchester Airport

The Detailed Assessment of PM_{10} against the 2004 objectives, described in full in Section 6.7 of this report, indicated that locations close to Manchester Airport would meet the 2004 objectives.

A new PM_{10} objective, for 2010, has been proposed. The new provisional 2010 objective is lower, (and therefore more challenging), than the existing 2004 objective.

Projected 2010 concentrations of PM_{10} around Manchester Airport indicated that exceedences of the 2010 annual average objective could occur.

Atmospheric dispersion modelling was carried out. The results of the dispersion modelling also indicated that exceedences of the 2010 annual average objective could occur at Manchester Airport

6.8 2010 PM_{10} dispersion modelling results for Manchester Airport

Section 6.8 concluded that there would not be any exceedences of the 2004 objectives at locations near the airport. However, the provisional objectives for 2010 are considerably more stringent than the 2004 objectives. An assessment for 2010 was also carried out.

Particulate matter monitoring is carried out at the Manchester South AURN site, near Manchester Airport, using an 'M' type sampler unit. Results from this sampling programme are shown in figure 6.16 below.

Figure 6.16 Bias adjusted particulate matter concentrations measured at the Manchester South AURN site

Year	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave. 2004	Annual Ave. 2010
1997	17.10	21.03	100%	27.57	26.51
1998	16.45	21.88	86%	26.85	25.66
1999	16.14	22.27	96%	26.72	25.48
2000	14.89	29.48	82%	32.99	30.91
2001	15.28	14.21	96%	19.38	19.07
2002	12.26	13.36	84%	18.46	18.25
2003	19.55	24.63	77%	28.83	27.31
All results ug/m^3 TEOM equivalent					

The results indicate that there is a possibility of exceedences of the 2010 annual average objective at this site.

Atmospheric dispersion modelling was carried out, using the same receptor points as were used for the assessment against the 2004 objectives. The results obtained at these receptor points are described in figure 6.17 below.

Figure 6.17 2010 PM_{10} results at receptor points in Area 20.

Location of Area of Potential Exceedence	Receptor Location	2004 Annual average (ug/m^3)	98.08%ile 24 hour (ug/m^3)	No. of 24 hour periods > 50 ug/m^3
Runway & taxiway	Ravenscar Crescent	20.07	31.73	0
Airport car park	Hilary Road	20.28	30.84	0
Airport approach road	Oak Farm	20.41	30.98	0
Directly under flightpath	Manchester South AURN	18.24	30.43	0

Results in ug/m^3 (gravimetric)

The results indicate that there are unlikely to be exceedences of the 24-hour objective at any of these locations. However, exceedences of the annual

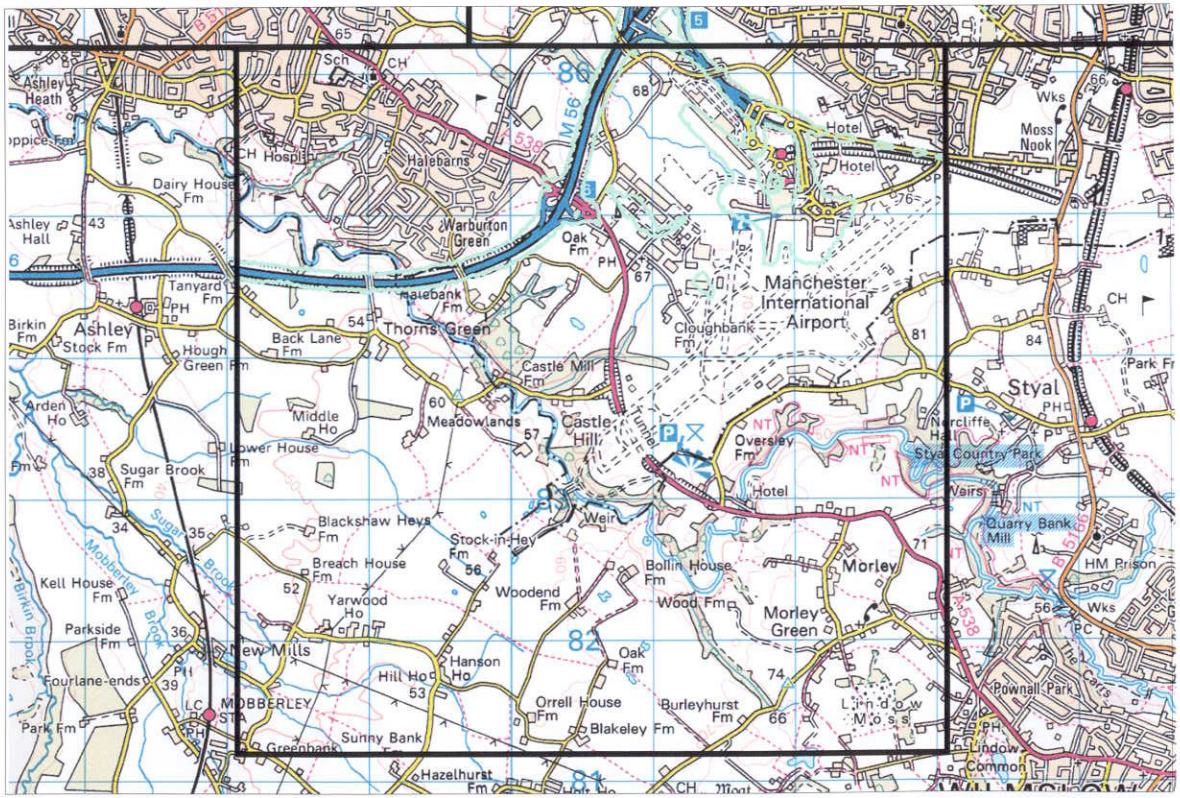
average objective were predicted at the residential locations close to the airport.

Contour plots of 2010 annual average PM_{10} concentration were produced, to determine the location and magnitude of the areas of exceedence. This contour plot is shown on the following page.

The plot shows that the area of exceedence is confined to the area around the airport buildings, on-site car parks, and the airport approach road.

These results will inform the Manchester Airport Environment Plan to 2015, and Manchester Airport Plc have committed to a continuing partnership approach with Manchester City Council, to work together to improve air quality in the city.

Area 20 - 2010 annual average



Model area

PM10 (ug/m³)

20.0

30.0

36.8

40.0

43.2

N

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2 0 2 4 Kilometers

ARIC, January 2004

6.9 PM_{10} dispersion modelling results for other locations in the city of Manchester

Monitoring of PM_{10} was carried out across the city of Manchester. Results from this monitoring network indicated that concentrations of PM_{10} in Manchester are currently below the 2004 objective levels.

Results from this monitoring network were projected forward to 2004. The projected results indicated that the 2004 PM_{10} objectives would be achieved in Manchester.

Atmospheric dispersion modelling was carried out, at worst case locations close to the busiest road junctions in Manchester. The results of this dispersion modelling indicated that there would be no exceedences of the 2004 objectives.

The 2004 PM_{10} objectives will be met at all locations in the city of Manchester.

6.9 PM_{10} dispersion modelling results for other locations in the city of Manchester

The assessments of PM_{10} concentrations carried out in sections 6.5 to 6.8 of this report, have dealt with the predicted areas of exceedence that can be expected in Manchester city centre, and in the vicinity of Manchester Airport. Section 6.9 will provide a Detailed Assessment of PM_{10} concentrations across the rest of the Manchester City Council area.

