

Diffusion Tube and Continuous Monitoring Summary

Bodmin

January 1st – December 30th 2009

Prepared for Cornwall Council by;

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Report on the nitrogen dioxide diffusion tube and continuous monitoring in Bodmin**January 1st – December 30th 2009**

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Commissioned by: Karen German, Senior Environmental Protection Officer. Cornwall Council.

1.0 Introduction

This nitrogen dioxide (NO₂) monitoring programme is a continuation of previous monitoring programmes in Bodmin, which were commissioned by the former North Cornwall District Council. –As the result of high concentrations of traffic-related pollution monitored in areas around Dennison Road and Higher Bore Street a continuous monitor was installed at the corner of Dennison Road and Turf Street in 2006 as this was highlighted as an area of particular concern.

1.1 Nitrogen dioxide

NO₂ is not only a health damaging pollutant but also a proxy measure for other traffic-related pollutants. The UK Government's National Air Quality Strategy (NAQS) objectives for NO₂ (DEFRA, 2000) are given in Table 1 below. As stated in the LAQM.TG (09) the NAQS annual mean objective applies to *'the quality of the air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present'*. The NAQS 1-hour mean objective is more specific and only applies to those locations where members of the public are regularly present for an hour or more. Air Quality Consultants state that if an annual mean concentration exceeds 60 µg m⁻³ then it is likely that the NAQS 1-hour mean objective would have been exceeded.

Table 1. NAQS objectives for NO₂.

Nitrogen dioxide (NO₂)	Measured as	Concentration	Objective deadlines
	Annual mean	40 µg m ⁻³	31st Dec 2005
	1 hour mean	200 µg m ⁻³ (not to be exceeded more than 18 times per year)	

1.2 NO₂ background concentrations

The background NO₂ concentration for the surveyed area in Bodmin for 2008, as estimated by the National Environment Technology Centre (NETCEN), is ~8.2 µg m⁻³. This figure is recommended for use by Local Authorities in LAQM.TG (09).

1.3 Bodmin and Dennison Road

The town of Bodmin (SX074667) is located in North Cornwall. The A30, Cornwall's primary trunk road, bypasses Bodmin to the south; however the A389, including Dennison Road, Higher Bore Street and St Leonards, is a major route for traffic accessing North Cornwall and runs east-to-west through Bodmin. The A389 carried an annual average daily traffic (AADT) volume of 13,114 vehicles in 2008, including medium and heavy goods vehicles.

An airpointer[®] automatic monitor is mounted on a lamp-post against the façade of residential houses at the eastern end of Dennison Road. The eastern end of Dennison Road is lined on one side by tall residential properties and, on the other, a tall hedge creating a 'canyon street' effect that compounds poor air quality. Higher Bore Street is characterised by its proximity to the Five Ways roundabout, a pedestrian crossing and houses situated close to the road.

2.0 Equipment

2.1 Continuous monitor

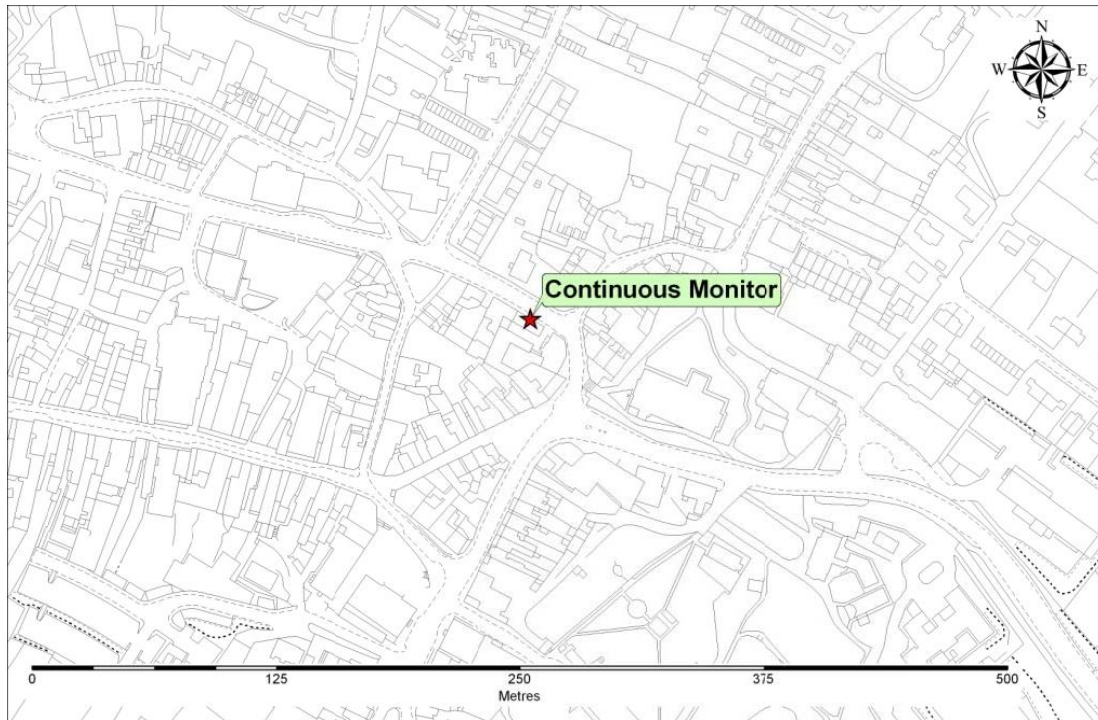
The Air Monitors' airpointer[®] (Plate 1 and Figure 1) monitors oxides of nitrogen and is a DEFRA accepted method of NO₂ data collection. The airpointer[®] is a chemiluminescent monitor which, due to its relatively small size, can be mounted on street furniture (lamppost etc) at the epicentre of the pollution hotspot. The monitor records NO and NO_x concentrations every minute which enables detailed analysis of NO₂.

