The Royal Borough of Windsor & Maidenhead

Local Air Quality Management

Review & Assessment - Detailed Assessment, Final Report

August 2004

Entec UK Limited

Report for

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Certificate No. EMS 69090 Certificate No. FS 13881

Executive Summary

Entec UK Limited was commissioned by the Environmental Health Department of the Royal Borough of Windsor & Maidenhead (RBWM) to undertake, on their behalf, a Detailed Review and Assessment of local air quality in the Borough for nitrogen dioxide (NO_2).

The assessment forms part of the statutory duties surrounding Local Air Quality Management (LAQM) and the on-going process of air quality assessment. Part IV of the Environment Act 1995 requires Local Authorities (LA) to periodically review air quality within their areas. This process of LAQM is an integral part of delivering the Government's Air Quality Objectives.

The Detailed Assessment develops further the information gathered and the conclusions reached from the Updating & Screening Assessment (USA) and involves the use of more sophisticated modelling and monitoring techniques. The USA concluded that the area including the roads Broadway, Queen Street and Grenfell Place in Maidenhead and the junction of the A332 and Clarence Road in Windsor should proceed to a Detailed Assessment for NO_2.

The Detailed Assessment will be used to determine whether the likelihood exists for the Air Quality Objectives (AQOs) to be exceeded and the consequent need to declare an Air Quality Management Area (AQMA) in any of these locations.

An assessment of domestic sources of PM_{10} was also previously undertaken as part of the USA and, this was based on the assumption that coal is the primary fuel used within the assessment area. The USA therefore recommended that RBWM undertake a survey of domestic fuel, to provide more detailed data to support the conclusion that emissions from this source do not require further assessment. This survey is not addressed within this Detailed Assessment report.

Owing to the current unavailability of continuous monitoring data in RBWM, this current assessment has included model verification against continuously monitored NO_X and NO_2 at a chemiluminescent monitor at Gerrard's Cross, in the neighbouring Borough of South Buckinghamshire. Owing to elevated NO_2 concentrations in the towns of Windsor and Maidenhead, model verification based on chemiluminescent monitoring data from elsewhere was inappropriate and, therefore, verification in these areas has been largely dependent on diffusion tubes which, unfortunately, results in increased uncertainty.

The Detailed Assessment concludes:

- The Council should consider declaring an AQMA in relation to NO_2 annual mean concentrations in the following areas;
  - Maidenhead Town Centre
  - Windsor – junction of the A332 and Clarence Road
- Modelled concentrations, verified against continuous monitoring, are below the objectives at sensitive receptors adjacent to the M4 and M25. Monitored diffusion tube concentrations (at roadside sites near to the M4 and M25) do indicate that current NO_2 levels are above the objectives, although these locations are not relevant in terms of exposure. Additional diffusion tube monitoring should be introduced to provide further clarity as to the levels of NO_2 at residential property façades in these areas;

- M4 (Figure 5.3)
- M25 (Figure 5.5)

On the basis of the above conclusions, the following recommendations can be made:

- Consider the installation of continuous NO_X/NO_2 monitoring in Windsor and/or Maidenhead. Co-locate triplicate diffusion tubes with the monitor(s). This data should be used to reduce the uncertainty surrounding model concentrations.
- Consider the need to declare AQMAs in Maidenhead town centre and in Windsor at the junction of the A332 and Clarence Road.
- Site diffusion tubes at residential property façades, in all areas where high levels of NO_2 are forecast.
- Continue the co-location survey with triplicate diffusion tubes sited at the Gerrard's Cross and Hillingdon Hospital chemiluminescent monitors.
- In the areas where high levels of NO_2 are predicted, confirmation should be attained that the buildings are under residential occupation.
- RBWM should consult with the Highways Agency regarding the action that can be taken to reduce emissions from the M4 and M25.
- Future air quality reviews within RBWM should continue to consider the status of development at Heathrow. The Council should liaise with the airport operators and other neighbouring local authorities in terms of assessing the likely air quality impacts of any such development.

Glossary

Abbreviation	
AADT	Annual Average Daily Traffic (vehicles per day)
AQMA	Air Quality Management Area
AQO	Air Quality Objective
AURN	Automatic Urban and Rural Network
CO_2	Carbon dioxide
Defra	Department for the Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
LAQM	Local Air Quality Management
mg/m^3	Milligram per cubic metre
NAEI	National Atmospheric Emissions Inventory
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NRTF	National Road Traffic Forecasts
PM_{10}	Particulate Matter with an equivalent aerodynamic diameter of ten micrometers (10 µm) or less
RBWM	Royal Borough of Windsor & Maidenhead
SO_2	Sulphur dioxide
TEOM	Tapered Element Oscillating Microbalance
USA	Updating and Screening Assessment
$µg/m^3$	Microgram per cubic metre

Contents

1. Introduction

1.1 Scope

The Environmental Health Department of the Royal Borough of Windsor and Maidenhead (RBWM) has commissioned Entec UK to undertake a Detailed Assessment of air quality within the Borough. The assessment forms part of the statutory duties surrounding Local Air Quality Management (LAQM) under Part IV of the Environment Act, 1995 and subsequent Regulations.

This report will update the conclusions of the Updating & Screening Assessment that was published in January 2004. Where relevant, the potential impacts of new or revised information have been assessed.

The report reviews the pollutants specified under LAQM with regard to guidance issued by Defra in 2003[1] and the objectives specified in the Air Quality (England) Regulations (2000)[2], amendment to the Regulations[3] and EU Limit Values.

For the purposes of determining the focus of review and assessment, local authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. The objectives do not apply at offices or other places of work where members of the general public do not have regular access.

Where the Detailed Assessment indicates that some or all of the objectives may be potentially exceeded, the Local Authority has a duty to declare an Air Quality Management Area (AQMA). The declaration of an AQMA requires the local authority to implement an action plan, in consultation with others, to reduce air pollution levels so that the required air quality objectives are met.

Elevated concentrations of NO_2 were identified in the USA at a number of monitoring locations. Before undertaking the Detailed Assessment, further investigation was undertaken in terms of the diffusion tube locations at Priors Way, Wraysbury Road, St Lukes Road and Straight Road, to ensure that they were representative of exposure. It was considered that these locations were largely unrepresentative of exposure, as the diffusion tubes are placed at roadside locations. However, it was considered that, on the basis of emissions from the M25 motorway, dispersion modelling would be undertaken in the vicinity of Wraysbury Road.

This report is structured firstly to outline the framework for Review and Assessment, followed by the presentation and discussion of all available monitoring data in the Borough. This is followed by the dispersion modelling assessment and the modelled predictions of pollutant concentrations and the overall summary and conclusions.

[1] Defra, Scottish Executive, Welsh Assembly Government, Department of Environment in Northern Ireland. Technical Guidance (LAQM.TG(03)). February 2003.

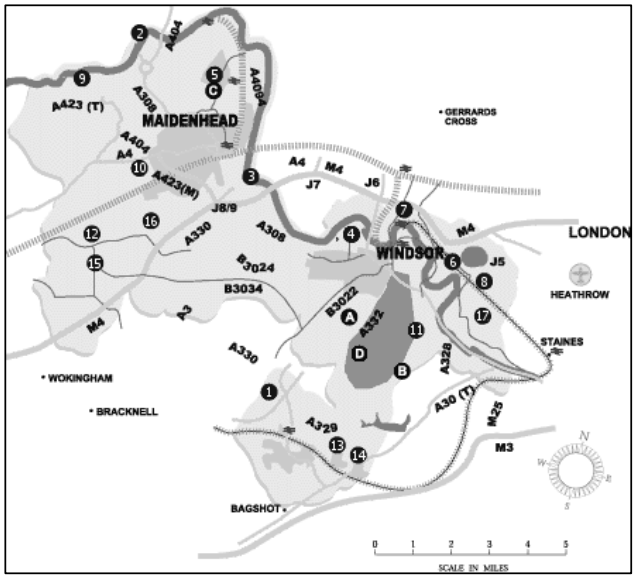
[2] The Air Quality (England) Regulations (2000), Statutory Instrument Nº 928.

[3] The Air Quality (England) (Amendment) Regulations (2002), Statutory Instrument Nº 3043.

1.2 Location

Windsor & Maidenhead is located to the west of London in the County of Berkshire, bordered by the Counties of Surrey and Buckinghamshire. RBWM has seven main urban locations with the largest being Maidenhead and Windsor, with the M4 providing the main transport route through the District. The M3 and M25 border the District to the south and east respectively. A plan of the District is shown below in Figure 1.1.

Figure 1.1 Location of the Royal Borough of Windsor and Maidenhead.



1.2.1 Heathrow Airport Expansion

Although air traffic from Heathrow Airport is unlikely to contribute significantly to ground level pollutant concentrations in the Borough, road traffic generated by the airport is an important consideration for the Council. A proportion of traffic travelling to Heathrow will use road links within RBWM, including the M4 and M25. Any expansion at the airport will introduce additional vehicles to these roads and the contribution of the airport to local air quality will increase.

The Government's recent White Paper[4] refers to aviation policy across the UK and concludes that provision should be made for two additional runways in the South East over the next three decades. These proposals are in addition to the already permitted fifth terminal at Heathrow.

[4] The Future of Air Transport, DoT, December 2003.

One of the proposed runways is likely to be at Stansted Airport, but further development of Heathrow is supported, including a further new runway and additional terminal capacity to be delivered as soon as possible (within the 2015-2020 period), but only if stringent environmental limits can be met.

