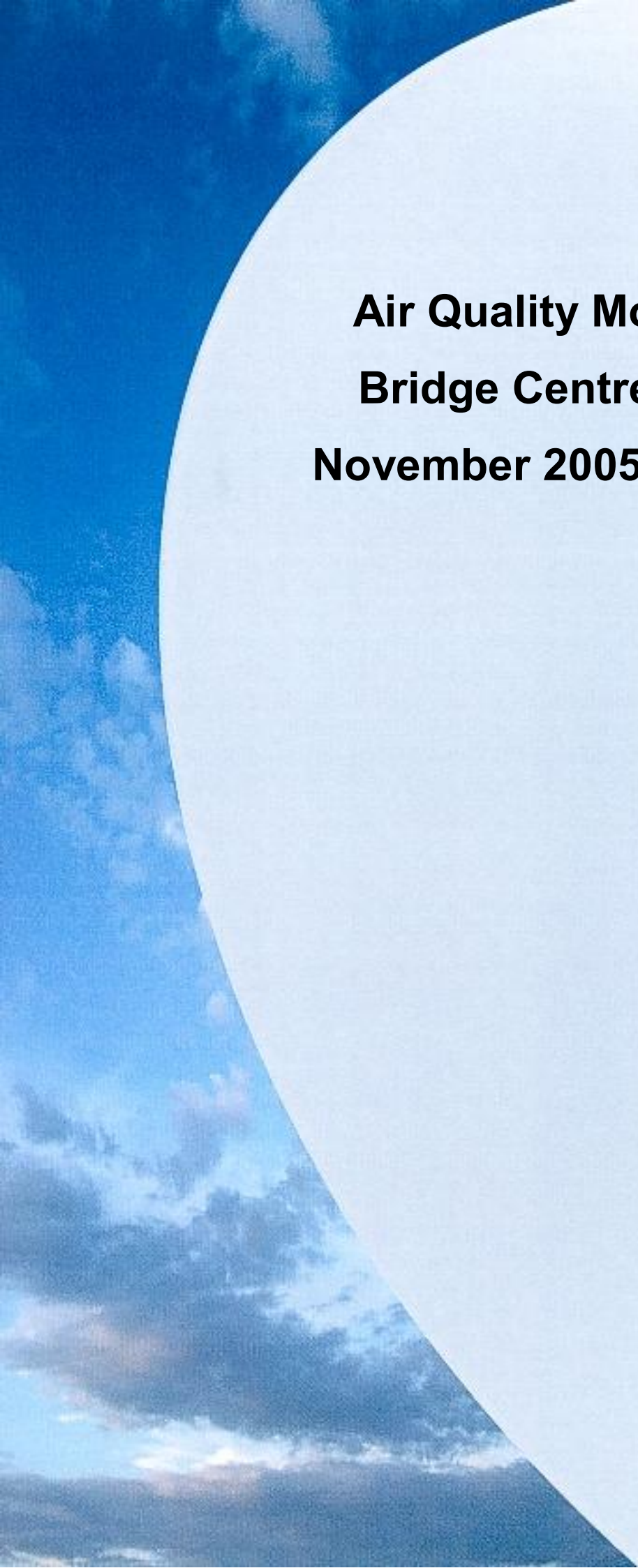
Air Quality Monitoring at the Bridge Centre, Chippenham November 2005 – February 2006



Air Quality Consultants

Air Quality Monitoring at the Bridge Centre, Chippenham

November 2005 – February 2006

Prepared by

Prof. Duncan Laxen, Dr Ben Marner

and Dr Denise Welch

for

North Wiltshire District Council

April 2006

Air Quality Consultants Ltd 23 Coldharbour Road Bristol BS6 7JT
Tel: 0117 974 1086 Fax: 0117 973 9523 E-Mail: AQC@aqconsultants.co.uk

DOCUMENT CONTROL

Client

North Wiltshire District Council	Principal Contact	John Freegard

Job Number	J497

Report Prepared By:	Ben Marner and Denise Welch

Document Status and Review Schedule

Issue No.	Date	Status	Description	Reviewed by:
1	30/3/06	Draft Report	Sent by email to client	NA
2	6/4/06	Final Report	Sent by email and hard copy to client	Duncan Laxen

Contents

1	Introduction	3
2	The Monitoring	3
3	Results for the Monitoring Period	5
4	Comparison with the Air Quality Objectives	13
5	Summary and Conclusions	16
	References	17

1 Introduction

1.1 This report presents measurements of nitrogen dioxide and PM_{10} made in the Centre of Chippenham in the winter of 2005/2006. It is one of a series of reports commissioned by North Wiltshire District Council over a number of years, which have presented and analysed data from monitoring sites across the District (e.g. Laxen *et al.*, 2005). In order to place the measurements in context, they have been compared with data collected at other monitoring sites in the region.

