

Royal Borough of Windsor and Maidenhead

Local Air Quality Management

Review & Assessment – Further
Assessment, Final Report

March 2006

Entec UK Limited

Report for

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Local Air Quality Management

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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 Further Assessment of local air quality in the Borough for nitrogen dioxide (NO₂).

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 to periodically review air quality within their areas. This process of LAQM is an integral part of delivering the Government's Air Quality Objectives (AQOs).

The Further Assessment builds on the information gathered and the conclusions reached in the Detailed Assessment, submitted to Defra in August 2004. The Detailed Assessment concluded that on the basis of detailed dispersion modelling and passive diffusion tube monitoring, the annual mean NO₂ air quality objective was unlikely to be met by the required date at locations in Maidenhead town centre and at the junction of the A332 and Clarence Road in Windsor. This led to RBWM declaring two Air Quality Management Areas (AQMAs) at these locations, which became effective from February 2005. Continuous monitoring of NO_x/NO₂ commenced within the AQMAs in March 2005.

This Further Assessment provides an opportunity for the Council to revisit and revise if necessary, the conclusions from the Detailed Assessment in relation to the location and extent of the AQMAs. It also forms the basis for the Council to develop an Action Plan to reduce emissions of nitrogen oxides (NO_x) from road traffic sources in the Borough.

The Further Assessment incorporates several new and updated sources of information since the Detailed Assessment, including:

- Updated traffic data to 2004 and revised 2005 forecasts;
- Updated and new NO₂ diffusion tube monitoring undertaken in the RBWM area;
- New continuous monitoring data from sites in Windsor and Maidenhead;
- Revised modelling methodologies concentrating upon the area where the AQMAs have been declared;
- Verification of the model against local continuous monitoring data.

The Further Assessment has demonstrated that on the basis of 2005 forecasts, using year 2004 meteorological data, with updated traffic data and air quality monitoring data, that exceedences of the NO₂ annual mean AQO remain likely at the locations identified in the Detailed Assessment, namely Maidenhead town centre and at the junction of the A332 and Clarence Road in Windsor.

It is concluded that the Council should not need to revoke or amend the AQMA at this time. The Council should proceed to the formulation of an Air Quality Action Plan.

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
1.1	Scope	1
1.2	Location	2
1.2.1	Heathrow Airport Expansion	2
1.3	Designated AQMAs	3
2.	The LAQM Framework	5
2.1	Legislative Background	5
2.2	Phase 1 of Review and Assessment	5
2.2.1	Royal Borough of Windsor & Maidenhead Phase 1 Assessments	7
2.3	Phase 2 of Review and Assessment	7
2.3.1	Updating & Screening Assessment (USA)	8
2.3.2	Detailed Assessment and Progress Reports	9
2.4	LAQM Guidance and Methodologies	9
3.	Review of Air Quality Monitoring Data	11
3.1	Introduction	11
3.2	Continuous NO _x /NO ₂ Monitoring	11
3.2.1	Converting Period Means to Annual Means	14
3.2.2	Continuous Monitoring - Quality Assurance	16
3.3	Passive NO ₂ Monitoring	17
3.3.1	Diffusion Tube Locations	17
3.3.2	Diffusion Tube Monitoring Results	19
3.3.3	Diffusion Tubes Bias	21
3.3.4	Local Diffusion Tube Co-location Data	23
4.	Dispersion Modelling Methodology	27
4.1	Introduction	27
4.2	Roads Modelling	27
4.2.1	Accounting for Background Concentrations	28
4.3	Margins of Error and Levels of Confidence in Monitored and Predicted Concentrations	29

4.3.1	Annual Mean Predictions of NO _x /NO ₂	29
4.3.2	All Sites - Hourly Mean Predictions of NO _x /NO ₂	30
4.4	Random Error of the Model	30
5.	Predicted Concentrations from Road Traffic	33
5.1	Summary of Approach	33
5.2	Summary of Modelled Annual Mean NO ₂ concentrations	33
5.3	Comparison with Diffusion Tube Monitoring	34
5.4	Areas of Potential NO ₂ Exceedence	34
5.4.1	Location 1 - Windsor (495640,176560)	35
5.4.2	Location 2 - Maidenhead (488750,180960)	37
5.5	Emission Reduction Requirements	39
6.	Conclusions and Recommendations	41
6.1	Summary of Road Traffic Impacts	41
6.2	Recommendations for Further Work	42
Table 2.1	Summary of Air Quality Objectives, Included in the Air Quality Regulations (England) (Wales) 2000 and in Air Quality (England) (Wales) (Scotland) (Amendment) Regulations 2002 for the Purpose of Local Air Quality Management.	6
Table 3.1	Clarence Road, Windsor - Summary of Continuously Monitored NO _x and NO ₂ Concentrations (1st March 2005 – 21st September 2005 Provisional Data)	14
Table 3.2	Maidenhead Town Centre - Summary of Continuously Monitored NO _x and NO ₂ Concentrations (1 st March 2005 – 21 st September 2005 Provisional Data)	14
Table 3.3	Ratios between Period Means and Annual Mean NO ₂ concentrations at Defra Monitoring Stations.	15
Table 3.4	Ratios between Period Means and Annual Mean NO ₂ concentrations at London Air Quality Network Monitoring Stations. Error! Bookmark not defined.	
Table 3.5	Location of diffusion tubes in the RBWM	18
Table 3.6	Diffusion tube monitoring results (non bias corrected data)	20
Table 3.7	Diffusion tube bias for tubes prepared and analysed by Gradko using 20% TEA in water. Results presented for 2002, 2003 and 2004.	22
Table 3.8	Diffusion tube monitoring results, bias corrected data using a factor of 1.03	25
Table 4.1	Background NO _x and NO ₂ concentrations derived from Netcen estimates and applied to Modelled Values	28
Table 5.1	Verified modelling results at sensitive receptors in RBWM	33
Table 5.2	Comparison of verified modelling results and bias corrected monitored diffusion tube concentrations in RBWM.	34

Figure 1.1	Location of the Royal Borough of Windsor and Maidenhead.	2
Figure 1.2	Maidenhead AQMA	4
Figure 1.3	Windsor AQMA	4
Figure 2.1	Timetable for Review and Assessment (Hashed area shows current assessment timescale)	8
Figure 3.1	Maidenhead NO _x /NO ₂ Monitoring Station, Frascati Way (OS Ref: 488626, 180994)	12
Figure 3.2	Windsor NO _x /NO ₂ Monitoring Station, Clarence Road (OS Ref: 495664,176592)	13
Figure 5.1	Windsor, 2005 Predicted Concentrations of NO ₂ (µg/m ³)	36
Figure 5.2	Maidenhead (North), 2005 Predicted Concentrations of NO ₂ (µg/m ³)	38
Figure 5.3	Maidenhead (South), 2005 Predicted Concentrations of NO ₂ (µg/m ³)	39
Figure 5.3	Maidenhead (South), 2005 Predicted Concentrations of NO ₂ (µg/m ³)	39

Appendix A Road Traffic Data

Appendix B Model Verification

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 Further 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 Detailed Assessment that was published in August 2004. Where relevant, the potential impacts of new or revised information have been assessed, including most significantly, site specific continuous monitoring data.

