In fulfilment of Part IV of the Environment Act 1995

Local Air Quality Management

Air quality review and assessment

Annual progress report 2011

NORWICH
City Council

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Air Quality Review & Assessment
Annual Progress Report 2011

MG Stephenson
Public Protection Manager
Norwich City Council

Local Authority Officer	Mark Leach

Department	Environmental Protection
Address	City Hall St Peters Street Norwich NR2 1NH
Telephone	01603 212515
e-mail	markleach@norwich.gov.uk

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Executive Summary

The first round of review and assessment of air quality in Norwich was carried out in four stages to determine whether the national air quality objectives would be met by the end of 2005. The results of these assessments indicated that there were areas of Norwich almost certain to exceed the annual mean objective for Nitrogen Dioxide (NO_2). Consequently, Norwich City Council declared three Air Quality Management Areas (AQMA's) on 1st June 2003 for exceedance of the annual NO_2 objective at Grapes Hill St, Augustines Street, and the Castle area of Norwich. The location and extent of these three areas is shown in Figs 1.1 to 1.4.

In partnership with AEA Technology, Updating and Screening Assessments (USA's) of local air quality for Norwich were produced in January 2004, March 2006 and July 2009. These reviewed the previous assessments undertaken for all pollutants identified in the Air Quality Regulations.

Where a significant risk of exceedance is identified for a pollutant, the local authority has to proceed to a Detailed Assessment (DA). However, the Updating and Screening Assessments concluded that Norwich did not require a Detailed Assessment for NO2, PM_{10}, Benzene, Carbon Monoxide, Lead, 1-3 Butadiene or Sulphur Dioxide. Where a local authority does not need to undertake a DA, an annual progress report (APR) is required instead.

The results of the diffusion tube survey in 2007 confirmed that the annual mean objective for NO_2 was not met at several locations in Norwich. It was therefore decided to undertake a Detailed Assessment (DA) in 2008 to include dispersion modelling at these locations. The DA concluded that a further AQMA was required at Riverside. This area was declared in Dec 2009, and is shown in Figs 1.1 and 1.5.

A Further Assessment (FA) of the Riverside AQMA was completed in 2010. The study confirmed the findings of the previous DA, namely that there are exceedances of the annual mean NO_2 objective to the south of Riverside Road, and that the position and extent of the AQMA was appropriate.

The 2010 APR revealed exceedances of the annual mean NO_2 objective at King Street and Bull Close Road. The Bull Close Road exceedance was very marginal and it was decided to carry out a DA by increasing the monitoring in the area for a further year. It was stated that King Street should be declared as an AQMA.

Since the production of the 2010 APR, discussion has taken place between the city council, county council and DEFRA. It has been agreed in principle that rather than declare King Street as a further AQMA, it would be preferable to revoke the existing four AQMA's and replace them with one larger area to encompass all of them.

Proposed actions arising from this Progress Report are as follows:

- Continue with automatic and passive NO_2 monitoring within the city area
- Declare a larger area of central Norwich as an AQMA and revoke the four existing AQMA's
- Develop an Action Plan to work towards compliance with the air quality objectives within the proposed Norwich Central AQMA. This plan should draw upon the results of the monitoring program, DA's and FA's carried out previously.

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1 Introduction

1.1 Description of Local Authority Area

Norwich covers approximately 39 square kilometres in the heart of Norfolk with a population of circa 132,000 people. The population of the Norwich 'Travel to Work Area' ie the area of Norwich in which most people both live and work is 376,500. Norwich is the fourth most densely populated Local Authority district in the eastern region with 33.9 people per hectare.

The workforce of the Norwich Travel to Work Area is approximately 194,000 people. The Norwich City Council area supports around 95,500 jobs. The built-up urban area supports approximately 132,500 jobs. Almost one-third of Norfolk's workforce is based within the City Council area, and 40% are employed in the urban area. Approximately 73.5% of the City Council's working age resident population is economically active.

Employment in Norwich is predominantly service sector based reflecting the national picture. The Business & Financial Sector accounts for 31% of employment in Norwich. Around 26% of people employed in Norwich work in public services (Government, Health and Education). A further 12% of the workforce is employed in the retail sector and 7% work in tourism. The manufacturing sector accounts for almost 8% of employment in Norwich.

The City permits 46 'Part B' authorised processes, including petrol stations, road stone coating plant, vehicle resprayers and a crematorium. The major pollutant source in the city is road traffic.

1.2 Purpose of Progress Report

Progress Reports are required in the intervening years between the three-yearly Updating and Screening Assessment reports. Their purpose is to maintain continuity in the Local Air Quality Management process.

They are not intended to be as detailed as Updating and Screening Assessment Reports, or to require as much effort. However, if the Progress Report identifies the risk of exceedence of an Air Quality Objective, the Local Authority (LA) should undertake a Detailed Assessment immediately, and not wait until the next round of Review and Assessment.

1.3 Air Quality Objectives

The air quality objectives applicable to Local Air Quality Management (LAQM) **in England** are set out in the Air Quality (England) Regulations 2000 (SI 928), and the Air Quality (England) (Amendment) Regulations 2002 (SI 3043). They are shown in Table 1.1. This table shows the objectives in units of microgrammes per cubic metre ($\mu g/m^3$). For carbon monoxide, the units used are milligrammes per cubic metre (mg/m^3). Table 1.1 includes the number of permitted exceedences in any given year (where applicable).

Table 1.1 Air Quality Objectives included in Regulations for the purpose of Local Air Quality Management in England.

Pollutant	Concentration	Measured as	Date to be achieved by
Benzene (C_6H_6)	16.25 $\mu g/m^3$	Running annual mean	31.12.2003
	5.00 $\mu g/m^3$	Annual mean	31.12.2010
1,3-Butadiene (C_4H_6)	2.25 $\mu g/m^3$	Running annual mean	31.12.2003
Carbon monoxide (CO)	10.0 mg/m^3	Maximum daily running 8-hour mean	31.12.2003
Lead (Pb)	0.5 $\mu g/m^3$	Annual mean	31.12.2004
	0.25 $\mu g/m^3$	Annual mean	31.12.2008
Nitrogen dioxide (NO_2)	200 $\mu g/m^3$ not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 $\mu g/m^3$	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 $\mu g/m^3$, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 $\mu g/m^3$	Annual mean	31.12.2004
Sulphur dioxide (SO_2)	350 $\mu g/m^3$, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 $\mu g/m^3$, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 $\mu g/m^3$, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

Table 1.2 Air Pollution Bandings & Index, and the impact on the health of people who are sensitive to air pollution.

Banding	Index	Health Descriptor
Low	1	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
	2	
	3	
Moderate	4	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
	5	
	6	
High	7	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
	8	
	9	
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Table 1.3 Boundaries between Index Points for each Pollutant.

Band	Index	Ozone *		Nitrogen Dioxide		Sulphur Dioxide		Carbon Monoxide		PM_{10} Particles
		8 hourly running mean or hourly mean		hourly mean		15 minute mean		8 hour running mean		24 hour running mean
		µg/m³	ppb	µg/m³	ppb	µg/m³	ppb	mg/m³	ppm	µg/m³
Low										
	1	0-32	0-16	0-95	0-49	0-88	0-32	0-3.8	0.0-3.2	0-16
	2	33-66	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	17-32
	3	67-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	33-49
Moderate										
	4	100-126	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	50-57
	5	127-152	63-76	382-476	200-249	355-442	133-166	13.5-15.4	11.6-13.2	58-66
	6	153-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	67-74
High										
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	75-82
	8	240-299	120-149	363-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	83-91
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	92-99
Very High										
	10	360 or more	180 or more	764 or more	400 or more	1064 or more	400 or more	23.2 or more	20 or more	100 or more

* Note that in view of the transboundary nature of this pollutant, and thus the limited effectiveness of action on a local scale, Ozone is not included in the regulations for air quality management

1.4 Summary of Previous Review and Assessments

Norwich City Council (NCC) has completed the following review and assessments of air quality to date:

- Review and Assessment of Air Quality (1998),
- Further Assessment (1999);
- Further Assessment update (2002),
- Detailed Assessment (2003);
- Updating and Screening Assessment (January 2004);
- Progress Report (2005);
- Updating and Screening Assessment (2006);
- Progress Report (2007);
- Detailed Assessment (2008); and
- Updating and Screening Assessment (July 2009).
- Progress Report (2010)
- Further Assessment for Riverside Road AQMA (2010)

First Round of Air Quality Review and Assessment

The first stage of the review and assessment process concluded that within the City the Government's objectives were likely to be met for carbon monoxide, benzene, 1,3-butadiene and lead. However, there were doubts as to whether the Government's objectives would be met with respect to nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter less than 10µm (PM_{10}). The report recommended that the Norwich City Council progress to a Further Assessment for NO_2, SO_2 and PM_{10}.

The findings are presented in greater detail in the following report:

- **Review and Assessment of the Air Quality, Norwich City Council (1998)**

The findings of the Further Assessment are presented in greater detail in the following report:

- **Review and Assessment of Air Quality – Further Assessment, Norwich City Council (2001)**

The Further Assessment included estimation, modelling/measurement of pollutants and indicated which national objectives would not be achieved.

The assessment for SO_2 and PM_{10} concluded that the Air Quality objectives for 2005 would be achieved.

Nitrogen dioxide (NO_2) was taken straight to a Stage 3 review and assessment as Stage 1 indicated Norwich was unlikely to achieve the Air Quality objectives in 2005.

The Further Assessment for NO_2 concluded that the Air Quality Objective was unlikely to be achieved in certain areas of the city by 2005.

As a result of the Further Assessment the council concluded that three AQMAs (shown in Figure 1.1) would be declared to tackle the issue of NO_2 Air Quality objective exceedences.

An update to the Further Assessment was produced in 2002. The findings of the report are presented in greater detail in the following report:

- **Air Quality Review and Assessment Further Assessment Update, Norwich City Council (2002)**

The Further Assessment concluded that there could be an exceedence of the NO_2 objectives as a result of traffic sources. Declaration of three AQMAs was recommended. Norwich City Council considered the likelihood of receptor exposure to exceedences based on the modelling and decided the appropriate locations of AQMAs in the city. Three AQMAs were proposed, Castle, Grapes Hill and St Augustines.

There were no predicted exceedences of the PM_{10} objective either by traffic or industrial sources. As such, there was no need for further review and assessment of PM_{10}.

There were no sources that would result in predicted exceedences of the SO_2 objective by industrial sources.

There were no sources that would result in predicted exceedences of the lead objective by industrial sources.

Norwich City Council then proceeded to a Detailed Assessment for NO_2. The findings of the 2003 Detailed Assessment are presented in greater detail in the following report:

- **Detailed Assessment, Norwich City Council (2003)**

The monitoring and modelling carried out at this stage of review and assessment showed that NO_2 concentrations were expected to exceed the annual mean objective at certain locations in each of the three declared AQMAs.

The source apportionment work identified emissions of oxides of nitrogen (NO_x) from traffic on roads close to the AQMAs as the main source from which emissions could be reduced. Emissions of NO_x from local traffic accounted for approximately 68-79 % of the total modelled oxides of nitrogen concentration at the most affected properties within the AQMAs.

This assessment also considered a number of options in order to assess their potential to reduce the nitrogen dioxide concentration at the most sensitive receptors in the Norwich AQMAs.

Further Stages of Review and Assessment

A summary of conclusions from the second and third rounds of review and assessment reports is provided below.

2004, 2005 and 2007 Progress Reports
Each report concluded that no further action was required in respect of the pollutants:

- CO;
- Benzene;
- 1,3-Butadiene;
- Lead;
- SO_2;
- NO_2; and
- PM_{10}.

2004 and 2006 Updating and Screening Assessments
These updating and screening assessment for NCC concluded that a Detailed Assessment was **not** required for NO_2, PM_{10}, benzene, CO, lead, 1,3 – butadiene or SO_2.

2008 Detailed Assessment
As part of this Detailed Assessment air dispersion modelling was carried out for NCC covering the following locations:

- Grapes Hill;
- King Street;
- Riverside Road;
- Magdalen Street; and
- Boundary Road.

The assessment concluded that on the basis of the modelled and measured results in the Grapes Hill AQMA, and also that the NO_2 concentrations were predicted to fall in 2010, the Council could consider revoking this AQMA. However, as pollution concentrations are variable due to meteorological conditions from year to year, it was recommended that this AQMA be retained at the moment.

On the basis of the modelled and measured NO_2 results in King Street it was recommended that NCC should continue to monitor this site and review each year. Should the 2009 data exceed the objective it was recommend that this area should be declared an AQMA.

Modelling and measured results for Riverside Road suggested that the council consider implementing an improved synchronised fixed time traffic signaling system to reduce queuing effect in Riverside Road. It was recommended that NCC declare an AQMA in this area. This new area was declared in December 2009.