2 The Monitoring

2.1 Air quality monitoring was carried out at a roadside site at the Bridge Centre in Chippenham between the 21st of November 2005 and the 28th of February 2006. The monitor was positioned on the Bridge Centre roundabout, which forms the junction of the A4 and the A420 in the centre of Chippenham. The site is shown in Figure 1. This site was selected by officers of the Environmental Health Services Department. The monitoring station comprised a self-contained air-conditioned unit equipped with a Met One BAM 1020 Dust Monitor without a heated inlet for measuring PM_{10} concentrations and a chemiluminescence monitor (API M200E) for measuring nitrogen dioxide concentrations.

2.2 Previous reports for North Wiltshire District Council have compared measurements with those from the monitoring station at Bristol Centre which was part of the UK Government's Automatic Urban and Rural Network (AURN) of monitoring sites. This site has recently been decommissioned and so the same comparison is not possible. Nitrogen dioxide data have thus been compared with the roadside AURN station at Bristol Old Market. PM_{10} concentrations are not measured at the Bristol site, and so PM_{10} measurements have been compared with those from a rural site at Harwell. Data from both AURN sites have been obtained from Defra (2006a).

2.3 The AURN site at Harwell measures PM_{10} concentrations using a TEOM analyser with a heated inlet that results in loss of the volatile component of the particulate matter. In consequence, the TEOM systematically under-reads in comparison with a gravimetric sampler. Current advice from the Government is to multiply TEOM results by a default adjustment factor of 1.3 to approximate gravimetric results. This has been done in the present study. It should be recognised, however, that this 1.3 factor will vary from site to site and from one period to another. It is nevertheless considered to be near worst-case.

North Wiltshire District Council

Figure 1 Position of the Automatic Monitor

2.4 Conversely, BAM analysers with unheated inlets are thought to systematically over-predict gravimetric PM_{10} concentrations. Current advice from Defra (2006b) is to divide the annual mean from un-heated BAMs by 1.2 to estimate gravimetric concentrations. This has been done in the present study. As with TEOM data, this factor will vary from site to site and from one period to another but is considered the most appropriate method.

2.5 To validate the data, calibration factors were applied to the raw data. Nitrogen dioxide and nitrogen oxide concentrations were then converted from ppb to µg/m^3 (assuming standard temperature and pressure, i.e. 1 ppb = 1.913 µg/m^3). The concentration data were plotted as a time series and a visual examination was carried out. A comparison with monitoring data from the closest national automatic network monitoring sites (Bristol Old Market, Bath Roadside, Oxford Centre Roadside and Harwell) was made to determine any erroneous data, which were removed.

3 Results for the Monitoring Period

3.1 The results of the monitoring over concurrent periods at Chippenham Bridge Centre, Bristol Old Market, and Harwell are summarised in Table 1 and shown as plots in Figures 3 to 9. The Bristol and Harwell data have been verified by the Network managers, but not ratified by the QA/QC unit. There may therefore be small changes once ratification has taken place.

Table 1: November 2005 – February 2006 Data Summary

Pollutant	NOx		NO_2		PM_{10}[a]	
	Chipp	Bris	Chipp	Bris	Chip	Harwell
Period mean (µg/m^3)	196	252	56	60	24	20
Maximum hourly mean (µg/m^3)	1524	1377	209	243	na	na
No 1-h >200 µg/m^3	na	na	1	1	na	na
24-h Max (µg/m^3)	na	na	na	na	62	53
No 24-hour >50 µg/m^3	na	na	na	na	2	1
Data capture	84%	99%	84%	99%	100%	98%