The report reviews the pollutants specified under LAQM with regard to guidance issued by Defra in 2003¹ and the objectives specified in the Air Quality (England) Regulations (2000)², amendment to the Regulations³ 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.

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 including 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.

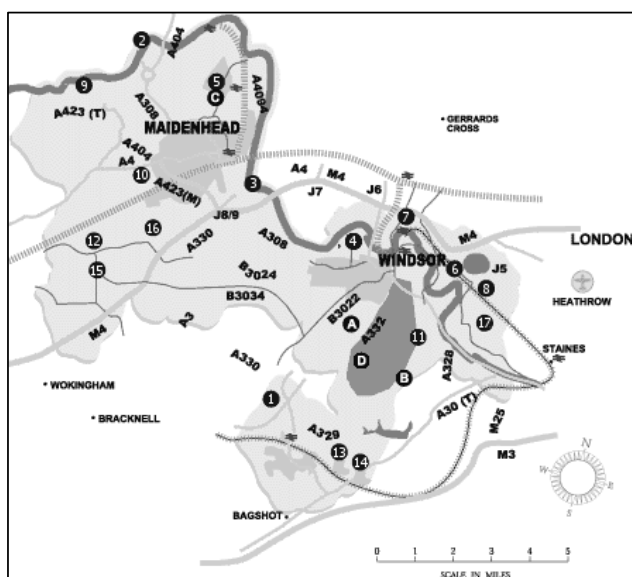
² The Air Quality (England) Regulations (2000), Statutory Instrument N^o 928.

³ The Air Quality (England) (Amendment) Regulations (2002), Statutory Instrument N^o 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. The M4 provides the main transport route through the Borough while the M3 and M25 border the Borough to the south and east respectively. A map of the Borough 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 Paper⁴ 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.

1.3 Designated AQMAs

Where the Review and Assessment process 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.

Figures 1.2 and 1.3 illustrate the location and extent of the AQMAs declared following the completion of the Detailed Assessment.

Figure 1.2 Maidenhead AQMA

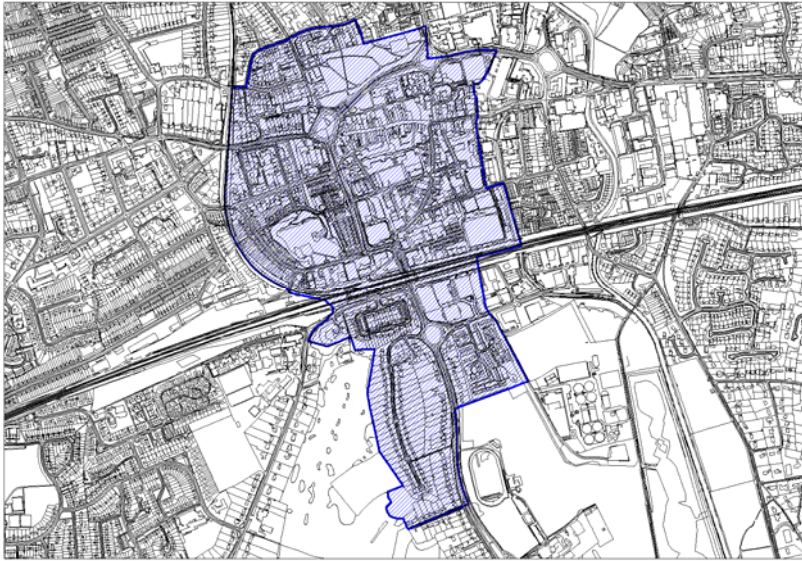
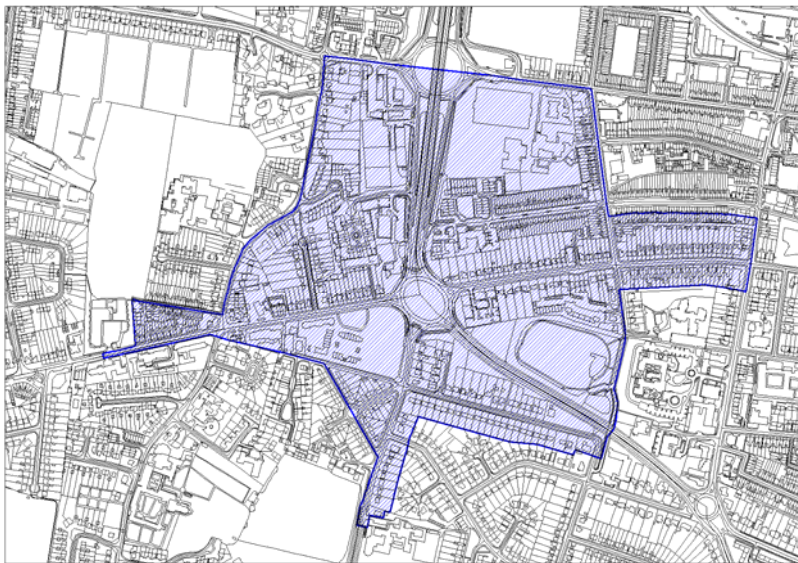


Figure 1.3 Windsor AQMA



2. The LAQM Framework

2.1 Legislative Background

Part IV of the Environment Act 1995 requires that local authorities 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 (PM₁₀) were published in 2002, the objectives for PM₁₀ 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, although the AQOs are at least as stringent as the Limit Values and in some cases more stringent. This report provides an assessment against the statutory 2005 AQOs for NO₂, in line with exceedences predicted in relation to this pollutant in the earlier Detailed Assessment.

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 local authority had a duty to declare an Air Quality Management Area (AQMA). The declaration of an AQMA required the local authority 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.

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Table 2.1 Summary of Air Quality Objectives, Included in the Air Quality Regulations (England) (Wales) 2000 and in Air Quality (England) (Wales) (Scotland) (Amendment) Regulations 2002 for the Purpose of Local Air Quality Management.

Pollutant	Applies to	Standard		Objective		EU AQ Daughter Directive
		Concentration	Measured as	Annual Exceed - ences Permitted	Target Date	
Benzene	All UK	16.25 µg/m ³	Running annual mean	-	31/12/03	-
	Eng & Wales	5.00 µg/m ³	Annual mean	-	31/12/10	As Standard. 01/01/10
	Scotland	3.25 µg/m ³	Running annual mean	-	31/12/10	-
1,3 Butadiene	All UK	2.25 µg/m ³	Running annual mean	-	31/12/03	-
Carbon monoxide	Eng & Wales	10.0 mg/m ³	Maximum daily running 8-hour mean	-	31/12/03	As Standard. 01/01/05
	Scotland ²	10.0 mg/m ³	Running 8-hour mean	-	31/12/03	As Standard. 01/01/05
Lead	All UK	0.5 µg/m ³	Annual mean	-	31/12/04	As Standard. 01/01/05
	All UK	0.25 µg/m ³	Annual mean	-	31/12/08	-
Nitrogen Dioxide (NO₂)¹	All UK	200 µg/m³	1-hour mean	18	31/12/05	As Objective. 01/01/10
	All UK	40 µg/m³	Annual mean	-	31/12/05	As Standard. 01/01/10
Particles (PM ₁₀) (gravimetric)	All UK	50 µg/m ³	24-hour mean	35	31/12/04	As Objective. 01/01/05
	All UK	40 µg/m ³	Annual mean	-	31/12/04	As Objective. 01/01/05
	Scotland ³	50 µg/m ³	24-hour mean	7	31/12/10	As Objective. 01/01/10
	Scotland ³	18 µg/m ³	Annual mean	-	31/12/10	-
Sulphur Dioxide (SO ₂)	All UK	350 µg/m ³	1-hour mean	24	31/12/04	-
	All UK	125 µg/m ³	24-hour mean	3	31/12/04	As Objective. 01/01/05
	All UK	266 µg/m ³	15-minute mean	35	31/12/05	As Objective. 01/01/05

Notes:

µg/m³ micrograms per cubic metre mg/m³ milligrams per cubic metre

- The objectives for nitrogen dioxide are provisional, subject to special attention in the review of the Air Quality Strategy
- The Air Quality Objective in Scotland has been defined in the Regulations as the running 8-hour mean, in practice this is equivalent to the maximum daily running 8-hour mean.
- These 2010 Air Quality Objectives for PM₁₀ apply in Scotland only, as set out on the Air Quality (Scotland) Amendment Regulations 2002.