2.2 Mova

A MOVA (Microprocessor Optimised Vehicle Actuation) system was installed at the pedestrian crossing in Dennison Rd. Via loop detectors the MOVA is able to detect gaps in the traffic at distance, thereby identifying approaching vehicles sooner and reducing vehicle waiting times. It is anticipated that this will provide better optimisation of vehicle stops and delays and therefore have a positive impact on emissions. The scheme started in the summer of 2009 and the effect of this installation on traffic flow will be evaluated.



Plate 1. The airpointer[®] in Dennison Road (with MOVA antennae installed above).



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Figure 1. The location of the airpointer® in Dennison Road, Bodmin.

2.3 Diffusion tubes

Diffusion tubes are a relatively cheap and accepted method of monitoring NO₂ concentrations in specific locations. Diffusion tubes are exposed for monthly periods and have been used extensively in Bodmin at a total of 111 separate sites, of these 111 surveyed sites, 45 are currently monitored. This has provided useful data regarding the extent of air pollution problems in the area as well as highlighting areas where air quality is of concern.

A single diffusion tube has been collocated with the continuous monitor since March 2006, this has been triplicated since August 2008. This is for comparative purposes in order to provide a local bias adjustment factor using AEA's Diffusion Tube Precision, Accuracy and Bias spreadsheet (available to download from www.airquality.co.uk/laqm/tools/AEA_DifTPAB_v03.xls) to apply to individual tubes in the surrounding area. Due to the triplication not starting until August 2008, cessation of the diffusion tube monitoring in April and May 2009 and severe monitor malfunctions in late 2009 a local bias adjustment factor cannot be calculated for 2008 or 2009 but highlights the "good precision" of the diffusion tubes (see Figure 2). The national bias adjustment factor of 0.86 (available from www.uwe.ac.uk/aqm/review/) has been used for 2009 and will be used for 2010 diffusion tube results until a local bias adjustment factor can be calculated. This national bias adjustment factor will be updated regularly in 2010 as new and additional collocated diffusion tube data are collected by AEA. The next scheduled update to the bias adjustment spreadsheet is late March 2010.

Tubes are supplied by Gradko International with a preparation method of 20% TEA (triethanolamine) in water. Tubes are exposed for monthly periods and are deployed at the beginning of each month.

QA/QC testing undertaken by the Workplace Analysis Scheme for Proficiency (WASP) programme for NO₂ diffusion tube analysis (operated by the Health and Safety Laboratory), tubes supplied by Gradko International displayed "Good" performance.