[a] Values expressed as gravimetric equivalent

Nitrogen Dioxide and Nitrogen Oxides

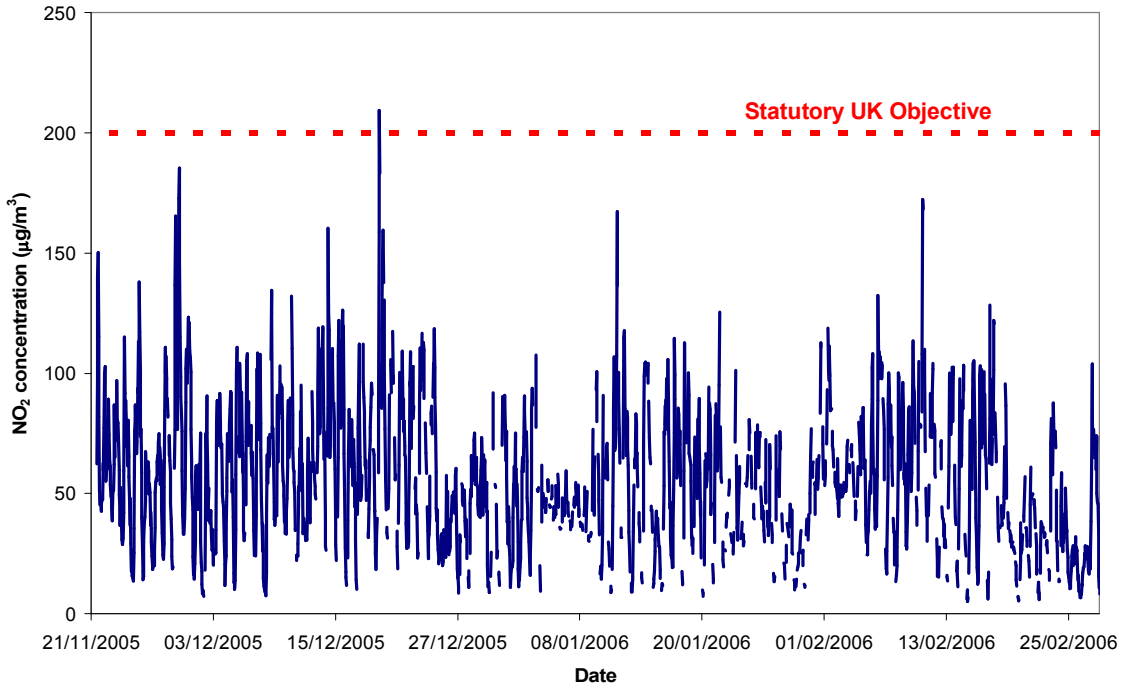


Figure 2: 1-Hour Mean Nitrogen Dioxide Concentrations at Chippenham Bridge Centre

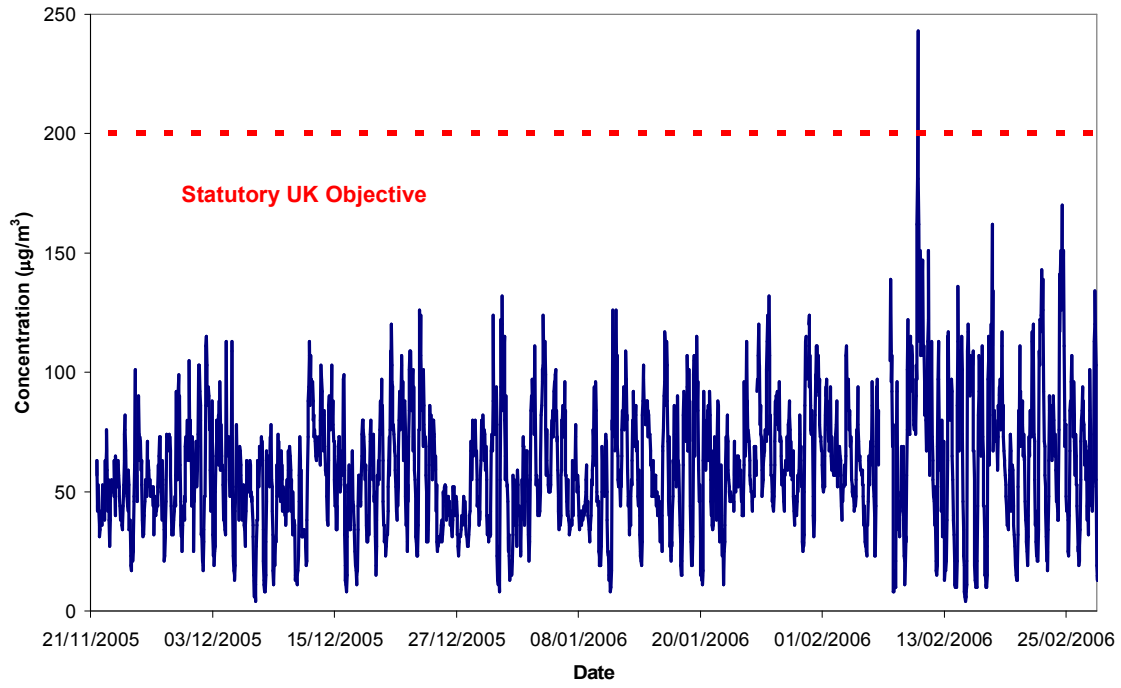


Figure 3: 1-Hour Mean Nitrogen Dioxide Concentrations in Bristol Old Market

3.2 On average, nitrogen dioxide levels at Chippenham Bridge Centre were slightly lower than those at Bristol Old Market. Figures 2 and 3 show that concentrations in Bristol were characterised by lower concentrations at the start of the monitoring period, followed by somewhat higher concentrations toward the end of the period. If anything, those at the Chippenham site displayed the opposite trend. Even though both datasets contain a single exceedence of 200 μg/m^3 as a 1-hour mean, the Chippenham data are characterised by frequently elevated concentrations, with 150 μg/m^3 as a 1-hour mean exceeded at least once during each month. There were no exceeedences of this level at the Bristol site prior to February, reflecting the relative uniformity of the Bristol data during the November to January period.

3.3 In order to examine the factors driving these differences, the two time series have been plotted against each other in Figure 4. If the concentrations measured at the two sites were the same, then the data would lie on the 1:1 line. For those hours when the concentration measured in Chippenham was greater than the concentration measured in Bristol, the data lie above the 1:1 line. The hours when Bristol measured the higher concentrations are shown below the 1:1 line. There is clearly a very wide spread to the data. The periods of peak concentration at each site were not replicated at the other site. This indicates that local factors, such as emissions from the nearby roads, drove the trends that were measured at each site.