The concentration measured at the location of the diffusion tube in Magdalen Street marginally exceeded the objective in 2007 and was under the objective in 2008. As

such, it was recommended that NCC continue to monitor the area. It was not recommended to declare this area as an AQMA.

Finally, it was recommended that the Council continue to monitor the area around Boundary Road. An AQMA was not recommended for this location.

2009 Updating and Screening Assessment

This updating and screening assessment concluded that a Detailed Assessment was not required for NO_2, PM_{10}, benzene, CO, lead, 1,3 – butadiene or SO_2.

2010 Annual Progress Report

This report noted that NCC carried out diffusion tube monitoring for NO_2 at 34 locations throughout the city during 2009. The results indicated that concentrations of NO_2 exceeded the annual mean objective at several locations. These locations were:

- King Street;
- St Stephens (Mid);
- St Augustines;
- Cattlemarket Street;
- Castle Meadow;
- Castle Meadow 2
- Bull Close Road; and
- Riverside Road.

Of the areas where the exceedences were found, St Augustines, Cattlemarket Street, both Castle Meadow sites and Riverside Road are within existing AQMAs. The site at St Stephens Street is not situated in a location representative of relevant exposure to the general public for the annual mean. The King Street site exceeded the objective level by 4.2$\mu g/m^3$. The Bull Close Road location exceeded the objective level by 0.5$\mu g/m^3$.

A Detailed Assessment was carried out of the King Street area in 2008. It concluded that if the 2009 monitoring data confirmed King Street to exceed the annual mean objective for NO_2, then this area should be declared as an AQMA.

The Bull Close Road site had not been the subject of any previous detailed assessment.

Therefore, in line with the recommendations of the 2008 DA, the report stated that NCC would declare an area of King Street as an AQMA and revoke the existing AQMA at Grapes Hill.

The Bull Close Road location exceeded the objective level by 0.5$\mu g/m^3$. Since this was the first, very marginal, exceedence of the annual objective level for NO_2 based on a single tube at this location, it was proposed to carry out a Detailed Assessment by increasing the monitoring in the area; to include the commencement of triplicate tubes at the existing site, and deployment of additional tubes at new nearby relevant locations. Should the monitoring results for the full 2010 calendar year show a

continuing exceedence, then it was proposed to declare an AQMA in the area during 2011.

The report also concluded that, based upon the findings of previous assessments, the concentrations of 1,3-butadiene, benzene, carbon monoxide, lead, PM_{10} and SO_2 were unlikely to be in excess of the air quality objectives at any location.

2010 Further Assessment for Riverside Road

This report assessed concentrations of NO_2 in and around the Riverside Road AQMA for 2009 using a combination of available monitoring data and a dispersion modelling exercise. The study took account of traffic conditions in the area and the latest meteorological data available.

The study confirmed the findings of the previous detailed assessment, namely that there are exceedences of the annual mean NO_2 objective to the south of Riverside Road.

It was estimated that ambient NOx reductions of approximately 48% are required in the AQMA to achieve compliance with the annual mean NO_2 objective.

Source apportionment indicated that the primary source of emissions is derived from local moving traffic, although queuing vehicles are also particularly important near the junction. Light vehicles are thought to be the main source type although important contributions were also noted from buses and other heavy vehicles.

The report concluded that the monitoring and dispersion modelling demonstrated that the AQMA boundary is appropriate and that Norwich City Council should proceed with air quality action planning for the area.