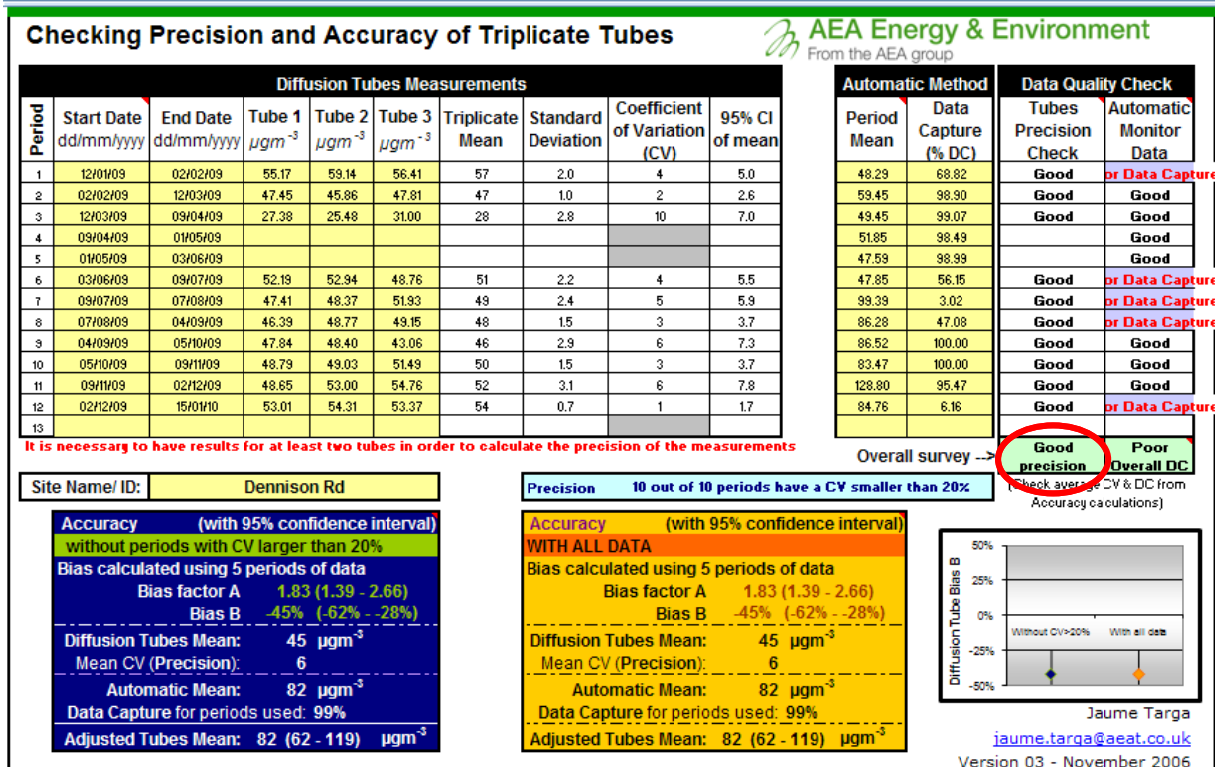


Figure 2. Collocation data applied to the Diffusion Tube Precision, Accuracy and Bias spreadsheet (diffusion tube performance circled in red).

3.0 Results

3.1 Continuous monitoring

3.1.1 Dennison Road Air Pointer Summary (01/01/2009 – 31/12/2009)

Table 2 provides a summary of the continuous monitoring data for the period 1st January 2009 to 31st December 2009. The mean NO₂ concentration recorded in Dennison Road for the 361 valid days monitoring was 55.0 µg m⁻³ with a maximum 1 hour mean concentration of 227.31 µg m⁻³. The monitoring period mean recorded concentration would potentially exceed the NAQS annual mean objective. 17 exceedences of the 200 µg m⁻³ hourly objective were recorded in this period all of which occurred between 22nd and 29th August 2008. Hourly means exceeded the objective level of 40 µg m⁻³ for a total of 59% of the monitoring period.

Table 2. A summary of the continuous monitoring data in Dennison Road for the reporting period 01/06/2008 – 31/05/2009.

Start date	No. of days	Mean	200µg 1hr	
01/06/08	365	55.0	Exceedences	17
End date	Data Capture		Max	227.31
31/05/09	98.8%		Percentile	148.04

3.1.2 Dennison Road Air Pointer Summary (2008)

Table 3 provides a summary of continuous monitoring data for 2008. The annual mean NO₂ concentration recorded on Dennison Road was 52.5 µg m⁻³, exceeding the NAQS annual objective for NO₂, there were also 18 exceedences of the NAQS 1-hour mean objective of a permitted 18 which occurred on 9th January and between 22nd and 29th August 2008. Hourly means exceeded the objective level of 40 µg m⁻³ for a total of 59% of the monitoring period.

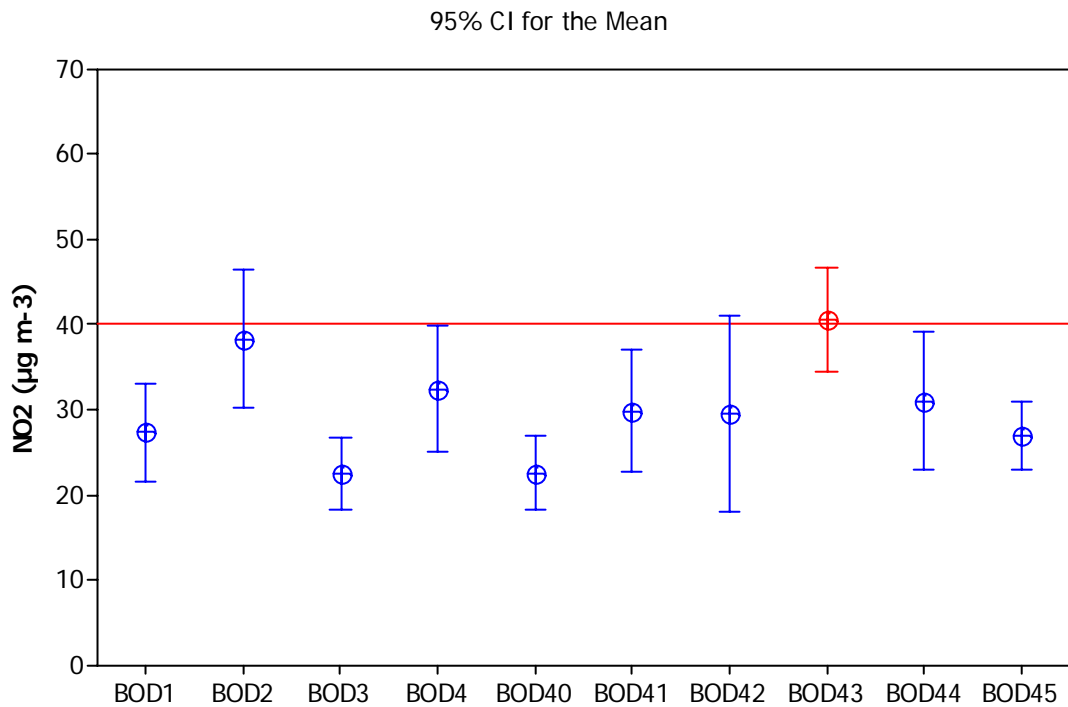
Table 3. A summary of the continuous monitoring data in Dennison Road for 2008.