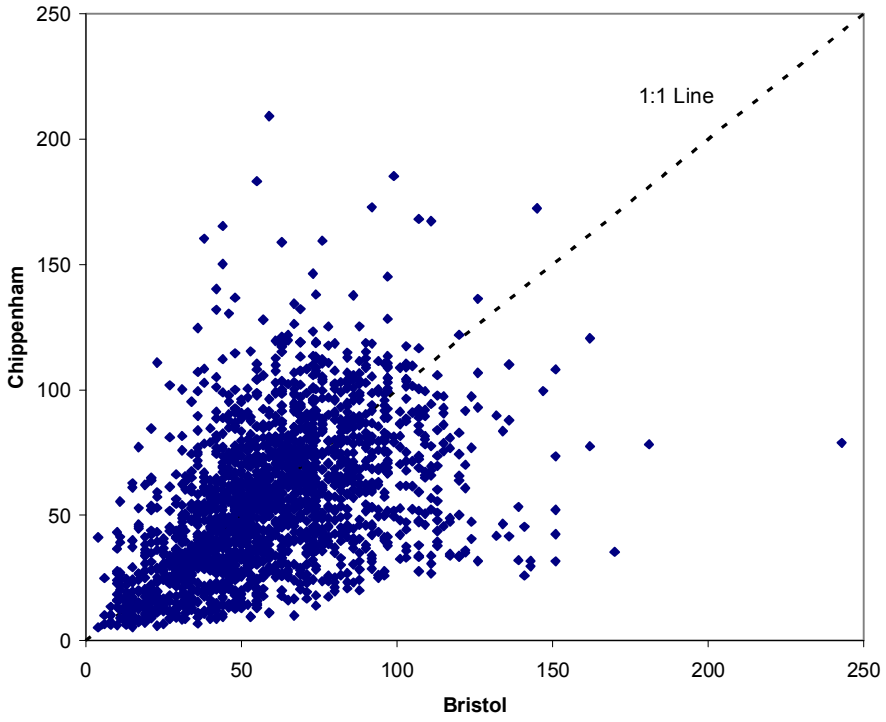


Figure 4: 1-hour Mean Nitrogen Dioxide at Chippenham Bridge Centre vs Bristol Old Market (μg/m^3)

3.4 The relative importance of local emissions can be inferred from the ratio of the nitrogen dioxide concentration to the total nitrogen oxides (NOx) concentration. This is because while some nitrogen dioxide is emitted directly, most is emitted as nitric oxide and subsequently converted to nitrogen dioxide in the atmosphere. Although the speed of this conversion depends on very many factors and is difficult to judge, the difference between nitrogen dioxide and NOx gives an indication of the relative "age" of the air pollution. The nitrogen dioxide to NOx ratio for each hour of measurements from the Chippenham site is shown in Figure 5. Figure 6 shows these data for the Bristol site. As noted in Table 1, the maximum NOx concentration measured at each site was greater than 1000 $\mu g/m^3$, but the horizontal scales have been truncated for the sake of clarity.

3.5 Both sites exhibit NOx concentrations way in excess of the concurrent nitrogen dioxide concentrations, which is only to be expected and shows that local emissions are frequently important at each site. The vertical scatter in the Chippenham data is much less than the vertical scatter in the Bristol data. This indicates that all of the periods of high nitrogen dioxide concentration in Chippenham were driven by large NOx concentrations and thus very local emissions. The picture for Bristol is more varied; exhibiting periods with relatively high NOx concentrations but relatively low nitrogen dioxide concentrations, and also periods when the nitrogen dioxide concentration was elevated without peak NOx concentrations. The most likely explanation is that the Bristol monitor is surrounded by numerous other significant emission sources and thus the relative "age" of the pollution measured is much more variable than it is in Chippenham.

3.6 In summary, periods of peak concentration at the Bristol site tend to be driven by emissions from many different sources, which might be some distance from the monitor. Periods of peak concentration at the Chippenham site tend to be driven by emissions from the local roads.