Figure 1.1 AQMA's within City of Norwich

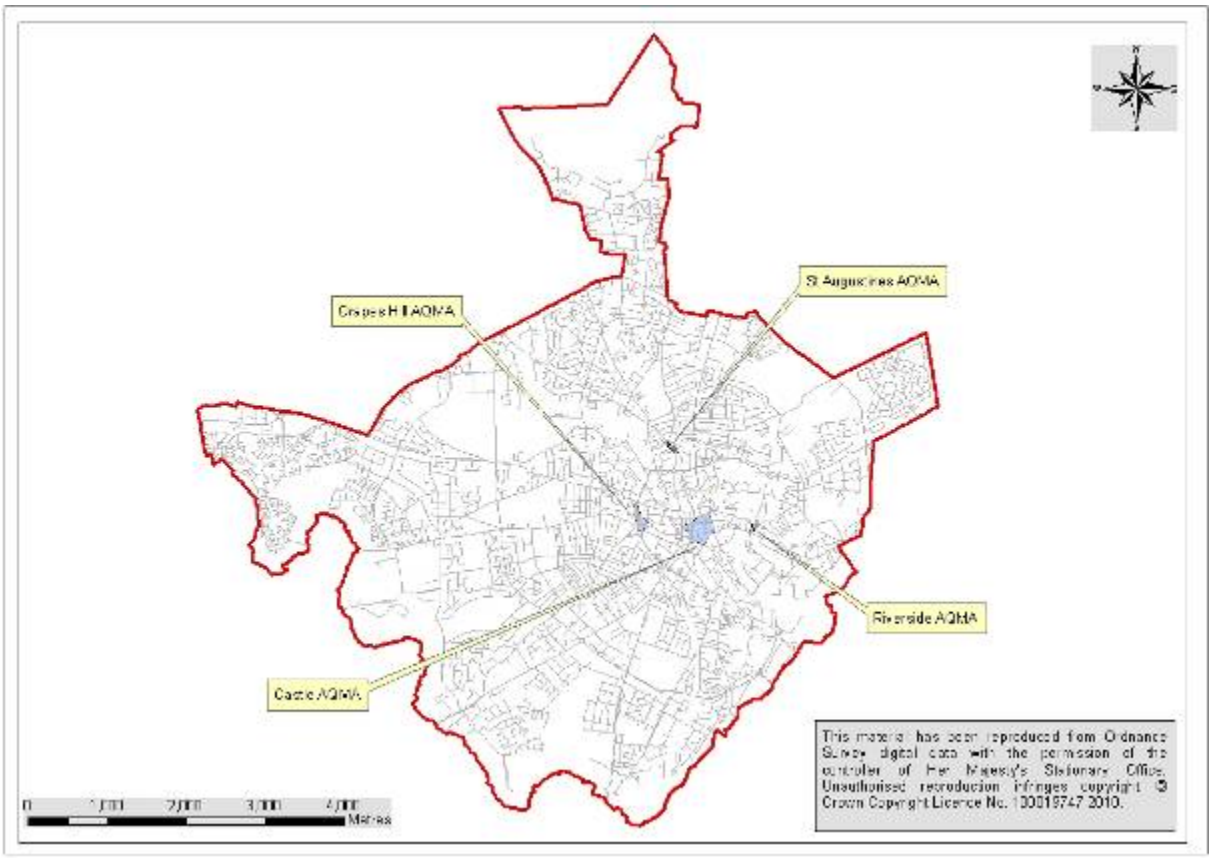


Figure 1.2 Grapes Hill AQMA

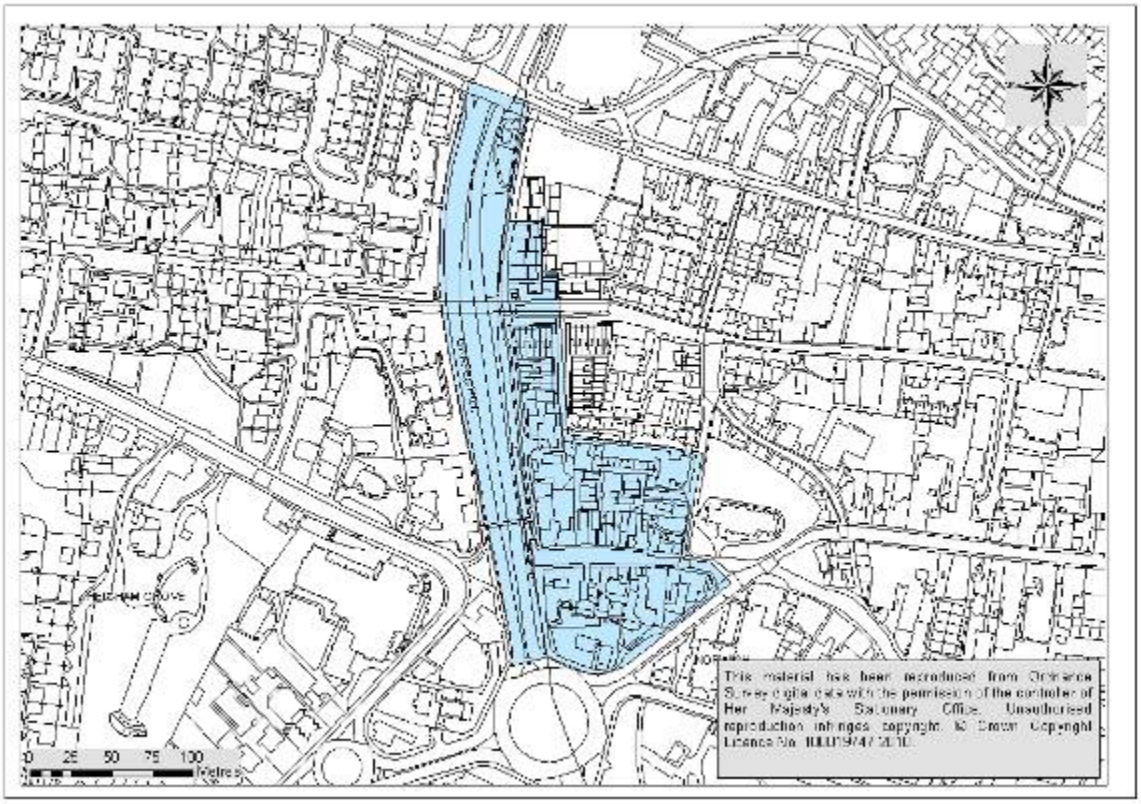


Figure 1.3 St Augustines AQMA

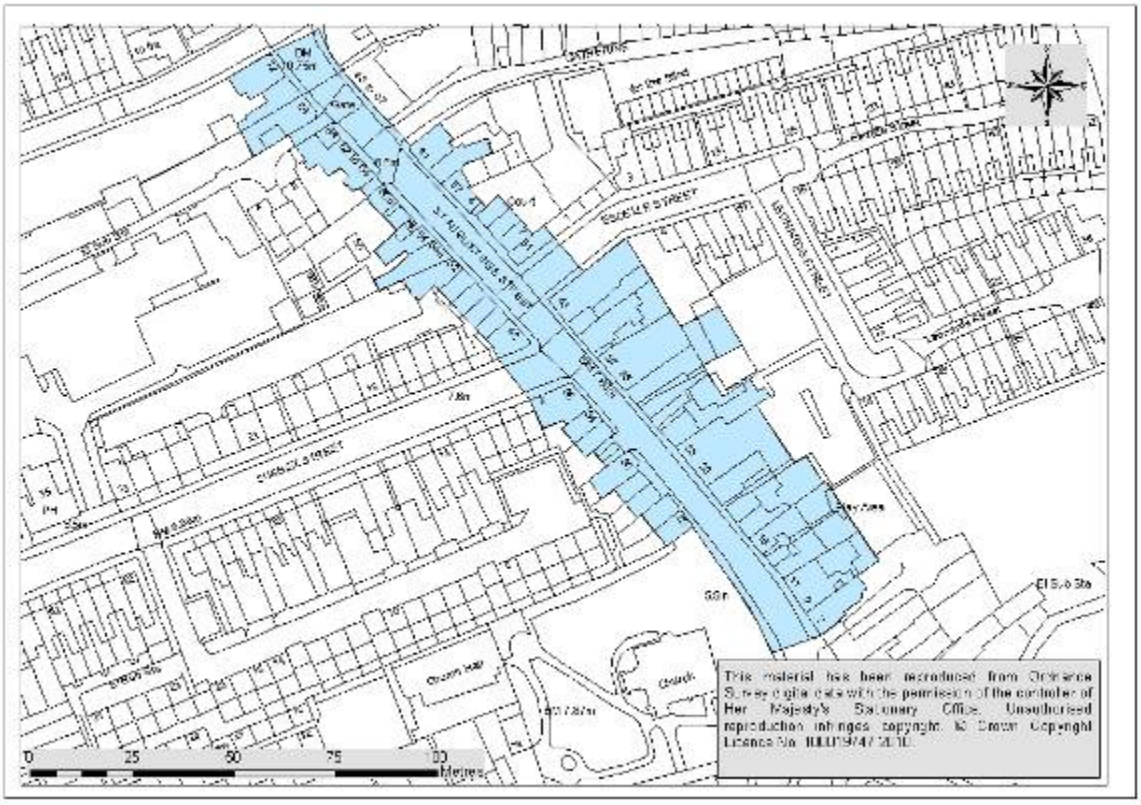


Figure 1.4 Castle AQMA

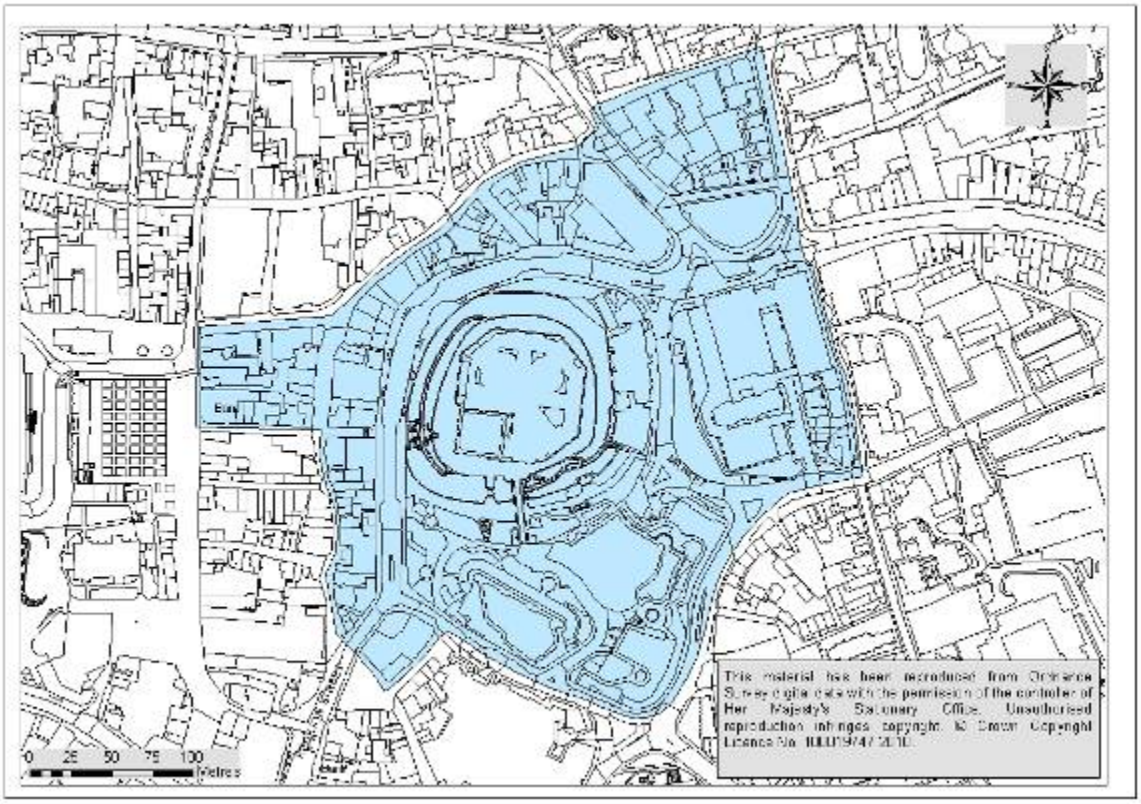
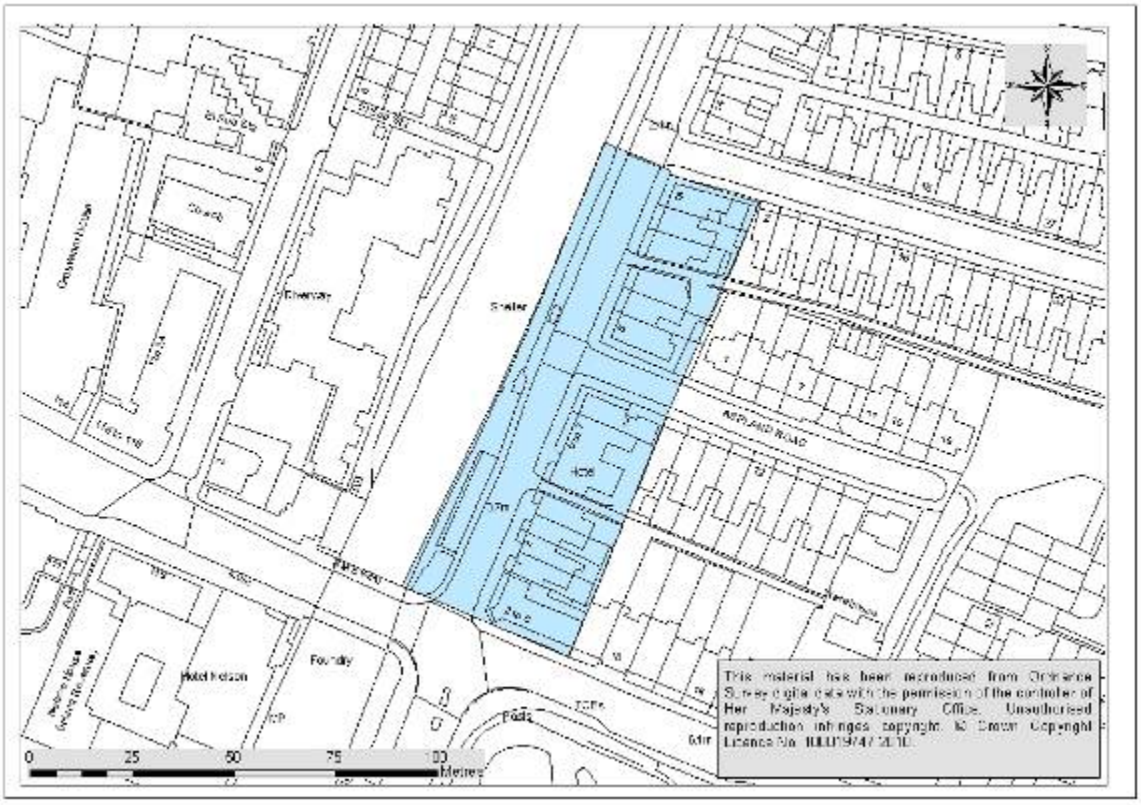


Figure 1.5 Riverside AQMA



2 New Monitoring Data

2.1 Summary of Monitoring Undertaken

2.1.1 Automatic Monitoring Sites

Automatic monitoring was carried out at two locations in Norwich during 2010. The locations are shown in Figures 2.1 and 2.2. The Norwich Lakenfields site is an urban background location and is part of Defra's Automatic Urban and Rural Network (AURN). The Norwich Castle Meadow site is a mobile unit that currently monitors roadside concentrations within the Norwich Castle AQMA.

Data for 2010 is available for both the Castle Meadow site (98% NO_2 and 95% PM_{10} data capture) and the Lakenfields site (91% NO_2 and 78% PM_{10} data capture).

The Norwich Lakenfields site incorporates an FDMS device on the PM_{10} and $PM_{2.5}$ TEOM's to correct for loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by these instruments. PM_{10} data from Castle Meadow has not been corrected using the VCM, as the model indicated low data capture combined with warnings that distant sites were needed to provide the corrections. Therefore, a factor of 1.3 has been applied to give indicative gravimetric equivalent concentrations for the annual mean and 24-hour mean readings.

Figure 2.1 Castle Meadow Automatic Monitoring Station

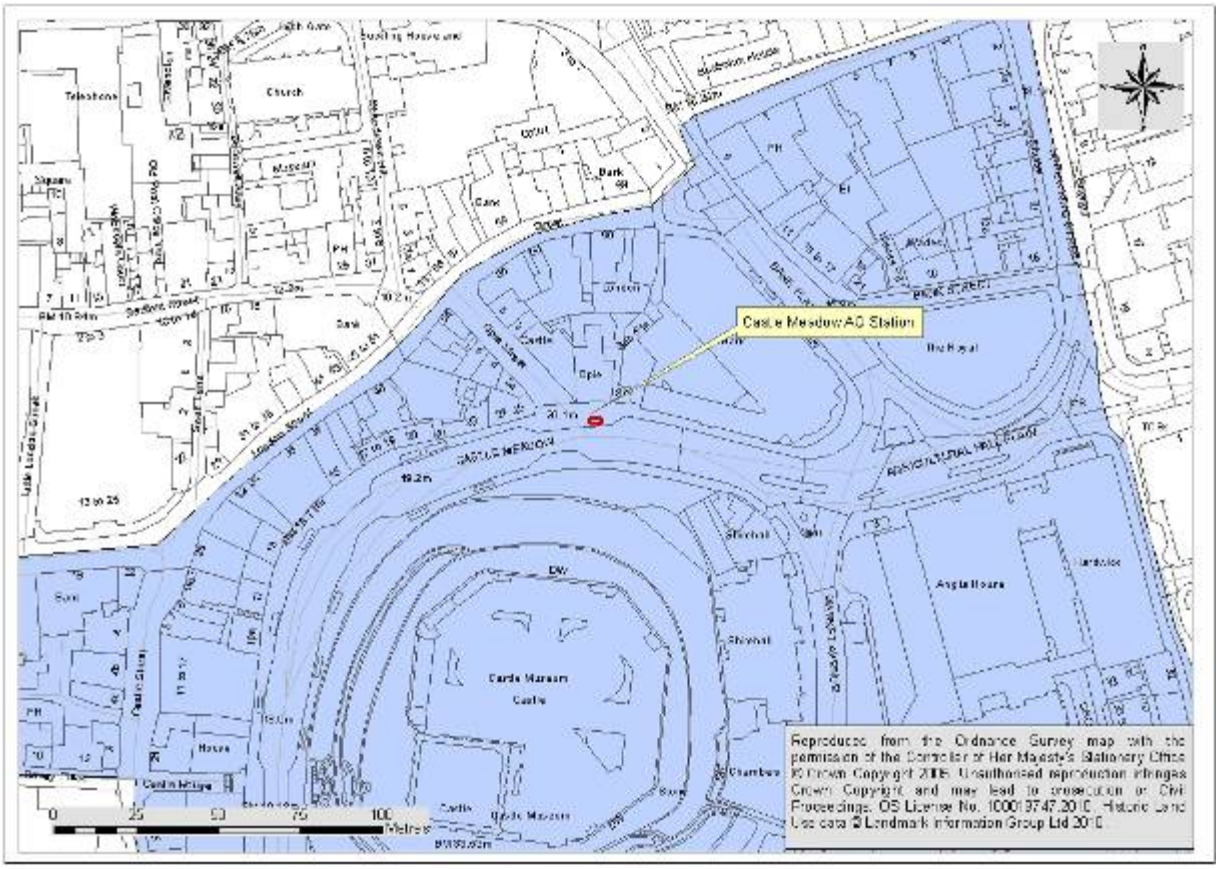


Figure 2.2 Lakenfields Automatic Monitoring Station

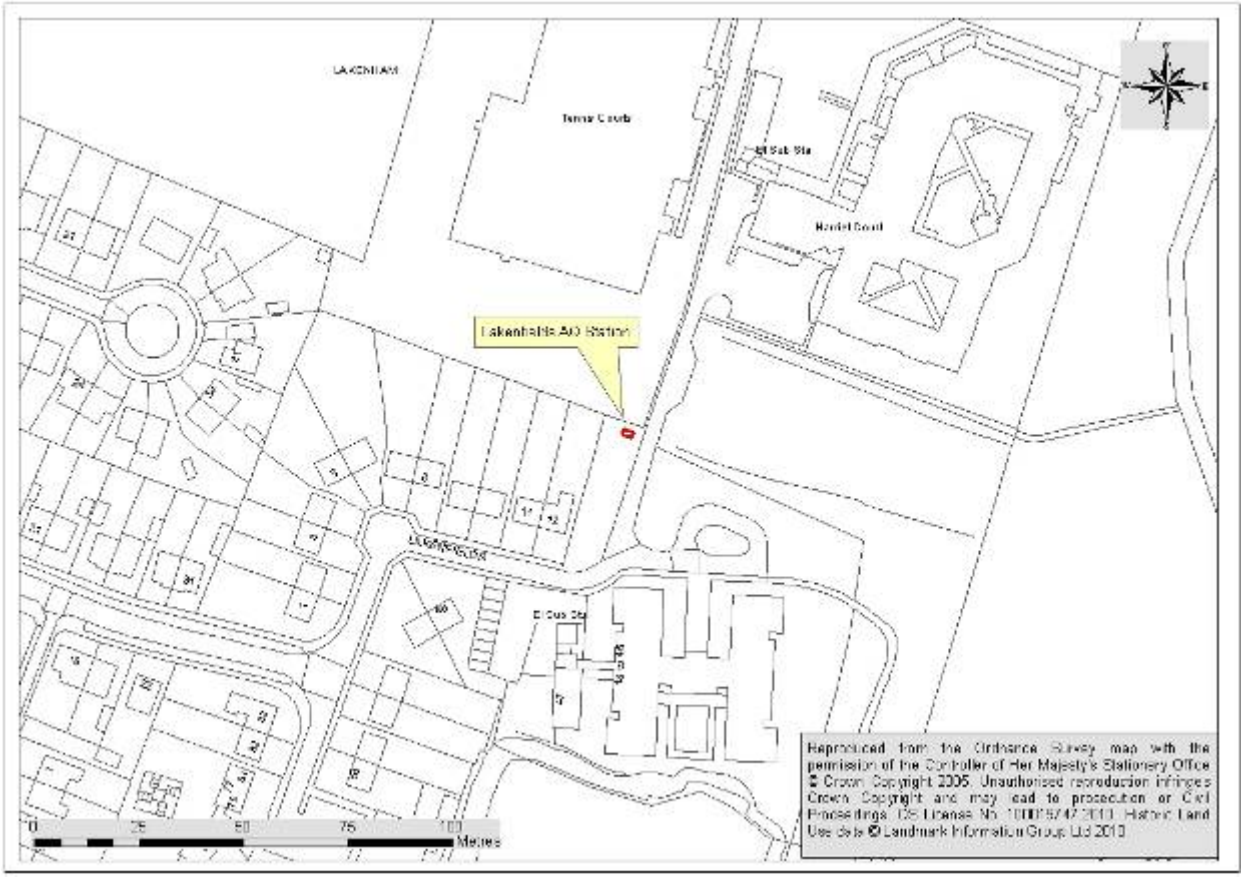


Table 2.1 Details of Automatic Monitoring Sites

Site Name	Site Type	OS Grid Ref	Pollutants Monitored	Monitoring Technique	In AQMA?	Relevant Exposure? (Y/N with distance (m) to relevant exposure)	Distance to kerb of nearest road (N/A if not applicable)	Worst case exposure?
Norwich Castle Meadow	Urban Roadside	X623202 Y308615	O_3, CO, SO_2, PM_{10}, NO_x, NO_2, $PM_{2.5}$	Ambirak TEOM	Y	N	1m	N/A
Norwich Lakenfields	Urban Background	X623637 Y306940	O_3, SO_2, PM_{10}, NO_x, NO_2, $PM_{2.5}$	Thermo FDMS	N	Y (20m)	N/A	N