Start date	No. of days	Annual Mean	200µg 1hr	
01/01/08	366	52.5	Exceedences	18
End date	Data Capture		Max	227.31
31/12/08	99.4%		Percentile	163.88

3.2 Diffusion tubes

When analysing diffusion tube data it is preferable to use a large dataset as opposed to individual monthly values as a more reliable conclusion can be drawn. There were 7 sites (highlighted in red, in Figure 3a and 3b) that exceeded the NAQS annual mean objective for NO₂ concentrations. Exceeding tubes are located in both Higher Bore Street (Figure 4a) and along Dennison Road (Figure 4b). Tubes were removed from the collocated site (BOD8) during December 2008 and no tubes were deployed during April and May 2009 due to a delay in renewing of contracts caused by the implementation of the unitary process in Cornwall. A further 76 tubes were removed during the reporting period (June 2008 – May 2009) with one site, BOD42, having tubes stolen from November 2008 to March 2009. As this site does not show an exceedence of NAQS objective levels, and is situated between two further sites showing no exceedences, it is suggested that the site be resituated on the opposite side of the road to further investigate the exceedence at BOD43.

(a)



(b)

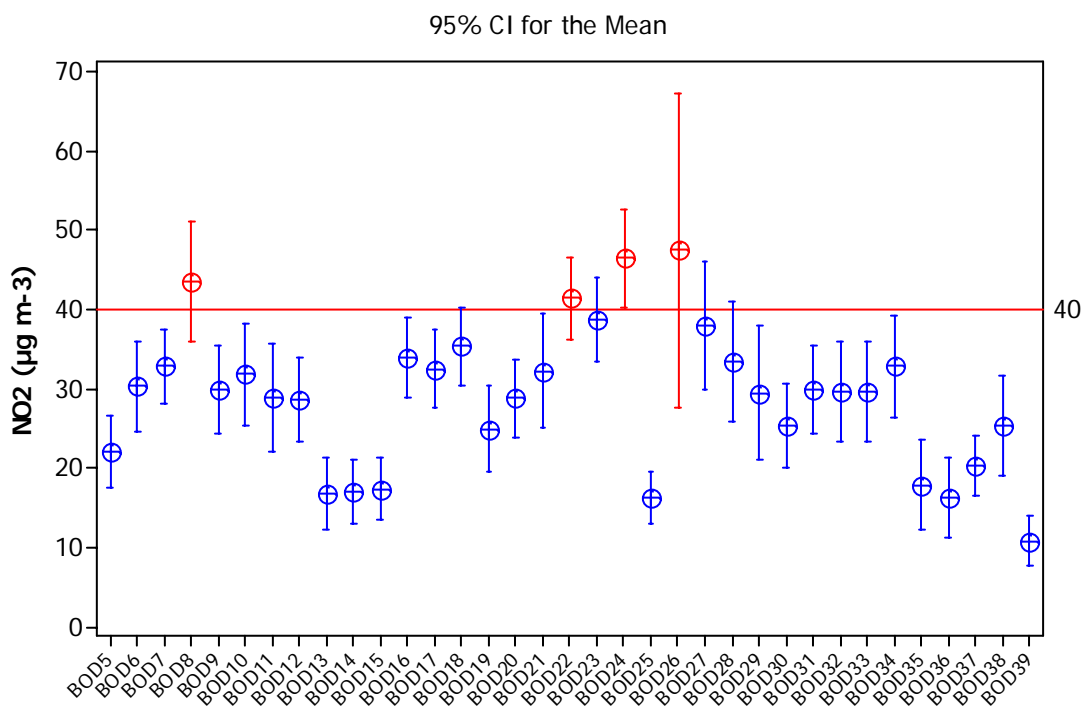
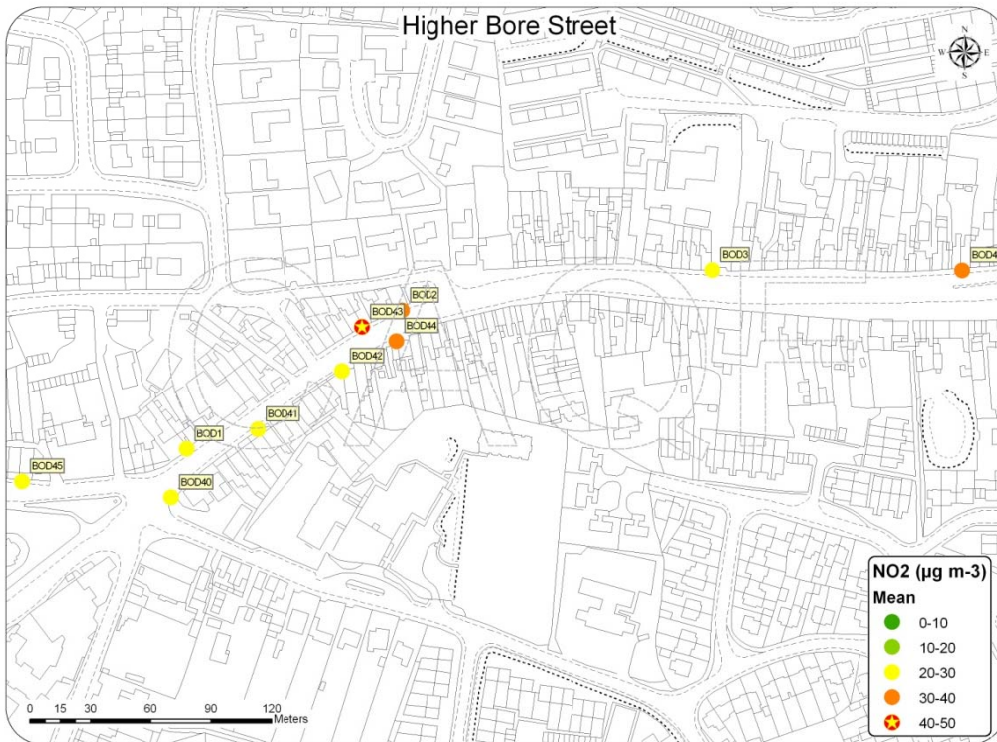