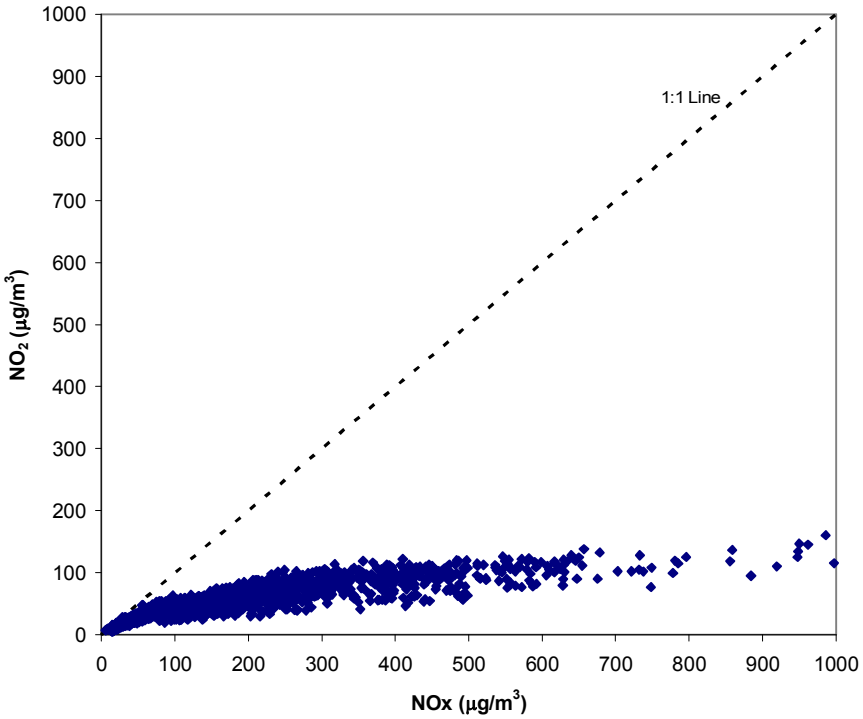


Figure 5: 1-hour Mean Nitrogen Oxides vs Nitrogen dioxide at Chippenham Bridge Centre

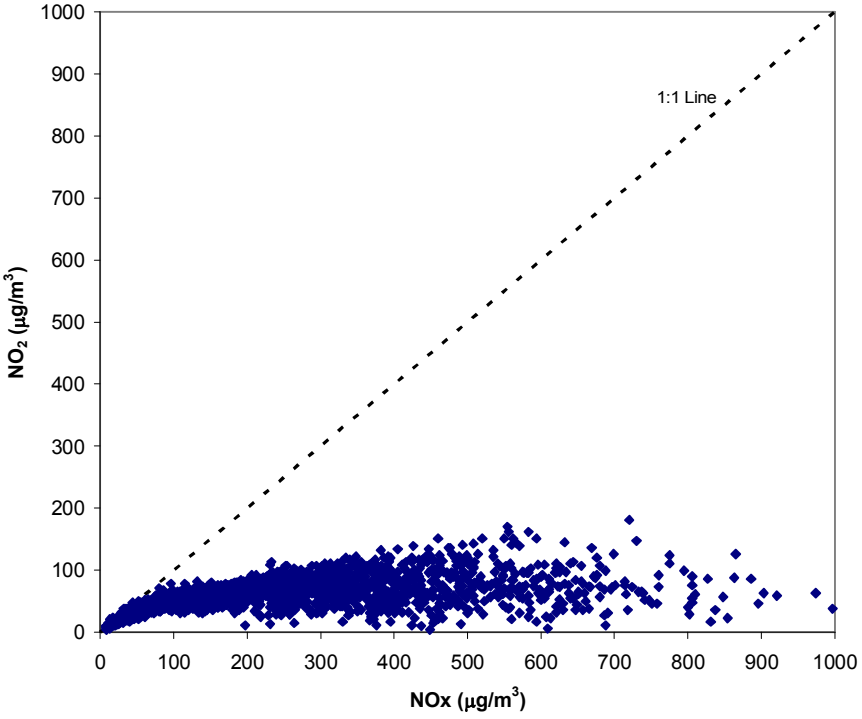


Figure 6: 1-hour Mean Nitrogen Oxides vs Nitrogen dioxide at Bristol Old Market

The horizontal scales on Figures 5 and 6 have been truncated at 1000 for the sake of clarity

PM_{10}

3.7 On average, concentrations at the Chippenham site were slightly higher than those measured at Harwell. This is not surprising as the Harwell monitor is at a rural site, well away from busy roads. Figure 7 shows the 24-hour mean PM_{10} concentrations measured at the Chippenham site throughout the monitoring period. Figure 8 shows the same data from the Harwell site. Both sites tended to experience peak 24-hour mean concentrations during late January to early February. These peaks are likely to have been primarily driven by regional trends, which affected both sites. This is highlighted in Figure 9, which plots the Chippenham data against those from Harwell. As would be expected, concentrations at the rural Harwell site never exceeded the concurrent concentrations at Chippenham by any great amount. Concentrations at Chippenham, however, did show isolated peaks, which are likely to reflect the influence of local emissions. Despite these events, overall, the data follow the 1:1 line reasonably closely, showing that regional patterns were just as important as local emissions in driving the Chippenham PM_{10} concentrations.

3.8 There was a fire at the Bunsfield Oil Depot near Hemel Hempstead (which is approximately 125km east-north-east of Chippenham) which began on the 11th December 2005. As can be seen from Figure 7, the Chippenham PM_{10} data do not show any clear response to this event.