2.1.2 Non-Automatic Monitoring Sites

Norwich City Council carried out indicative monitoring of NO_2 by diffusion tubes at 30 sites throughout the city during 2010. Triplicate tubes were located at 130 Magdalen Street, 26 Bull Close Road, 5 Riverside and 256 King Street to give increased confidence in the results from these areas. A co-location study was also carried out using triplicate tubes at the Lakenfields AURN site. Sites at Surrey Street and Prince of Wales Road were discontinued in May as they did not threaten the annual mean objective. New sites were added at Carrow Bridge House and 288 King Street in July to give better spatial coverage of the King Street area. New sites were also added at Zipfel House and 68 Bull Close Road in August as part of the detailed assessment of the Bull Close Road area proposed in the 2010 Annual Progress Report.

Details of the diffusion tube monitoring locations are provided in Table 2.2. The locations include roadside and urban background sites. Non-bias corrected diffusion tube data is presented in Appendix B.

Appendix A contains information on automatic and non-automatic monitoring QA/ QC procedures.

Table 2.2 Details of Non- Automatic Monitoring Sites

Site Name	Site Type	OS Grid Ref	Pollutants Monitored	In AQMA?	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to kerb of nearest road	Worst-case Location?
256 King Street	R	X 623863.04 Y 307678.60	NO_2	N	Y (1m)	3.5m	Y
Queens Rd Travelodge	R	X 622917.08 Y 307974.49	NO_2	N	N	N/A	N/A
25 Surrey Street	R	X 623060.33 Y 308034.28	NO_2	N	N	N/A	N/A
St Stephens (mid)	K	X 622879.16 Y 308089.96	NO_2	N	N	N/A	N/A
Lakenfields	UB	X 623681.24 Y 307015.82	NO_2	N	Y (20m)	N/A	N
Chalk Hill Road	R	X 623906.97 Y 308596.92	NO_2	N	Y (1m)	7m	Y
130 Magdalen Street	R	X 623160.89 Y 309550.43	NO_2	N	Y (1m)	4m	Y
Reads Flour Mill	K	X 623796.25 Y 307772.13	NO_2	N	Y (1m)	1m	Y
Grapes Hill (upper)	R	X 622383.05 Y 308653.15	NO_2	Y	Y (1m)	14m	Y
Exchange St	K	X 623007.27 Y 308716.34	NO_2	N	N	N/A	N/A
St Augustines	K	X 622825.70 Y 309572.99	NO_2	Y	Y (1m)	1m	Y
Upper King Street	K	X 623337.40 Y 308632.52	NO_2	Y	N	N/A	N/A
73 Prince of Wales Road	R	X 623610.05 Y 308577.12	NO_2	N	Y (1m)	3m	Y
Cattlemarket Street	R	X 623320.58 Y 308430.88	NO_2	Y	Y (1m)	2m	Y
Castle Meadow	R	X 623141.06 Y 308606.69	NO_2	Y	N	N/A	N/A
Castle Meadow 2	R	X 623250.50 Y 308590.12	NO_2	Y	N	N/A	N/A
Grapes Hill (lower)	R	X 622386.31 Y 308838.52	NO_2	Y	N	N/A	N/A
Zipfel House	R	X 623185.69 Y 309649.68	NO_2	N	Y (1m)	3m	Y
68 Bull Close Road	R	X 623305.49 Y 309543.95	NO_2	N	Y (1m)	4m	Y
Boundary PH 414 Aylsham Rd	R	X 621740.97 Y 311534.55	NO_2	N	Y (1m)	12m	Y
Kerrisons 353 Aylsham Rd	R	X 621803.79 Y 311500.49	NO_2	N	Y (1m)	6m	Y
221 Mile Cross lane	R	X 621805.30 Y 311594.73	NO_2	N	Y (1m)	6m	Y
Carrow Bridge House	R	X 623900.96 Y 307709.56	NO_2	N	Y (1m)	5m	Y
288 King Street	R	X 623936.99 Y 307591.51	NO_2	N	Y (1m)	8m	Y
62 Magpie Road	R	X 622970.72 Y 309652.02	NO_2	N	Y (1m)	2m	Y
26 Bull Close Road	R	X 623228.63 Y 309625.14	NO_2	N	Y (1m)	5.5m	Y
24 Bargate Court	R	X 623422.42 Y 309388.23	NO_2	N	Y (1m)	4m	Y
5 Riverside Road	R	X 623870.26 Y 308515.77	NO_2	N	Y (1m)	3m	Y
Wellington Lane (lower)	K	X 622419.52 Y 308797.22	NO_2	Y	Y (15m)	1m	Y
71 Dukes Court	R	X 622431.35 Y 308663.05	NO_2	Y	Y (1m)	4m	Y

2.2 Comparison of Monitoring Results with Air Quality Objectives

2.2.1 Nitrogen Dioxide (NO_2)

Automatic Monitoring Data

The annual mean concentration at the Castle Meadow automatic monitoring site was recorded as **53 µg/m^3** for 2010, which exceeds the annual mean objective by 13µg/m^3. This monitoring site is within the Castle Meadow AQMA, although it does not represent any nearby relevant exposure. There were 15 exceedences of the 1-hour mean on nine days during 2010 at this site. For the Norwich Lakenfields urban background automatic monitoring site the annual mean concentration for 2010 was 13 µg/m^3. There were no exceedences of the 1-hour mean.

Table 2.3a Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with Annual Mean Objective

Site ID	Location	Within AQMA?	Data Capture for monitoring period %	Data Capture for full calendar year 2010 %	Annual mean concentrations (µg/m^3)		
					2008	2009	2010
N/A	Norwich Lakenfields	N	91	91	N/A	16	13
N/A	Norwich Castle Meadow (mobile site)	Y	98	98	**45**	**41**	**53**

Table 2.3b Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with 1-hour Mean Objective

Site ID	Location	Within AQMA?	Data Capture for monitoring period %	Data Capture for full calendar year 2010 %	Number of Exceedences of hourly mean (200 µg/m^3) (99.8th percentile of hourly means in brackets)		
					2008	2009	2010
N/A	Norwich Lakenfields	N	91	91	N/A	0 (80)	0
N/A	Norwich Castle Meadow (mobile site)	Y	98	98	0	1	15

Diffusion Tube Monitoring Data

Table 2.4a shows the diffusion tube results for 2010, uncorrected and corrected for bias using a national bias adjustment factor of 1.03 and the local bias adjustment factor of 0.9 (derived from measurements using triplicate tubes located at the Lakenfields AURN site), using Gradko Labs for analysis and the 50% TEA in Acetone method. The national bias spreadsheet is available via the following weblink: http://laqm.defra.gov.uk/documents/Diffusion_Tube_Bias_Factors-v09_11.xls and is shown in Appendix A. A copy of the precision and accuracy spreadsheet used to calculate the local bias correction is also shown in Appendix A.

Table 2.4a Results of Nitrogen Dioxide Diffusion Tubes

Location	Within AQMA?	Data Capture 2010 (%)	2010 Annual mean concentrations (µg/m^3)		
			Uncorrected	National Bias Corrected	Local Bias Corrected
256 King Street	N	92	**40.3***	**41.5***	36.3*
Queens Rd Travelodge	N	**83**	39.2	**40.3**	35.3
25 Surrey Street	N	**42**	30.2	31.1	27.2
St Stephens (mid)	N	100	**53.0**	**54.5**	**47.7**
Lakenfields	N	100	14.7*	15.1*	13.2*
Chalk Hill Road	N	100	33.1	34.1	29.8
130 Magdalen Street	N	100	38.5*	39.7*	34.7*
Reads Flour Mill	N	100	24.2	24.9	21.8
Grapes Hill (upper)	Y	100	25.5	26.3	23.0
Exchange St	N	100	37.6	38.7	33.8
St Augustines	Y	**58**	**53.4**	**55.0**	**48.1**
Upper King Street	Y	100	35.3	36.3	31.8
73 Prince of Wales Road	N	**42**	35.2	36.3	31.7
Cattlemarket Street	Y	100	**47.0**	**48.4**	**42.3**
Castle Meadow	Y	**75**	**56.7**	**58.4**	**51.0**
Castle Meadow 2	Y	**83**	**48.2**	**49.6**	**43.4**
Grapes Hill (lower)	Y	100	28.6	29.5	25.7
Zipfel House	N	**42**	**41.1**	**42.3**	37.0
68 Bull Close Road	N	**42**	33.5	34.5	30.2
Boundary PH 414 Aylsham Rd	N	100	28.3	29.1	25.5
Kerrisons 353 Aylsham Rd	N	92	36.1	37.2	32.5
221 Mile Cross lane	N	**83**	35.0	36.0	31.5
Carrow Bridge House	N	**50**	27.9	28.8	25.1
288 King Street	N	**50**	27.6	28.4	24.8
62 Magpie Road	N	100	31.2	32.1	28.1
26 Bull Close Road	N	100	36.6*	37.7*	32.9*
24 Bargate Court	N	100	38.2	39.3	34.4
5 Riverside Road	N	100	**50.6***	**52.1***	**45.5***
Wellington Lane (lower)	Y	100	32.9	33.9	29.6
71 Dukes Court	Y	100	28.0	28.8	25.2

* Mean of triplicate diffusion tubes

Using the National bias correction, a total of nine sites exceeded the NO_2 annual mean objective of 40 $\mu g/m^3$. These sites were:

- 256 King Street;
- Queens Road;
- St Stephens (Mid);
- St Augustines;
- Cattlemarket Street;
- Castle Meadow;
- Castle Meadow 2;
- Zipfel House; and
- Riverside Road.

Of the areas where the exceedences were found, St Augustines, Cattlemarket Street, both Castle Meadow sites and Riverside Road are within existing AQMAs. The tubes at St Stephens Street and Queens Road are not situated at locations representative of relevant exposure. Using the National bias correction, the King Street site exceeded the objective level by 1.5$\mu g/m^3$ and the Zipfel House location exceeded the objective level by 2.3$\mu g/m^3$. However, using the local bias correction, both these sites were under the objective level.

The 2010 Progress Report concluded that Norwich City Council would declare an AQMA in an area of King Street. The commencement of triplicate tubes at this location in June 2009 gave increased confidence in the results for the full 2010 calendar year, and indicates that an AQMA is still appropriate for this location when applying the National bias correction. However, the exceedence may be considered borderline, especially when taking the results after applying the local bias correction into account.

The 2010 report also stated that the Grapes Hill AQMA would be revoked, as the monitoring carried out at Grapes Hill (Upper & Lower), Wellington Lane (Lower) and Dukes Court showed that NO_2 levels within this AQMA were below the annual mean objective, and had been so for the previous four years. The monitoring results show that the objective level was comfortably met at all the tube locations in the area during 2010 also.

Table 2.4b displays the bias adjusted diffusion tube monitoring results across the time series 2006 to 2010. Non bias-corrected monthly diffusion tube results are shown in Appendix B.

