Diffusion Tube and Continuous Monitoring Summary

Bodmin

January 1st – June 30th 2010

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Six-monthly interim report on the nitrogen dioxide diffusion tube and continuous monitoring in Bodmin

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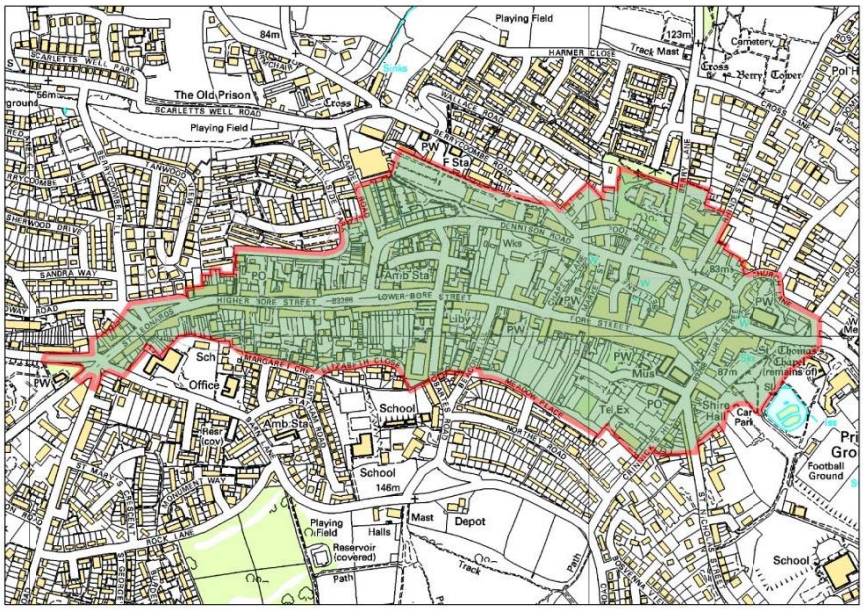
1.0 Introduction

This nitrogen dioxide (NO_2) monitoring programme is a continuation of previous monitoring programmes in Bodmin, the first of which focused on NO_2 diffusion tube monitoring and was commissioned by the former North Cornwall District Council (NCDC) in 2003. All subsequent monitoring programmes have consistently recorded exceedences of the UK Government's National Air Quality Strategy (NAQS) objectives for NO_2 (DEFRA, 2007) at sites in the centre of Bodmin. As the result of the 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.

In response to continual exceedences of NAQS objectives (Table 1), in July 2008 the former NCDC declared an Air Quality Management Area (AQMA) incorporating the town centre of Bodmin and coterminous with the extent of the Bodmin town centre framework study. The AQMA covers all the areas that are currently being investigated for redevelopment within the town centre, but excludes the outskirts of Bodmin (Plate 1). In December 2009 NCDC submitted their AQMA Action Plan (AQMA-AP) to DEFRA, outlining the actions which they were proposing to take in order to reduce traffic related pollution within the AQMA area (http://www.cornwall-airquality.org.uk/airqual_nort.html).

Plate 1. Bodmin AQMA area.



This monitoring programme is designed to monitor traffic-related air pollution at sites of concern within the AQMA and to also provide data against which to assess the effects of AQMA-AP actions.

Copies of previous reports are available on request (aqu@cornwall.ac.uk).

1.1 Nitrogen dioxide

NO_2 is not only a health damaging pollutant but also a proxy measure for other traffic-related pollutants. The UK NAQS objectives for NO_2 are given in Table 1 below. As stated in the LAQM.TG (09) (Air Quality Archive (AQA) 2010) 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. AEA Energy and Environment (AEA, 2008), 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 NO_2.

Nitrogen dioxide (NO_2)	**Measured as**	**Concentration**
	Annual mean	40 µg m^{-3}
	1 hour mean	200 µg m^{-3} (not to be exceeded more than 18 times per year)

1.2 NO_2 background concentrations

The AQA provides estimated (not monitored) UK background (ambient) values for NO_x, NO_2, PM_{10} and $PM_{2.5}$. Numerical data can be downloaded for each 1 km x 1 km of the UK in the form of comma separated (CSV) files. Co-ordinates are given for the centre of each 1 km x 1 km grid square. A separate CSV file is available for each Local Authority area, each pollutant and for each year from 2006 to 2020. Background values for NO_2 for the Wesley Street area are given in Table 2.