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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, NO₂ and PM₁₀ 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 NO₂ and PM₁₀ 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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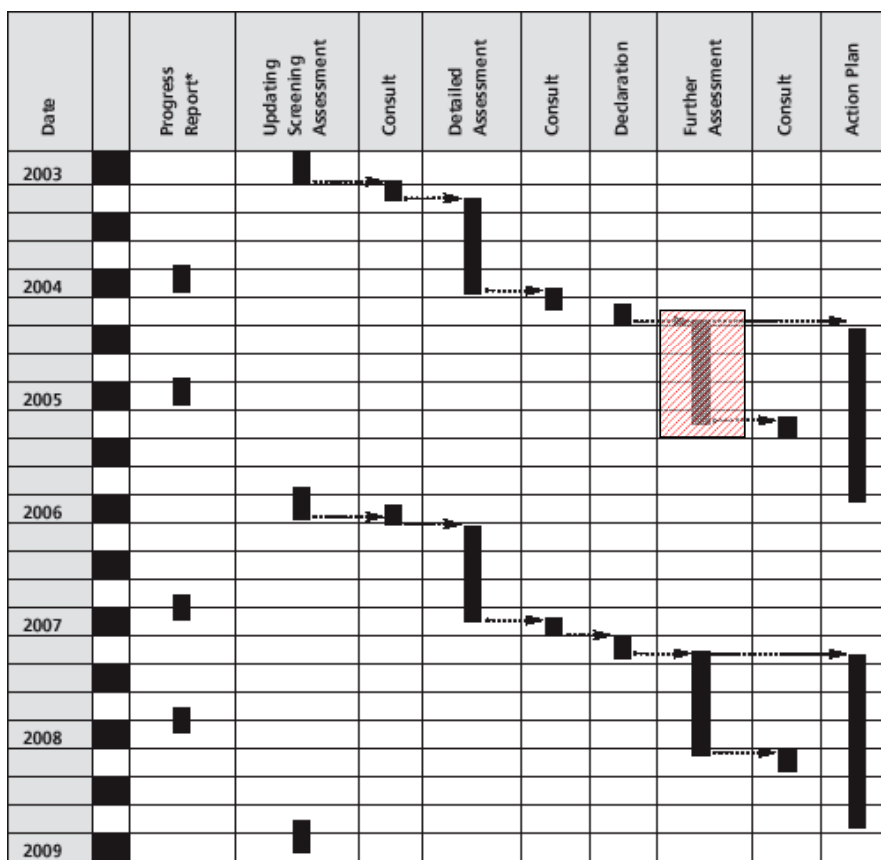
2.3 Phase 2 of Review and Assessment

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.

Where the USA identifies a potential for the AQOs to be exceeded at locations of relevant public exposure, the local authority will be required to undertake a Detailed Assessment. If a Detailed Assessment was not required at this time, a Progress Report would be 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.

A Further Assessment follows the Detailed Assessment, if the need for an AQMA has been identified.

Figure 2.1 Timetable for Review and Assessment (Hashed area shows current assessment timescale)



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

Source: Defra Technical Guidance LAQM.TG(03).

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 local authority 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 NO₂. Elevated monitored concentrations of NO₂ 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.

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2.3.2 Detailed Assessment and Progress Reports

The Detailed Assessment developed further the information gathered and the conclusions reached from the USA. This involved the use of more sophisticated modelling and monitoring techniques, concluding that there was potential for the annual mean NO₂ AQO to be exceeded. Consequently, two AQMAs were declared, as discussed in Section 1.3.

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 Further 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. Since the 2004 Detailed Assessment, RBWM has commenced real-time continuous monitoring of NO_x/NO₂, and has extended the network of passive NO₂ 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, a three-month co-location of triplicate tubes was undertaken by RBWM at the following continuous monitoring stations:

- M25 Gerrard's Cross (South Buckinghamshire District Council)
- Hillingdon Hospital analyser (London Borough of Hillingdon)

In April 2005, co-location of diffusion tubes at the Maidenhead town centre and Clarence Road, Windsor continuous monitoring stations commenced.

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 NO_x/NO₂ Monitoring

In the 2004 Detailed Assessment, Entec incorporated where appropriate, continuous monitoring data from sites outside the Borough, but on the same roads, including the M4 and M25. The monitoring stations included those operated by neighbouring Local Authorities and the Highways Agency. These data were used in the model verification process.

With the introduction of continuous monitoring in the RBWM area, these data will be used in preference, as the locations of the monitoring stations coincide with the AQMAs and thus uncertainties associated with model verification process can be reduced.

The locations of the monitoring stations in Maidenhead town centre and in Windsor at the junction of the A332 and Clarence Road are shown in Figure 3.1 and Figure 3.2 below.

A summary of data from the Maidenhead and Windsor continuous monitors is presented in Tables 3.1 and 3.2.

Figure 3.1 Maidenhead NO_x/NO₂ Monitoring Station, Frascati Way (OS Ref: 488626, 180994)