Table 2.4b Nitrogen Dioxide Diffusion Tube Trends

Location	Within AQMA?	Annual mean concentrations (µg/m³) Adjusted for bias				
		2006[1]	2007[2]	2008[3]	2009[4]	2010[5]
256 King Street	N	N/A	**45.2**	**41.2**	**44.2**	**41.5**
Queens Rd Travelodge	N	N/A	**41.9**	32.8	37.3	**40.3**
25 Surrey Street	N	N/A	33.5	27.3	29.9	31.1
St Stephens (mid)	N	**46.0**	**46.4**	**48.4**	**52.1**	**54.5**
Chapelfield / Wessex St	N	32.0	35.6	30.5	36.1	N/A
Lakenfields	N	N/A	N/A	N/A	13.6	15.1
26 Johnson Place	N	**41.0**	33.7	24.3	31.9	N/A
Chalk Hill Road	N	N/A	N/A	N/A	30.9	34.1
130 Magdalen Street	N	N/A	**40.1**	36.7	35.2	39.7
Reads Flour Mill	N	N/A	N/A	N/A	23.8	24.9
Grapes Hill (upper)	Y	25.0	28.4	23.2	26.7	26.3
Exchange St	N	**42.0**	**42.3**	**41.0**	40.0	38.7
St Augustines	Y	**50.0**	**52.1**	**50.9**	**56.2**	**55.0**
Tombland	N	**42.0**	**47.7**	27.8	30.1	36.3
Upper King Street	Y	32.0	37.8	32.4	34.0	26.3
73 Prince of Wales Road	N	N/A	39.1	31.8	35.4	36.3
Cattlemarket Street	Y	**42.0**	**52.8**	**43.1**	**50.3**	**48.4**
Castle Meadow	Y	**46.0**	**52.9**	**48.8**	**53.0**	**58.4**
Castle Meadow 2	Y	**46.0**	**46.6**	**45.3**	**47.1**	**49.6**
Grapes Hill (lower)	Y	29.0	30.7	28.0	27.8	29.5
32 Key & Castle Yard	N	N/A	35.6	31.9	33.7	N/A
29 St Martins Road	N	N/A	25.3	22.7	26.3	N/A
Boundary PH 414 Aylsham Rd	N	N/A	N/A	25.0	23.8	29.1
Kerrisons 353 Aylsham Rd	N	N/A	N/A	35.5	37.4	37.2
221 Mile Cross Lane	N	N/A	N/A	33.0	34.8	36.0
13 Aylsham Road	N	N/A	32.7	26.8	30.9	N/A
158 Waterloo Road	N	N/A	**41.1**	23.9	25.0	N/A
62 Magpie Road	N	N/A	34.9	32.6	34.2	32.1
26 Bull Close Road	N	N/A	39.9	35.6	**40.5**	37.7
24 Bargate Court	N	N/A	38.4	32.8	37.9	39.3
124 Barrack Street	N	N/A	32.1	24.9	27.6	N/A
5 Riverside Road	Y	**47.0**	**48.6**	**46.4**	**54.4**	**52.1**
Wellington Lane (lower)	Y	32.4	36.7	32.1	33.6	33.9
71 Dukes Court	Y	N/A	31.1	27.6	28.4	28.8
Carrow Bridge House	N	N/A	N/A	N/A	N/A	28.8*
288 King Street	N	N/A	N/A	N/A	N/A	28.4*
Zipfel House	N	N/A	N/A	N/A	N/A	**42.3***
68 Bull Close Road	N	N/A	N/A	N/A	N/A	34.5*

* Not based on full year's measurements

[1] Bias correction factor applied was 0.98
[2] Bias correction factor applied was 1.051
[3] Bias correction factor applied was 0.93
[4] Bias correction factor applied was 0.99
[5] Bias correction factor applied was 1.03

- 2009 figures are quoted from Progress Report for Norwich City Council, 2010
- 2008 figures are quoted from Updating & Screening Assessment for Norwich City Council, 2009.
- 2007 figures are quoted from Detailed Assessment for Norwich City Council, 2008.
- 2006 figures are quoted from Progress Report for Norwich City Council, 2007.

2.2.2 PM_{10}

The annual mean concentration at the Castle Meadow automatic monitoring site was recorded as 19 µg/m^3, which is below the annual mean objective. There were three exceedences of the 24-hour mean on three days, and the maximum daily mean recorded was 65 µg/m^3 (95% data capture). For the Norwich Lakenfields urban background automatic monitoring site, there were four exceedences of the 24-hour mean on four days, and the maximum daily mean recorded was 56 µg/m^3. The annual mean concentration was 18 µg/m^3 (78% data capture).

Table 2.5a Results of PM_{10} Automatic Monitoring: Comparison with Annual Mean Objective (40µg/m^3)

Site ID	Location	Within AQMA?	Data Capture for monitoring period %	Data Capture for full calendar year 2010 %	Annual mean concentrations (µg/m^3)		
					2008	2009	2010
N/A	Norwich Lakenfields	N	78	78	N/A	17	18
N/A	Norwich Castle Meadow (mobile site)	Y	95	95	19	21	19

Table 2.5b Results of PM_{10} Automatic Monitoring: Comparison with 24-hour Mean Objective

Site ID	Location	Within AQMA?	Data Capture for monitoring period %	Data Capture for full calendar year 2010 %	Number of Exceedences of daily mean objective (50 µg/m^3) (90th percentile of daily means in brackets)		
					2008	2009	2010
N/A	Norwich Lakenfields	N	78	78	N/A	0 (26)	4
N/A	Norwich Castle Meadow (mobile site)	Y	95	95	4	2	3

2.2.3 Sulphur Dioxide (SO_2)

There are two automatic sites in Norwich that monitor SO_2.

Norwich Lakenfields had 92% data capture for the calendar year. There were no exceedences of the 15-minute mean during the calendar year, the maximum being 16 $\mu g/m^3$. There were no exceedences of the 1-hour or 24-hour means at this site, with maximums being 11 $\mu g/m^3$ and 5 $\mu g/m^3$ respectively. The recorded annual mean at Lakenfields was 1 $\mu g/m^3$.

The other automatic monitoring site in Norwich, Castle Meadow, had 97% data capture for SO_2. There was one exceedence of the 15-minute mean during the calendar year, the maximum being 319 $\mu g/m^3$. There were no exceedences of the 1-hour or 24-hour means at this site, with maximums being 101 $\mu g/m^3$ and 29 $\mu g/m^3$ respectively. The recorded annual mean at Norwich Castle Meadow was 14 $\mu g/m^3$.

Table 2.6 Results of SO_2 Automatic Monitoring: Comparison with Objectives

Site ID	Location	Within AQMA?	Data Capture for monitoring period (%)	Data Capture (%)	Number of Exceedences		
					15-minute objective (266$\mu g/m^3$)	1-hour objective (350$\mu g/m^3$)	24-hour objective (125 $\mu g/m^3$)
N/A	Norwich Lakenfields	N	92	92	0	0	0
N/A	Norwich Castle Meadow (mobile site)	Y	97	97	1	0	0

2.2.4 Benzene

NCC no longer monitors benzene as it has been determined that ambient levels in Norwich are insignificant in terms of the Air Quality Objective.

2.2.5 Other pollutants monitored

Carbon Monoxide

Monitoring data is available for carbon monoxide from the Norwich mobile monitoring unit at Castle Meadow for the 2010 calendar year. There were no exceedences of the air quality strategy objective of 10 mg/m^3 (8-hour running mean) for carbon monoxide in Norwich during 2010. The recorded data shows a maximum 8-hour running mean of 1.9 mg/m^3.

Ozone

Monitoring data is available for ozone from the Norwich mobile monitoring unit at Castle Meadow for the 2010 calendar year. Ozone is not included in the regulations for air quality management for local authorities due to its transboundary nature, and thus the limited effectiveness of action on a local scale. There is however a provisional objective level for this pollutant of 100µg/m^3 as a running 8-hour mean that is not to be exceeded more than 10 times per year. The recorded data shows a maximum 8-hour running mean of 140µg/m^3 and five occasions where the 8-hour running mean exceeded 100µg/m^3. There was therefore no exceedence of this provisional objective.

$PM_{2.5}$

Monitoring data is available for $PM_{2.5}$ from the Norwich mobile monitoring unit at Castle Meadow for the 2010 calendar year. $PM_{2.5}$ is not included in the regulations for air quality management for local authorities. The recorded data shows an annual mean of 8µg/m^3 and a maximum daily mean of 36µg/m^3.

$PM_{2.5}$ data is also available for the Lakenfields site. The recorded data shows an annual mean of 13µg/m^3 and a maximum daily mean of 49µg/m^3.

2.2.6 Summary of Compliance with AQS Objectives

Norwich City Council has measured concentrations of NO_2 above the annual mean objective at relevant locations in King Street and Zipfel House (Bull Close Road), which are outside of the existing AQMAs.

The monitoring carried out at Grapes Hill (Upper & Lower), Wellington Lane (Lower) and Dukes Court showed once again that NO_2 levels within the Grapes Hill AQMA were below the annual mean objective, and have been so for the previous five years.

3 New Local Developments

3.1 Road Traffic Sources

NCC confirms that there are no new/ newly identified congested streets with a flow above 5,000 vehicles per day and residential properties close to the kerb, that have not been adequately considered in previous rounds of Review and Assessment.

NCC confirms that there are no new/newly identified busy streets where people may spend 1 hour or more close to traffic.

NCC confirms that there are no new/newly identified roads with high flows of buses/HDVs.

NCC previously assessed new/newly identified junctions meeting the criteria in Section A.4 of Box 5.3 in TG (09) as part of the latest USA.

NCC confirms that there are no new/proposed roads other than mentioned below.

NCC confirms that there are no new/newly identified roads with significantly changed traffic flows other than mentioned below.

NCC confirms that there are no relevant bus stations in the Local Authority area.

Work to create a new gyratory system around the St Augustines AQMA (as reported in the last APR) was completed in December 2010. St Augustines Street has become a one-way, going northbound. A new short stretch of link road was created to complete the gyratory between Edward Street and Pitt Street. It is anticipated that the improved, and reduced, flow of traffic through St Augustines Street will improve air quality. The first opportunity to assess a full year's data with the new system in operation will be available in 2012. Much of the 2010 monitoring was hampered by the construction and closure of the road for several months, which resulted in the reduced data capture shown in Table 2.4a.

3.2 Other Transport Sources

NCC confirms that there are no airports in the Local Authority area that meet the criteria outlined in Box 5.4 of LAQM TG (09).

NCC confirms that there are no locations where diesel or steam trains are regularly stationary for periods of 15 minutes or more, with potential for relevant exposure within 15m.

NCC confirms that there are no locations with a large number of movements of diesel locomotives, and potential long-term relevant exposure within 30m.

NCC confirms that there are no ports or shipping that meet the specified criteria within the Local Authority area.

3.3 Industrial Sources

NCC previously assessed new/proposed industrial installations as part of the latest USA.

NCC confirms that there are no industrial installations with substantially increased emissions or new relevant exposure in their vicinity within its area.

NCC confirms that there are no new or proposed industrial installations for which planning approval has been granted within its area.

There are no major fuel (petrol) storage depots within the Local Authority area.

NCC confirms that there are no petrol stations meeting the specified criteria**.**

NCC confirms that there are no poultry farms meeting the specified criteria.

3.4 Commercial and Domestic Sources

NCC confirms that there are no new biomass combustion plants in the Local Authority area since the last USA.

NCC confirms that there are no new areas of significant domestic fuel use in the Local Authority area since the last USA.

3.5 New Developments with Fugitive or Uncontrolled Sources

NCC confirms that there are no new potential sources of fugitive particulate matter emissions in the Local Authority area since the last USA.

NCC has identified the following new or previously unidentified local developments which may impact on air quality in the Local Authority area:

- The new St Augustines gyratory system.

This will be taken into consideration in the next Updating and Screening Assessment, scheduled for 2012.

4 Planning Applications

Despite the present economic climate, progress has been made on improvement and regeneration of the area around the St Augustines Street AQMA as part of the Northern City Centre Area Action Plan. A planning application for the comprehensive regeneration of Anglia Square (which is in close proximity to St Augustines Street) and its environs was approved for mixed use development, including residential and a food store. The redevelopment will include modified car parking, improved access (including enhanced pedestrian, cycle, public transport accessibility, as well as the new gyratory road layout mentioned above. More information on the Northern City Centre Area Action Plan can be found on the council's website at:

http://www.norwich.gov.uk/Planning/Pages/Planning-NorthernCityCentreAreaActionPlanNCCAAP.aspx

5 Air Quality Planning Policies

The *City of Norwich replacement local plan* (adopted in November 2004) provides guidance for developers and the council's own development control service on where and what kind of development may be permitted in the city. It has detailed planning policies for the city and allocates uses for particular sites.