Table 2. AQA estimated (not monitored) NO_2 background values for 2010 for the Dennison Road area.

Netcen 1 km sq grid reference	**NO_2 2010**
X – 27500, Y - 67500	6.7 µg m^{-3}

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 14,316 vehicles in 2009, 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® (Plates 2 & 3) monitors oxides of nitrogen and is a DEFRA accepted method of NO_2 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 NOx concentrations every minute which enables detailed analysis of NO_2.

Plate 2. Pedestrian crossing Dennison Road, showing a MOVA sensor (mounted on top of crossing light) and Airpointer® mounted on house façade distant right.

2.2 Mova

A Microprocessor Optimised Vehicle Actuation (MOVA) system was installed at the pedestrian crossing in Dennison Road (Plate 2 and Plate 4). Via loop detectors and sensors, 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 3. Close up of the Airpointer and MOVA sensor

Plate 4. Close up of MOVA mounted on the pedestrian crossing

2.3 Diffusion tubes

Diffusion tubes are a relatively cheap method of monitoring NO_2 which provide monthly averages for NO_2 concentrations for the area in which they are deployed. [1] 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.

The Defra bias adjustment factor which is applied to the tube data, has been updated from 0.89 to 0.90 for 2008 and 2009 (http://www.uwe.ac.uk/aqm/review/diffusiontube050509.xls). This national bias adjustment factor will be updated regularly in 2010 as new and additional collocated diffusion tube data are collected by AEA. The last scheduled update to the bias adjustment spreadsheet was late March 2010.

2.4 Collocated, triplicated diffusion tubes

A single diffusion tube has been co-located 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. Tube precision for this the six-month period was classed as "Good" (details are given Table 3 below).[2]

Diffusion Tubes Measurements										Precision Check
Period	Start Date	End Date	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	
1	01/01/2010	31/01/2010	48.03	48.82	45.85	48	1.5	3	3.8	**Good**
2	01/02/2010	28/02/2010	42.5	47.4	40.7	44	3.5	8	8.7	**Good**
3	01/03/2010	31/03/2010								
4	01/04/2010	30/04/2010	35.5	37.5	37.9	37	1.3	3	3.1	**Good**
5	01/05/2010	31/05/2010	42.4	41.9	38.0	41	2.4	6	6.0	**Good**
6	01/06/2010	30/06/2010	37.8	35.6	40.6	38	2.5	7	6.2	**Good**

Table 3. Collocation data applied to the Diffusion Tube Precision, Accuracy and Bias spreadsheet. Tubes for March 2010 were stolen.

[1] 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. In field inter-comparison exercises and QC testing undertaken by the Workplace Analysis Scheme for Proficiency (WASP 2008) programme for NO_2 diffusion tube analysis (operated by the Health and Safety Laboratory), tubes supplied by Gradko International (Type 1, 20% triethanolamine (TEA) in water) demonstrated "good" performance.

[2] As detailed in TG(09) "*Tube precision is categorised as "good" or "poor" as follows: "good" precision applies where the coefficient of variation (CV) of triplicate diffusion tubes for eight or more periods during the year is less than 20%, and the average CV of all monitoring periods is less than 10%; "poor" precision applies where the CV of four or more periods is greater than 20% and/or the average CV is greater than 10%. It should be noted that this is merely an arbitrary criterion, based on what a competent laboratory should be able to achieve."*

3.0 Results

3.1 Continuous monitoring

As stated in the previous Bodmin Report (January 1st – December 30th 2009) "*The mean concentration recorded in 2009 by the continuous Airpointer® monitor located in Dennison Road was 31.4 µg m^{-3}, well below the NAQS annual mean objective. This is a reduction in NO_2 concentrations of 21.1 µg m^{-3} on 2008's mean recorded concentration of 52.5 µg m^{-3}. This reduction in levels is not echoed by the co-located diffusion tube results and along with the low data capture of the automatic monitor, suggests that the continuous monitor annual mean be ignored.*"

This situation has not yet been resolved and as shown by Table 4 below, the data capture is well below DEFRA guidelines and the data received for January – May 2010 must be discounted. The Airpointer® failed completely at the beginning of June 2010 and an alternative monitor is in the process of being installed adjacent to the pedestrian crossing in Dennison Road (Plate 5). For this reason, this report will not give any further results for the continuous Airpointer® monitor.