Figures 4.11 and Map 5.3, showed the city of Manchester, and the location of the city centre, airport, and a number of selected districts within the city. Figure 5.3, showing selected districts in the city, is reproduced on the next page.

The Manchester City Council Update & Screening Assessment identified the following locations, where the PM_{10} objectives may be exceeded. These locations were the junctions of;

9. A57 Hyde Road and B6167 Reddish Lane.
10. A62 Oldham Road and B6393 Thorp Road.
11. Briscoe Lane and Culceth Street.
12. Firbank and Simonsway, and junction 4 of the M56
13. A576 Middleton Road and A665 Cheetham Hill Road.

Monitoring of particulate matter is carried out at a number of locations across Manchester. Results from this monitoring network are shown in table 6.18 below. The Clayton and St Pauls, (Wythenshawe) sites are urban background locations. The M56 site is a roadside location.

Figure 6.18 Results from the 'M' type sampler network

Year	Clayton			St. Pauls School			M56 Junction 4		
	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture
1995	-	-	-	22.94	28.68	81%	31.45	39.31	85%
1996	24.04	33.18	100%	20.92	28.87	96%	29.42	40.60	100%
1997	23.59	29.02	100%	20.48	25.19	96%	29.45	36.22	96%
1998	18.69	24.86	96%	19.51	25.95	98%	26.46	35.19	96%
1999	19.83	27.37	98%	19.08	26.33	100%	27.34	37.73	98%
2000	16.37	32.41	98%	17.40	34.45	100%	25.97	51.42	100%
2001	19.75	18.37	81%	17.18	15.98	94%	27.46	25.54	90%
2002	17.97	19.59	86%	16.44	17.92	92%	24.00	26.16	96%
2003	22.38	28.20	88%	22.16	27.92	88%	32.27	40.66	88%
All results ug/m^3 TEOM equivalent									

The results show that the 2004 annual average objective is unlikely to be exceeded at the urban background locations. Exceedences may be expected at roadside locations.

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

Atmospheric dispersion modelling was carried out across the city, to determine the location of the areas of potential exceedence. Receptor points were selected at the nearest residential location, (or nearest location where public exposure was possible), to the junctions identified in the USA. The results obtained at these receptor points are shown in figure 6.19 below.

Figure 6.19 Results of PM_{10} modelling, for the 24 hour 2004 objective

Location of Area of Potential Exceedence	Receptor Location	2004 90.4%ile of 24 hour averages	No of 24 hour averages > 50 ug/m^3
Junction of A57 & B6167	All Saints Primary School	27.88	0
Junction of A56 & A6042	Flats facing onto A6042 Trinity Way at Ducie Bridge	33.94	1
Junction of A57M & A5103	Tenement blocks adjacent to the junction	29.52	0
Junction of A62 & B6393	Moston Brook High School	27.73	0
Junction of Briscoe Ln & Culceth Street	Houses on Morse Rd (nearest exposure point)	27.77	0
Junction of Firbank & Simonsway	St. Pauls High School (adjacent to the junction)	28.79	0
Junction of A576 & A665	Houses on A665	28.50	0

Results in ug/m^3 (gravimetric)

The results indicate that the 2004 objectives will be achieved at all of these locations. The receptor points chosen were representative of worst case locations, for PM_{10} exposure. As no exceedences were observed at these locations, it can be presumed that other locations in the city will also achieve the objectives.

6.10 2010 PM_{10} dispersion modelling results for other locations in the city of Manchester

The Detailed Assessment of PM_{10} against the 2004 objectives, described in Section 6.9 of this report, indicated that all locations in Manchester would meet the 2004 PM_{10} objectives.

PM10 concentrations are expected to decline over time, thanks to the increasing use of vehicle emissions control technology.

A challenging new PM_{10} air quality objective has been proposed for 2010.

Existing concentrations of PM_{10} in Manchester exceed the proposed 2010 annual average objective. Projected future concentrations, based on existing monitoring data, will also exceed the 2010 annual average objective.

Atmospheric dispersion modelling was carried out. The dispersion modelling indicated that despite the expected reductions in PM_{10} concentrations, there will be widespread exceedences of the 2010 annual average objective, at roadside locations across the city.

6.10 2010 PM_{10} dispersion modelling results for other locations in the city of Manchester

Section 6.9 of this report contained an assessment of PM_{10} concentrations against the 2004 objectives. The assessment concluded that there will not be any exceedences of the 2004 objectives.

However, the provisional 2010 objectives are more challenging than the 2004 objectives.

Monitoring of particulate matter is carried out at a number of locations across Manchester. Results from this monitoring network are shown in figure 6.18 below. The Clayton and St Pauls, (Wythenshawe) sites are urban background locations. The M56 site is a roadside location.

Figure 6.18 Results from the 'M' type sampler network

Year	Clayton			St. Pauls School			M56 Junction 4		
	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture
1995	-	-	-	22.94	28.68	81%	31.45	39.31	85%
1996	24.04	33.18	100%	20.92	28.87	96%	29.42	40.60	100%
1997	23.59	29.02	100%	20.48	25.19	96%	29.45	36.22	96%
1998	18.69	24.86	96%	19.51	25.95	98%	26.46	35.19	96%
1999	19.83	27.37	98%	19.08	26.33	100%	27.34	37.73	98%
2000	16.37	32.41	98%	17.40	34.45	100%	25.97	51.42	100%
2001	19.75	18.37	81%	17.18	15.98	94%	27.46	25.54	90%
2002	17.97	19.59	86%	16.44	17.92	92%	24.00	26.16	96%
2003	22.38	28.20	88%	22.16	27.92	88%	32.27	40.66	88%
All results ug/m^3 TEOM equivalent									

The results show that the 2010 annual average objective is likely to be exceeded at all of these locations.

Atmospheric dispersion modelling was carried out, in order to determine the extent of the exceedences identified from the monitoring results.

The receptor points used for the modelling against the 2004 objectives were remodelled for 2010. The results of the 2010 modelling are shown in figure 6.20 overleaf.

Figure 6.20 Results of PM_{10} modelling, for the 2010 objectives

Location of Area of Potential Exceedence	Receptor Location	2004 90.4%ile of 24 hour averages	No of 24 hour averages > 50 ug/m^3	2010 Annual average concentration
Junction of A57 & B6167	All Saints Primary School	25.33	0	18.98
Junction of A56 & A6042	Flats facing onto A6042 Trinity Way at Ducie Bridge	29.55	0	22.05
Junction of A57M & A5103	Tenement blocks adjacent to the junction	26.67	0	20.20
Junction of A62 & B6393	Moston Brook High School	25.13	0	18.87
Junction of Briscoe Ln & Culceth Street	Houses on Morse Rd (nearest exposure point)	25.27	0	18.87
Junction of Firbank & Simonsway	St. Pauls High School (adjacent to M56 junction 4)	25.88	0	21.01
Junction of A576 & A665	Houses on A665	25.70	0	19.27

Results in ug/m^3 (gravimetric)

The results indicated that exceedences of the annual average objective were possible at locations close to a number of these junctions. There were no predicted exceedences of the 24-hour objective.

Contour plots were produced for the city, showing the locations of exceedences of the 2010 annual average objective. These contour plots are shown on the following pages.