The city council agreed with the Government Office for the East of England that we could continue to use around 70% of the policies in the local plan beyond 30 November 2007. These are called 'saved policies'. Those relating to air pollution and air quality management areas are referenced EP5 & EP6 respectively. Extracts from the plan are quoted below:

Air Pollution

4.19 No specific policy dealing with air pollution was contained in the 1995 adopted Local Plan. This matter was drawn to the City Council's attention by an appeal decision in 1997, which demonstrated that there are circumstances where a Local Plan policy is necessary. PPG23 advises that Local Plans should include policies to separate potentially polluting uses from those uses that are sensitive to such pollution and especially residential development. The abolition of the Special Industrial Classes in the Use Classes Order now also requires that more consideration be given to the potential polluting effects of any general industrial development.

4.20 The policy refers to 'demonstrable harm' being shown to affect human health or the environment. PPG23 accepts that it may be necessary, on occasion, for policies in Local Plans to override the normal criteria of Integrated Pollution Control regimes, particularly where harm to human health can be demonstrated by such emissions. 'Sensitive uses' will include housing, schools, hospitals and certain other activities, such as food processing, where air pollution would have a particularly deleterious impact. The issue of air quality and the Air Quality Management Areas is dealt with in the next policy – although there may in some circumstances be an overlap with policy EP5 on specific emissions from premises.

*[Relates to **Resource Objectives: Air (i), Quality of Life (i) and (iv)**]*

EP5 - Air Pollution emissions and sensitive uses

Development which may give rise to air-borne emissions of harmful substances, including smoke, grit and dust, will be required to assess the level of risk of demonstrable harm to human health or to the environment and to identify appropriate mitigation measures. Particular account will be taken of any sensitive uses, which would adjoin or otherwise be affected by such emissions.

Air Quality Management Areas

4.21 The air quality issues arising in Norwich are nearly all associated with excess traffic volumes in confined areas. Whilst these will not, in general, be resolved by land use measures alone, it is nevertheless important to include such a policy, in order to provide for any control on land uses which may be necessary – including, potentially, the need to exclude uses which may generate heavy car traffic and/or to restrict sensitive uses in the affected locations. Policy EP6 will therefore apply any controls that are necessary when the Air Quality Management Action Plans are published under Part IV of the Environment Act 1995.

*[Relates to **Resource Objectives: Air (i) and (ii); Quality of Life (iv)**]*

EP6 - Air Quality Management Areas

Where an Air Quality Management Area has been declared (under the Environment Act, 1995), development which may have an impact on air quality will be required to take account of the action plan for that area in respect of its location and density.

In 2004, the government introduced a new system to prepare and deliver planning policy. This is called the *Local Development Framework* (LDF). It is a process that provides a timetable to produce new policies (the *Local development scheme*), a code of practice on how the council will involve people in producing planning policies (the *Statement of community involvement*), a family of policy documents to guide development in the city,) and regular monitoring of the planning services progress (the *Annual monitoring report*).

Local plans will therefore be phased out over the next few years and gradually replaced by a new system of related planning policy documents.

Further information can be found on the link to the Norwich City council website below:

http://www.norwich.gov.uk/webapps/atoz/service_page.asp?id=1501

6 Local Transport Plans and Strategies

Norfolk's 3rd transport plan, Connecting Norfolk has been adopted. This describes the county's strategy and policy framework for delivery up to 2026. It will be used as a guide for transport investment and considered by other agencies when determining planning or delivery decisions.

Norfolk's Transport Vision:

A transport system that allows residents and visitors a range of low carbon options to meet their transport needs and attracts and retains business investment in the county.

Connecting Norfolk reflects the views of local people and stakeholders, identifying six priorities for transport:

- Maintaining and managing the highway network
- Delivering sustainable growth
- Enhancing strategic connections
- Reducing emissions
- Improving road safety
- Improving accessibility

It is important that Connecting Norfolk takes adequate regard of sustainability considerations, such as its impact on biodiversity, social exclusion, carbon emissions and health of the population.

With specific regard to transport emissions:

Measures must be taken to reduce emissions from transport in Norfolk. Connecting Norfolk places importance on:

1. Aiding a shift to a more efficient vehicle fleet through development and facilitation of necessary infrastructure like electric vehicle charging points
2. Promoting active and healthier travel options for short journeys to schools, services and places of employment
3. Enhancing integration between different travel modes, particularly at key bus and rail stations and Norwich Airport
4. Tackling traffic problems where they are resulting in poor air quality.

The full report can be viewed at:

http://www.norfolk.gov.uk/Travel_and_transport/Transport_future_for_Norfolk/Local_Transport_Plan/index.htm

7 Implementation of Action Plans

Table 7.1 Action Plan Progress

No.	Measure	Original Timescale	Progress with Measure	Outcome to Date	Comments relating to emission reductions
St Augustines Street					
1	Road Layout Changes	2011	Completed Dec 2010	One-way gyratory system to reduce traffic levels and hence emissions in St Augustines Street constructed	Scheme will also deliver regeneration and road safety benefits
Castle Area					
2	Low Emission Zone	Design 04/05 phased implementation 06/07 through to 2009/10	Original LEZ measures fully introduced	European match funding has been secured through CIVITAS SMILE. Engine switch off TRO to be implemented April 2007. Retro-fit programme commencing	Continuous automatic monitoring showed a reduction in year on year NO_2 levels from 2007 to 2009. However, 2010 saw an increase in both the annual and hourly mean levels. The cause of this increase is unknown, but may be down to environmental or weather related conditions. Individual tubes on Castle Meadow show relatively stable levels, revealing localised issues that will be investigated. The Castle Meadow 2 tube shows a continuing exceedance that relates to a separate issue due to general traffic, which will not be affected by the LEZ, but which will be investigated further.
3				Castle Meadow Low Emission Zone now fully introduced with application of Traffic Regulation Condition in full	
4	Quality Bus Partnerships & Contracts	Ongoing process	On-going discussions between County/City and First.	Increasingly close working between NCC and operators on quality, but no formal partnerships. Voluntary joint investment partnership established between First, County Council and City Council during 2007 - 2010 period	Joint investment partnership has delivered new Euro IV buses and improved fleet management

No.	Measure	Original Timescale	Progress with Measure	Outcome to Date	Comments relating to emission reductions
Grapes Hill					
5	Road Layout Changes	Design 04/05 Implemented 05/06	Layout and traffic light sequence changes completed, resulting in reduced queuing on Grapes Hill	NO_2 levels consistently below objective for previous five years. 2008 DA concluded that AQMA could be revoked, as reported in the 2010 APR.	Intention is to revoke this AQMA.
Area Wide Measures					
6	Park and Ride and Car Parking Policy	Ongoing Process	All programmed Park and Ride works complete	3.727 million passengers using Park and Ride in 2005/06	6 Park and Rides sites in Norwich, with over 5,000 spaces - the most in the country. However, city centre car parking spaces have been converted to short and medium-term stay, increasing overall traffic. There are ongoing promotions to use P&R. Currently looking at providing coach parking at Harford P&R. Norfolk County Council has developed a P&R fuel save calculator.
Soft Measures:					
7	Car Sharing	Ongoing process	Norfolk Car Share going through continued development.	European match funding has been secured through CIVITAS SMILE project	Norfolk CarShare powered by Liftshare is continuing to be promoted in Norfolk County Council and Norwich City Council. A bid is being submitted through the LSTF fund to promote Norfolk CarShare in businesses in Norfolk. A new Travel Plan officer has been employed for Norfolk County Council to promote sustainable travel.
8	Travel Wise	Ongoing process		No outcome to date	The new Act TravelWise website now up and running. http://www.acttravelwise.org/home . Norfolk County Council still activity promoting.
9	School Travel Plans	Ongoing process	Target Met	Complete	All existing schools now have travel plans. New schools must have a travel plan implemented through their planning application. Norfolk County Council monitor these travel plans
10	Workplace Travel Plans	Ongoing process	Ongoing process agreements in period 2001-2006	No outcome to date	Integrated into CIVITAS SMILE project Two dedicated workplace travel plan officers are in post at Norfolk County Council to monitor and

No.	Measure	Original Timescale	Progress with Measure	Outcome to Date	Comments relating to emission reductions
					implement workplace travel plans.
Alternative Fuels:					
11	Cleanup Motorvate Powershift	Ongoing process	None (see comments)	No outcome to date	Grant programmes ended and revised to move to a technology neutral approach, and adjusted to comply with State Aid rules. Continuous research but nothing planned.
12	Retro-fit	2005-2009	Complete	Bus fleet using Castle Area AQMA Euro III or better	Retro-fit evaluated as part of CIVITAS SMILE project as part of wider project to introduce a Low Emission Zone
13	Bio-fuels	2005-2009	Trials commenced with bio-diesel bus and police vehicle fleets. Further work carried out including introduction of first bio-gas powered bus between 2003/04 and 2009/10	Up to 20% bio-diesel blends have no impact and may improve NOx emissions. However uncertainty over supply etc means that Local Authorities now investigating bio-gas with both CO_2 and NOx benefits	Trials evaluated as part of CIVITAS SMILE project
14	Land Use Planning	Ongoing	Local Development Framework for Norwich area takes an integrated approach to land use and transportation planning	Long term effect	LDF seeks to minimise need for travel and encourage use of non motorised modes and public transport
15	Engine Switch Off	2008	Complete	Vehicles stopping in Castle Meadow required to turn off engine if stationary unless passengers alighting/boarding continuously	To be applied in remainder of city centre on clarification of appropriate approach to enforcement.

Leading by example:					
16	Alternative Fuel Trials	2003/2004	Trial completed in summer 2004.	County Council will use results to make better use of alternative fuels in its vehicle fleet	Petrol/electric cars have been available as a lease car option, but relative cost and a change of supplier is bringing this to an end.
17	Commuter Plan	Ongoing process	New Travel Plan for Norwich City Council and Norfolk County Council agreed.	Travel to work survey undertaken annually. Cycling and pedestrian routes reviewed and improvements made, including increased cycle storage facilities. Increased promotion of bus services serving County Hall. Further improvements anticipated in 2011/2012	Ongoing works are taking place on Travel Plans with businesses throughout the County. Funding is being sought through the LSTF bid to promote Travel Planning in key businesses. A new Travel Plan officer has been employed by Norfolk County Council to oversee its Travel Plan and implement appropriate measures. A great deal of work is ongoing on using alternative technologies to promote working from home and remote working. Further work and improvements are expected.

8 Conclusions and Proposed Actions

8.1 Conclusions from New Monitoring Data

NCC undertakes both continuous and diffusion tube nitrogen dioxide monitoring in their area. Continuous monitoring carried out at Castle Meadow in 2010 showed that the NO_2 concentration exceeded the annual mean objective of 40 $\mu g/m^3$. The monitoring also showed that the 1-hour mean objective for NO_2 was exceeded 15 times during the year. Automatic monitoring carried out at Norwich Lakenfields did not indicate any exceedence of the annual mean or the 1-hour mean objectives.

NCC carried out diffusion tube monitoring for NO_2 at 30 locations throughout the city. The 2010 national bias-adjusted results indicated that concentrations of NO_2 exceeded the annual mean objective at several locations. These locations were:

- 256 King Street;
- Queens Road;
- St Stephens (Mid);
- St Augustines;
- Cattlemarket Street;
- Castle Meadow;
- Castle Meadow 2;
- Zipfel House; and
- Riverside Road.

Of the areas where the potential exceedences were found, St Augustines, Cattlemarket Street, both Castle Meadow sites and Riverside Road are within existing AQMAs. The tubes at St Stephens Street and Queens Road are not situated at locations representative of relevant exposure. Using the national bias correction, the King Street site exceeded the objective level by 1.5$\mu g/m^3$ and the Zipfel House location exceeded the objective level by 2.3$\mu g/m^3$. However, using the local bias correction, both these sites were under the objective level.

As proposed in the 2010 APR, a detailed assessment of Bull Close Road has been carried out by increasing the monitoring in the area, to include the commencement of triplicate tubes at the existing site and deployment of additional tubes at new relevant locations. The triplicate tubes at the original site did not show an exceedence of the annual mean objective for 2010 when applying the national bias correction. Similarly, the new site at 68 Bull Close Road recorded a corrected concentration of 34.5$\mu g/m^3$. However, the new site at Zipfel House showed an exceedence of the annual mean objective of 2.3$\mu g/m^3$ when using the national bias correction. Using the local bias correction the concentration was below the objective level at 37.0$\mu g/m^3$.

Unfortunately, due to construction and maintenance on Zipfel House, two months data was lost, resulting in only three months data capture.

As the monitoring period for Zipfel House covered less than 9 months of the year, a period adjustment calculation (as detailed in Box 3.2 of LAQM.TG(09)) has been carried out. Data for the full 2010 period from Norwich Castle Meadow and Norwich Lakenfields has been used to calculate the ratios applied to the Zipfel House data. These calculations are summarised in the table below. As can be seen, the adjusted annual mean is **46.5µg/m^3**.