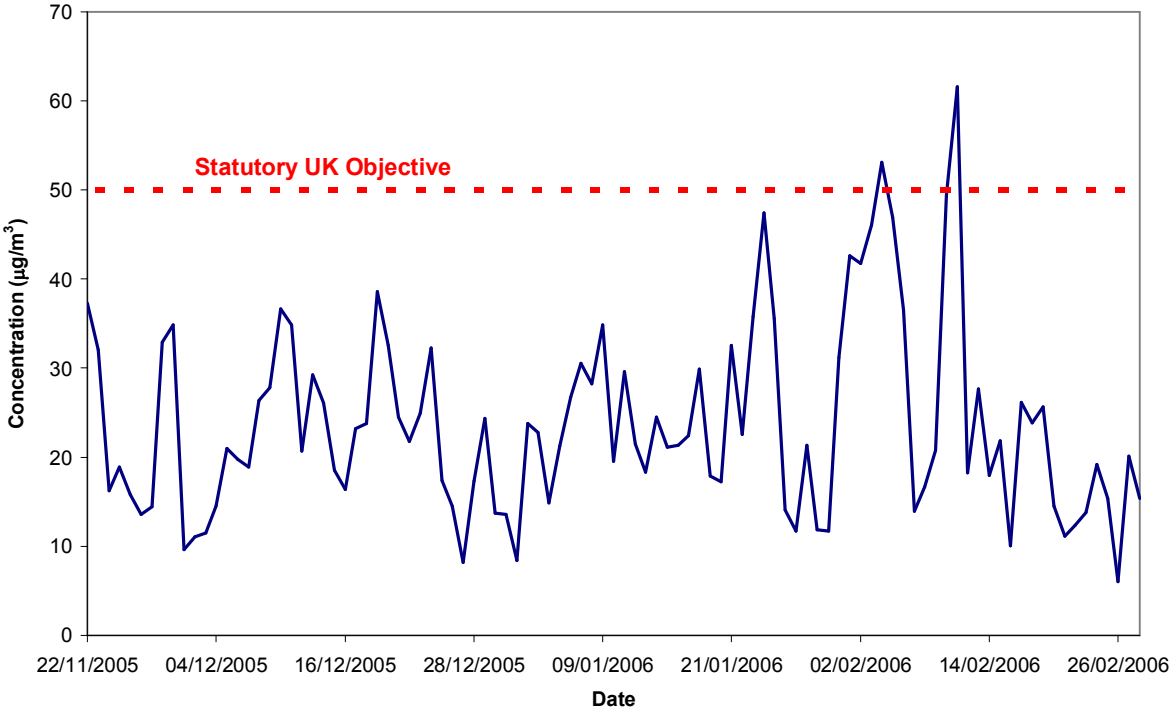


Figure 7: 24-hour Mean PM_{10} Concentrations at Chippenham Bridge Centre

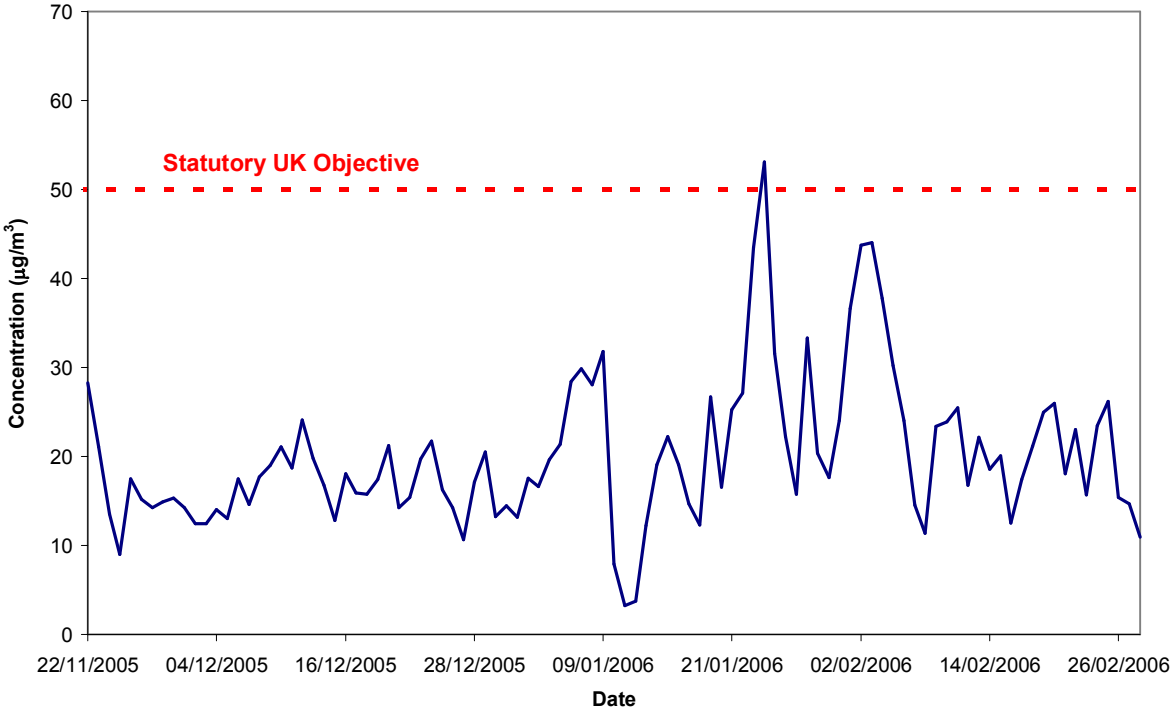


Figure 8: 24-hour Mean PM_{10} concentrations at Harwell

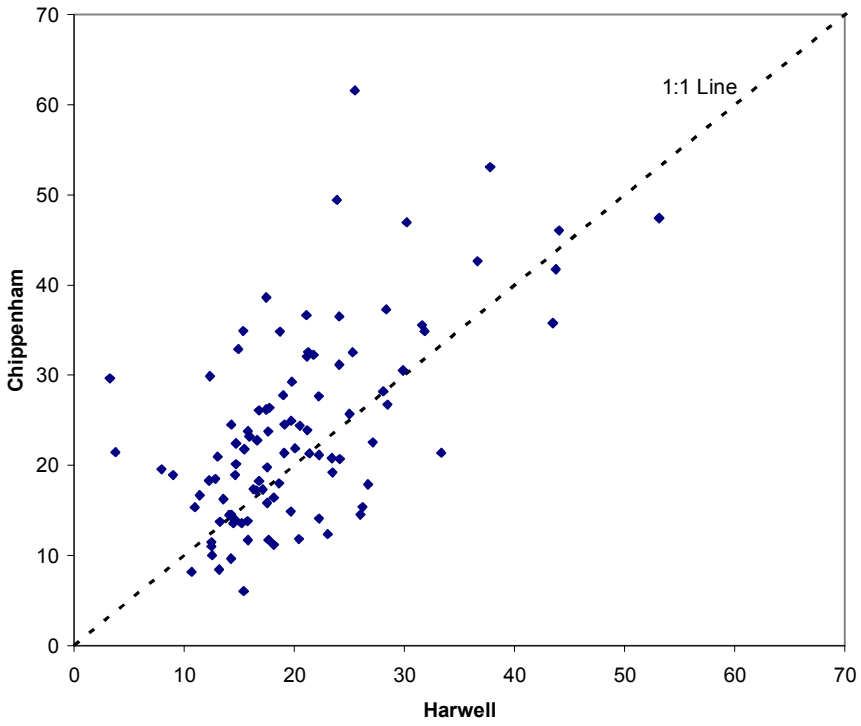


Figure 9: 24-hour mean PM_{10} Concentrations at Chippenham Bridge Centre vs Harwell ($\mu g/m^3$; gravimetric equivalent)

4 Comparison with the Air Quality Objectives

The Air Quality Objectives

4.1 Pollutant concentrations are best assessed by reference to the national air quality standards and objectives, established by the Government to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of the costs, benefits, feasibility and practicality of achieving the standards. The objectives are prescribed within the *Air Quality (England) Regulations, 2000* (Stationery Office, 2000) and the *Air Quality (England) (Amendment) Regulations 2002,* (Stationery Office, 2002). The objectives for nitrogen dioxide were to be achieved in 2005, and will continue to apply in each subsequent year. The objectives for PM_{10} were to be achieved by 2004 and continue to apply. These statutory PM_{10} objectives are supplemented with provisional objectives to be achieved by 2010. A summary of these objectives is provided in Table 1.