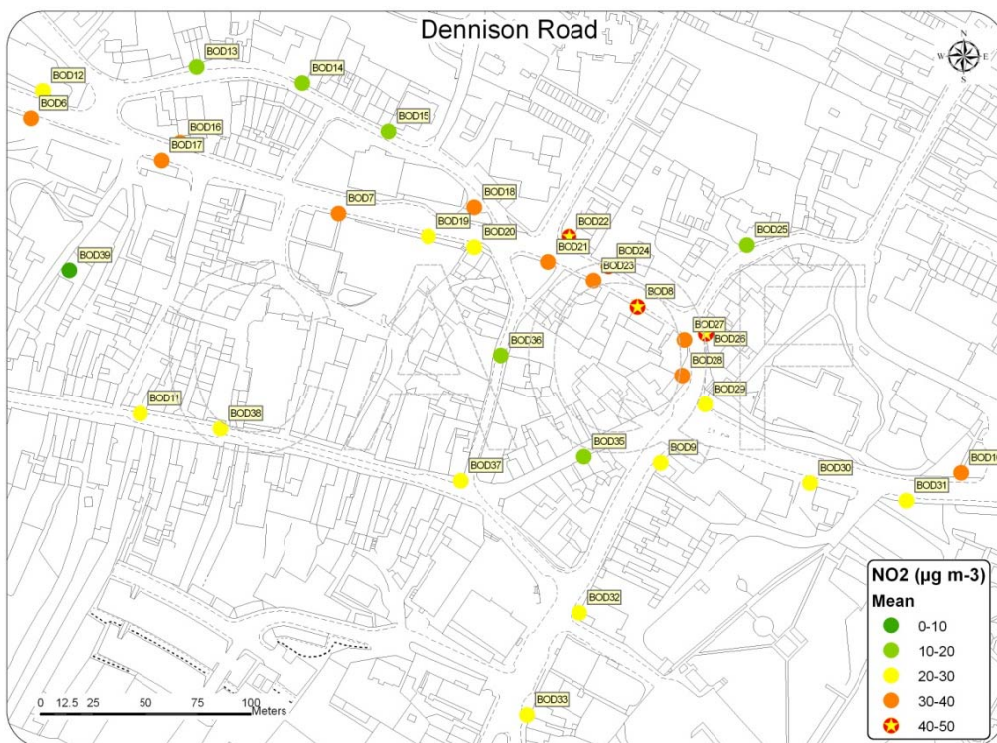
Figure 3. 12-month mean NO₂ concentrations for the period June 2008 – May 2009 recorded by diffusion tubes in Bodmin (a) west and (b) east; the red line indicates the NAQS annual mean objective concentration (for exact site locations refer to Figure 4).

(a)



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(b)



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Figure 4.(a) Higher Bore Street and (b) Dennison Road and Bodmin town centre displaying the location and mean NO₂ concentrations for the period June 2008 – May 2009.