2. The LAQM Framework

2.1 Legislative Background

Part IV of the Environment Act 1995 requires that local authorities (LA's) periodically review air quality within their areas. This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's Air Quality Objectives (AQOs) first detailed in 1997 and updated in the Air Quality (England) Regulations 2000 (hereafter referred to as the Regulations). New targets for benzene, carbon monoxide (CO) and particulate matter (PM_{10}) were published in 2002, the objectives for PM_{10} and benzene supplement the 2000 Regulations whilst the objective for CO will replace the existing target.

The pollutants specified in the Regulations and to be assessed in the Review and Assessment process, with their relevant AQO concentrations, are shown in Table 2.1. In addition to the Regulations, the EU set Limit Values for nitrogen dioxide (NO_2) and benzene and indicative values for PM_{10}, to be achieved by 1 January 2010. This report provides an assessment against the 2005 AQO's for NO_2.

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2.2 Phase 1 of Review and Assessment

To carry out an 'Air Quality Review and Assessment' the Government recommended a three-stage approach. This phased review process used initial simple screening methods and progressed through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the objectives in the Regulations. This process was to be completed by December 2000.

The review and assessment of local air quality aimed to identify areas where national policies to reduce vehicle and industrial emissions were unlikely to result in air quality meeting the Government's AQOs at locations of relevant public exposure. Where the review and assessment work indicated that some or all of the objectives might potentially be exceeded, the LA had a duty to declare an Air Quality Management Area (AQMA). The declaration of an AQMA required the LA to undertake what has been referred to as a Stage 4 assessment and implement an Air Quality Action Plan (AQAP) to reduce air pollution levels so that the required AQOs are met.

Table 2.1 Summary of Relevant Air Quality Objectives

Pollutant	Objective Concentration	Measured as	Date to be achieved by
Benzene	16.25 μg/m^3	Running annual mean	31/12/2003
	5.00 μg/m^3	Running annual mean	31/12/2010
1,3 Butadiene	2.25 μg/m^3	Running annual mean	31/12/2003
Carbon monoxide	10.0 mg/m^3	Maximum daily 8-hour mean	31/12/2003
Lead	0.5 μg/m^3	Annual mean	31/12/2004
	0.25 μg/m^3	Annual mean	31/12/2008
Nitrogen Dioxide (NO_2)[1]	200 μg/m^3 (not to be exceeded more than 18 times a year)	1-hour mean	31/12/2005
	40 μg/m^3	Annual mean	31/12/2005
Particles (PM_{10}) (gravimetric)	50 μg/m^3 (not to be exceeded more than 35 times a year)	24-hour mean	31/12/2004
	40 μg/m^3	Annual mean	31/12/2004
	50 μg/m^3 (not to be exceeded more than 7 times a year)	24-hour mean[2]	31/12/2010
	20 μg/m^3	Annual mean[2]	31/12/2010
Sulphur Dioxide (SO_2)	350 μg/m^3 (not to be exceeded more than 24 times a year)	1-hour mean	31/12/2004
	125 μg/m^3 (not to be exceeded more than 3 times a year)	24-hour mean	31/12/2004
	266 μg/m^3 (not to be exceeded more than 35 times a year)	15-minute mean	31/12/2005

Notes:

μg/m^3 micrograms per cubic metre

mg/m^3 milligrams per cubic metre

1. objectives are provisional

2. objectives are provisional & not set in the Regulations

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2.2.1 Royal Borough of Windsor & Maidenhead Phase 1 Assessments

RBWM has completed Stage 1,2 and 3 of the phase 1 Review and Assessment process. The Stage 1&2 report identified 4 Part A and 12 Part B authorised industrial processes in and around the Windsor & Maidenhead Borough. The Part A processes are located outside of the Windsor & Maidenhead Borough and were not considered further in the Council's review and assessment. The Part B processes and other sources of emissions were investigated in the Council's Stage 2 review of the potential sources, NO_2 and PM_{10} emissions from road traffic required further assessment at Stage 3. Potential sources of mobile emissions were identified from the A404, A404(M), A355, A322 (Eton), A308 (Braywick Road), A4, M4 (Junctions 7-8/9) and M25. The Stage 3 report concluded that the annual mean NO_2 and PM_{10} AQOs may be exceeded at number of locations. The Council concluded that there was no 'relevant exposure' at these locations and did not declare an AQMA.

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2.3 Phase 2 of Review and Assessment

A second phase of Review and Assessment is required under the 'on-going' review and assessment process, which is designed to build on the technical approach developed for the first round assessments, and identify the on-going needs or requirements for an AQMA designation. Whilst authorities must carry out what is termed the Updating and Screening Assessment (USA), it is not the intention that all will need to progress to a Detailed Assessment.

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2.3.1 Updating & Screening Assessment (USA)

Since the publication of reports for the first round of review and assessment, there were a number of potential issues that needed to be addressed in terms of changes to the sources and emissions of pollutants that may affect ambient air quality in LA areas. Furthermore, new policy developments and revisions to published guidance required consideration within the on-going assessment of air quality. An Updating & Screening Assessment was issued by RBWM in January 2004.

The USA concluded that the area including the roads, Broadway, Queen Street and Grenfell Place and the junction of the A332 and Clarence Road should proceed to a Detailed Assessment for NO_2. Elevated monitored concentrations of NO_2 were identified at a number of locations and, before undertaking a Detailed Assessment, it was recommended that further investigation of the diffusion tube locations, to ensure that they were representative of exposure, be undertaken at Priors Way, Wraysbury Road, St Lukes Road and Straight Road.

2.3.2 Detailed Assessment and Progress Reports

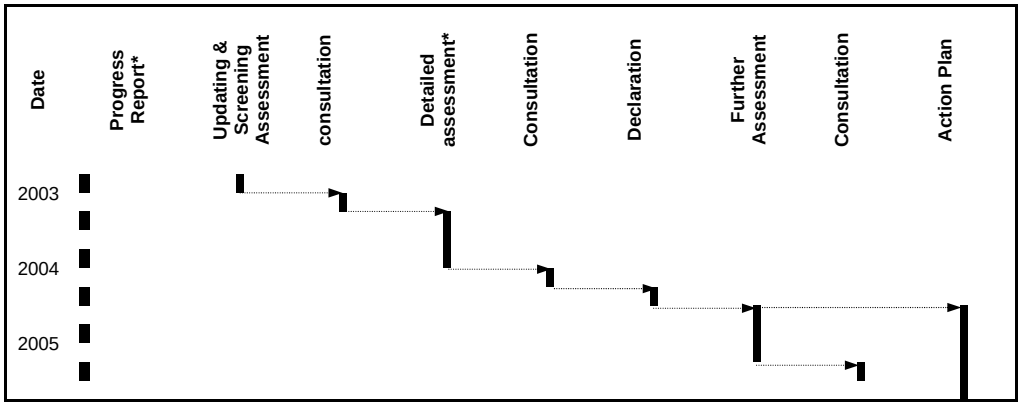
Where the USA identified a potential for the AQOs to be exceeded at locations of relevant public exposure, RBWM has been required to undertake a Detailed Assessment.

The Detailed Assessment develops further the information gathered and the conclusions reached from the USA and involves the use of more sophisticated modelling and monitoring techniques.

The Detailed Assessment will be used to determine whether the likelihood exists for the NO_2 Air Quality Objectives (AQOs) to be exceeded and the consequent need to declare an AQMA in any of these areas.

If a Detailed Assessment was not required at this time, a Progress Report would have been required to be produced on an annual basis (in years when an USA or Detailed Assessment are not required), as detailed in Figure 2.1 below.

Figure 2.1 Timetable for Review and Assessment



* A Progress Report is not required if a Detailed Assessment is being carried out.

2.4 LAQM Guidance and Methodologies

Defra has produced a series of guidance documents detailing assumptions and methodologies for the assessment of air quality, including factors for the prediction of future pollution concentrations from current monitoring, ratification and verification methods for monitoring and modelling and guidance on the declaration of AQMAs.

LAQM.TG(03)[5] was published in 2003 and replaces the second set of technical guidance documents (LAQM.TG1(00), TG2(00), TG3(00) and TG4(00)). This guidance has therefore been followed within the Detailed Assessment.

[5] LAQM.TG(03) Local Air Quality Management, Technical Guidance, Defra, January 2003.

3. Review of Air Quality Monitoring Data

3.1 Introduction

In order to undertake a robust assessment of air quality impacts in the Borough, it is necessary to incorporate suitable monitoring data. This is to provide a means against which the predictive modelling results can be compared and the accuracy of the model can be investigated.

There are two principal methods by which air pollution can be monitored, either using passive sampling or by more sophisticated continuous monitoring devices. Royal Borough of Windsor & Maidenhead do not currently undertake real-time continuous monitoring of NO_2, but do have a number of passive NO_2 diffusion tube monitoring sites. Until April 2004 no co-location studies had been undertaken, either in RBWM or using RBWM diffusion tubes at the site of neighbouring Local Authorities continuous monitoring stations.

From April 2004, co-location of triplicate tubes has been introduced by RBWM at the following continuous monitoring stations:

- M25 Gerrards Cross (South Buckinghamshire District Council)
- Hillingdon Hospital analyser (London Borough of Hillingdon)

This section reviews the available monitoring data and, consideration has been given to the quality assurance and control aspect of the monitoring programmes, to ensure that the data is of a suitably high standard and appropriate for the purpose of Review and Assessment.

3.2 Continuous Nitrogen Oxide Monitoring

Entec has reviewed and incorporated where appropriate, continuous monitoring data from sites outside the Borough, but on the same roads that are included in this Detailed Assessment, such as the M4 and M25. The monitoring stations include those operated by neighbouring Local Authorities and the Highways Agency.