6.9 PM_{10} dispersion modelling results for other locations in the city of Manchester

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

The AQMA was based on predicted 2005 exceedences of the annual average nitrogen dioxide objective. The entire area north of the city centre was included in the AQMA, as were significant areas of the south of the city. The AQMA is shown in Section 1, Map 1.2 of this report.

Nitrogen dioxide concentrations have been measured in Manchester, using diffusion tubes since 1986. Bias adjusted diffusion tube results are available from 1997.

The concentration of nitrogen dioxide, measured at roadside locations is currently above the objective. However, roadside concentrations measured across the city show a downward trend, and if this trend continues, the concentration at roadside locations will have reduced to approximately the objective, or below the objective level, by 2005. The downward trend at roadside sites is due to the increasing use of vehicle emission control technology, and does not take into account the reductions that will be achieved by the additional local air quality actions being planned.

The concentration of nitrogen dioxide, measured using diffusion tubes at urban background locations is currently below the objective. The majority of the city will achieve the air quality objectives by 2005.

Areas of predicted exceedence of the 2005 annual average objective are confined to locations close to busy roads and junctions.

The roadside areas of exceedence do include some residential areas, and so public exposure is relevant in these locations.

The results from the Detailed Assessment will be used to inform the Manchester Air Quality Action Plan.

6.9 PM_{10} dispersion modelling results for other locations in the city of Manchester

The assessments of PM_{10} concentrations carried out in sections 6.5 to 6.8 of this report, have dealt with the predicted areas of exceedence that can be expected in Manchester city centre, and in the vicinity of Manchester Airport. Section 6.9 will provide a Detailed Assessment of PM_{10} concentrations across the rest of the Manchester City Council area.

Map 4.11 and Map 5.3, showed the city of Manchester, and the location of the city centre, airport, and a number of selected districts within the city. Map 5.3, showing selected districts in the city, is reproduced on the next page.

The Manchester City Council Update & Screening Assessment identified the following locations, where the PM_{10} objectives may be exceeded. these locations were;

14. The junction of the A57 Hyde Road and B6167 Reddish Lane.
15. The junction of the A62 Oldham Road and B6393 Thorp Road.
16. The junction of Briscoe Lane and Culceth Street.
17. The junction of Firbank and Simonsway, and junction 4 of the M56
18. The junction of the A576 Middleton Road and A665 Cheetham Hill Road.

Monitoring of particulate matter is carried out at a number of locations across Manchester. Results from this monitoring network are shown in table 6.18 below. The Clayton and St Pauls, (Wythenshawe) sites are urban background locations. The M56 site is a roadside location.

Table 6.18 Results from the 'M' type sampler network

Year	Clayton			St. Pauls School			M56 Junction 4		
	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture	Annual Ave.	PM_{10} equiv	Data capture
1995	-	-	-	22.94	28.68	81%	31.45	39.31	85%
1996	24.04	33.18	100%	20.92	28.87	96%	29.42	40.60	100%
1997	23.59	29.02	100%	20.48	25.19	96%	29.45	36.22	96%
1998	18.69	24.86	96%	19.51	25.95	98%	26.46	35.19	96%
1999	19.83	27.37	98%	19.08	26.33	100%	27.34	37.73	98%
2000	16.37	32.41	98%	17.40	34.45	100%	25.97	51.42	100%
2001	19.75	18.37	81%	17.18	15.98	94%	27.46	25.54	90%
2002	17.97	19.59	86%	16.44	17.92	92%	24.00	26.16	96%
2003	22.38	28.20	88%	22.16	27.92	88%	32.27	40.66	88%
All results ug/m^3 TEOM equivalent									

The results show that the 2004 annual average objective is unlikely to be exceeded at the urban background locations. Exceedences may be expected at roadside locations.

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

Atmospheric dispersion modelling was carried out across the city, to determine the location of the areas of potential exceedence. Receptor points were selected at the nearest residential location, (or nearest location where public exposure was possible), to the junctions identified in the USA. The results obtained at these receptor points are shown in Table 6.19 below.

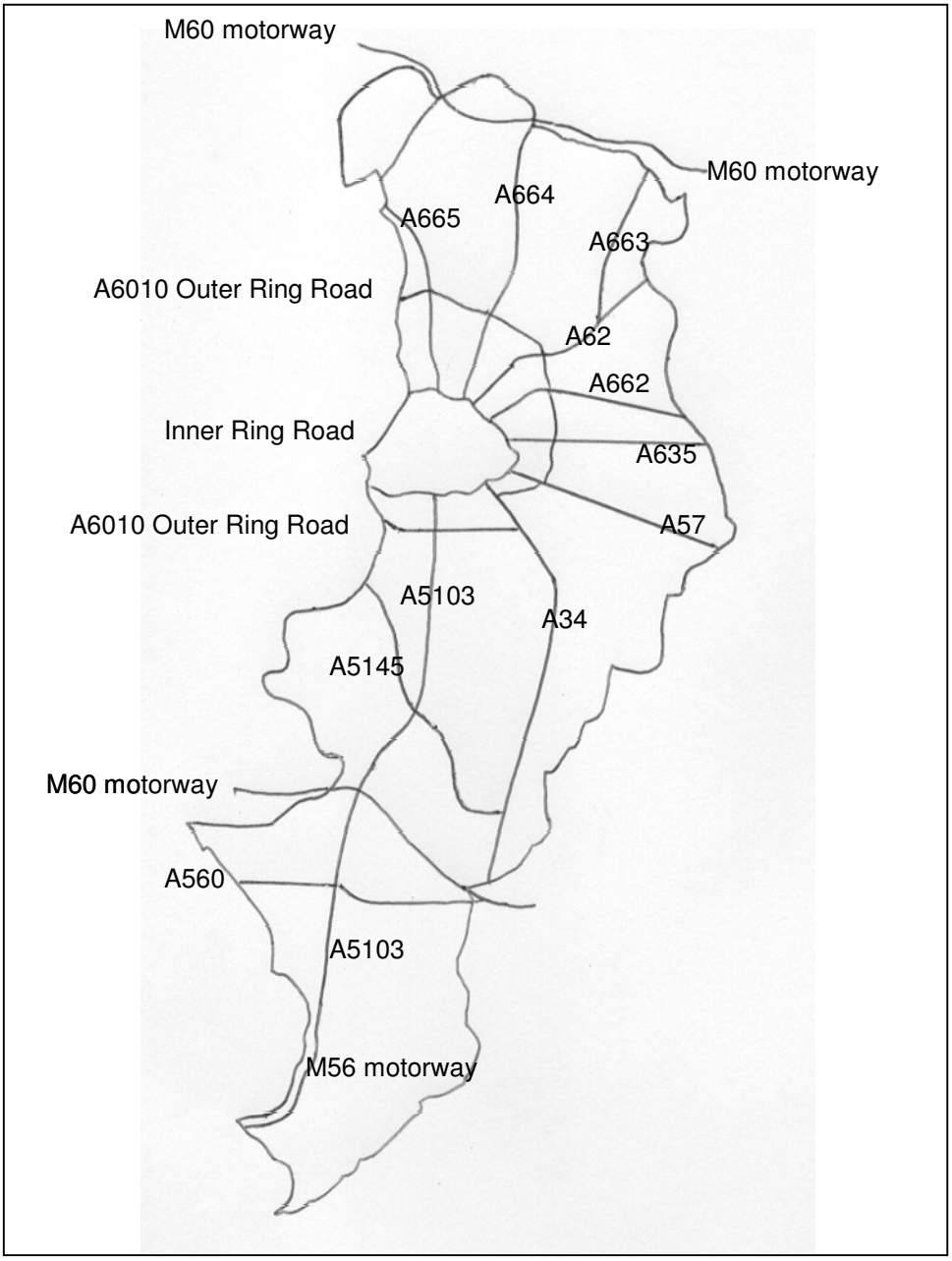
Table 6.19 Results of PM_{10} modelling, for the 24 hour 2004 objective