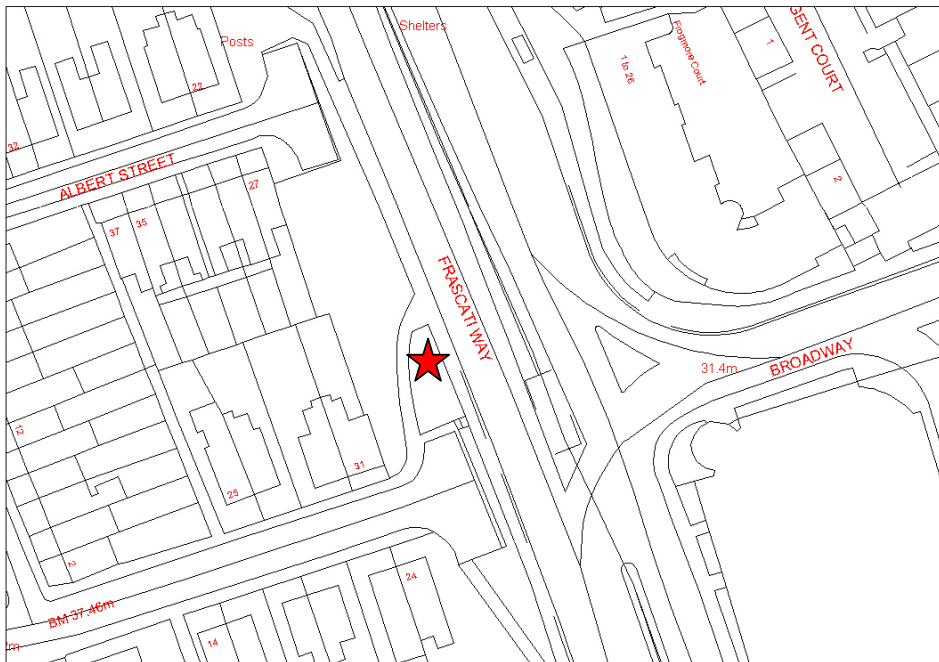
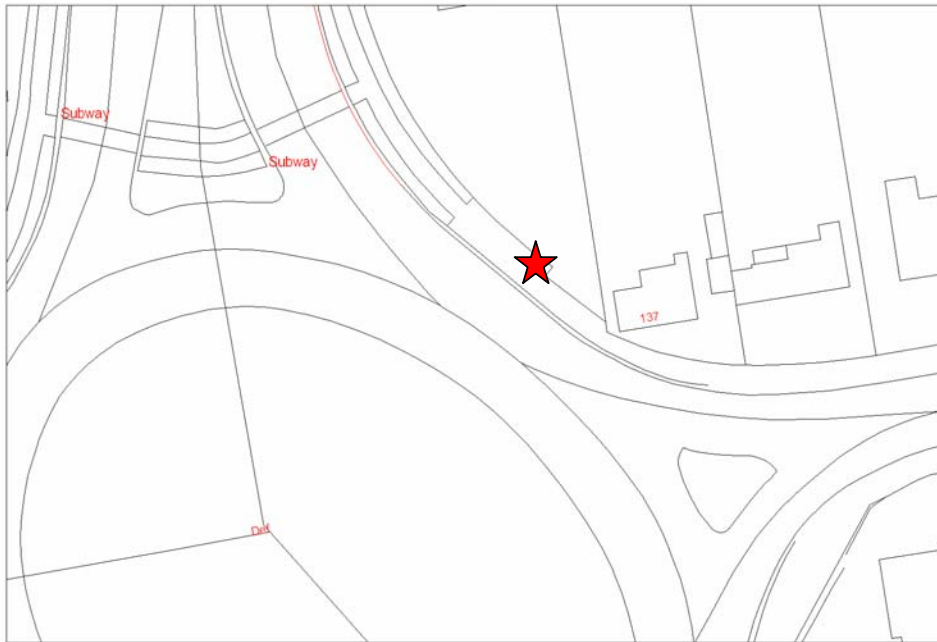


Figure 3.2 Windsor NO_x/NO₂ Monitoring Station, Clarence Road (OS Ref: 495664,176592)



Data available until the 31st December 2005, as presented in Table 3.1, demonstrate that the period mean NO₂ concentration in Windsor was 48.7 µg/m³ and, therefore, in excess of the 40 µg/m³ AQO, if monitoring results from the remainder of the twelve month period were to be similar. The 99.8th percentile NO₂ concentration of 101.4 µg/m³ is significantly below the AQO of 200 µg/m³.

As shown in Table 3.2, at the Maidenhead monitoring station, the period mean NO₂ concentration was 51.1 µg/m³ and, therefore, in excess of the 40 µg/m³ AQO, if monitoring results from the remainder of the twelve month period were to be similar. The 99.8th percentile NO₂ concentration of 101.0 µg/m³ is significantly below the AQO of 200 µg/m³.

Period means have been converted to equivalent annual means, as discussed further in Section 3.2.1.

Table 3.1 Clarence Road, Windsor - Summary of Continuously Monitored NO_x and NO₂ Concentrations (1st March 2005 – 31st December 2005 Provisional Data)

Statistic	2005 NO _x (µg/m ³) Period Mean	2005 NO ₂ (µg/m ³) Period Mean	2005 NO _x (µg/m ³) – Estimated Annual Mean	2005 NO ₂ (µg/m ³) – Estimated Annual Mean
99.8 th Percentile of 1-hour means (µg/m ³)	-	101.4	-	-
Data Capture (%)	92.0	92.0	-	-
Period Mean (µg/m ³)	111.3	48.7	120.6	48.9

Table 3.2 Maidenhead Town Centre - Summary of Continuously Monitored NO_x and NO₂ Concentrations (1st March 2005 – 31st December 2005 Provisional Data)

Statistic	2005 NO _x (µg/m ³) Period Mean	2005 NO ₂ (µg/m ³) Period Mean	2005 NO _x (µg/m ³) – Estimated Annual Mean	2005 NO ₂ (µg/m ³) – Estimated Annual Mean
99.8 th Percentile of 1-hour means (µg/m ³)	-	101.0	-	-
Data Capture (%)	91.0	91.0	-	-
Period Mean (µg/m ³)	133.1	51.1	144.2	51.3

3.2.1 Converting Period Means to Annual Means

With ten months of continuous monitoring data, there is uncertainty in extrapolating the average concentration over this ten month period to an annual mean equivalent. Owing to climatic conditions during the winter months, which may include still and foggy mornings, dispersion

may be restricted. It may therefore be expected that the monitored concentrations over the winter months would be higher than those from March to December and therefore, the annual mean may be higher than the period mean.

A review of year 2004 monitoring data from Defra monitoring stations at Reading, Harlington, Teddington and West London has shown that the period mean is consistently below the annual mean. The period means from 1st March to 31st December 2005, have been compared to the 2004 annual mean, and the ratios between the period mean and the annual means are shown below in Table 3.3.

The site classifications are provided in Table 3.3 and the Defra⁶ definitions of the classifications are as follows:

- Urban Background - Urban locations distanced from sources and broadly representative of city-wide background concentrations which may include elevated locations, parks and urban residential areas;
- Suburban - Sites typical of residential areas on the outskirts of a town or city;
- Roadside - Sites with sample inlets between 1m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5m of the kerbside. Sampling heights are within 2-3m.

Table 3.3 Ratios between Period Means and Annual Mean NO₂ concentrations at Defra Monitoring Stations.

Site Name	Site Classification	2004 Annual Mean NO ₂ (µg/m ³)	2005 Period Mean NO ₂ (µg/m ³)	Ratio of Annual: Period Means
Harlington	Urban Background	38.0	37.2	1.02
Teddington	Urban Background	24.5	24.5	1.00
West London	Urban Background	51.0	49.8	1.02
Reading New Town	Urban Background	25.4	23.7	1.07

On the basis of the statistics presented in Table 3.3, it is considered that the annual mean NO₂ concentration at the Windsor and Maidenhead monitoring stations are likely to be higher than the period mean of 48.7 µg/m³ and 51.1 µg/m³ respectively, which have already been measured. Concentrations in the order of 47.5µg/m³ to 50.9 µg/m³ at the Windsor site and between 49.8 µg/m³ to 53.4 µg/m³ at the Maidenhead site, assuming ratios of 1.00 and 1.07 have been applied to the 2004 period mean (corrected to 2005) may be expected to occur.