South Buckinghamshire District Council's continuous monitoring station has been located at Gerrard's Cross since 2001 and summary data are presented in Table 3.1. Data from 2003 show that the annual mean concentrations are marginally beyond the 40 $\mu g/m^3$ objective limit, but there are no exceedences shown for the hourly mean objective. The monitoring data indicate that, at the location of the monitor, the air quality objectives in relation to NO_2 are likely to be achieved in 2005.

Data are also available from other nearby monitoring sites, operated by the Highways Agency, adjacent to the M25 and M4. Summary data from 2002 and 2003 are shown in Table 3.2 and Table 3.3. These data show that the 40 $\mu g/m^3$ annual mean objective concentration is exceeded at each of the monitoring sites. It is important to note the significant variation in monitored concentrations year on year and that the M25 and the M4 sites are unrepresentative of relevant exposure, as the monitoring stations are mounted close to the motorway hard-shoulder and, therefore, the monitored concentrations would not be considered as exceedences.

Table 3.1 Gerrard's Cross - Summary of Continuously Monitored NOX and NO2 Concentrations.

Statistic	2002 NO_X ($\mu g/m^3$)	2002 NO_2 ($\mu g/m^3$)	2003 NO_X ($\mu g/m^3$)	2003 NO_2 ($\mu g/m^3$)
Minimum 1-hour ($\mu g/m^3$)	0.0	1.9	0	0
Maximum 1-hour ($\mu g/m^3$)	573.0	204.7	1459	155
19th highest hourly value	322.0	111.0	844	136
Data Capture (%)	90.1	90.1	83.4	83.4
Period Mean ($\mu g/m^3$)	55.6	40.1	116.97	42.13

Table 3.2 M25 Staines - Summary of Continuously Monitored NO_X and NO_2 Concentrations.

Statistic	2002 NO_X ($\mu g/m^3$)	2002 NO_2 ($\mu g/m^3$)	2003 NO_X ($\mu g/m^3$)	2003 NO_2 ($\mu g/m^3$)
Minimum 1-hour ($\mu g/m^3$)	3.4	1.0	4.1	1.0
Maximum 1-hour ($\mu g/m^3$)	669.6	151.1	831.0	196.1
19th highest hourly value	535.4	120.5	572.9	144.4
99.8th Percentile of 1-hr means	539.0	121.5	623.2	148.3
Data Capture (%)	95.4	95.4	88.5	88.5
Period Mean ($\mu g/m^3$)	142.5	39.1	159.1	56.7

Table 3.3 M4 Theale - Summary of Continuously Monitored NO_X and NO_2 Concentrations.

Statistic	2002 NO_X ($\mu g/m^3$)	2002 NO_2 ($\mu g/m^3$)	2003 NO_X ($\mu g/m^3$)	2003 NO_2 ($\mu g/m^3$)
Minimum 1-hour ($\mu g/m^3$)	2.2	0.6	0	0
Maximum 1-hour ($\mu g/m^3$)	889.3	171.6	1284.8	244.7
19th highest hourly value	655.1	133.9	900.7	173.6
99.8th Percentile of 1-hr means	660.7	136.5	935.7	179.0
Data Capture (%)	83.5	83.5	76.2	76.2
Period Mean ($\mu g/m^3$)	134.0	41.6	159.9	56.9

3.2.1 Continuous Monitoring - Quality Assurance

The monitor at Gerrards Cross is calibrated and ratified by AEA Technology as part of their National Automatic Air Monitoring Calibration Club, to the same standard as required by Defra for the AURN sites. The results are fully validated, and at all times the equipment was functioning within all normal operating parameters. The monitoring undertaken by the Highways Agency is also to these standards.

3.2.2 Passive NO_2 Monitoring

Most Local Authorities in the UK use diffusion tubes as a cost-effective monitoring technique, mainly for determining NO_2 concentrations. Results from this method of measurement have always been subject to varying degrees of uncertainty, dependent largely on the method of tube preparation and analysis, but also on the laboratory that supplies and analyses the diffusion tubes.

This section presents monitoring data from the RBWM diffusion tube survey and, investigates the uncertainties within these data.

3.2.3 Diffusion Tube Locations

RBWM undertake ambient monitoring of NO_2 concentrations using passive diffusion tubes at 13 locations in the Borough. Three sites are operated as part of the National NO_2 Diffusion Tube Network. All diffusion tube locations are summarised in Table 3.4.

Table 3.4 Location of diffusion tubes in the RBWM

Tube Reference	Location	Site Class	Easting	Northing	Year Started
1 (N)	Broadway - Maidenhead	Roadside	488824	181027	1999
2	South Road - Maidenhead	Roadside	488623	180962	2002
3 (N)	Thames Crescent - Maidenhead	Background	489861	182541	1999
4 (N)	Mossey Vale - Maidenhead	Roadside	488000	182400	1999
5	The Binghams - Maidenhead A308	Roadside	489633	179292	2002
6	Priors Way - Maidenhead M4	Roadside	489837	178741	2002
7	Longmead - Dedworth	Roadside	494172	176744	2002
8	Alama Road - Windsor	Roadside	496250	176250	2002
9	Imperial Way - Windsor	Roadside	495750	175750	2002
10	High Street - Maidenhead	Roadside	488927	181213	2002
11	Wraysbury Road - Hythe End M25	Background	502114	172459	2002
12	St Lukes Road - Old Windsor	Roadside	498424	174720	2003
13	Straight Road - Windsor	Roadside	499288	173421	2003

Notes: (N) = National Diffusion Tube Locations

3.2.4 Diffusion Tube Monitoring Results

Table 3.5 shows the concentrations monitored at the diffusion tube sites in RBWM since 2002. The tube references are linked to Table 3.4, which provides full details of the site locations. These data have not been bias corrected.

The base year for the predicted values was taken as 2003, which UK-wide was a higher than average year in terms of ambient pollution levels due to the unusually warm weather. This may be a partial explanation for the higher NO_2 levels monitored across the Borough, although it is recognised by Defra that the increases seen across the UK were not outside the normal year on year variation seen in data over a long period. These data should therefore still be included in the Review & Assessment decision making process[6].

Table 3.5 Diffusion tube monitoring results (non bias corrected data)

Ref	Location	Annual Mean NO_2 ($\mu g/m^3$) - Values in brackets show no. months data			
		2002	2003	2004	2005*
1	Broadway	61.45 (11)	68.00 (10)	54.83 (5)	64.46
2	South Road	34.36 (11)	43.32 (8)	35.44 (6)	41.06
3	Thames Crescent	24.76 (11)	26.89 (10)	22.03 (6)	25.49
4	Mossey Vale	27.12 (10)	33.62 (9)	37.16 (2)	31.87
5	The Binghams	40.87 (10)	45.26 (10)	39.24 (6)	42.90
6	Priors Way	43.99 (11)	49.02 (10)	40.57 (6)	46.47
7	Longmead	25.88 (9)	32.90 (8)	26.09 (6)	31.19
8	Alama Road	36.68 (10)	51.36 (7)	33.77 (6)	48.68
9	Imperial Way	38.32 (10)	55.38 (10)	43.82 (6)	52.50
10	High Street	32.72 (10)	35.75 (9)	34.07 (6)	33.89
11	Wraysbury Road	43.89 (9)	45.15 (9)	44.41 (6)	42.80
12	St Lukes Road	- (0)	41.53 (8)	31.55 (6)	39.37
13	Straight Road	- (0)	49.17 (8)	39.72 (6)	46.61

* 2003 x (0.892 / 0.941) = 2005 estimate

[6] www.uwe.ac.uk/aqm/review, April 2004.

3.2.5 Diffusion Tubes Bias

Where possible, Local Authorities should undertake a co-location study whereby diffusion tubes, preferably in triplicate, are mounted at the inlet to a continuous chemiluminescent NO_2 analyser. Essentially, an estimate of bias for the diffusion tubes is determined on the basis of the difference between the NO_2 period averages given by the tubes and the continuous analyser. A correction factor can then be applied to the diffusion tube concentrations to account for this inherent bias.

The diffusion tubes used in RBWM have been supplied and analysed by Gradko International utilising a 20% triethanolamine (TEA) in water preparation method.

Gradko participates in the UK NO_2 diffusion tube network laboratory inter-comparison scheme, run on an annual basis by Netcen. Although this scheme does enable the performance of tubes from one laboratory to be compared against another, the data is only compiled on the basis of a one-month period of monitoring data. Longer-term co-location data is recommended for bias correction.

As discussed in Section 3.1, from April 2004, co-location of triplicate tubes with chemiluminescent analysers has been introduced by RBWM at two locations. The results of this survey are discussed further in Section 3.2.6.

Where co-location has not been undertaken, or where there is only a short period of co-location data available, data presented in a recent report produced on behalf of Defra[7] can be used to help identify an appropriate bias correction factor for the Local Authority to apply to their data. In this study, several Local Authorities that use diffusion tubes supplied and analysed by Gradko using a 20% TEA in water method, submitted data for the survey, the results of which are shown in Table 3.6.

From the data available, it is shown that on average, the diffusion tubes in 2002 and 2003 underestimate concentrations of NO_2 in comparison with a continuous monitor. However, some Local Authority tubes underestimate NO_2 concentrations by as much as -18.9%, while others overestimate by as much as 50.7%. Calculating a mean bias correction factor therefore seems inappropriate due to the large range between the upper and lower bias estimates and, a mean of 1.00 would suggest that the RBWM diffusion tubes perform very well which, is considered unlikely. Although the bias correction for 2003 is also calculated at 0.97, this is based on data from fewer surveys and, further caution should be exercised when interpreting the results which range from -5.3% of the monitored value to 21.4%.