Location of Area of Potential Exceedence	Receptor Location	2004 90.4%ile of 24 hour averages	No of 24 hour averages > 50 ug/m^3
Junction of A57 & B6167	All Saints Primary School	27.88	0
Junction of A56 & A6042	Flats facing onto A6042 Trinity Way at Ducie Bridge	33.94	1
Junction of A57M & A5103	Tenement blocks adjacent to the junction	29.52	0
Junction of A62 & B6393	Moston Brook High School	27.73	0
Junction of Briscoe Ln & Culceth Street	Houses on Morse Rd (nearest exposure point)	27.77	0
Junction of Firbank & Simonsway	St. Pauls High School (adjacent to the junction)	28.79	0
Junction of A576 & A665	Houses on A665	28.50	0

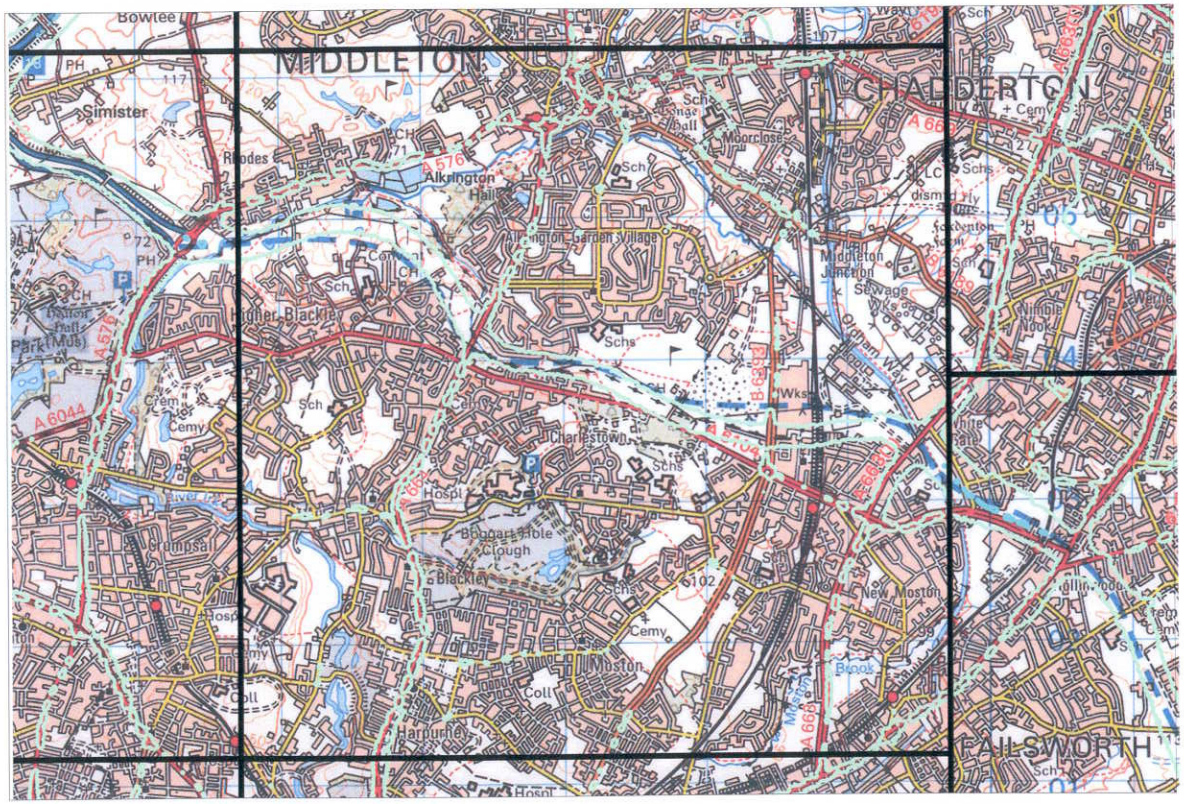
Results in ug/m^3 (gravimetric)

The results indicate that the 2004 objectives will be achieved at all of these locations. The receptor points chosen were representative of worst case locations, for PM_{10} exposure. As no exceedences were observed at these locations, it can be presumed that other locations in the city will also achieve the objectives.

Map 5.19 Map of selected major roads in Manchester.



Area 10 - 2010 annual average



Model area

PM10 (ug/m³)