An average ratio of 1.03 has been applied to the monitored data to give an estimated annual mean in 2005 of 48.9 µg/m³ in Windsor and 51.3 µg/m³ in Maidenhead.

⁶ <http://www.stanger.co.uk/siteinfo/SiteClassification.asp>

Table 3.4 presents an identical exercise for NO_x, which shows that the average ratio is 1.12, giving an estimated annual mean concentration (corrected to 2005) of 120.6 µg/m³ in Windsor and 144.2 µg/m³ in Maidenhead, compared to period means of 111.3 µg/m³ and 133.1 µg/m³ respectively.

Table 3.4 Ratios between Period Means and Annual Mean NO_x concentrations at Defra Monitoring Stations.

Site Name	Site Classification	2004 Annual Mean NO _x (µg/m ³)	2005 Period Mean NO _x (µg/m ³)	Ratio of Annual: Period Means
Harlington	Urban Background	71.4	58.8	1.21
Teddington	Urban Background	36.6	33.7	1.09
West London	Urban Background	81.4	72.1	1.13
Reading New Town	Urban Background	41.2	39.7	1.04

These NO_x and NO₂ values are used in the model verification process that is discussed further in Section 4.3.

3.2.2 Continuous Monitoring - Quality Assurance

The RBWM monitoring sites are included as part of the London Air Quality Network⁷. Data are downloaded remotely and then scaled and ratified by ERG⁸. Fortnightly calibration checks and filter changes are undertaken by RBWM. UKAS accredited (ISO 17025) six monthly independent audits are undertaken for both analysers and it is only after this audit has taken place that the final data ratification will be complete and the data will be confirmed as 'final'.

It is important to note that at this stage these data are classified by the London Air Quality Network as 'provisional'. It is however unlikely that the 'final' concentrations will vary considerably from the 'provisional' data set.

⁷ <http://www.londonair.org.uk/london/asp/advstats.asp>

⁸ Environmental Research Group, Kings College London.

3.3 Passive NO₂ Monitoring

Most Local Authorities in the UK use diffusion tubes as a cost-effective monitoring technique, mainly for determining NO₂ 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. Although the focus of the Further Assessment is Maidenhead town centre and Clarence Road in Windsor, the diffusion tube monitoring results are presented for all sites across the Borough.

3.3.1 Diffusion Tube Locations

RBWM undertake ambient monitoring of NO₂ concentrations using passive diffusion tubes at 29 locations in the Borough. Fifteen of these diffusion tubes were added to the survey at the start of 2005, in response to the conclusions and recommendations from the Detailed Assessment. Three sites are operated as part of the National NO₂ Diffusion Tube Network.

All diffusion tube locations are summarised in Table 3.5 and those within an AQMA are presented in bold text.

Table 3.5 Location of diffusion tubes in the RBWM

Tube Reference	Location	Site Class	Easting	Northing	Year Started	
1 (N)	WM5	Broadway - Maidenhead	Roadside	488831.69	181030.90	1999
2	WM6	South Road - Maidenhead	Roadside	488627.22	180963.05	2002
3 (N)	WM7	Thames Crescent - Maidenhead	Background	489857.82	182554.19	1999
4 (N)	WM8	Mossey Vale - Maidenhead	Roadside	487982.65	182307.71	1999
5	WM4	The Bingham's - Maidenhead A308	Roadside	489601.68	179201.58	2002
6	WM2	Priors Way - Maidenhead M4	Roadside	489706.19	178789.33	2002
7	WM1	Longmead - Dedworth	Roadside	494067.16	176764.19	2002
8	WM9	Alma Road - Windsor	Roadside	496177.98	176329.84	2002
9 (a)	WM10(a)	Imperial Way - Windsor	Roadside	495607.67	176464.58	2002-2004
9 (b)	WM10(b)	Imperial Way - Windsor	Roadside	495616.08	176439.44	Feb 2005
10 (a)	WM14(a)	High Street - Maidenhead	Roadside	n/a	n/a	2002-2004
10 (b)	WM14(b)	High Street – Wraysbury	Roadside	500484.51	174027.59	2005
11	WM13	Wraysbury Road - Hythe End M25	Background	502103.87	172507.70	2002
12	WM11	St Lukes Road - Old Windsor	Roadside	498433.11	174706.92	2003
13	WM12	Straight Road - Windsor	Roadside	499290.08	173422.84	2003
14	WM24	Clarence Rd	Roadside	495686.18	176577.81	2005
15	WM18	AQMS Windsor 1	Roadside	495664.00	176592.00	2005
16	WM19	AQMS Windsor 2	Roadside	495664.00	176592.00	2005
17	WM20	AQMS Windsor 3	Roadside	495664.00	176592.00	2005
18	WM21	AQMS Maidenhead 1	Roadside	488626.00	180994.00	2005
19	WM22	AQMS Maidenhead 2	Roadside	488626.00	180994.00	2005
20	WM23	AQMS Maidenhead 3	Roadside	488626.00	180994.00	2005
21	WM3	M4 Façade Priors Way Façade	Roadside	489557.00	178782.61	2005
22	WM28	Eton Wick	Roadside	496604.07	177865.68	2005
23	WM16	Ousley Road Lamp post adj 47	Roadside	499135.65	173623.52	2005
24	WM25	Sunninghill High Street	Roadside	493625.63	167811.69	2005
25	WM27	London A30 train station	Roadside	495289.77	166765.54	2005
26	WM17	Horton Road	Roadside	498876.67	177041.81	2005
27	WM26	Windsor Road, Paddock House	Roadside	n/a	n/a	2005
28	WM29	M4 Façade site2 Windsor Road	Roadside	489984.21	178715.91	2005
29	WM15	M25 Façade Wrays Road	Roadside	502260.09	172335.34	2005

Notes: (N) = National Diffusion Tube Locations

3.3.2 Diffusion Tube Monitoring Results

Table 3.6 shows the concentrations monitored at the diffusion tube sites in RBWM since 2002. The tube references are linked to Table 3.5, which provides full details of the site locations. These data have not been bias corrected.

Table 3.6 Diffusion tube monitoring results (non bias corrected data)