[7] Compilation of diffusion tube co-location studies carried out by Local Authorities. Laxen, D & Wilson, P, on behalf of Defra, November 2002.

Table 3.6 Diffusion tube bias for tubes prepared and analysed by Gradko using 20% TEA in water. Results presented for 2002 and 2003.

Year	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m3)	Automatic Monitor Mean Conc. (Cm) (µg/m3)	Bias (B)	Bias Adjustment Factor (A) (Cm/Dm)
2002	Exeter CC	12	31	38	-18.9%	**1.23**
2002	Southampton CC	12	40	27	45.1%	**0.69**
2002	Southampton CC	12	35	37	-4.5%	**1.05**
2002	Southampton CC	10	34	30	13.5%	**0.88**
2002	Dartford BC	12	52	61	-14.7%	**1.17**
2002	LB Ealing	11	24	28	-16.0%	**1.19**
2002	LB Ealing	11	45	52	-13.6%	**1.16**
2002	South Lakeland DC	12	36	36	-0.5%	**1.01**
2002	Coventry CC	12	36	42	-14.2%	**1.17**
2002	Coventry CC	11	42	35	19.0%	**0.84**
2002	Coventry CC	11	22	14	50.7%	**0.66**
2002	Ellesmere Port & Neston BC	10	36	36	-2.3%	**1.02**
2002	Dudley MBC	9	52	52	0.6%	**0.99**
2002	Dudley MBC	11	27	30	-9.0%	**1.10**
2002	Rushmoor BC	12	36	42	-13.0%	**1.15**
					Average	***1.00***
2003	Exeter CC	12	39	41	-4.4%	**1.05**
2003	Charnwood BC	12	32	33	-4.5%	**1.05**
2003	LB Ealing	9	45	41	10.7%	**0.90**
2003	LB Ealing	10	58	59	-2.6%	**1.03**
2003	North Warwickshire BC	10	50	47	5.2%	**0.95**
2003	South Lakeland DC	12	39	35	11.8%	**0.89**
2003	Bromsgrove DC	10	49	52	-5.3%	**1.06**
2003	AEA Tech intercomparison	12	39	32	21.4%	**0.82**
2003	Mid Beds DC	12	39	38	1.4%	**0.99**
					Average	***0.97***

http://www.uwe.ac.uk/aqm/review/index.html Data from Spreadsheet version 06/04

3.2.6 Local Diffusion Tube Co-location Data

A bias adjustment factor has been calculated, in line with Defra guidance, that has been based on triplicate diffusion tubes and chemiluminescent analyser concentrations monitored at Gerrard's Cross and at Hillingdon Hospital. The diffusion tube bias has been calculated on the basis of three-months of monitoring data (April, May, June 2004).

This data should be used in preference to those presented in Table 3.6, although with only three-months of local co-location data, uncertainties in the bias estimates are significantly increased due to variations in seasonal performance of diffusion tubes, particularly with TEA in water tubes.

The calculations are shown below and, indicate that the diffusion tubes under-estimate levels of NO_2.

Gerrard's Cross:

- (Dm) Diffusion Tube Mean = 41.43 $\mu g/m^3$
- (Cm) Analyser Mean Feb-Dec = 44.95 $\mu g/m^3$
- Cm/Dm = 44.95 $\mu g/m^3$ / 41.43 $\mu g/m^3$ = 1.08

Hillingdon Hospital:

- (Dm) Diffusion Tube Mean = 36.27 $\mu g/m^3$
- (Cm) Analyser Mean Feb-Dec = 37.53 $\mu g/m^3$
- Cm/Dm = 37.53 $\mu g/m^3$ / 36.27 $\mu g/m^3$ = 1.03

Table 3.7 shows the same data as Table 3.5 but, the diffusion tube concentrations have been bias corrected by a factor of 1.03, based on the three-month local co-location study at Hillingdon Hospital.

The bias corrected 2003 data demonstrates that there are likely exceedences of the 40 $\mu g/m^3$ objective concentration at 9 of the 13 monitored locations. The forecast estimates for 2005 suggest that exceedences will continue to occur at each of these locations, although the NO_2 concentrations will reduce.

Table 3.7 Diffusion tube monitoring results (bias corrected data using a factor of 1.03)

Ref	Location	Bias Corrected Annual Mean NO_2 ($\mu g/m^3$) - Values in brackets show no. months data			
		2002	**2003**	**2004**	**2005***
1	Broadway	63.30 (11)	70.04 (10)	56.48 (5)	66.39
2	South Road	35.40 (11)	44.62 (8)	36.51 (6)	42.30
3	Thames Crescent	25.50 (11)	27.70 (10)	22.69 (6)	26.25
4	Mossey Vale	27.94 (10)	34.63 (9)	38.27 (2)	32.83
5	The Binghams	38.27 (10)	46.61 (10)	40.42 (6)	44.19
6	Priors Way	45.31 (11)	50.49 (10)	41.79 (6)	47.86
7	Longmead	23.99 (9)	33.89 (8)	26.87 (6)	32.13
8	Alama Road	34.34 (10)	52.90 (7)	34.78 (6)	50.14
9	Imperial Way	39.47 (10)	51.86 (10)	45.14 (6)	49.16
10	High Street	33.70 (10)	33.14 (9)	35.10 (6)	31.42
11	Wraysbury Road	36.99 (9)	46.51 (9)	45.75 (6)	44.09
12	St Lukes Road	- (0)	42.77 (8)	32.49 (6)	40.55
13	Straight Road	- (0)	50.64 (8)	40.91 (6)	48.00

* 2003 x (0.892 / 0.941) = 2005 estimate

4. Dispersion Modelling Methodology

4.1 Introduction

Dispersion modelling of emissions from road traffic sources has been undertaken through the use of the commercially available Breeze Roads model. Designed specifically to model emissions from road traffic, it allows predictions to be made at a greater spatial resolution than monitoring techniques alone permit.

Further information concerning the model used, methodology and uncertainties is included in this section.

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4.2 Roads Modelling

Breeze Roads has been used across the RBWM area to model the dispersion of pollutants from road traffic vehicles. The model itself incorporates enhanced versions of previously developed models that include CAL3QHCR, CALINE4 and CAL3QHC, designed to model the dispersion of CO, NO_2 and PM_{10}. As identified in the USA, the pollutant of focus for the Detailed Assessment is NO_2.

The model has been used to predict concentrations of pollutants in two stages. The first stage, effectively acting as a screening method for identifying pollution hotspots, was to model at all building façades that fall within a 100 metre buffer of roads included in the modelling. The point on the façade was that which is closest to the road. The exposure criteria in terms of exceedence areas for the annual objective relates to all background locations where members of the public might be regularly exposed and at building façades of residential properties, schools, hospitals and other public buildings. Therefore, if all buildings are modelled and show compliance with the annual mean objective of 40 $\mu g/m^3$ in the year 2005, then no further modelling would be required to determine the extent of exceedence.

If exceedences were predicted at building façades, or where monitored concentrations were above the Objective, the second stage of the modelling was to undertake predictions on a grid of receptors. With this method, receptors are placed at 10 metre intervals on a two-dimensional grid, which facilitates the interpolation of contour lines of equal levels of pollution.

All modelling is undertaken for the base year (2003) and the year of the relevant objective, which is 2005 for nitrogen dioxide.

4.2.1 Accounting for Background Concentrations

The Breeze Roads model has been used to predict the contribution of NO_X from road traffic only, i.e. as a consequence of vehicle numbers and vehicle mix, excluding ambient background concentrations of the pollutant. Therefore, in addition to the modelled concentration, a suitable background value needs to be incorporated to obtain a value for the total concentration at each modelled receptor.

In the absence of continuous background monitoring, or diffusion tubes located at suitable background sites, Defra approved UK wide estimates developed by Netcen have been applied. These background concentrations are derived through a detailed process of modelling and verification against the Defra AURN monitoring sites. These data provide background NO_X and NO_2 ($\mu g/m^3$) estimates for the year 2001 and 2005.

From this data, a NO_x background concentration of 68.3 $\mu g/m^3$ for 2001 was selected as most representative of concentrations in Windsor and 70.7 $\mu g/m^3$ was selected for Maidenhead. A background NO_x concentration of 61.9$\mu g/m^3$ was selected for areas adjacent to the M4 and M25. Using the correction factors in LAQM TG(03), these 2001 concentrations were scaled to levels estimated for 2003, which were used for the base year modelling and for 2005. The same approach was taken to estimate background concentrations of NO_2.

A summary of these concentrations is shown in Table 4.1. It can be seen that the 2003 background NO_2 concentration derived from the Netcen estimates (~35 $\mu g/m^3$) falls approximately mid-way between the background NO_2 concentrations monitored by diffusion tubes at Thames Crescent (27 $\mu g/m^3$) and Wraysbury Road (45 $\mu g/m^3$) as shown in Section 3.0.