Table 8.1 Period Adjustment of Data from Zipfel House

Site	Annual Mean µg/m^3	Period Mean (01/08/10 – 31/12/10) µg/m^3	Ratio
Lakenfields	17	14.04	1.211
Castle Meadow	53	53.51	0.990
Average Ratio			1.1
Zipfel House Annual Mean			**46.5 (42.3 x 1.1)**

Based upon the findings of previous assessments, the concentrations of 1,3-butadiene, benzene, carbon monoxide, lead, PM_{10} and SO_2 are unlikely to be in excess of the air quality objectives at any location.

8.2 Conclusions relating to New Local Developments

Section 3.1 refers to a new gyratory system encompassing the current St Augustines AQMA. The construction of the gyratory was completed at the end of 2010. It is anticipated that the improved, and reduced, flow of traffic through St Augustines Street will improve air quality. New monitoring data relating to this area will be available for consideration within the next Updating and Screening Assessment. A plan of the new gyratory system (as originally proposed) is shown in Appendix C.

8.3 Proposed Actions

The 2010 APR reported that an area of King Street was to be declared as an AQMA and the Grapes Hill AQMA was to be revoked. Bull Close Road was to be the subject of a Detailed Assessment and declared as an AQMA in 2011 if required. A Further Assessment of the Riverside AQMA was to be reported later in that year.

The first two of these actions have not been completed. There is further discussion on this point later in this section. The Detailed Assessment of Bull Close Road has been carried out, and is discussed below. The FA for Riverside Road was submitted to Defra for comment. Their response concluded that the AQMA is justified and should be retained.

As noted in Sec. 8.1 the increased monitoring at Bull Close Road was put into place in August 2010. The results were rather ambiguous however, and open to varying interpretation depending on the chosen bias correction applied. The original monitoring location at number 26, along with one of the new sites (at number 68), were below the objective level. The new site at Zipfel House exceeded the annual mean objective by 2.3$\mu g/m^3$ when using the national bias correction. There was no exceedence when using the local bias correction. However, when a period adjustment was applied to the Zipfel House data (shown above), a potentially more significant exceedence was evident.

There are arguments for and against using the national bias adjustment factor as opposed to a local figure. However, it is clear that some areas of King Street and Bull Close Road are a potential threat to the annual objective. It has therefore been decided to apply the nationally derived bias adjustment factor. Further discussion on this is given in Appendix A.

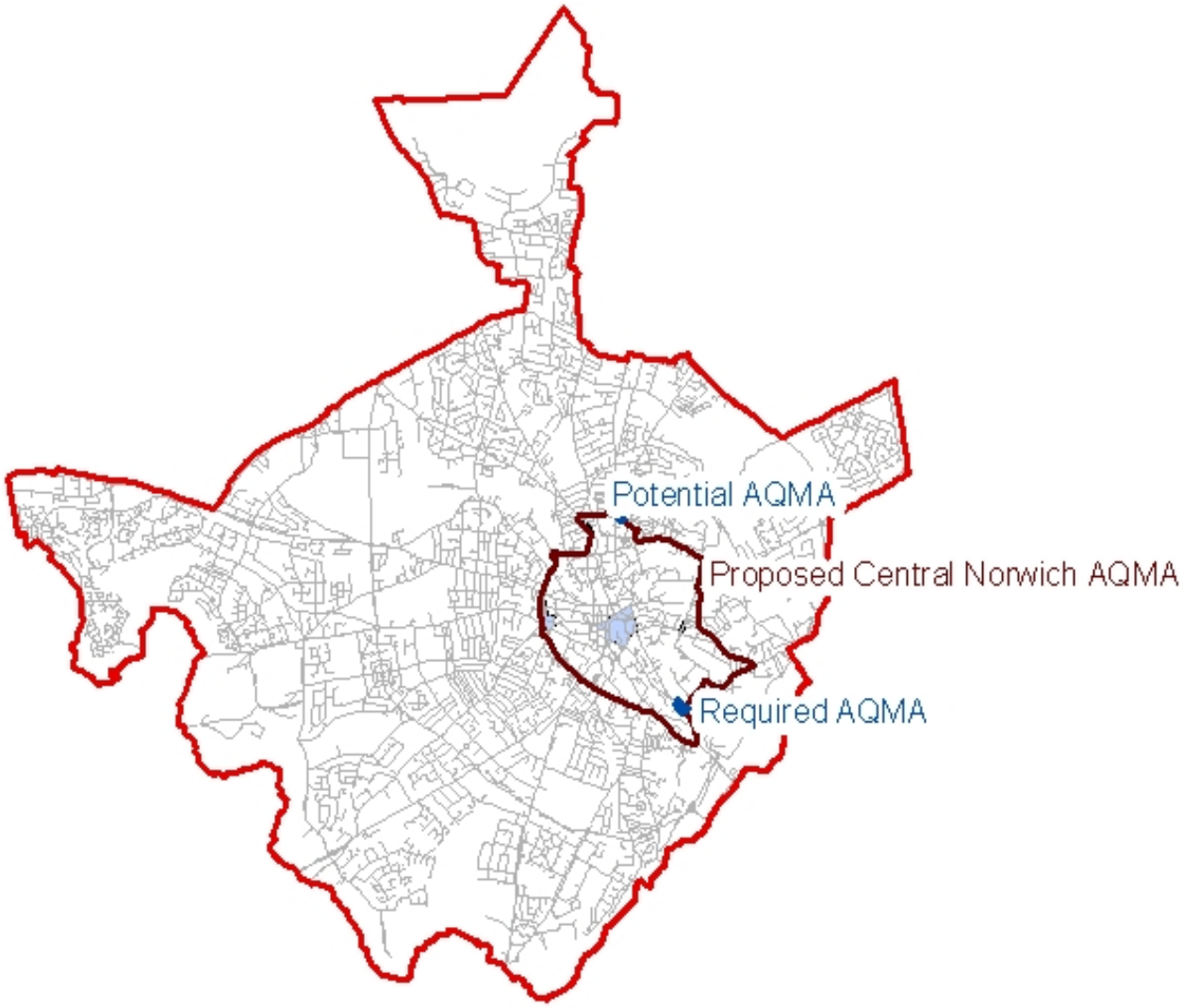
In September 2010 NCC contacted Defra regarding the proposed declaration of an area of King Street as an AQMA, the revocation of the Grapes Hill AQMA, and the potential exceedences at Bull Close Road. Having further discussed these issues, Norfolk County Council (as Highways Authority) and NCC considered the alternative possibility of declaring a larger area of central Norwich as an AQMA. This area would encompass all of the existing AQMA's, the proposed one at King Street, and also Bull Close Road. Defra responded positively, stating that they would not have any objection if NCC decided to go ahead with this proposal.

Many of the roads in question are in fairly close proximity, and influence each other in how they react to traffic flow changes etc. This obviously has a knock-on effect on how issues in the various AQMA's are addressed. Creating the larger AQMA would enable a broader approach to action planning, rather than having to address very localised issues which, in turn, affect other nearby areas.

It is therefore NCC's intention to **declare** an area of Central Norwich as an AQMA and **revoke** the existing AQMA's at Grapes Hill, St Augustines, Castle area and Riverside Road.

A plan showing the location and extent of the proposed Norwich Central AQMA is shown in Fig 8.1.

Figure 8.1 Proposed Norwich Central AQMA



9 References

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Appendices

Appendix A: QA/QC Data

Appendix B: 2010 Uncorrected Monthly NO_2 Concentrations ($\mu g/m^3$)

Appendix C: Plan of St Augustines Gyratory System

Appendix A: QA:QC Data

National Diffusion Tube Bias Adjustment Factor

Supplier/ Analyst: Gradko
Preparation Method: 50% TEA in Acetone
National Bias Adjustment Factor (from spreadsheet v09/11): **1.03**

Factor from Local Co-location Studies (Local Bias Adjustment Factor)

Norwich Lakenfields urban background AURN site **(based on 12 periods of data)**

Bias Factor A: **0.90** (0.83 – 0.98)

Bias B: 11% (2% - 20%)

Diffusion Tubes Mean: 15µg/m³

Automatic Mean: 13µg/m³

Data Capture for periods used: 91%

Adjusted Tubes Mean: 13 (12-14) µg/m³

A copy of the precision and accuracy spreadsheet used to calculate the local bias correction is shown below:

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 µgm^{-3}	Tube 2 µgm^{-3}	Tube 3 µgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	30/12/2009	03/02/2010	21.9	21.0	22.8	22	0.9	4	2.1	18.1	80	Good	Good
2	03/02/2010	03/03/2010	20.6	20.6	19.7	20	0.5	3	1.3	17.1	76	Good	Good
3	03/03/2010	31/03/2010	13.9	13.3	14.0	14	0.4	3	0.9	15.4	90	Good	Good
4	31/03/2010	05/05/2010	12.3	11.5	10.2	11	1.1	9	2.6	9.5	95	Good	Good
5	05/05/2010	04/06/2010	9.6	10.3	10.4	10	0.5	5	1.2	10	95	Good	Good
6	04/06/2010	07/07/2010	9.9	9.8	9.3	10	0.3	3	0.7	11	95	Good	Good
7	07/07/2010	03/08/2010	11.1	11.7	11.5	11	0.3	2	0.7	9	87	Good	Good
8	03/08/2010	02/09/2010	9.5	10.0	9.5	10	0.3	3	0.8	8	92	Good	Good
9	02/09/2010	29/09/2010	12.9	13.2	12.6	13	0.3	3	0.8	11	91	Good	Good
10	29/09/2010	04/11/2010	13.7	14.3	13.9	14	0.3	2	0.8	13	95	Good	Good
11	04/11/2010	01/12/2010	17.7	18.0	18.0	18	0.2	1	0.5	19.3	95	Good	Good
12	01/12/2010	06/01/2011	22.6	24.8	22.9	23	1.2	5	3.0	19	96	Good	Good
13													
											Overall survey -->	Good precision	Good Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

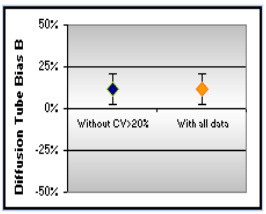
(Check average CV & DC from Accuracy calculations)

Site Name/ ID:	Norwich Lakenfields

Precision	12 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval) without periods with CV larger than 20%	
Bias calculated using 12 periods of data	
Bias factor A	0.9 (0.83 - 0.98)
Bias B	11% (2% - 20%)
Diffusion Tubes Mean:	15 µgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	13 µgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA	
Bias calculated using 12 periods of data	
Bias factor A	0.9 (0.83 - 0.98)
Bias B	11% (2% - 20%)
Diffusion Tubes Mean:	15 µgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	13 µgm^{-3}



Intro / Instructions / Precision & Accuracy / Single Tube Adjustment / Multiple Tubes Adjustment

Discussion of Choice of Factor to Use

With regard to the application of a bias adjustment factor for the diffusion tubes, Technical Guidance LAQM.TG(09) and the LAQM Support website recommend the use of a local bias adjustment factor where available and relevant to diffusion tube sites. The co-location site at Lakenfields was therefore used to derive a local bias correction factor to be considered and applied if appropriate.

However, the technical guidance also states that where the survey consists of tubes exposed over a range of settings, which differ from the co-location site (eg the co-location site is in a very exposed setting and the tubes being assessed are on a building façade in a canyon like street), then this indicates that the national adjustment factor may be more representative. This scenario is more appropriate when comparing the King Street and Zipfel House locations to the Lakenfields AURN site.

There are other arguments for and against using the national bias adjustment factor as opposed to a local figure, and some of these arguments may be applied to the circumstances in Norwich. However, what is clear is that some areas of King Street and Bull Close Road are close to the objective level. Therefore, in order to be conservative, it has been decided to apply the nationally derived bias adjustment factor of 1.03. The Spreadsheet of National Bias Adjustment Factors (v.09/11) is shown below.

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 09/11

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadhseet will be updated every few months; the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated at the end of March 2012

LAQM Helpdesk Website

The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.

Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.