20.0

30.0

36.8

40.0

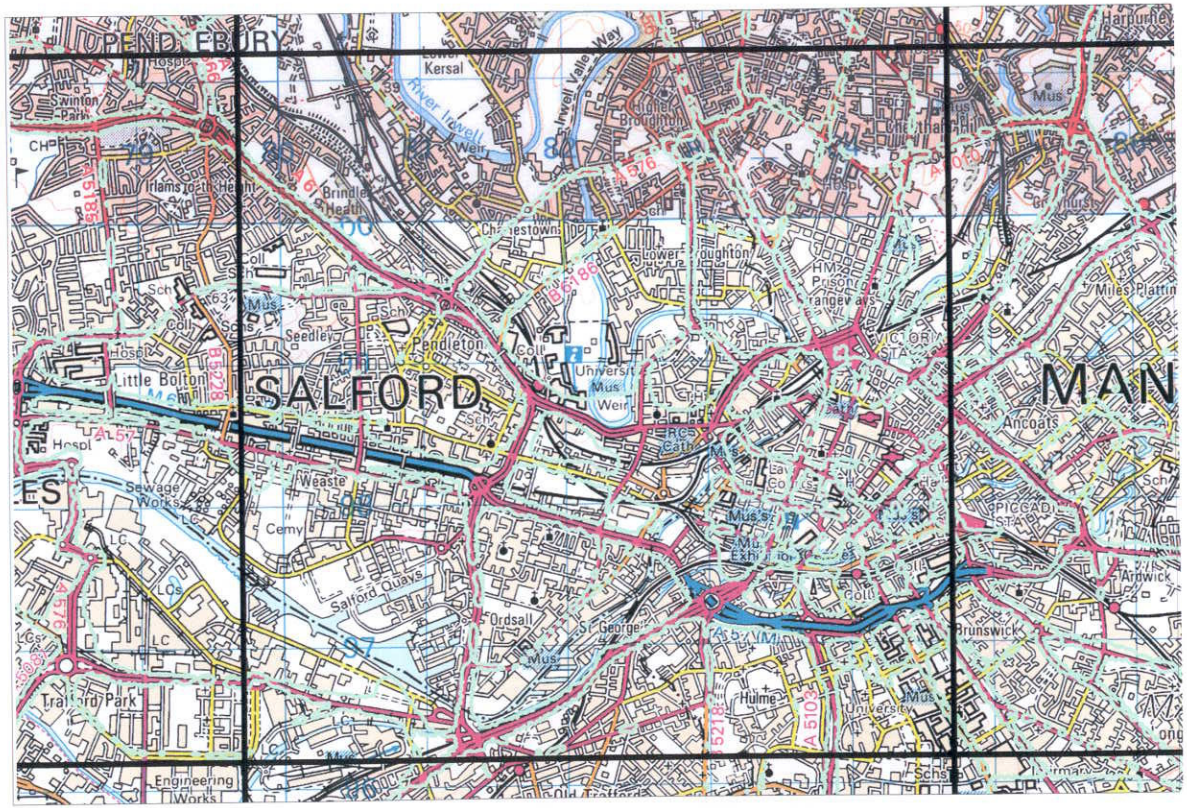
43.2

N

2 0 2 4 Kilometers

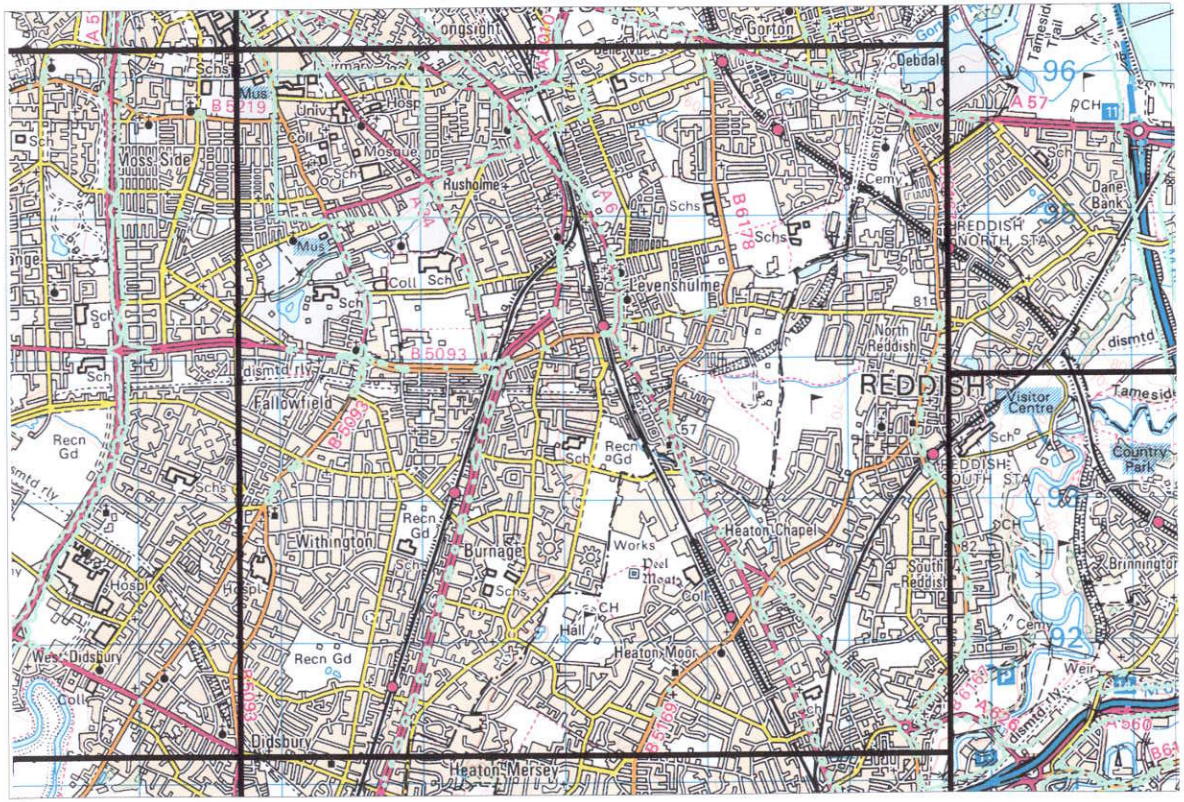
ARIC, December 2003

Area 17 - 2010 annual average



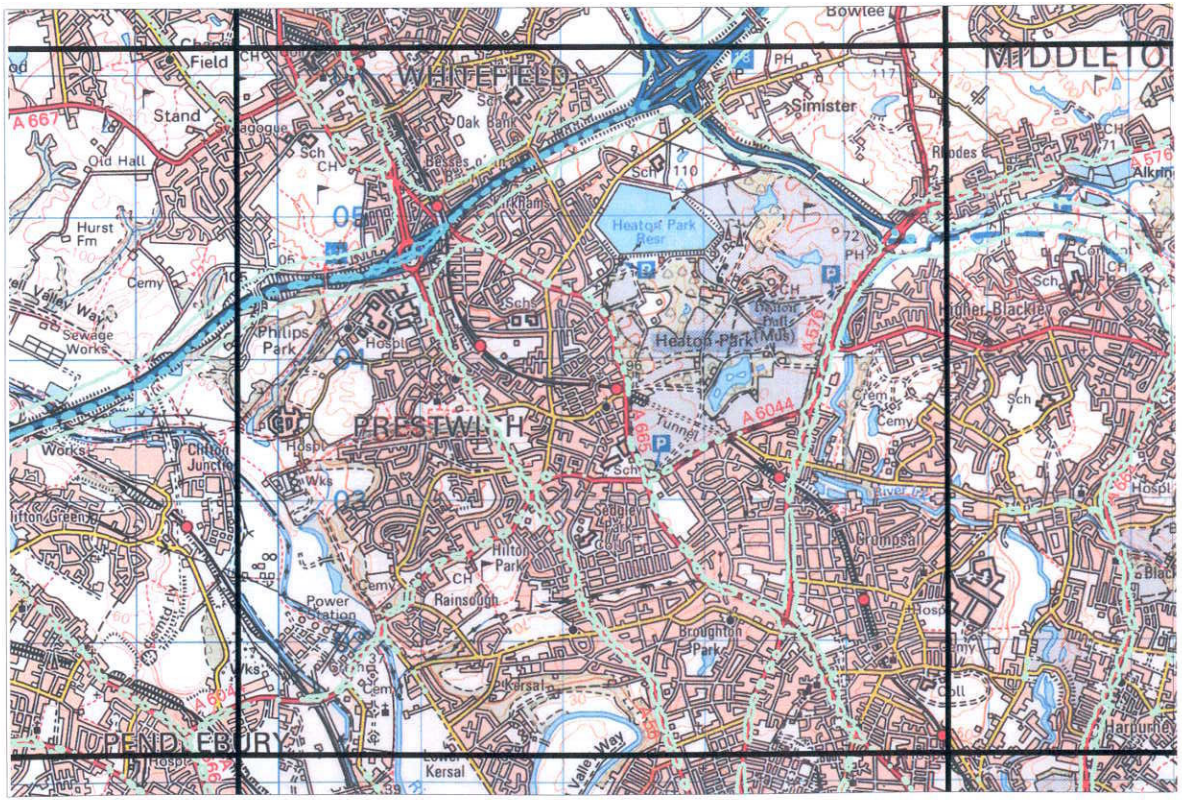
ARIC, December 2003

Area 12 - 2010 annual average



ARIC, December 2003