Table 4.1 Background NO_X and NO_2 concentrations derived from Netcen estimates applied to Modelled Values

Pollutant	2001	2003	2005
NO_X ($\mu g/m^3$) Windsor	68.3	63.6	57.5
NO_2 ($\mu g/m^3$) Windsor	35.4	33.7	31.4
NO_X ($\mu g/m^3$) Maidenhead	70.7	65.5	58.2
NO_2 ($\mu g/m^3$) Maidenhead	36.2	34.3	31.7
NO_X ($\mu g/m^3$) M4 / M25	61.9	57.3	51.4
NO_2 ($\mu g/m^3$) M4 / M25	33.0	31.2	29.0

4.3 Margins of Error and Levels of Confidence in Monitored and Predicted Concentrations

For the purposes of a Detailed Assessment, it is considered important to undertake an estimation of uncertainty and systematic errors associated with the monitoring and modelling components of the study. Section 3.2 of this report addressed uncertainty surrounding the application of passive diffusion tube sampling, while the following Section investigates the relationship between modelled concentrations against monitored concentrations. There are many explanations for these errors, which may stem from uncertainty in the modelled number of vehicles, speeds and vehicle fleet composition.

The preferred method of model verification requires the comparison of modelled concentrations against continuous NO_X and NO_2 monitoring. As discussed in Section 3.1, there is currently no continuous monitoring undertaken in RBWM and, therefore, the verification procedure is reliant upon the modelled versus monitored relationship at similar locations in neighbouring Boroughs.

Monitored NO_2 diffusion tube concentrations are particularly elevated in Windsor and Maidenhead and, in the absence of continuous monitoring data, the model verification process has relied heavily on this diffusion tube data. Modelled concentrations adjacent to the M4 and M25 have been verified on the basis of continuous monitoring undertaken by South Buckinghamshire District Council at Gerrard's Cross. The verification methods are discussed further below.

4.3.1 Annual Mean Predictions of NO_X / NO_2

In TG(03) Defra has provided guidance in terms of three preferred methods for undertaking dispersion model verification[8], each suitable for different situations. Each method is summarised below:

- Method 1 - Adjustment of annual average NO_2 based on a single continuous monitoring site using a multiplication factor;
- Method 2 - Adjustment of annual average NO_2 based on a single continuous monitoring site using a constant offset of background;
- Method 3 - Verification of annual average NO_2 based on two continuous roadside monitoring sites and 10 roadside diffusion tube sites.

At the current time, continuous monitoring is not undertaken in the RBWM area. This is a significant limitation in terms of carrying out a thorough model verification.

Entec has reviewed all the available monitoring data within the RBWM area and has investigated the suitability of applying model verification correction factors derived for other nearby road traffic modelling assessments to the RBWM Detailed Assessment.

[8] LAQM TG.(03) page A3-37.

Model Verification - M25 and M4

The South Buckinghamshire continuous monitor located at Gerrard's Cross, near to the M25 and A40 will be useful for the verification of modelling in the vicinity of motorways within the RBWM.

It was considered that the most appropriate method of verification would be through the application of Method 1. The final result of the verification did however show that the relationship assumed between NO_X and NO_2 could have been improved at the location of the Gerrard's Cross continuous monitor, as the final modelled concentration was 3.4 $\mu g/m^3$ higher than the actual monitored concentration. On the basis of this information, a secondary correction factor (0.92) was applied to the final NO_2 modelled concentration (NO_2TotMod) to bring this into line with the monitored concentration at Gerrard's Cross.

Model Verification - Windsor and Maidenhead

Defra guidance recommends against undertaking model verification on the basis of diffusion tubes in isolation. A continuous monitor provides accurate measurements in terms of both NO_X and NO_2, whereby diffusion tubes at best, only provide an estimate of NO_2 concentrations, which should then be bias corrected. In the absence of continuous monitoring data for either Windsor or Maidenhead and, owing to the high NO_2 concentrations monitored by diffusion tubes in these towns, it is considered that a verification technique based on bias corrected diffusion tube measurements is the most suitable approach to adopt.

There are three diffusion tubes located within the modelled areas in Windsor and Maidenhead. The method adopted for estimating the systematic error of the model, based primarily on earlier Defra guidance, is detailed below:

- Convert monitored NO_2 diffusion tube concentrations to NO_X using the kerbside/roadside relationship in TG4(00):

  Annual mean NO_X = (Annual mean NO_2 / 3.3931)$^{(1 / 0.5278)}$

- From the concentration of monitored NO_X, subtract the background NO_X for year 2003. This then gives the contribution from the road only.

- Plot a scattergraph and regression line (with a zero origin) of modelled NO_X (excluding background) against monitored NO_X (excluding background). This gives the following equation:

  Monitored annual mean NO_X = 27.9 x Annual mean modelled NO_X

  The R^2 value is 0.3614

- The modelled concentrations of NO_X (excluding background) are then applied using the above equation to give a value of corrected monitored NO_X. The background concentration is then added back in.

- This value of corrected NO_X (including background) is then converted to NO_2 using the kerbside/roadside relationship in TG4(00):

  Annual mean NO_2 ($\mu g/m^3$) = 3.3931 x (Annual Mean NO_X ($\mu g/m^3$)$^{0.5278}$)

- To obtain a value for the final corrected annual NO_2 concentration, plot a scattergraph and regression line of modelled NO_2 (including background) against monitored NO_2 (including background). This gives the following equation:

Monitored annual mean NO_2 = 0.974 x Annual mean modelled NO_2 ($\mu g/m^3$)

The R^2 value is 0.3609.

It is observed that the relationship at three diffusion tube locations, between the model and the monitored concentrations is not particularly strong, as demonstrated by the low R^2 values. A perfect fit would give an R^2 value of 1.0.

4.3.2 All Sites - Hourly Mean Predictions of NO_X / NO_2

The main issue in terms of the objectives in RBWM for nitrogen dioxide is the more stringent annual mean objective. If predicted concentrations of the annual mean are below 40 $\mu g/m^3$, an exceedence of hourly mean objective is unlikely. Data from Gerrard's Cross, Staines and Theale, presented in Section 3.2, show that monitored 1-hour mean concentrations are comfortably within the air quality objective of 200 $\mu g/m^3$ with 18 permitted exceedences.

4.4 Random Error of the Model

Even after systematic errors have been taken into consideration, the model may still sometimes predict higher or lower concentrations than measured values. This is referred to as random error, and requires additional consideration.

Guidance issued by the NSCA[9], provides a methodology for assessing random errors when there are insufficient monitoring data available to accurately determine the uncertainty associated with random errors.

Previous studies have identified a number of 'Stock U Values', which enable a calculation to be made of the standard deviation of the model:

SDM = U x Co (where Co is the air quality objective under consideration)

The Stock U Value for nitrogen dioxide is given as between 0.1 and 0.2 for an annual mean, or between 0.3 and 0.5 for the 99.8th percentile of the 1-hour mean. Generally, Stock U values are higher for shorter averaging periods, which reflect the increased level of random error when predicting concentrations over this period.

Using the above information, the SDM of the model when applying a mean Stock U Value for the annual NO_2 objective is given as follows:

SDM = 0.1 x 40

= 4 $\mu g/m^3$

[9] Air Quality Management Areas: Turning Reviews into Action. National Society for Clean Air & Environmental Protection, 1999.

This methodology adopts a top down approach to assessing pollutant concentrations. Where an exceedence of the objective is shown by validated model predictions, the line of uncertainty due to random errors is drawn at minus 1 SDM (the 36 $\mu g/m^3$ contour). This therefore indicates confidence in predicting the location of the exceedence, but uncertainty in defining the extent of an exceedence. Therefore, if exceedences of the annual mean NO_2 objective are shown, it would be recommended that an AQMA should be drawn based on the 36 $\mu g/m^3$ contour line rather than the 40 $\mu g/m^3$ line.

5. Predicted Concentrations from Road Traffic

5.1 Summary of Approach

The model has been used to predict concentrations of pollutants in two stages. The first stage, effectively acting as a screening method for identifying pollution hotspots, was to model at all building façades that fall within a 100 metre buffer of roads included in the modelling. The point on the façade was that which is closest to the road.

The results of the modelling and a discussion of systematic and random errors associated with modelling are presented in the following sections.

5.2 Summary of Modelled Annual Mean NO_2 concentrations

Table 5.1 presents a summary of the maximum and minimum predicted NO_2 concentrations at sensitive receptors in the towns of Windsor and Maidenhead and, adjacent to the M4 and M25. The concentrations in Windsor and Maidenhead are significantly above the 40 $\mu g/m^3$ Objective.

Table 5.1 Verified modelling results at sensitive receptors in RBWM

Annual Mean	Minimum	Maximum
Windsor - NO_2 ($\mu g/m^3$) 2003	31.73	81.96
Windsor - NO_2 ($\mu g/m^3$) 2005	30.57	77.64
Maidenhead - NO_2 ($\mu g/m^3$) 2003	35.75	90.90
Maidenhead - NO_2 ($\mu g/m^3$) 2005	24.93	89.80
M4 - NO_2 ($\mu g/m^3$) 2003	29.97	40.67
M4 - NO_2 ($\mu g/m^3$) 2005	27.79	37.52
M25 - NO_2 ($\mu g/m^3$) 2003	30.68	35.54
M25 - NO_2 ($\mu g/m^3$) 2005	28.44	32.89

5.3 Comparison with Diffusion Tube Monitoring

Following this process of model verification, the modelled concentrations at the diffusion tube locations have been compared with the monitored values. Monitored diffusion tube concentrations in 2003 were used for this comparison, as they represented the most recent full calendar year of NO_2 monitoring.

Table 5.2 indicates the percentage difference between modelled and monitored concentrations at the location of each tube. A negative value indicates that the monitored concentrations are below those modelled. As shown by the data in Table 5.2, the modelled values fall between minus 15.83% and plus 56.80% of the monitored annual average concentrations. Only those diffusion tubes located within the areas included in the modelling assessment are shown in Table 5.2.