4.2 The European Union has also set limit values for nitrogen dioxide and PM_{10}. Achievement of these values is a national obligation rather than a local one. The limit value for nitrogen dioxide is the same level as the UK objective, and is to be achieved by 2010. The limit value for PM_{10} is also the same level as the UK statutory objectives, and was to be achieved by 2005.

Table 2: Relevant Air Quality Objectives

Pollutant	Status	Time Period	Objective / Value	To be Achieved by[a]
Nitrogen Dioxide	Statutory UK Objective	1-hour mean	200 μg/m^3 not to be exceeded more than 18 times a year	2005
		Annual mean	40 μg/m^3	2005
	EU Limit Value	1-hour mean	200 μg/m^3 not to be exceeded more than 18 times a year	2010
		Annual mean	40 μg/m^3	2010
Fine Particles (PM_{10})[b]	Statutory UK Objective	24-hour mean	50 μg/m^3 not to be exceeded more than 35 times a year	2004
		Annual mean	40 μg/m^3	2004
	EU Limit Value	24-hour mean	50 μg/m^3 not to be exceeded more than 35 times a year	2005
		Annual mean	40 μg/m^3	2005
	Provisional UK Objective[c]	24-hour mean	50 μg/m^3 not to be exceeded more than 7 times a year	2010
		Annual mean	20 μg/m^3	2010

[a] The achievement dates for the UK objectives are the end of the specified year; achievement dates for the EU limit values are the start of the specified year.
[b] Measured by the gravimetric method.
[c] Not included in the Regulations.