Area 16 - 2010 annual average



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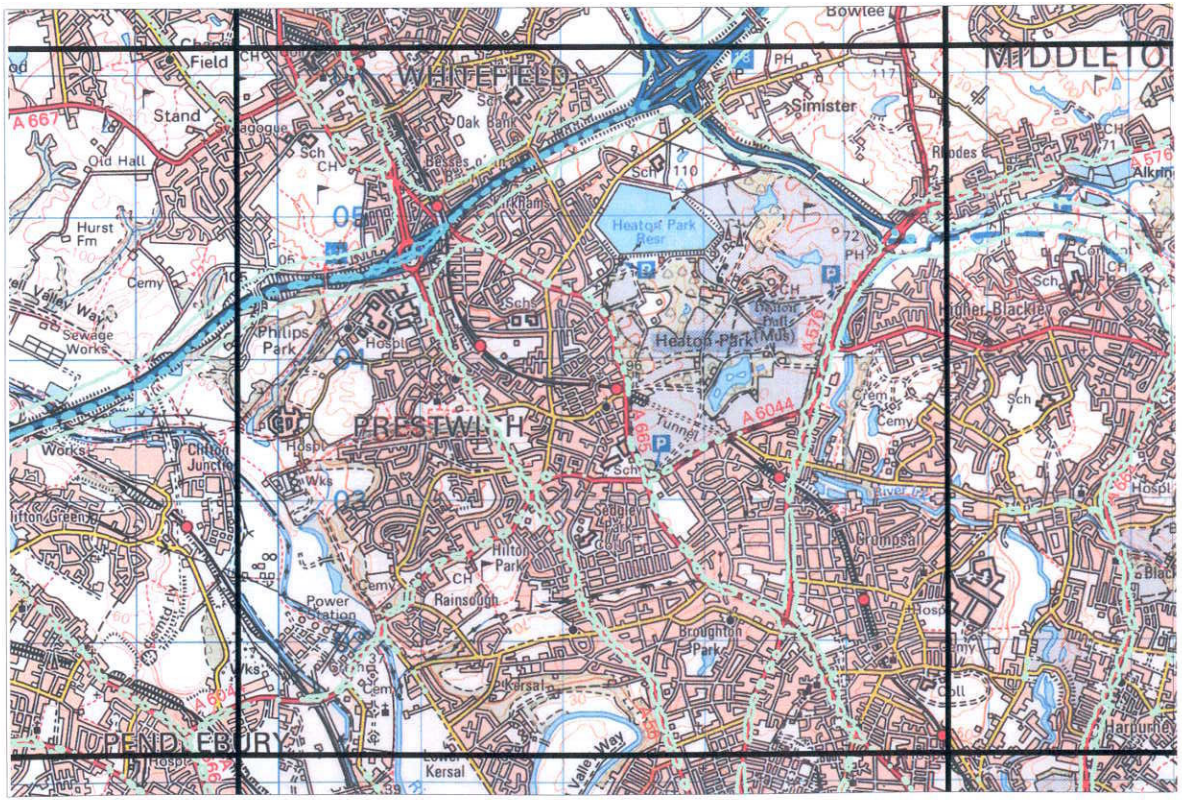
ARIC, December 2003

Area 16 - 2010 annual average



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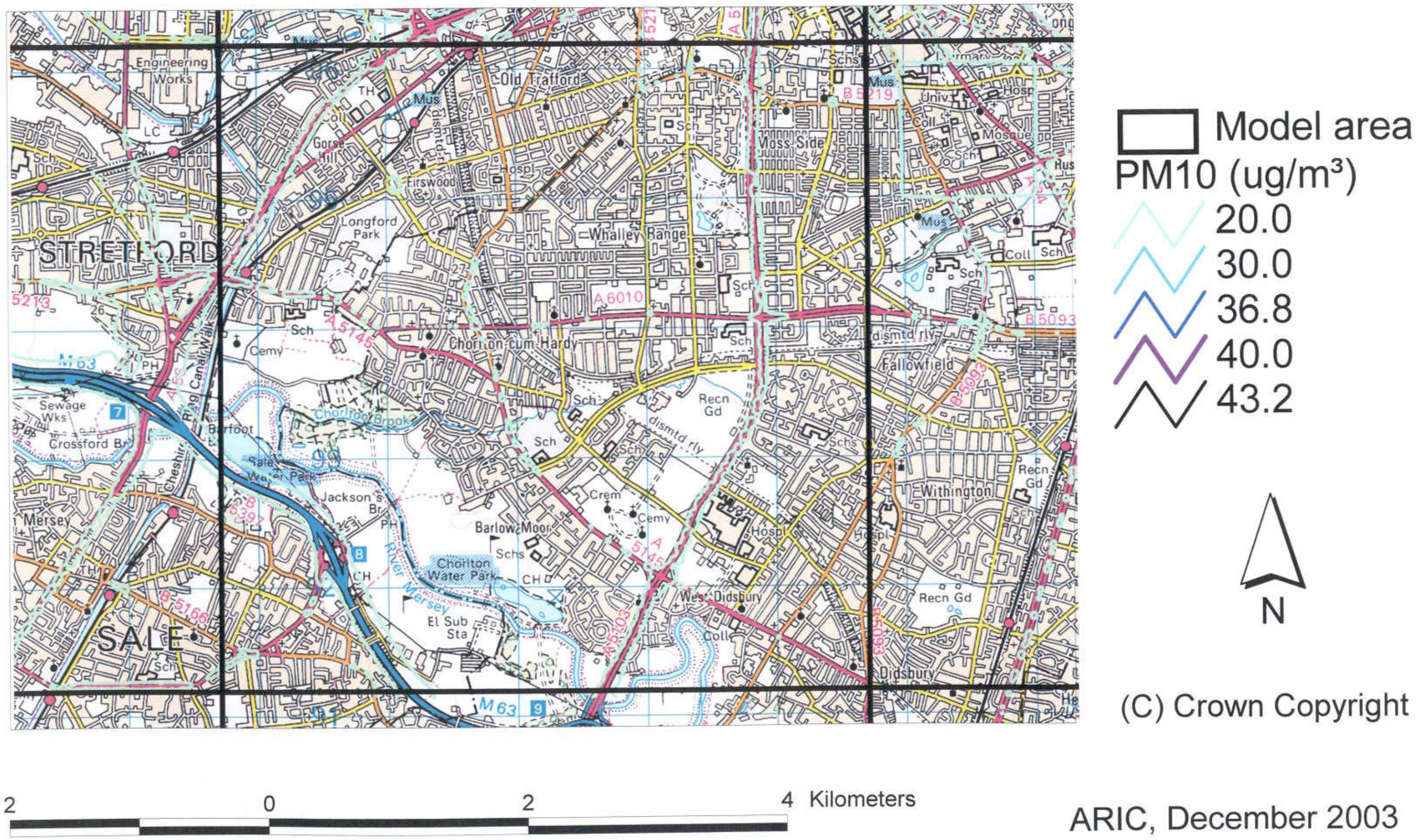
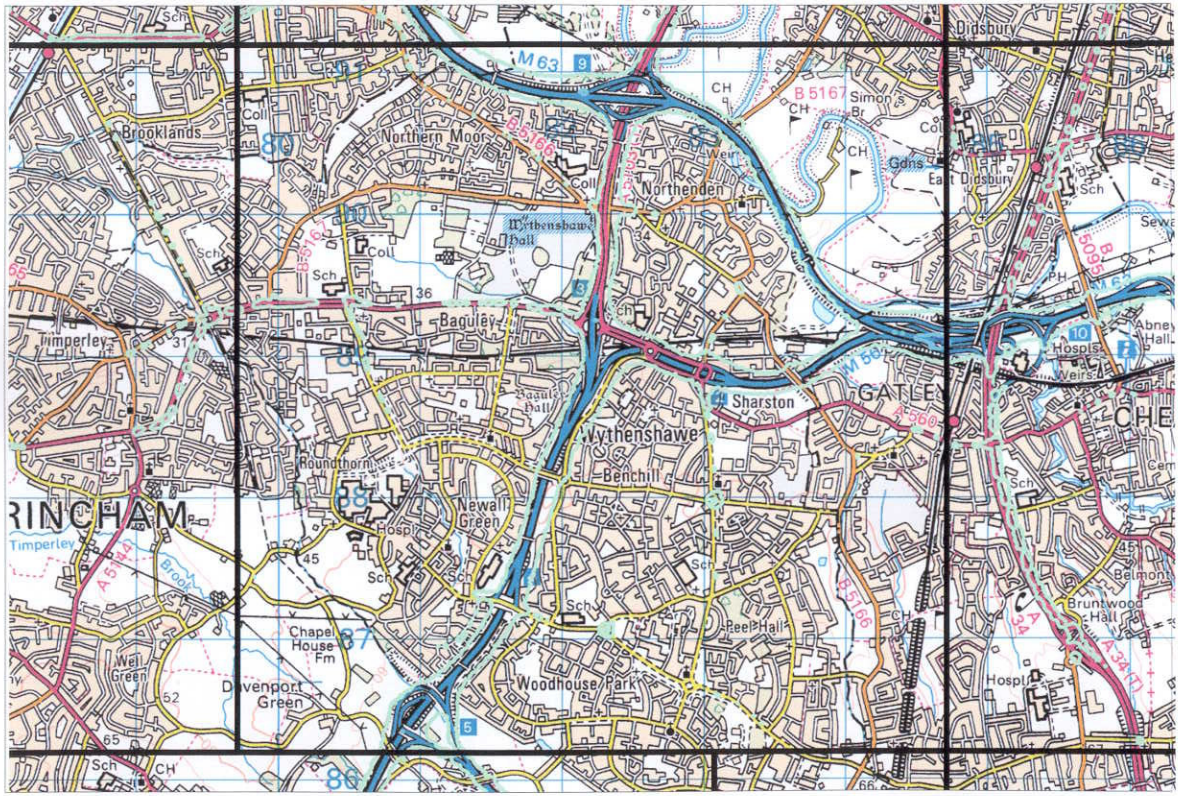
ARIC, December 2003