The diffusion tube concentrations have been corrected for bias in relation to the co-location study undertaken by RBWM, as discussed in Section 3.2.4.

Table 5.2 Comparison of verified modelling results and bias corrected monitored diffusion tube concentrations in RBWM.

Receptor	Location	Site Class	Modelled Annual Mean NO_2 ($\mu g/m^3$) 2003	Monitored Mean NO_2 ($\mu g/m^3$) 2003	% Diff 2003 Model : Monitor	Modelled Annual Mean NO_2 ($\mu g/m^3$) 2005
1	Broadway	Roadside	59.41	70.04	17.89	55.63
2	South Road	Roadside	53.01	44.62	-15.83	50.62
6	Priors Way	Roadside	32.20	50.49	56.80	29.80
9	Imperial Way	Roadside	56.53	51.86	-8.26	52.09
11	Wraysbury Road	Background	34.06	46.51	36.55	31.53

5.4 Areas of Potential NO_2 Exceedence

The data presented in Table 5.1 demonstrates that there are a number of receptors where the 2005 annual mean NO_2 air quality objective is shown as likely to be exceeded. These areas are summarised in Table 5.3 but exceedences may not necessarily occur at residential properties or at other locations where the objectives apply. Further assessment of potential exceedences is therefore required in these areas.

This next stage initially requires the confirmation that the predicted exceedences occur at a receptor that is relevant in terms of the exposure criteria. Locations modelled may include farm outbuildings, warehouses or occupational locations where the air quality objectives do not apply. Concentrations have therefore been assessed in each of the areas identified in Table 5.3 and, where necessary, contouring has been undertaken to determine the extent of any relevant exceedence. Figures 5.1 to 5.5 show contour maps of predicted annual mean NO_2 concentrations in the areas where elevated concentrations have been modelled.

The contours should be reviewed in the context of uncertainties as discussed in Section 4.4. Where annual mean NO_2 concentrations exceed 40 $\mu g/m^3$ at a relevant receptor, the 36 $\mu g/m^3$ contour should be considered as the line of possible exceedence.

Table 5.3 Locations of possible NO_2 annual mean exceedence in 2005

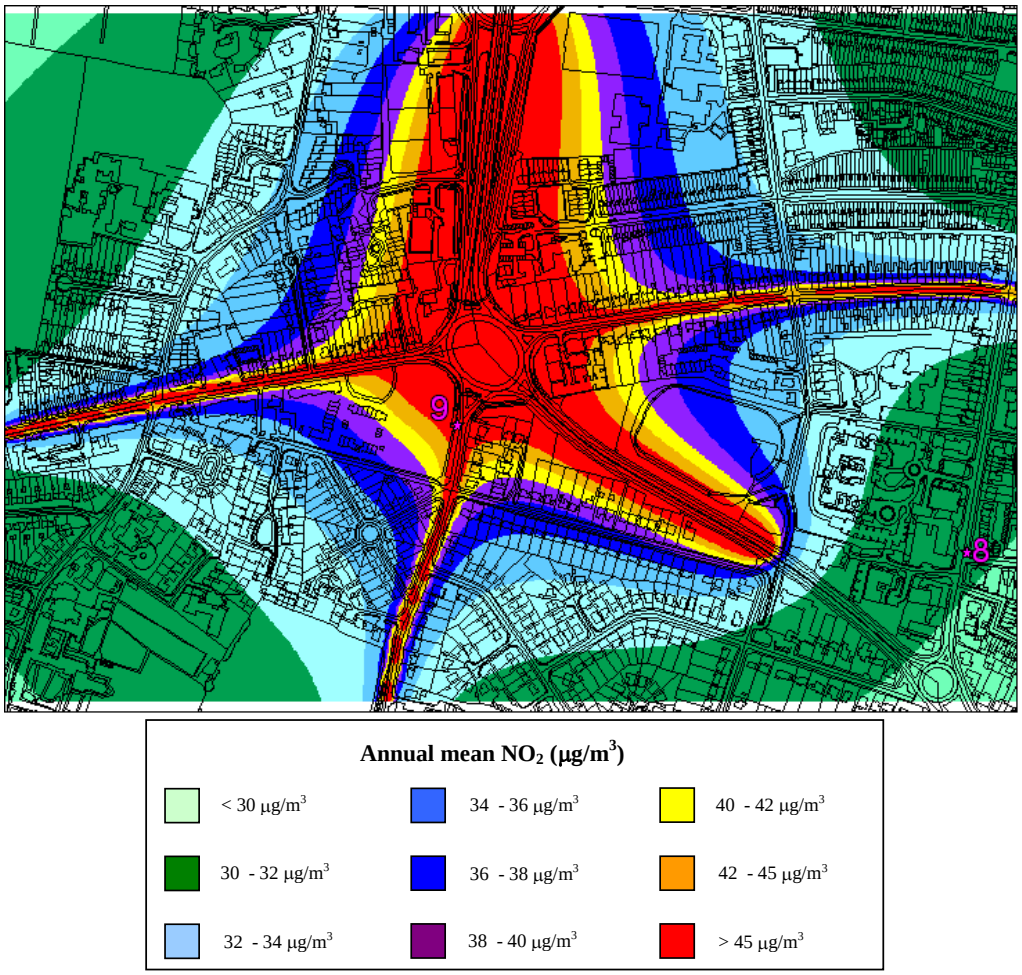
Ref	Location
1	Windsor Town Centre
2	Maidenhead Town Centre
3	M4 (Junction 7 to 8)
4	M25 (Junction 12 to 13)

5.4.1 Location 1 - Windsor (495640,176560)

Contouring was undertaken in this area to determine the extent of the predicted exceedence. The contour map and basemap are shown below in Figure 5.1. It can be seen that the 40 μg/m^3 contour extends in all directions from the A332 roundabout and appears that residential areas are subject to predicted exceedences of the NO_2 annual mean air quality objective.

The locations of diffusion tubes at Alma Road (8) and Imperial Way (9) are also shown in Figure 5.1, although traffic flows in the vicinity of Alma Road were not included in the modelling assessment. As discussed in Section 5.3, a comparison can be made between the modelled and the monitored diffusion tube concentrations for the same year. On the basis of the 2003 baseline, the model predicted an annual mean NO_2 concentration of 56.53 μg/m^3, compared to a bias corrected monitored concentration of 51.86 μg/m^3.

Figure 5.1 Windsor, 2005 Predicted Concentrations of NO_2 (μg/m^3)



5.4.2 Location 2 - Maidenhead (488750,180960)

Contouring was undertaken in central Maidenhead to determine the extent of the predicted exceedence. The contour maps and basemaps are shown below in Figure 5.2 and Figure 5.3 for north and south Maidenhead respectively. It can be seen that the 40 μg/m^3 contour extends into residential areas on either side of the A308.

The locations of diffusion tubes at Broadway (1) and South Road (2) are also shown in Figure 5.2.. On the basis of the 2003 baseline, the model predicted an annual mean NO_2 concentration of 59.41 μg/m^3 at Broadway compared to a bias corrected monitored concentration of 70.04 μg/m^3. At the South Road diffusion tube site, the model gives a concentration of 53.0 μg/m^3 compared to a monitored annual average of 44.62 μg/m^3.

Figure 5.2 Maidenhead (North), 2005 Predicted Concentrations of NO_2 (μg/m^3)