Calculation of Annual Mean Equivalent Data

4.3 In order to compare the monitoring data with the air quality objectives, a factor has been calculated and applied to the period mean data to give a 2005 annual mean equivalent value. This factor was calculated as the ratio of concentrations over the full 2005 calendar year at three sites where long-term continuous monitoring data are available (from Defra, 2006a), to those during the monitoring period of interest (Nov 2005-Feb 2006). The Harwell, Reading New Town and Portsmouth sites have been used for this purpose because they have reliable long term datasets (data capture >90%) and are Background sites, however only the Harwell site is within 50 miles of the Chippenham monitoring station (LAQM.TG(03) Box 6.5 (Defra, 2003)). Tables 3 and 4 summarise these calculations.

Table 3: Calculation of a Factor to Adjust Short-Term Period Nitrogen Dioxide Mean to 2005 Annual Mean Equivalent.

Site	Site Type	Period Mean (μg/m^3)	Annual Mean (μg/m^3)	Ratio
Harwell	Rural	18.0	11.8	0.656
Reading New Town	UB	33.3	23.0	0.691
Portsmouth	UB	31.4	24.0	0.764
Average				**0.704**

Table 4: Calculation of a Factor to Adjust Short-Term Period PM_{10} Mean to 2005 Annual Mean Equivalent.

Site	Site Type	Period Mean ($\mu g/m^3$)	Annual Mean ($\mu g/m^3$)	Ratio
Harwell	Rural	20.2	19.0	0.940
Reading New Town	UB	23.4	22.0	0.940
Portsmouth	UB	24.0	21.0	0.876
Average				**0.919**

5.1 Table 5 sets out the annual mean-equivalent data from the Chippenham Bridge Centre site. The number of exceedences of the 24-hour PM_{10} objective has been estimated according to the relationship with the annual mean concentration set out in Defra (2003). Measurements from across the country have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded unless the annual mean nitrogen dioxide concentration is greater than 60 $\mu g/m^3$ (Laxen and Marner, 2003).

5.2 None of the statutory objectives for nitrogen dioxide or PM_{10} are expected to be exceeded at this site. The statutory PM_{10} objectives are likely to be achieved by a very substantial margin. The provisional PM_{10} objectives do not relate to existing conditions and concentrations are expected to fall in the future as a result of measures introduced by the UK and the EU Governments to reduce emissions from vehicles and other sources. Although the annual mean nitrogen dioxide objective is unlikely to be exceeded, it is important to note that it is only likely to have been achieved by a relatively small margin.

Table 5: 2005 Annual Mean-Equivalent Nitrogen Dioxide and PM_{10} Concentrations at the Chippenham Monitoring Site

	NO_2	PM_{10}[a]	
	Annual Mean ($\mu g/m^3$)	**Annual Mean ($\mu g/m^3$)**	**No 24-hour >50 $\mu g/m^3$**
Calculated from the Measurements	39	22	6[b]
Statutory Objective	**40**	**40**	**35**
Provisional (2010) Objective		**20**	**7**

[a] Values expressed as gravimetric equivalent
[b] Estimated from the relationship between the annual mean concentration and the number of exceedences of the objective as described in LAQM.TG(03) (Defra, 2003)

5 Summary and Conclusions

6.1 Monitoring for nitrogen dioxide and PM_{10} has been carried out at a roadside site at Chippenham Bridge Centre between November 2005 and February 2006. To assist data interpretation, comparisons have been made with monitoring carried out at a roadside site in Bristol and with a rural site at Harwell. The Chippenham data have been scaled to allow comparison with the relevant air quality objectives.

6.2 Nitrogen dioxide concentrations at the Chippenham site were generally lower that those at the Bristol site over the same period. Trends in the Chippenham nitrogen dioxide data were driven mainly by local emissions, probably from the adjacent roads. PM_{10} concentrations at the Chippenham site were generally higher that those at the Harwell rural site over the same period. Trends in the Chippenham PM_{10} data were driven both by local and by regional factors.

6.3 None of the statutory air quality objectives for nitrogen dioxide or PM_{10} are likely to be exceeded at the Chippenham Bridge Centre, although the annual mean nitrogen dioxide objective is only achieved by a relatively small margin.

References

Defra, 2003. Review & Assessment: Technical Guidance LAQM.TG(03).

Defra, 2006a. Air Quality Archive via the internet www.airquality.co.uk.

Defra, 2006b. Air Quality Review and Assessment Helpdesk Website http://www.uwe.ac.uk/aqm/review/

Laxen, Marner and Short, 2005. Nitrogen Dioxide and PM_{10} Monitoring in Calne Town Centre, November – December 2004.

Laxen and Marner, 2003. Analysis of the Relationship Between 1-Hour and Annual Mean Nitrogen Dioxide at UK Roadside and Kerbside Monitoring Sites. Available from Defra, 2006a and b.

Stationery Office, 2000. Air Quality (England) Regulations, 2000, Statutory Instrument 928.

Stationery Office, 2002. The Air Quality (England) (Amendment) Regulations 2002. Statutory Instrument 3043.