4 Discussion

4.1 Exceedences

A mean concentration of $55.0 \mu\text{g m}^{-3}$ was recorded by the continuous monitor in Dennison Road over the 12-month monitoring period ending 31/05/2009. The mean NO_2 concentration for 2008 was $52.5 \mu\text{g m}^{-3}$. Both these annual means exceed the NAQS annual mean objective. In the 12-months ending 31/05/2009 there were 17 exceedences of the NAQS 1-hour objective with 18 exceedences being recorded in total for 2008. These 18 exceedences equal the allowance for the hourly mean but do not breach it.

Five of the 45 diffusion tube sites recorded an exceedence of the NAQS annual mean objective during the period June 2008 to May 2009. Exceeding sites are located along the Dennison Road/Higher Bore Street corridor, particularly at the eastern end of Dennison Road around the sharp corner (Figure 5) and approaching the junction of Higher Bore Street and Midway Road from the west (Figure 4a).

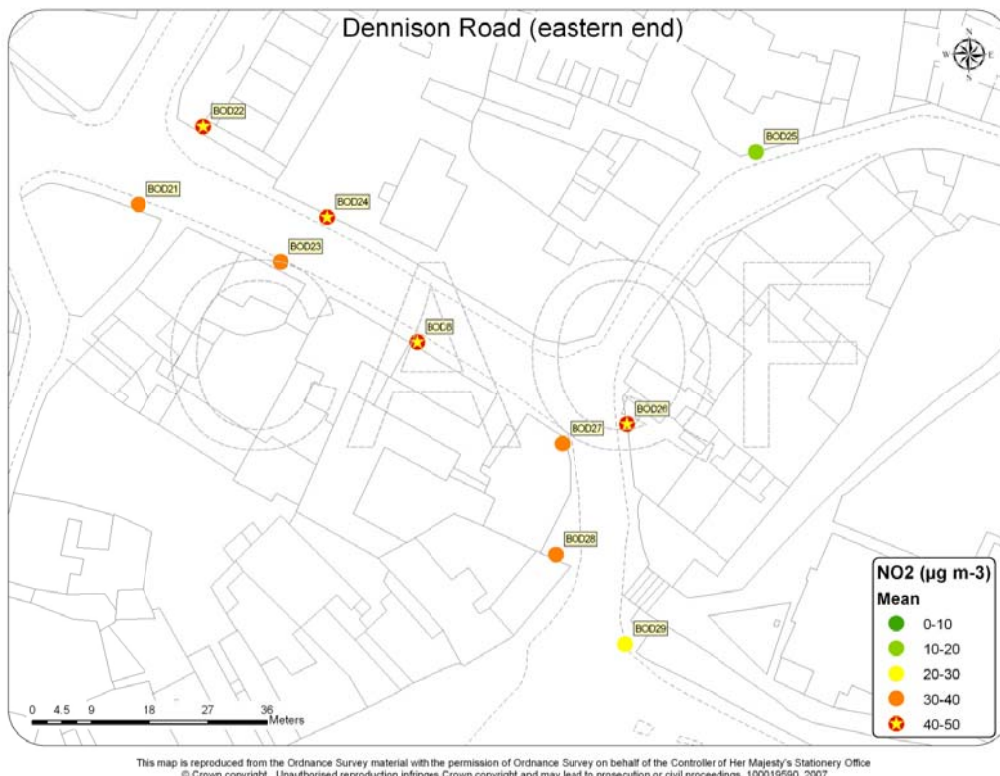


Figure 5. The eastern end of Dennison Road displaying the location and mean NO_2 concentrations for the period June 2008 – May 2009.

4.2 Data capture

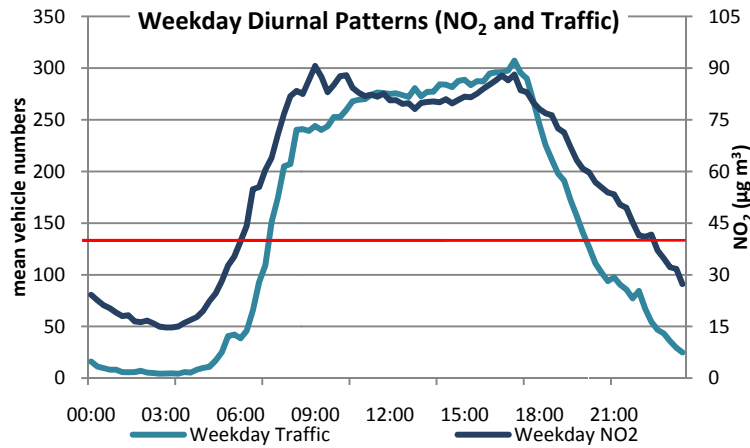
The continuous monitor recorded a data capture value for the 12-month period ending 31/05/2009 of 98.8%. The annual data capture for 2008 for the Dennison Road continuous monitor was 99.4%. Both the data capture for the monitoring period and for 2008 exceed DEFRA's data capture requirement of 90%.