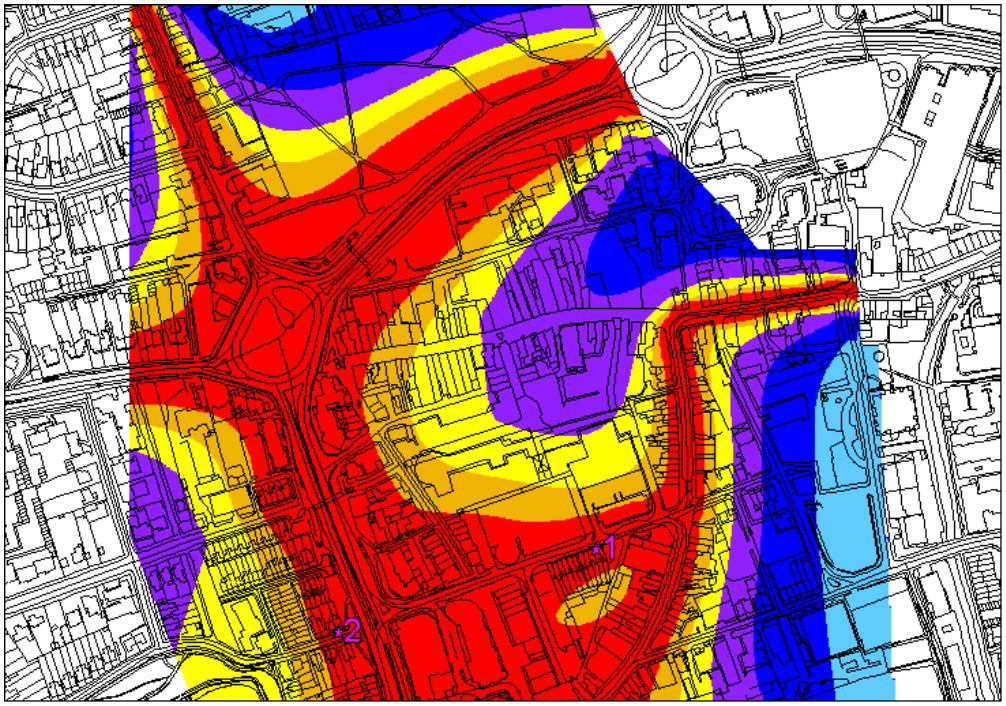
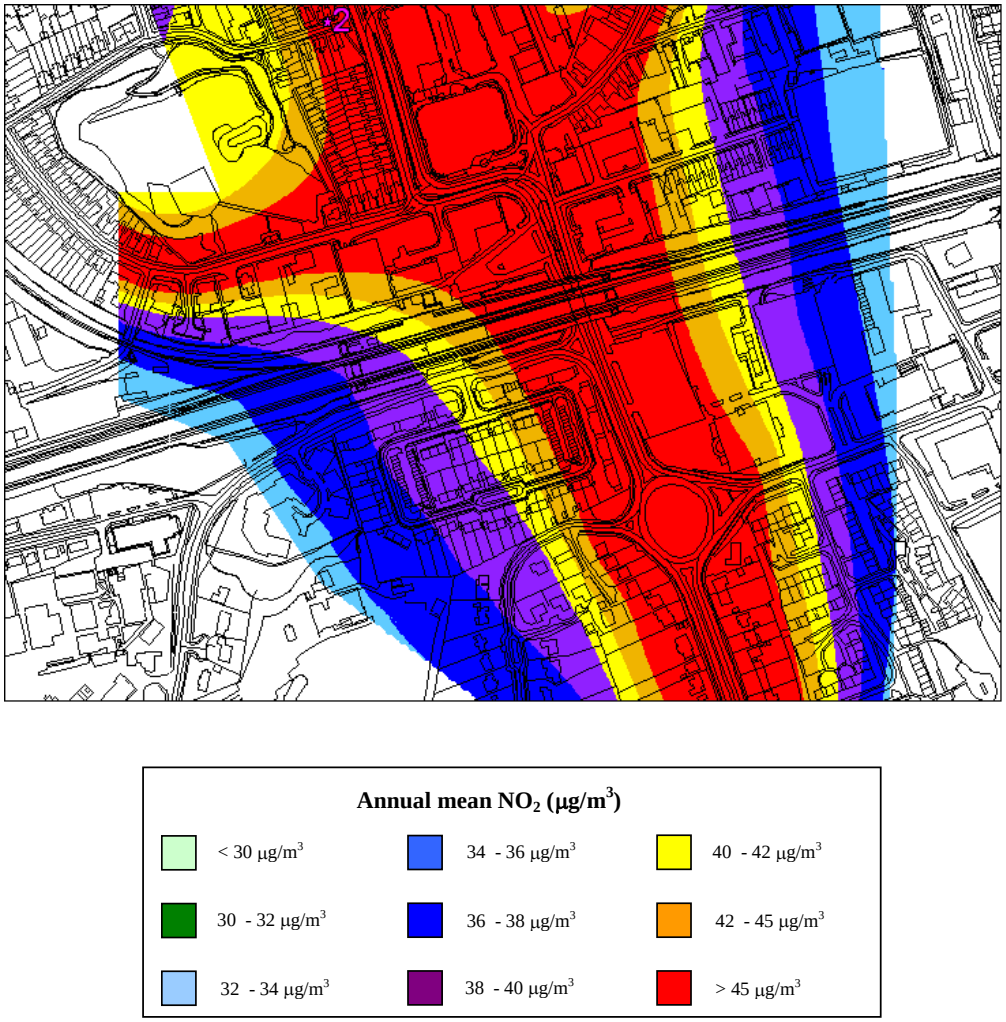


Figure 5.3 Maidenhead (South), 2005 Predicted Concentrations of NO_2 (µg/m^3)

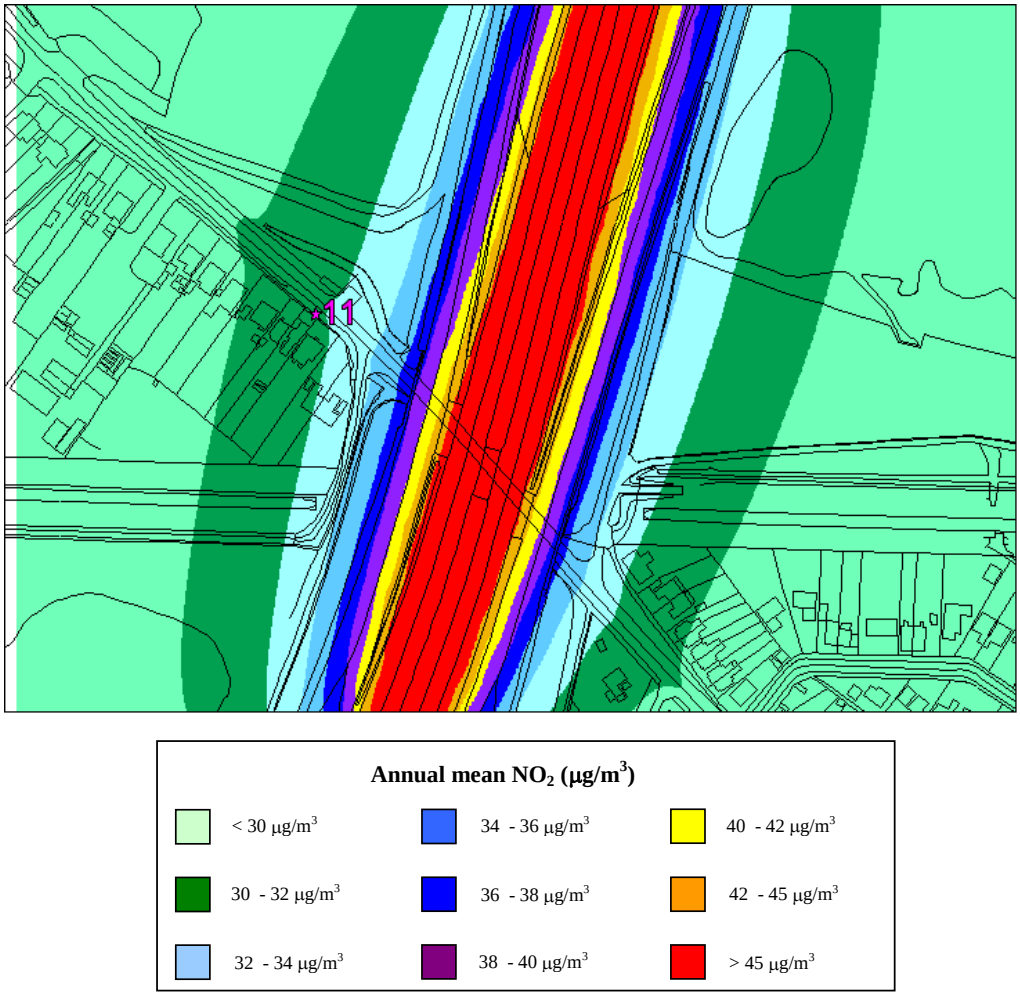


5.4.3 Location 3 – M25 Junction 12-13 (502208,172430)

Contouring was undertaken in close proximity to the M25 at Wraysbury Road, as shown in Figure 5.4. Residential properties in this area are closer to the M25 than at other locations in RBWM and this is therefore considered as a worst-case exposure location. On the basis of the model verification undertaken with the chemiluminescent analyser at Gerrard's Cross, it can be seen that in the vicinity of Wraysbury Road the 40 µg/m^3 contour does not extend beyond approximately 5 metres from the motorway and, therefore, exceedences are not predicted at property façades.

The location of the diffusion tube site at Wraysbury Road (11), which is mounted at a distance of 75 metres from the M25 and 2 metres from Wraysbury Road, is also shown in Figure 5.4. The modelled annual mean NO_2 concentration for 2003 was 34.06 µg/m^3, compared to a bias corrected monitored concentration of 46.51 µg/m^3.

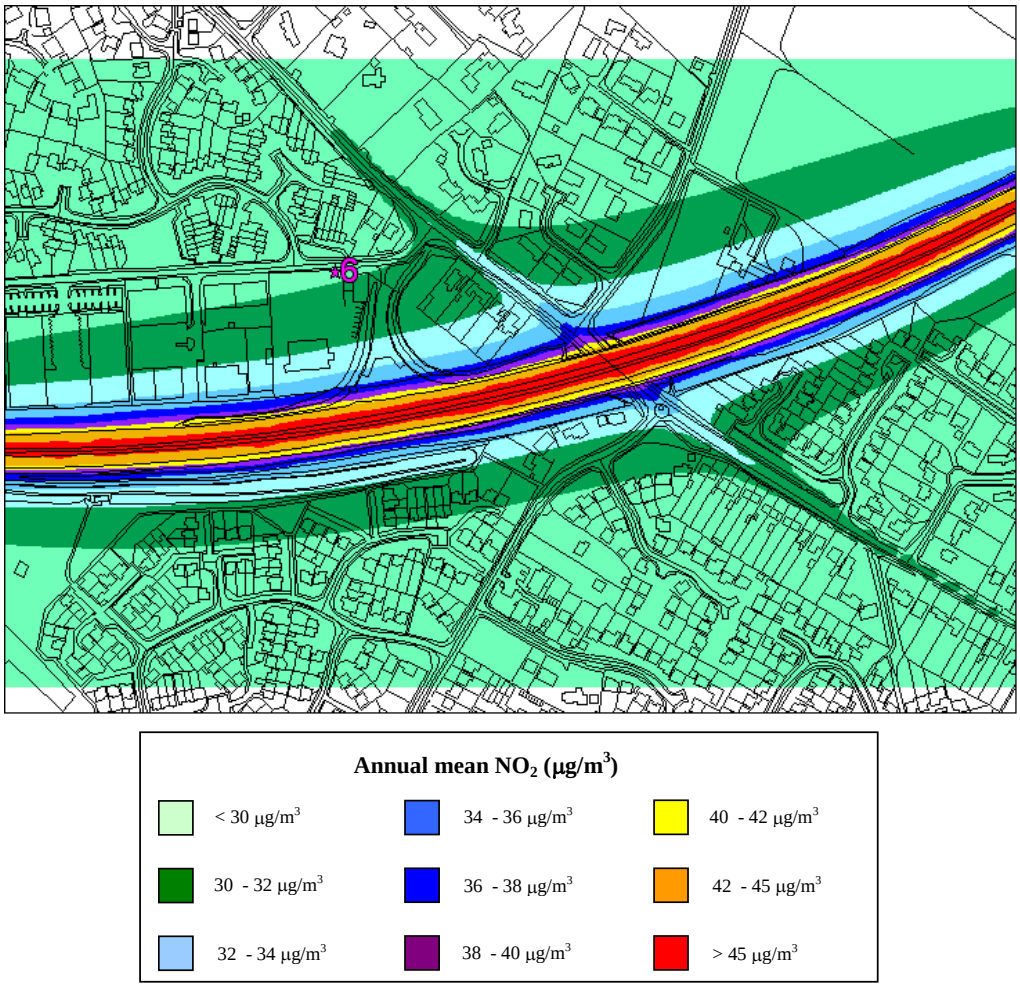
Figure 5.4 M25, 2005 Predicted Concentrations of NO_2 (µg/m^3)