Step 1: Select the Laboratory that Analyses Your Tubes from the Drop-Down List — If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List — If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List — If a year is not shown, we have no data[2]

Step 4: **Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.**

If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@uk.bureauveritas.com or 0800 0327953

Analysed By[1]	Method (To make your selection, choose (All) from the pop-up list)	Year[2] (To make your selection, choose (All))	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Monitor Mean Conc. (Cm) (µg/m³)	Bias (B)	Tube Precision[5]	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	50% TEA in Acetone	2010	R	Reading BC	12	40	46	-13.2%	G	**1.15**
Gradko	50% TEA in Acetone	2010	R	East Hampshire DC	11	27	25	6.5%	G	**0.94**
Gradko	50% TEA in Acetone	2010	R	Wolverhampton CC	12	42	41	4.1%	G	**0.96**
Gradko	50% TEA in Acetone	2010	R	Wolverhampton CC	12	38	38	0.8%	G	**0.99**
Gradko	50% TEA in Acetone	2010	R	Exeter CC	12	42	40	5.6%	G	**0.95**
Gradko	50% TEA in Acetone	2010	R	Lewisham Council	10	74	51	46.0%	G	**0.69**
Gradko	50% TEA in Acetone	2010	B	LB Brent	10	28	28	-1.5%	G	**1.01**
Gradko	50% TEA in Acetone	2010	R	Worthing BC	10	44	42	6.0%	G	**0.94**
Gradko	50% TEA in Acetone	2010	B	LB Brent	10	28	28	-1.5%	G	**1.01**
Gradko	50% TEA in Acetone	2010	R	LB Richmond	12	39	41	-5.7%	G	**1.06**
Gradko	50% TEA in Acetone	2010	B	LB Richmond	12	28	26	4.8%	G	**0.95**
Gradko	50% TEA in Acetone	2010	UB	Reading BC	9	20	26	-20.5%	G	**1.26**
Gradko	50% TEA in Acetone	2010	UB	Sandwell MBC	12	27	30	-10.2%	G	**1.11**
Gradko	50% TEA in Acetone	2010	R	Sandwell MBC	12	43	47	-7.3%	G	**1.08**
Gradko	50% TEA in Acetone	2010	R	Sandwell MBC	12	32	40	-18.6%	na	**1.23**
Gradko	50% TEA in Acetone	2010	UB	Sandwell MBC	11	19	23	-15.3%	na	**1.19**
Gradko	50% TEA in Acetone	2010		**Overall Factor[3] (16 studies)**				Use		**1.03**

PM Monitoring Adjustment

The Volatile Correction Method (VCM) allows corrections to be made to TEOM measurements for the loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by this instrument. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

The VCM works by using the volatile particulate matter measurements provided by nearby FDMS instruments (within 130 km) to assess the loss of PM_{10} from the TEOM; this value is then added back onto the TEOM measurements.

The VCM Model was not applied to results from TEOM measurements recorded at Castle Meadow, as the model indicated low data capture combined with warnings that distant sites were needed to provide the corrections. Therefore, a factor of 1.3 has been applied to give indicative gravimetric equivalent concentrations for the annual mean and 24-hour mean readings.

The Norwich Lakenfields site incorporates an FDMS device on the PM_{10} and $PM_{2.5}$ TEOM's

QA/QC of automatic monitoring

In order to satisfy the requirement outlined in the LAQM TG (09), the following QA/QC procedures were implemented:

- 2-weekly calibrations of the NO_x analyser;
- 6-monthly audits and servicing of the monitoring site; and
- Data ratification.

Calibrations of the NO_x analyser were carried out using certified compressed gas standards (ISO17025). This ensured that the calibration gas was traceable to national and international standards. In addition to the calibration sample filters were changed for both NO_x and TEOM analysers and any faults were identified thus minimising data loss.

Audits of the monitoring site consisted of a number of performance checks to identify any faults with the equipment. The calibration cylinder was also checked against another gas standard in order to confirm the gas concentration. Any identified faults were forwarded on to the service unit for repair.

The final stage of the QA/QC process was to ratify the data. During ratification, all calibration, audit and service data are collated and the data is appropriately scaled. Any suspect data identified are deleted therefore ensuring that the data are of a high quality.

QA/QC of diffusion tube monitoring

The Workplace Analysis Scheme for Proficiency (WASP) is an independent analytical performance-testing scheme, operated by the Health and Safety Laboratory (HSL). WASP formed a key part of the former UK NO2 Network's QA/QC, and remains an important QA/QC exercise for laboratories supplying diffusion tubes to Local Authorities for use in the context of Local Air Quality Management (LAQM). The laboratory participants analyse four spiked tubes, and report the results to HSL. HSL assign a performance score to each laboratory's result, based on their deviation from the known mass of nitrite in the analyte.

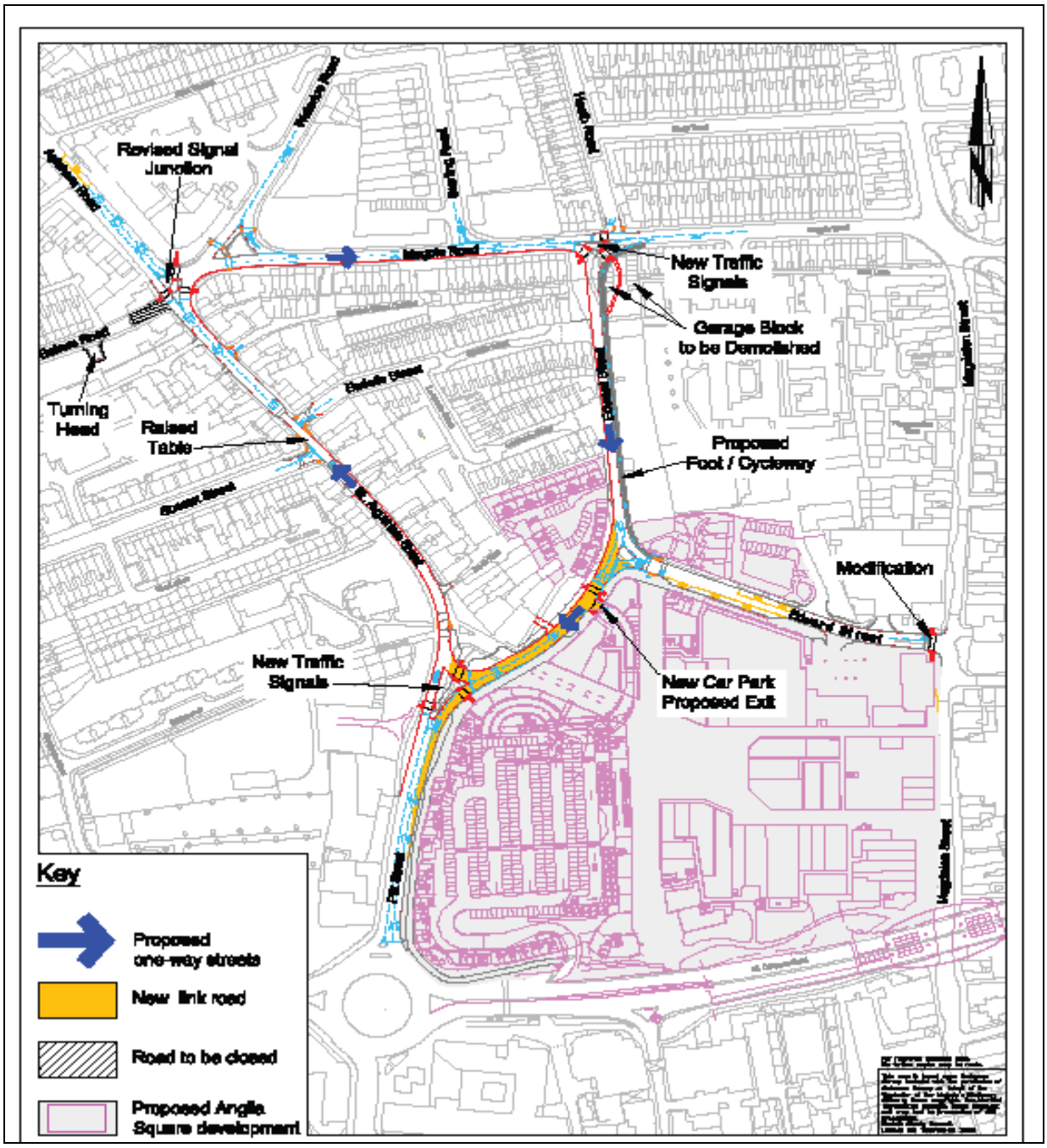
The Performance criteria were changed in April 2009, the criteria are now based upon the Rolling Performance Index (RPI) statistic and have been tightened to the following:

- GOOD: Results obtained by the participating laboratory are on average within 7.5% of the assigned value. This equates to an RPI of 56.25 or less.
- ACCEPTABLE: Results obtained by the participating laboratory are on average within 15% of the assigned value. This equates to an RPI of 225 or less.
- UNACCEPTABLE: Results obtained by the participating laboratory differ by more than 15% of the assigned value. This equates to an RPI of greater than 225.

Appendix B: 2010 Monthly Uncorrected NO2 Concentrations (µg/m3)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	2010 Bias Corrected 1.03
256 King Street	43.6		41.0	37.5	35.0	38.0	43.4	35.7	42.1	42.9	43.0	40.9	40.3	41.5
Queens Rd Travelodge	47.6	43.8	34.5	43.1		37.6	30.1	29.0	36.6	33.6		55.7	39.2	40.3
25 Surrey Street	38.7	35.4	28.5	27.2	21.3								30.2	31.1
St Stephens (mid)	54.2	59.2	54.3	47.8	49.7	51.0	53.3	42.7	55.5	60.6	55.9	51.1	53.0	54.5
130 Magdalen Street	41.3	42.5	38.9	37.8	34.9	29.6	37.3	41.2	41.3	39.5	42.1	35.5	38.5	39.7
Grapes Hill (upper)	34.8	34.4	27.8	21.0	20.7	18.5	18.4	16.4	24.0	29.3	27.4	33.7	25.5	26.3
Exchange St	38.7	43.2	34.6	32.6	34.6	26.0	30.7	28.0	30.4	42.0	62.3	48.0	37.6	38.7
St Augustines	59.4	57.7	52.5	49.1	47.5	57.3						50.3	53.4	55.0
Upper King Street	38.4	37.8	32.1	32.9	31.3	27.4	34.1	32.3	31.4	32.6	47.7	45.2	35.3	36.3
73 Prince of Wales Road	40.8	40.9	36.6	32.8	25.1								35.2	36.3
Cattlemarket Street	47.7	51.9	52.6	46.3	41.8	45.4	45.8	43.9	56.8	44.6	45.7	41.2	47.0	48.4
Castle Meadow		64.9	54.1	60.0	62.9	57.1	54.0	40.4	53.1		63.6		56.7	58.4
Castle Meadow 2	47.7	51.1	45.6		45.9	43.6	50.3		51.2	60.5	43.7	42.2	48.2	49.6
Lakenfields	21.9	20.3	13.7	11.4	10.1	9.7	11.4	9.7	12.9	14.0	17.9	23.5	14.7	15.1
Grapes Hill (lower)	36.8	40.2	28.6	23.0	24.6	25.9	22.0	18.7	27.1	29.7	31.7	35.0	28.6	29.5
Boundary PH 414 Aylsham Rd	31.0	35.2	27.8	27.6	30.8	23.8	22.1	14.4	26.4	32.8	34.6	32.7	28.3	29.1
Kerrisons 353 Aylsham Rd	40.5	40.5	33.2	36.2	34.3	33.5	36.6	33.1		34.6	40.3	34.5	36.1	37.2
221 Mile Cross lane	38.3	36.8	31.6	32.8	28.8	29.3	33.2	43.6	36.5			38.8	35.0	36.0
62 Magpie Road	38.6	38.0	31.5	30.2	21.2	18.1	38.2	15.4	36.3	37.3	35.0	34.5	31.2	32.1
26 Bull Close Road	39.4	38.9	36.4	31.6	27.8	28.5	40.9	38.8	39.7	39.5	41.6	36.5	36.6	37.7
24 Bargate Court	39.9	38.0	31.9	36.4	40.3	32.9	35.7	36.6	36.9	40.5	44.7	44.5	38.2	39.3
5 Riverside Road	51.7	54.6	52.1	55.4	49.0	49.2	51.8	42.8	53.9	53.2	47.9	45.1	50.6	52.1
Wellington Lane (lower)	36.7	40.7	30.3	31.6	27.9	30.4	32.8	26.7	33.4	34.0	33.1	37.5	32.9	33.9
71 Dukes Court	32.5	33.4	27.3	24.5	23.0	21.3	26.0	19.2	29.0	30.1	33.6	36.2	28.0	28.8
Chalk Hill Road	34.5	35.7	30.7	34.8	28.6	28.5	30.1	28.0	34.4	31.8	39.1	41.2	33.1	34.1
Reads Flour Mill	35.0	30.1	23.7	18.8	19.9	18.4	18.9	16.6	22.6	24.0	28.5	33.9	24.2	24.9
Carrow Bridge House							23.4	20.9	26.2	27.4	32.1	37.6	27.9	28.8
288 King Street							26.0	23.8	21.8	29.6	31.6	32.9	27.6	28.4
Zipfel House								37.7	46.5			39.1	41.1	42.3
68 Bull Close Road									33.9	34.2	31.9	34.2	33.5	34.5

Appendix C: Plan of St Augustines Gyratory



M G Stephenson
Public protection manager

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Public protection
City Hall
Norwich
NR2 1NH
t: 0344 980 3333
e: info@norwich.gov.uk

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