Ref	Location	Annual Mean NO ₂ (µg/m ³) - Values in brackets show no. mths data			
		2002	2003	2004	2005
1	Broadway	61.45 (11)	68.00 (10)	55.07 (11)	66.69 (8)
2	South Road	34.36 (11)	43.32 (8)	36.20 (12)	38.72 (8)
3	Thames Crescent	24.76 (11)	26.89 (10)	21.30 (12)	21.79 (8)
4	Mossey Vale	27.12 (10)	33.62 (9)	30.54 (4)	18.90 (4)
5	The Bingham	40.87 (10)	45.26 (10)	38.71 (12)	43.14 (8)
6	Priors Way	48.33 (10)	49.02 (10)	40.02 (12)	43.83 (8)
7	Longmead	25.88 (9)	32.90 (8)	24.75 (12)	27.09 (8)
8	Alma Road	36.68 (10)	51.36 (7)	34.38 (12)	36.54 (8)
9a	Imperial Way (West)	38.32 (10)	55.38 (10)	41.63 (9)	-
9b	Imperial Way (East)	-	-	-	41.22 (6)
10a	High St – Maidenhead	32.72 (10)	35.75 (9)	31.25 (12)	-
10b	High St – Wraysbury	-	-	-	27.60 (8)
11	Wraysbury Road	43.89 (9)	45.15 (9)	41.24 (12)	41.19 (8)
12	St Lukes Road	-	41.53 (8)	31.68 (12)	34.47 (8)
13	Straight Road	-	49.17 (8)	42.99 (12)	48.97 (8)
14	Clarence Rd	-	-	47.20 (2)	50.21 (7)
15	AQMS Windsor 1	-	-	-	47.43 (6)
16	AQMS Windsor 2	-	-	-	46.78 (6)
17	AQMS Windsor 3	-	-	-	46.09 (6)
18	AQMS Maidenhead 1	-	-	-	51.34 (6)
19	AQMS Maidenhead 2	-	-	-	53.53 (6)
20	AQMS Maidenhead 3	-	-	-	50.09 (6)
21	M4 Façade Priors Way	-	-	-	31.12 (4)
22	Eton Wick	-	-	-	38.76 (3)
23	Ousley Road	-	-	-	28.06 (3)
24	Sunninghill High Street	-	-	-	27.76 (3)
25	London A30 train station	-	-	-	23.30 (2)
26	Horton Road	-	-	-	28.77 (3)
27	Windsor Rd, Paddock Hse	-	-	-	25.79 (3)
28	M4 Façade Windsor Road	-	-	-	48.33 (2)
29	M25 Façade Wrays Road	-	-	-	45.81 (6)

3.3.3 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 NO₂ analyser. Essentially, an estimate of bias for the diffusion tubes is determined on the basis of the difference between the NO₂ 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 NO₂ 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, a three-month co-location of triplicate tubes was undertaken by RBWM. In April 2005, co-location of diffusion tubes at the Maidenhead town centre and Clarence Road, Windsor continuous monitoring stations commenced. The results of these surveys are discussed further in Section 3.3.4.

Where co-location has not been undertaken, or where there is only a short period of co-location data available, data presented in report produced on behalf of Defra⁹, 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 3.7.

From the data available, it is shown that on average, the diffusion tubes in 2002, 2003 and 2004 are more likely to underestimate concentrations of NO₂ in comparison with a continuous monitor. However, in 2002, some Local Authority tubes underestimated NO₂ concentrations by as much as -18.9%, while others overestimated 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 accurately, which is considered unlikely.

The bias correction for 2003 is calculated at 0.96, suggesting a slight underestimation, with the results ranging from -5.3% of the monitored value to 27.7%.

In 2004, the bias correction factor is calculated at 0.94, again suggesting a slight underestimation, with the results ranging from -14.9% to 34.0% of the continuously monitored value.

⁹ Compilation of diffusion tube co-location studies carried out by Local Authorities. Laxen, D & Wilson, P, on behalf of Defra, November 2002.

Table 3.7 Diffusion tube bias for tubes prepared and analysed by Gradko using 20% TEA in water. Results presented for 2002, 2003 and 2004.

Year	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) ($\mu\text{g}/\text{m}^3$)	Automatic Monitor Mean Conc. (Cm) ($\mu\text{g}/\text{m}^3$)	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
					<i>Average</i>	1.00
2003	Dudley MBC	9	52	52	0.6%	0.99
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	Mid Beds DC	12	39	38	1.4%	0.99
2003	Highland Council	9	27	24	11.4%	0.90
2003	AEA Tech intercomparison	12	39	31	27.7%	0.78
2003	St Albans DC	12	32	30	5.0%	0.95

Year	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) ($\mu\text{g}/\text{m}^3$)	Automatic Monitor Mean Conc. (Cm) ($\mu\text{g}/\text{m}^3$)	Bias (B)	Bias Adjustment Factor (A) (Cm/Dm)
					<i>Average</i>	0.96
2004	LB Ealing	10	55	54	0.9%	0.99
2004	LB Ealing	12	44	41	6.0%	0.94
2004	Exeter CC	12	35	39	-11.9%	1.13
2004	Dudley MBC	11	29	26	12.8%	0.89
2004	Macclesfield BC	12	33	38	-14.9%	1.18
2004	Dudley MBC	12	46	47	-2.5%	1.03
2004	South Lakeland DC	12	36	27	34.0%	0.75
2004	Rushmoor BC	11	39	30	27.4%	0.79
2004	St Albans DC	12	25	25	0.8%	0.99
2004	AEA Tech Intercomparison	12	30	24	21.8%	0.82
					<i>Average</i>	0.94

<http://www.uwe.ac.uk/aqm/review/index.html>

Data from Spreadsheet version 09/05

3.3.4 Local Diffusion Tube Co-location Data

A co-location study was undertaken by RBWM for a period of three months in 2004 and these data were incorporated into the Detailed Assessment. This was based on triplicate diffusion tubes and chemiluminescent analyser concentrations monitored at Gerrard's Cross and at Hillingdon Hospital, as no continuous monitoring was undertaken in RBWM. The diffusion tube bias was calculated on the basis of three-months of monitoring data (April, May, June 2004).

Since the installation of two continuous monitors in the Borough, RBWM has undertaken local co-location studies at the analysers located in Maidenhead town centre and Clarence Road, Windsor. Triplicate results are available for both sites from April 2005 to September 2005 (6 months).

Data from a local co-location study 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 co-location study from the Detailed Assessment demonstrates that the diffusion tubes at both locations are likely to slightly underestimate continuously monitored results. The Further Assessment results show that the tubes exposed in Windsor slightly underestimate, while those in Maidenhead slightly overestimate.

Details of the co-location studies are presented below:

Detailed Assessment Results (2004)

Gerrard's Cross:

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

Hillingdon Hospital:

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

Further Assessment Results (2005)

Windsor:

- (Dm) Diffusion Tube Mean April-August = $47.11 \mu\text{g}/\text{m}^3$
- (Cm) Analyser Mean April-August = $48.7 \mu\text{g}/\text{m}^3$
- $\text{Cm}/\text{Dm} = 48.7 \mu\text{g}/\text{m}^3 / 47.11 \mu\text{g}/\text{m}^3 = 1.03$

Maidenhead:

- (Dm) Diffusion Tube Mean April-August = $52.75 \mu\text{g}/\text{m}^3$
- (Cm) Analyser Mean April-August = $49.8 \mu\text{g}/\text{m}^3$
- $\text{Cm}/\text{Dm} = 49.8 \mu\text{g}/\text{m}^3 / 52.75 \mu\text{g}/\text{m}^3 = 0.94$

Table 3.8 shows the same data as Table 3.6 but, the diffusion tube concentrations have been bias corrected by a factor of 1.03, based on results of the local co-location studies undertaken by RBWM in 2004 and 2005. As a precautionary approach, the Maidenhead diffusion tubes have been bias corrected by a factor of 1.03 rather than 0.94.