5.4.4 Location 4 – M4 Junction 7-8 (489860,178620)

Contouring was undertaken in close proximity to the M4 between Junctions 7 and 8, in the Priors Way area. There are a number of locations within the RBWM where the M4 passes in close proximity to residential properties. It however considered that, if exceedences are not identified in the area near to Priors Way, where the prevailing wind carries pollutant from the motorway and towards houses, exceedences are also unlikely elsewhere in the Borough.

Figure 5.5 M4, 2005 Predicted Concentrations of NO_2 (µg/m^3)



Owing to the unavailability of local continuous monitoring data adjacent the M4, model verification was undertaken at the Gerrard's Cross analyser, operated by South Buckinghamshire District Council near to the M25 and A4. The modelling demonstrates that concentrations do not exceed 40 µg/m^3 beyond the M4 and, therefore, as properties are located beyond this distance and the contribution to NO_2 concentrations from nearby roads is minimal, then the air quality objectives are unlikely to be exceeded.

It is however important to compare the modelled concentrations against the available diffusion tube data in this area. The Priors Way diffusion tube site is located 110 metres from the M4 and 2 metres from Priors Way. At this location, the modelled annual mean NO_2 concentration for 2003 was 32.20 $\mu g/m^3$, compared to a bias corrected monitored concentration of 50.49 $\mu g/m^3$.

6. Conclusions and Recommendations

6.1 Summary of Road Traffic Impacts

Detailed dispersion modelling has been undertaken in the town centres of Windsor and Maidenhead to assist RBWM in the assessment of NO_2 concentrations in these areas.

The assessment has taken into consideration the exposure criteria of the relevant population, whereby the annual mean objective is relevant only at locations where the public may regularly be exposed. This involves modelling at building façades of residential properties, schools, hospitals, etc.

For the 1-hour objective, predictions should include kerbside locations such as the pavements of busy shopping streets, in addition to the locations where the annual mean objective would apply. Additional modelling was not required for the short-term objective as concentrations predicted at relevant receptors were not in exceedence of a level of the annual objective, whereby an exceedence of the hourly objective may be likely to occur. This was confirmed by nearby continuous monitoring.

Compensation has been made for systematic errors by comparing modelled concentrations against monitored concentrations and deriving multiplying factors. This verification process aims to bring the modelled results into line with local measurements. There are many explanations for these errors, which may stem from uncertainty in the modelled number of vehicles, speeds and vehicle fleet composition. Further errors may result from estimates of emission factors, the use of meteorological data obtained for a year other than for which predictions are made and, that a conservative approach is often adopted throughout the modelling process.

When considering the effects of the random error of the model, as discussed in Section 4.4, a level of increased uncertainly is applied to modelled concentrations where the objective is likely to be exceeded. In these situations, contours are drawn of predicted ground level concentrations around the exceedence and it is suggested that the line of the 36 $\mu g/m^3$ contour be used to define the extent of the likely exceedence.

Owing to the current unavailability of continuous monitoring data in RBWM, the assessment included model verification against continuously monitored NO_X and NO_2 at a chemiluminescent monitor at Gerrards Cross in the neighbouring Borough of South Buckinghamshire.

Defra guidance recommends against undertaking model verification on the basis of diffusion tubes in isolation. A continuous monitor provides accurate measurements in terms of both NO_X and NO_2, whereby diffusion tubes at best, only provide an estimate of NO_2 concentrations, which should then be bias corrected. Owing to elevated NO_2 concentrations in the towns of Windsor and Maidenhead, model verification based on chemiluminescent monitoring data from elsewhere was inappropriate and, therefore, verification in these areas has been largely dependent on diffusion tubes.

The following conclusions can then be drawn:

- The Council should consider declaring an AQMA in relation to NO_2 annual mean concentrations in the following areas;
  - Windsor A332/Clarence Road (Figure 5.1)
  - Maidenhead Town Centre (Figure 5.2 and Figure 5.3)
- Modelled concentrations verified against continuous monitoring are below the objectives at sensitive receptors adjacent to the M4 and M25. Monitored diffusion tube concentrations (at roadside sites) do indicate that current NO_2 levels are above the objectives, but these locations are not relevant in terms of exposure. Additional diffusion tube monitoring should be introduced to provide further clarity as to the levels of NO_2 at residential property façades in these areas;
  - M4 (Figure 5.4)
  - M25 (Figure 5.5)

6.2 Recommendations for Further Work

On the basis of the above conclusions, the following recommendations can be made:

- Consider the installation of continuous NO_X/NO_2 monitoring in Windsor and/or Maidenhead. Co-locate triplicate diffusion tubes with the monitor(s). This data should be used to reduce the uncertainty surrounding model concentrations.
- Consider the need to declare AQMAs in Maidenhead town centre and in Windsor at the junction of the A332 and Clarence Road.
- Site diffusion tubes at residential property façades in all areas where high levels of NO_2 are forecast.
- Continue the co-location survey with triplicate diffusion tubes sited at the Gerrard's Cross and Hillingdon Hospital chemiluminescent monitors.
- In the areas where high levels of NO_2 are predicted, confirmation should be attained that the buildings are under residential occupation.
- RBWM should consult with the Highways Agency regarding the action that can be taken to reduce emissions from the M4 and M25.
- Future air quality reviews within RBWM should continue to consider the status of development at Heathrow. The Council should liaise with the airport operators and other neighbouring local authorities in terms of assessing the likely air quality impacts of any such development.

Appendix A
Road Traffic Data

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Table A.1 Traffic Data and Emission Factors used in the Detailed Assessment.

Ref	Road	AADT 2003	AADT 2005[1]	HGV %	Speed (km/hr)	NOx 2003 ef	NOx 2005 ef
1	A308 Craufurd Road	16,605	17,171	3	50	0.640	0.532
2	A4 Saint Cloud Way	26,568	27,474	3	40	0.651	0.549
3	A4 Bath Road	20,129	20,815	3	55	0.642	0.530
4	Roundabout (A4) / 2	11674	12072	2	25	0.715	0.615
5	A308 Fra. Way	16,605	17,171	3	50	0.640	0.532
6	Grenfell Road	17,388	17,980	3	40	0.651	0.549
7	Grenfell Road (A308)	38,240	39,543	3	40	0.651	0.549
8	Broadway	10,000	10,340	3	35	0.664	0.564
9	Queen Street	10,000	10,340	3	40	0.651	0.549
10	High Street	10,000	10,340	3	40	0.651	0.549
11	A308 King Street	38,240	39,543	3	40	0.651	0.549
12	A308 Roundabout	19120	19772	3	25	0.715	0.615
13	A308 Roundabout / 2	9560	9886	3	25	0.715	0.615
15	A308 Braywick Road (N) / 2	19120	19772	3	40	0.651	0.549
16	A308 Braywick Road (S) / 2	19120	19772	3	40	0.651	0.549
20	A308 Braywick Road	38,240	39,543	3	40	0.651	0.549
21	B3024 Clarence Road (west)	5740	5936	3	30	0.685	0.585
22	B3173 Imperial Road	5740	5936	3	30	0.685	0.585
23	A308 Goslar Way	20,019	20,701	3	80	0.718	0.580
24	Clarence Road (east)	5035	5207	3	30	0.685	0.585
25	A332 W&E relief (slip on from Maidenhead Arthur Road)	5,766	5,962	3	30	0.685	0.585
26	A332 W&E relief south	28828	29810	3	80	0.718	0.580
27	A332 W&E relief north	28828	29810	3	80	0.718	0.580
28	A332 W&E relief (slip off to A308)	5766	5962	3	30	0.685	0.585
29	roundabout	28828	29810	3	25	0.715	0.615
30	M4 (J7-J8)	134184	138758	9	112	1.624	1.376
31	M25 (based on flows from J15-J16)	184290	190571	13	96	1.789	1.535
32	B376 Wraysbury Road	7000	7238	3	60	0.648	0.532
33	A308 slip road	18429	19057	3	80	0.718	0.580