Area 18 - 2010 annual average



Area 19 - 2010 annual average



ARIC, January 2004

The contour plots on the previous pages show that exceedences of the 2010 annual average objective will occur at roadside locations close to many of the major roads and junctions in the city.

There is also a 1km square shown as experiencing an exceedence of the annual average objective, centred on the Manchester Royal Infirmary. The Manchester Royal Infirmary is equipped with a coal fired boiler plant. Emissions from this site contribute to PM_{10} concentrations in this area, and when added to the road derived emissions and domestic emissions in the area this has pushed the concentration above 20 ug/m^3. Obviously the area of exceedence associated with these emissions would not be a perfect square. The emissions from the Infirmary will therefore be investigated closely in future Review & Assessment, to accurately identify where the exceedence will occur. The Manchester Royal Infirmary is currently reviewing the use of coal, and the results of this review will also be taken into account.

Figure 6.21 overleaf shows the names of the roads along which the exceedences are likely to occur. The 1km square associated with the Manchester Royal Infirmary is not shown on figure 6.21, so that it does not obscure the roads displayed on the map.

The areas identified as being at risk of not achieving the 2010 annual average objective will be investigated and assessed as part of Manchester City Councils ongoing commitment to local air quality management.

The results of this dispersion modelling will be used to inform the Manchester Air Quality Action Plan, and will provide a focus for programmes looking at the delivery of long term improvements in air quality.

Figure 6.21 Locations of exceedences of the 2010 annual average PM_{10} objective

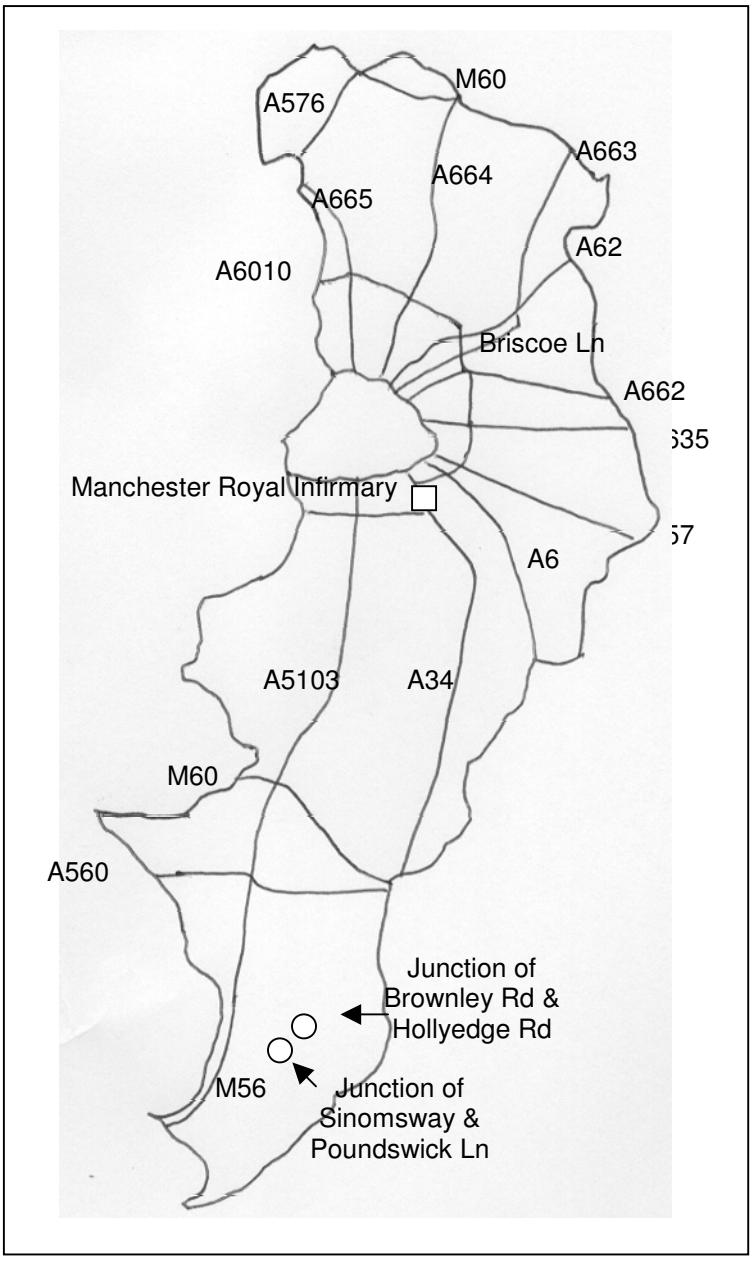


Figure 6.22 below indicates the traffic flow and composition of the roads and junctions which are associated with the predicted exceedences of the 2010 objectives.