4.3 Diurnal patterns

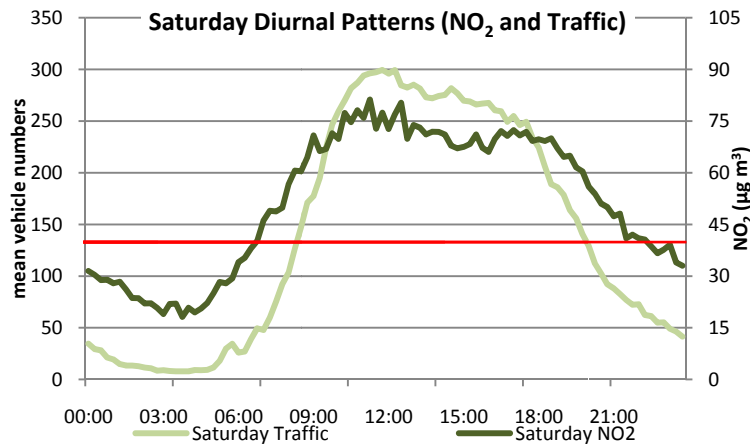
The mean diurnal NO_2 concentrations recorded on weekdays, Saturdays and Sundays in Dennison Road were $57.6 \mu\text{g m}^{-3}$, $51.5 \mu\text{g m}^{-3}$ and $42.3 \mu\text{g m}^{-3}$ respectively for the period 01/06/2008 – 31/05/2009. As illustrated in Figure 6 (a-c) the pollution scenario in Dennison Road has a classic traffic-related pattern. This is illustrated by pollution concentrations which increase in the morning coinciding with increasing volumes of traffic. This relationship persists throughout the day into the evening when traffic volumes and associated pollution levels fall; weekday pollution amplitudes are greater than those observed at weekends.

This phenomenon is closely correlated to traffic volume as highlighted in the recent source apportionment study for Dennison Road (Winkler, 2007). The report concludes that medium goods vehicles (vehicles between 3.5 and 7.5 tonnes) are a significant contributor to pollution concentrations.

(a)



(b)



(c)

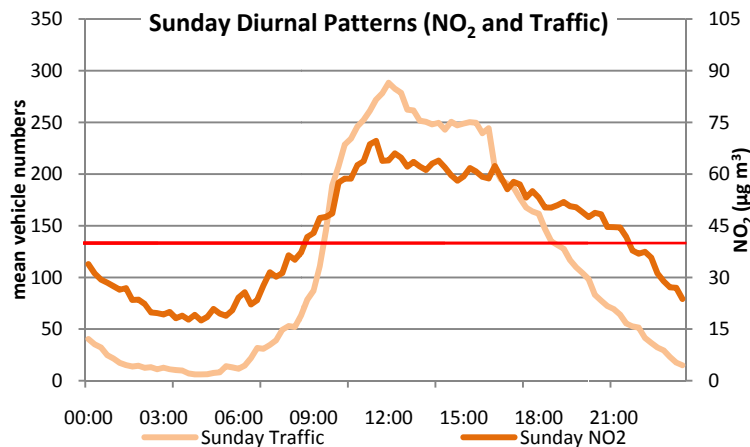
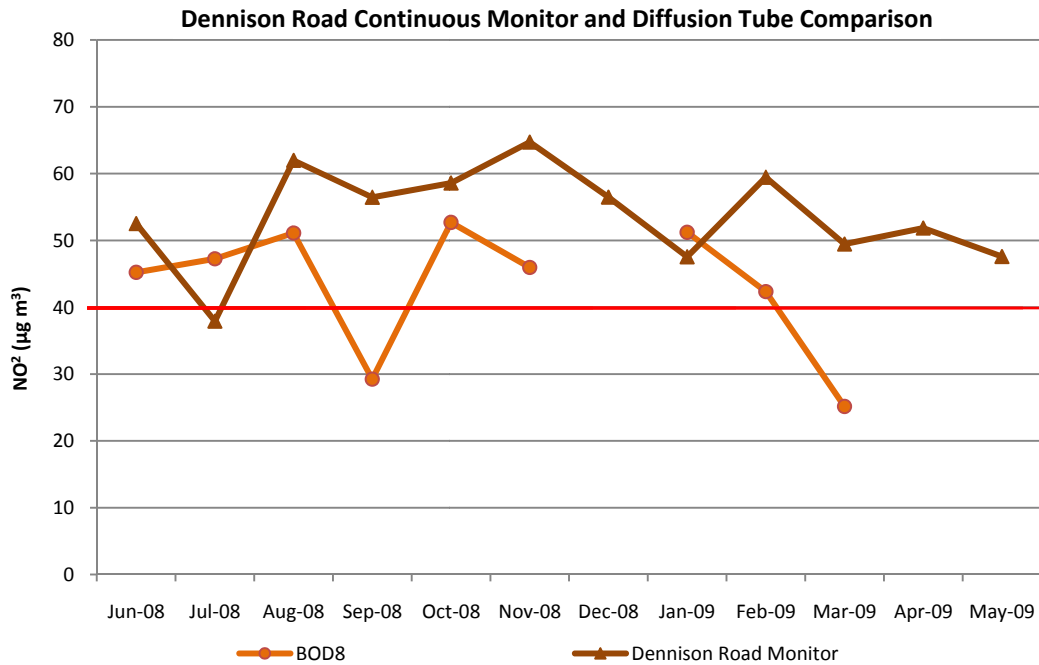


Figure 6 (a-c). Diurnal NO₂ concentrations and traffic numbers recorded in Dennison Road for the period 01/06/2008 – 31/05/2008 for (a) weekdays, (b) Saturdays and (c) Sundays (the red line indicates the NAQS annual objective level for NO₂ concentrations).