Table 3.8 Diffusion tube monitoring results, bias corrected data using a factor of 1.03

Ref	Location	Bias Corrected Annual Mean NO ₂ (µg/m ³)			
		2002	2003	2004	2005
1	Broadway	63.30 (11)	70.04 (10)	56.72 (11)	68.69 (8)
2	South Road	35.40 (11)	44.62 (8)	37.28 (12)	39.88 (8)
3	Thames Crescent	25.50 (11)	27.70 (10)	21.94 (12)	22.44 (8)
4	Mossey Vale	27.94 (10)	34.63 (9)	31.46 (4)	19.47 (4)
5	The Bingham	42.10 (10)	46.61 (10)	39.87 (12)	44.43 (8)
6	Priors Way	49.78 (10)	50.49 (10)	41.22 (12)	45.15 (8)
7	Longmead	26.65 (9)	33.89 (8)	25.50 (12)	27.90 (8)
8	Alma Road	37.78 (10)	52.90 (7)	35.41 (12)	37.64 (8)
9a	Imperial Way (West)	39.47 (10)	57.04 (10)	42.88 (9)	-
9b	Imperial Way (East)	-	-	-	42.45 (6)
10a	High St – Maidenhead	33.70 (10)	36.82 (9)	32.19 (12)	-
10b	High St – Wraysbury	-	-	-	28.43 (8)
11	Wraysbury Road	45.21 (9)	46.51 (9)	42.48 (12)	42.42 (8)
12	St Lukes Road	-	42.77 (8)	32.63 (12)	35.50 (8)
13	Straight Road	-	50.64 (8)	44.28 (12)	50.44 (8)
14	Clarence Rd	-	-	48.61 (2)	51.72 (7)
15	AQMS Windsor 1	-	-	-	48.86 (6)
16	AQMS Windsor 2	-	-	-	48.19 (6)
17	AQMS Windsor 3	-	-	-	47.47 (6)
18	AQMS Maidenhead 1	-	-	-	52.88 (6)
19	AQMS Maidenhead 2	-	-	-	55.14 (6)
20	AQMS Maidenhead 3	-	-	-	51.59 (6)
21	M4 Façade Priors Way	-	-	-	32.05 (4)
22	Eton Wick	-	-	-	39.93 (3)
23	Ousley Road	-	-	-	28.90 (3)
24	Sunninghill High Street	-	-	-	28.59 (3)
25	London A30 train station	-	-	-	24.00 (2)
26	Horton Road	-	-	-	29.64 (3)
27	Windsor Rd, Paddock Hse	-	-	-	26.57 (3)
28	M4 Façade Windsor Road	-	-	-	49.78 (2)
29	M25 Façade Wrays Road	-	-	-	47.19 (6)

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.

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, NO₂ and PM₁₀. As identified in the Detailed Assessment, the pollutant of focus for the Further Assessment is NO₂, in the areas of the designated AQMAs.

The model has been used to predict concentrations of pollutants in two stages. The first stage 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 µg/m³ in the year 2005, then no further modelling would be required to determine the extent of exceedence.

As monitored concentrations are above the AQO, and the modelled areas are within AQMAs, modelling was also undertaken at 10 metre intervals on a two-dimensional grid, which facilitates the interpolation of contour lines of equal levels of pollution.

All modelling was undertaken for the base year (2004) and the year of the relevant objective, which is 2005 for nitrogen dioxide. The year 2004 was used as the base year, as road traffic data and meteorological data are both available for this year, as 2004 was the last full calendar year.

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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 NO₂ (µg/m³) estimates for the year 2001 and 2005.

From this data, a NO_x background concentration of 64.7 µg/m³ for 2001 was selected as most representative of concentrations in the vicinity of Clarence Road in Windsor and 70.7 µg/m³ was selected for Maidenhead. Using the correction factors in LAQM TG(03), these 2001 concentrations were scaled to levels estimated for 2004, which were used for the base year modelling. The same approach was taken to estimate background concentrations of NO₂. Estimates for 2005 are provided directly in the Netcen data set.

A summary of these concentrations is shown in Table 4.1. It can be seen that the 2004 background NO₂ concentration derived from the Netcen estimates falls between the background NO₂ concentrations monitored by diffusion tubes at Thames Crescent (21 µg/m³) and Wraysbury Road (42 µg/m³) as shown in Section 3.0.

Table 4.1 Background NO_x and NO₂ concentrations derived from Netcen estimates and applied to Modelled Values

Pollutant	2001	2004	2005
NO _x (µg/m ³) Windsor	64.7	58.0	54.7
NO ₂ (µg/m ³) Windsor	34.1	31.6	30.4
NO _x (µg/m ³) Maidenhead	70.7	63.4	58.2
NO ₂ (µg/m ³) Maidenhead	36.2	36.2	31.7

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

For the purposes of a Detailed Assessment or Further 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 3.3 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 NO₂ monitoring and, data available from the monitoring stations in Maidenhead town centre and at Clarence Road, Windsor, will be used for this assessment. In comparison, before continuous monitoring data were available within the Borough, the Detailed Assessment verification relied on diffusion tube data for the modelling undertaken in Maidenhead and Windsor. Continuous monitoring undertaken by South Buckinghamshire District Council at Gerrard's Cross were used for verification of modelled concentrations adjacent to the M4 and M25 motorways.

The verification methods used in the Further Assessment are discussed further below. Additional information is included in Appendix B.

4.3.1 Annual Mean Predictions of NO_x/NO₂

In TG(03) Defra has provided guidance in terms of three preferred methods for undertaking dispersion model verification¹⁰, each suitable for different situations. Each method is summarised below:

- Method 1 - Adjustment of annual average NO₂ based on a single continuous monitoring site using a multiplication factor;
- Method 2 - Adjustment of annual average NO₂ based on a single continuous monitoring site using a constant offset of background;
- Method 3 - Verification of annual average NO₂ based on two continuous roadside monitoring sites and 10 roadside diffusion tube sites.

Model Verification - Windsor

The verification was based on the relationship between modelled and monitored concentrations at the site of the continuous monitoring station located within the AQMA at Clarence Road, Windsor.

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 NO₂ could have been improved at the location of the

¹⁰ LAQM TG.(03) page A3-37.

Clarence Road continuous monitor, as the final modelled concentration was 4.46 $\mu\text{g}/\text{m}^3$ lower than the actual monitored concentration. On the basis of this information, a secondary correction factor (1.10) was applied to the final NO_2 modelled concentration (NO_2TotMod) to bring this into line with the monitored concentration at Clarence Road.

Model Verification – Maidenhead

The verification was based on the relationship between modelled and monitored concentrations at the site of the continuous monitoring station located within the AQMA at Frascati Way, Maidenhead.

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 Clarence Road continuous monitor, as the final modelled concentration was 2.16 $\mu\text{g}/\text{m}^3$ lower than the actual monitored concentration. On the basis of this information, a secondary correction factor (1.04) was applied to the final NO_2 modelled concentration (NO_2TotMod) to bring this into line with the monitored concentration at Frascati Way.

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 $\mu\text{g}/\text{m}^3$, an exceedence of the hourly mean objective is unlikely. The continuous monitoring data from Clarence Road and Frascati Way supports the conclusion that the short-term NO_2 objective is unlikely to be exceeded.

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 NSCA¹¹, 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:

$$\text{SDM} = U \times \text{Co} \quad (\text{where Co is the air quality objective under consideration})$$

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.

¹¹ Air Quality Management Areas: Turning Reviews into Action. National Society for Clean Air & Environmental Protection, 1999.