Table 4. Summary of 2010 continuous monitoring data in Dennison Road, Bodmin (January to June).

Start date	No. of days	Annual Mean µg m^{-3}	% time > 40µg	8%
01/01/10	151	18.4	1hr Exceedences	1
End date	Data Capture		1hr Max	264.49
31/05/10	52.0%		1hr Percentile	127.59

Plate 5. Proposed location of new continuous monitor on Dennison Road, adjacent to the pedestrian crossing to the left of the picture

3.2 Diffusion tubes

Appendix 1, Figures 1(a) Higher Bore Street and 1(b) Dennison Road and Bodmin town centre display the location and mean NO_2 concentrations for the 6-month period January 2010 – June 2010, monthly and annual data are given in Appendix 1 Tables 1 and 2.

Average bias-adjusted values for the 6-month period exceed the NAQS annual object of 40 µg m^{-3} at 5 sites and are above 35 µg m^{-3} at a further 15 sites. The sites of exceedences are sites where values have continually exceeded the objective and values have risen at some background and non-exceeding sites although this is not a consistent pattern.

The highest average value (56 µg m^{-3}) continues to be recorded at Site 26, Turf Street which is located on a lamppost adjacent to a residential property. Traffic passes within 0.5 m of the façade of the property and is often slow moving or stationary due to the adjacent roundabout. There is also an incline and a sharp bend at this site, both of which also lead to slow moving traffic and associated increased amounts of traffic-related pollution.

Plate 6. Site 26 Turf Street

4.0 Traffic

Traffic values for all years, (on average 5 million vehicles per annum) increase in the summer months (Appendix 2, Figure 2 and Table 3). It is suggested that this is due to the use of the road for holiday traffic accessing the north coast. Due to equipment failure, traffic class data is not available for February 09 – June 09 or for November 09 to May 2010.

In 2006, for most months, values were higher than for subsequent years. This may have been due to factors such as the (relatively) good weather in 2006 or petrol prices. However, there is no continuous downward trend in traffic values for Dennison road and for three of the five (Jan – May) 2010 months values are higher than average.

Examination of the traffic data reveals a distinct seasonal variation of the traffic flow (Appendix 2, Figure 2). During the summer approximately 17,000 vehicles per day pass along Dennison Road between Monday and Saturday but in the winter the daily traffic count drops by approximately 3,500 vehicles, or slightly less than a quarter. The Sunday traffic count is about 2,000-3,000 cars less than the Monday to Friday count.

4.1 Traffic volume

The average hourly flow, particularly on Saturdays and Sundays, peaks around noon. The noon plateau also appears on weekdays, however, the volume of traffic during week days increases further during the afternoon, peaking at 17:00 and declining rapidly afterwards. During peak hours, the average traffic volume amounts to approximately 1000-1200 vehicles per hour on any day of the week. However, as the peak traffic on Sundays commences about 2 hours later and ceases about 2 hours earlier than between Monday and Friday, a lower daily volume results during Sundays.

4.2 Traffic composition

The traffic at Dennison Road is dominated by cars (Appendix 2, Table 4). Only medium goods vehicles (MGVs) contribute significantly to the traffic volume, particularly on Monday to Friday. In the morning, the volume of MGVs rises faster than the volume of cars and between 4:00 and 5:00, before the onset of the peak traffic, MGVs account for up to 16% of the total traffic volume. During peak hours, MGVs contribute to about 8% of the volume between Monday and Friday, and 2-4% of the volume on Saturdays and Sundays. At night, the share drops to about 2%.