4.4 Collocated diffusion tube and continuous monitor

A paired t-test reveals that there is no statistical similarity between the diffusion tube monthly values and the continuous monitor means calculated over the same periods ($p = 0.028$) further highlighting the need for a local bias adjustment.

(a)



(b)

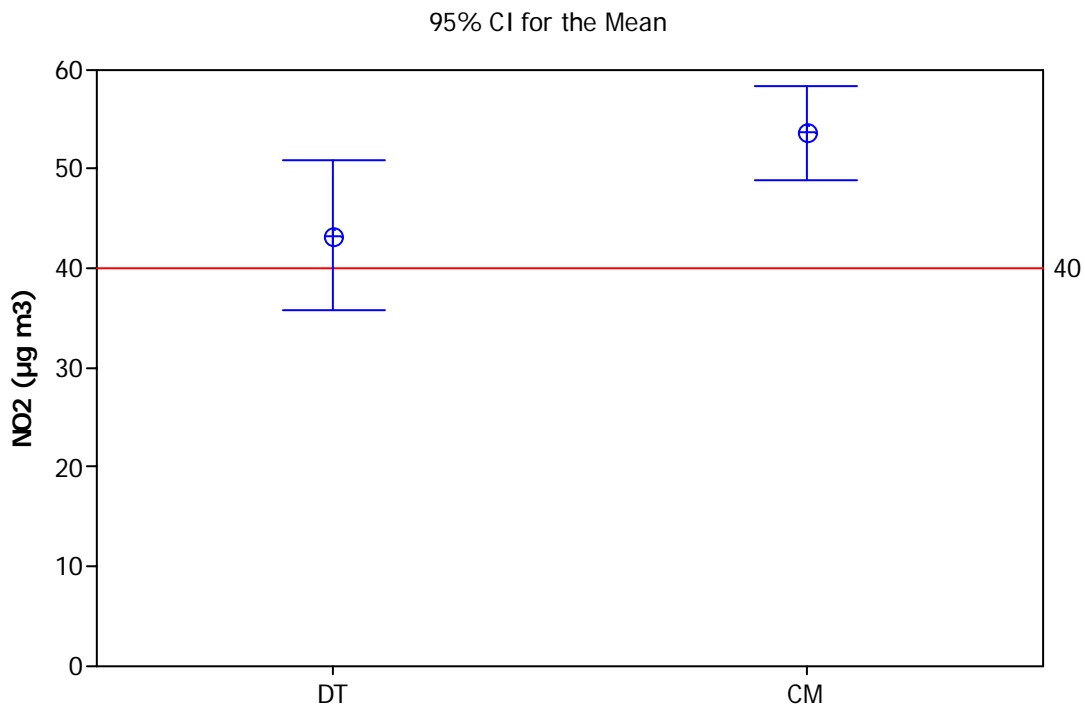


Figure 7 (a) Comparison of diffusion tube and continuous monitor monthly mean concentrations; and (b), comparison of the 12-month mean NO₂ concentration for the continuous monitor and the collocated tubes (BOD8); the red line indicates the NAQS annual mean objective concentration level (for exact site locations refer to Figure 4).

5.0 Conclusion

- The mean NO₂ concentration recorded by the continuous monitor in Dennison Road for the 12-month period ending 31/05/2009 were 55.0 µg m⁻³ and 52.5 µg m⁻³ for 2008; these values exceed the NAQS annual objective for NO₂ of 40 µg m⁻³.
- Data capture by the continuous monitor was 98.8% for the 12-month period ending 31/05/2009 and 99.4% for 2008. These values exceed DEFRA's data capture objective of 90%.
- Of the 45 diffusion tubes deployed in the Bodmin area five recorded annual means >40 µg m⁻³ and therefore exceed the NAQS annual objective; these were located at sites along the eastern end of Dennison Road (BOD8, BOD22, BOD24 and BOD26) and Higher Bore Street (BOD43).
- Traffic-related pollution is suggested as the primary pollution source, evident in the diurnal NO₂ concentration and traffic patterns and the lack of any local industrial sources.
- A statistical analysis of the diffusion tube and continuous monitoring methods reveals no agreement between the two monitoring methods suggesting the need for a local bias adjustment factor to be calculated.

Confidentiality

All sampling results from the monitoring sites in Bodmin will be the property of Cornwall Council, and will be subject to strict confidentiality and not disclosed to any third party without prior formal permission from Cornwall Council.

Disclaimer

Cornwall College cannot accept any responsibility for the use to which the information is put nor for decisions, inferences or conclusions that are made on the basis on the information provided. No responsibility is taken for the accuracy of the sampling unless this is done under our own supervision.