Figure 6.22 Extent of areas of exceedence (2005), associated with roads in Manchester, from atmospheric dispersion modelling

Road name	2010 Traffic flow on road (annual average daily traffic)	Buses / HGV as percentage of traffic flow
M60 motorway junctions 18 to 20	89982	11
A576 Middleton Road	41996	4
A665 Cheetham Hill Road	12774	4
A664 Rochdale Road	25451	8
A663 Broadway	19901	9
A62 Oldham Road	31142	6
Briscoe Lane	14653	6
A662 Ashton New Road	22606	4
A635 Ashton Old Road	28638	8
A57 Hyde Road	19086	9
A6 Stockport Road	19893	4
A34 Kingsway	35755	3
A5103 Princess Road	82331	3
M60 junctions 2 to 5 (south of city)	118004	9
A560 Altrincham Road	19893	7
M56	137290	8
Junction of Simonsway & Poundswick Lane	19001	2
Junction of Hollyedge Rd & Brownley Road	17921	5

The results indicate that exceedences of the 2010 annual average objective can be expected at roadside locations near roads with a traffic flow in excess of 12,000 vehicles per day, or where the road is used by more than 5% HGV and buses.

Appendix A Nitrogen dioxide diffusion tube bias correction

Manchester City Council expose a number of nitrogen dioxide diffusion tubes, at locations across the city. These diffusion tubes provide an effective means of establishing nitrogen dioxide concentrations across a wide spatial area. However, DEFRA has expressed concern over the accuracy of diffusion tubes.

Technical Guidance note LAQM TG(03) Boxes 6.3 and 6.4 provide a method for establishing whether diffusion tubes show a bias, and the boxes also provide a means for correcting that bias.

The nitrogen dioxide diffusion tubes used by Manchester City Council are supplied, prepared, and analysed by Casella Ltd, at their UKAS accredited facilities in Trafford Park. Diffusion tubes used by Manchester City Council are all prepared using the 10% TEA in water method.

Diffusion tubes have been co-located with the chemiluminescent NO_X analysers at both the Manchester Piccadilly and Manchester Town Hall AURN sites. The following results were obtained.

Figure 7:1 Calculation of nitrogen dioxide diffusion tube bias

Year	Manchester Piccadilly					
	AURN		Tube		Bias A	Bias B
	Result	Capture	Result	Capture		
1996	53	92%	59	100%	0.898	11%
1997	42	91%	57	96%	0.737	36%
1998	40	95%	57	88%	0.702	43%
1999	44	95%	57	96%	0.772	30%
2000	42	97%	55	86%	0.764	31%
2001	44	72%	55	84%	0.800	25%
2002	38	90%	63	98%	0.603	66%
2003	45	92%	59	98%	0.763	31%
Year	Manchester Town Hall					
	AURN		Tube		Bias	Bias
	Result	Capture	Result	Capture	A	B
1994	48	99%	67	100%	0.716	28%
1995	44	94%	62	98%	0.710	29%
1996	53	97%	62	100%	0.855	15%
1997	51	96%	56	96%	0.911	9%
1998	41	97%	57	90%	0.719	28%
1999	41	99%	55	98%	0.745	25%
2000	42	95%	53	94%	0.792	21%
2001	48	99%	53	98%	0.906	9%
2002	44	98%	62	94%	0.710	29%
2003	44	98%	51	98%	0.863	14%
All results in ug/m^3						

These results show that the diffusion tube bias has varied on a year to year basis, and that the bias is different at the two different sites. This effect could be due to the diffusion tubes performing differently at the different types of site. Manchester Piccadilly is an urban central site, which is subject to rapidly changing levels of NO_X, including occasional peak concentration events. Manchester Town Hall is an urban background site. To reflect these differences in site characteristic, the Piccadilly derived correction factor will be used to correct tubes in roadside and central locations, whilst the Town Hall derived correction factor will be used for tubes at other locations.

The results show that the tubes have consistently given readings higher than those recorded using the chemiluminescent analysers.

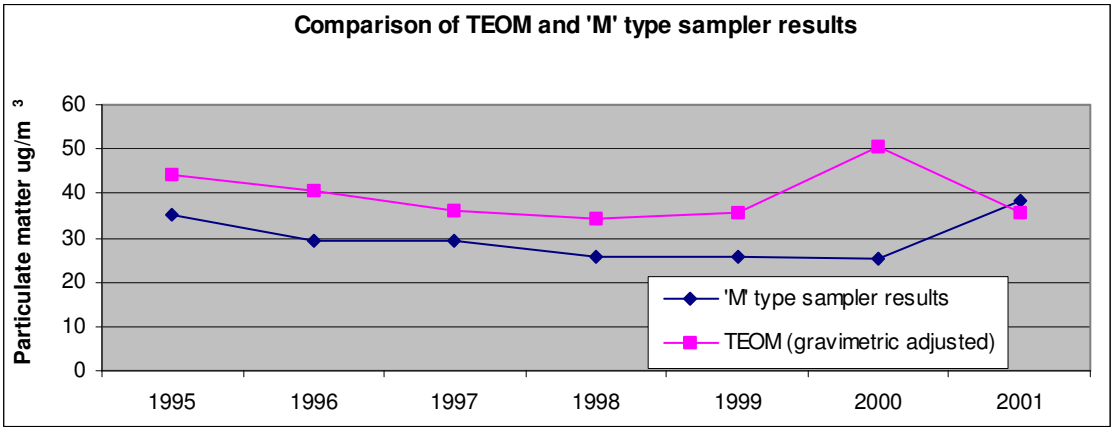
In order to improve the accuracy of calculated diffusion tube bias, Manchester City Council has begun exposing three diffusion tubes, at each of the three chemiluminescent analyser sites in the city. This programme began in January 2003, and therefore insufficient data was available for inclusion in this update and screening assessment.

Appendix B PM_{10} 'M' type sampler bias correction

Manchester City Council operate a number of 'M' type particulate matter sampling units. These units are an effective means of establishing concentrations of suspended particulate matter across a wide spatial area. Unfortunately, the 'M' type sampler unit is not equipped to selectively sample airborne particulate matter. Particles of all size are collected on the filter using this equipment, not just the PM_{10} size fraction.

Manchester City Council have co-located an 'M' type sampler with a TEOM continuous PM_{10} analyser, in an attempt to derive a correction factor for the 'M' type sampler. This would allow results from the 'M' type samplers to be expressed as a PM_{10} equivalent. The co-location was carried out at the Manchester Piccadilly AURN site. A comparison of the results of the TEOM unit and 'M' type sampler are shown below;

Figure 7:2 Comparison of TEOM and 'M' type sampler results



The results show a good correlation between measured PM_{10} and total suspended particulate matter. The TEOM results shown in this graph have been multiplied by 1.3, to produce a gravimetric equivalent figure. Using these two sets of data, a bias adjustment factor was derived.

Figure 7:3 Calculation of 'M' type sampler bias

Year	TEOM values	adjusted gravimetric values	'M' type sampler results	Bias A	Bias B
1995	34.01	44.21	35.31	1.25	-0.201
1996	31.21	40.57	29.41	1.38	-0.275
1997	27.72	36.04	29.30	1.23	-0.187
1998	26.30	34.19	25.67	1.33	-0.249
1999	27.48	35.72	25.82	1.38	-0.277
2000	38.89	50.56	25.47	1.98	-0.496
2001	27.48	35.72	38.33	0.93	0.073
					all results in ug/m^3

List of figures