Between 08:00 and 23:00 the contribution of all other categories, buses and coaches, cars towing a trailer or caravan, and motorcycles amounts to less than 1% each. Only during night-time hours, when the total traffic volume is low, heavy goods vehicles (HGVs) reach a higher percentage of up to 3%. However, as HGVs, buses and coaches emit higher amounts of NOx per vehicle than cars, such vehicles might nevertheless contribute significantly to the total NOx emissions.

5.0 Discussion

5.1 Continuous monitoring

Until the new continuous monitor is installed in Dennison Road it will not be possible to compare traffic flow and NO_2 data or to determine if the MOVA system is having an effect on traffic flow. Diffusion tubes provide a monthly average value for a specific site and do not allow detailed analysis of traffic and pollution levels to be made.

5.2 Diffusion tube exceedences

Table 2 (Appendix 1) shows the 6-monthly bias-adjusted average against the annual averages for 2008 and 2009. NO_2 values can be seen to have fallen at some sites of exceedences, resulting in only 5 sites of exceedences as opposed to 9 sites in 2009. It must be emphasised that this is only a 6-month average and this situation may change by the end of the year. It is possible that the introduction of the MOVA is having an impact on traffic-flow and consequently on traffic-related pollution.

5.3 Diffusion tube site changes

Previous diffusion tube monitoring programmes have provided an extensive and comprehensive NO_2 database covering the major roads in and through Bodmin, including urban background sites. The number of diffusion tube monitoring sites in Bodmin has now been reduced and the monitoring programme is now focusing on sites of long-term concern.

5.4 Data capture

5.4.1 Airpointer® continuous monitor

The continuous monitor recorded a data capture value for the 6-month period 1st January 2010 – 31st May 2010 of 52%. The data capture for the 6-month monitoring period falls below DEFRA's data capture requirement of 90%. The Airpointer® in Dennison Road is no longer functioning and it will not be possible to provide any continuous NO_2 data until a new monitor is installed.

5.4.2 Diffusion tubes

Over the 6-month period 20/288 (7%) diffusion tubes were stolen (Appendix 1, Table 1). The losses are random with no one-site being targeted more than twice.

5.5 Traffic

The Air Quality Expert Group (AQEG) report *Nitrogen dioxide trends in the UK* suggests that although reductions in total NOx emissions are expected to reduce the number of exceedences of NOx by 2010, this will not be the case with primary NO_2 emissions which are predicted to increase (AQEG, 2007). Bearing this in mind, it will not be sufficient to rely on reductions to pollutant concentrations occurring solely as a result of newer vehicles and fuel improvements even though all new diesel vehicles have to comply with stringent Euro 5 standards, as a result, even if traffic numbers in Bodmin are maintained, or increased, NO_2 concentrations may continue to rise.

6.0 Conclusion

- Data capture by the continuous monitor was 52% for the 5-month period 01/01/2010 – 31/05/2010. This value falls below DEFRA's data capture objective of 90%.

- The Airpointer® in Dennison Road is no longer functioning and it will not be possible to provide any further continuous NO_2 data until a new monitor is installed.

- Of the 45 sites in Bodmin, 5 sites recorded a 6-monthly mean >40 µg m^{-3} and they therefore exceeded the NAQS annual objective. These were located at sites along the eastern end of Dennison Road/Turf Street (BOD8 (triple-located), BOD23, BOD24 and BOD26) and Higher Bore Street (BOD43).

- Traffic-related pollution is suggested as the primary pollution source, evident in the diurnal NO_2 concentration (see previous Bodmin reports) traffic patterns and the lack of any local industrial sources.

- Without traffic class data it is not possible to assess the impact which the different classes of traffic have on pollution levels.

- Average traffic values for the A389 for January – May 2010 are 20% in excess of average values for the same periods for 2006-2009.

- Although reductions in total NOx emissions are expected to reduce the number of exceedences of NOx by 2010, this will not be the case with primary NO_2 emissions which are predicted to increase (AQEG, 2007).

Traffic-related pollution remains the primary cause of air quality exceedences in Bodmin.

7.0 References

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