Using the above information, the SDM of the model when applying a mean Stock U Value for the annual NO₂ objective is given as follows:

$$\begin{aligned}\text{SDM} &= 0.1 \times 40 \\ &= 4 \mu\text{g}/\text{m}^3\end{aligned}$$

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 $\mu\text{g}/\text{m}^3$ 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 NO₂ objective are shown, it would be recommended that an AQMA should be drawn based on the 36 $\mu\text{g}/\text{m}^3$ contour line rather than the 40 $\mu\text{g}/\text{m}^3$ 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 NO₂ concentrations

Table 5.1 presents a summary of the maximum and minimum predicted NO₂ concentrations at sensitive receptors in the Windsor and Maidenhead AQMAs. The modelled concentrations are significantly above the 40 µg/m³ Objective.

Table 5.1 Verified modelling results at sensitive receptors in RBWM

Annual Mean	Minimum	Maximum
Windsor - NO ₂ (µg/m ³) 2004	35.54	49.41
Windsor - NO ₂ (µg/m ³) 2005	34.18	47.47
Maidenhead - NO ₂ (µg/m ³) 2004	38.32	77.22
Maidenhead - NO ₂ (µg/m ³) 2005	36.12	74.04

5.3 Comparison with Diffusion Tube Monitoring

Following the process of model verification, the modelled concentrations at the diffusion tube locations have been compared with the monitored values. Monitored diffusion tube concentrations in 2004 were used for this comparison, as they represented the most recent full calendar year of NO₂ monitoring. To provide an additional comparison and to also reflect the variability in the diffusion tube measurements, the 2005 monitored concentrations are presented. The 2005 values are used in the percentage calculations where monitoring data are not available for 2004.

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 -28.41% and plus 10.34% 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 bias corrected on the basis of the co-location study undertaken by RBWM, using a factor of 1.03, as discussed in Section 3.2.4.

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

Tube Ref	Location	Site Class	Modelled Annual Mean NO ₂ (µg/m ³) 2004	Monitored Mean NO ₂ (µg/m ³) 2004 (2005 in brackets ¹)	% Diff Model : Monitor 2004 (2005 in brackets)	Modelled Annual Mean NO ₂ (µg/m ³) 2005
1	Broadway, M.Head	Roadside	58.87	56.72 (68.69)	-3.79	56.13
2	South Road' M.Head	Roadside	47.87	37.28 (39.88)	-28.41	45.36
8	Alma Road, Windsor	Roadside	35.48	35.41 (37.64)	-0.20	34.12
9a	Imperial Way (West), Windsor	Roadside	39.38	42.88 (-)	8.16	37.85
9b	Imperial Way (East), Windsor	Roadside	39.59	- (42.45)	(10.34)	38.06
14	Clarence Road, Windsor	Roadside	47.36	48.61 (51.72)	2.57	45.51
15-17	AQMS Windsor	Roadside	49.10	- (48.17)	(2.06)	47.18
18-20	AQMS M.Head	Roadside	51.32	- (53.20)	(8.52)	48.67

¹ Based on data to the end of September 2005.

5.4 Areas of Potential NO₂ Exceedence

The data presented in Table 5.1 demonstrates that there are a number of receptors where the 2005 annual mean NO₂ air quality objective is shown as likely to be exceeded. Exceedences

may not necessarily occur at residential properties or at other locations where the objectives and contouring has been undertaken to determine the extent of any relevant exceedence. Figures 5.1 to 5.3 show contour maps of predicted annual mean NO₂ concentrations in the areas that have been declared as AQMAs.

The contours should be reviewed in the context of uncertainties as discussed in Section 4.4. Where annual mean NO₂ concentrations exceed 40 µg/m³ at a relevant receptor, the 36 µg/m³ contour should be considered as the line of possible exceedence.

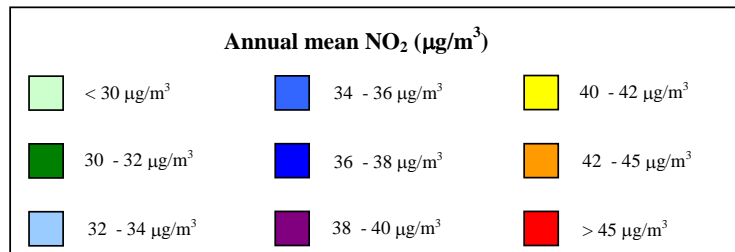
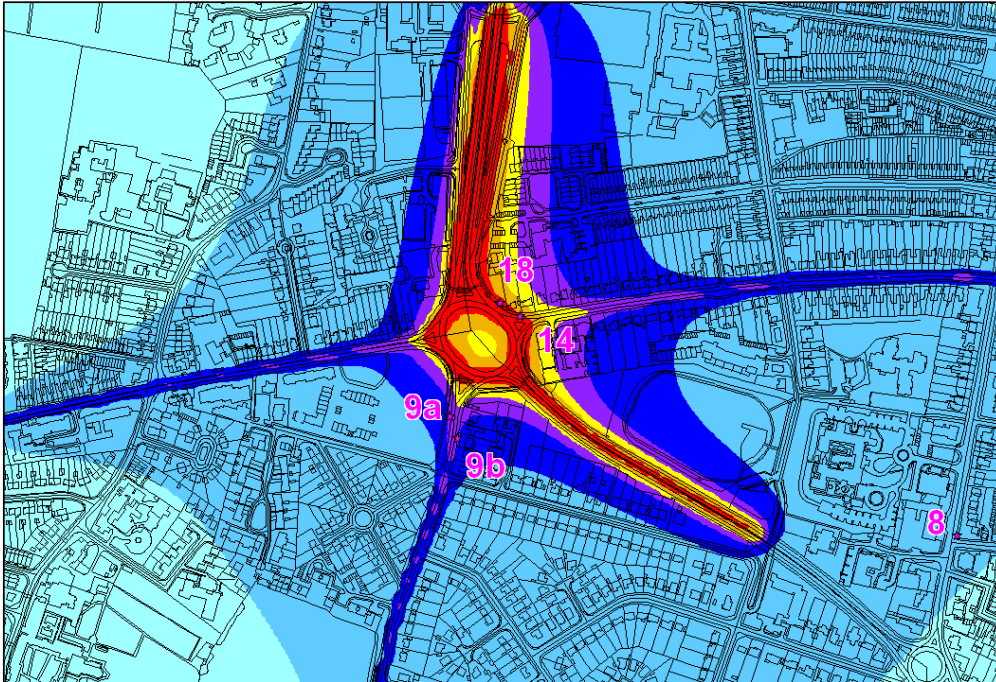
5.4.1 Location 1 - Windsor (495640,176560)

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/m³ contour extends in all directions from the A332 roundabout and appears that residential areas are subject to predicted exceedences of the NO₂ annual mean air quality objective.

The locations of diffusion tubes at Alma Road (8), Imperial Way (9a and 9b) and Clarence Road (14) 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 2004 baseline, the model predicted an annual mean NO₂ concentration at Alma Road (8) of 35.48 µg/m³, compared to a bias corrected monitored concentration of 35.41 µg/m³. At Imperial Way West (9a) the model predicted an annual mean NO₂ concentration of 39.38 µg/m³, compared to a bias corrected monitored concentration of 42.88 µg/m³.

At Imperial Way East (9b) the model predicted a 2005 annual mean NO₂ concentration of 38.06 µg/m³, compared to a bias corrected monitored concentration of 42.45 µg/m³. At Clarence Road (14) the model predicted a 2005 annual mean NO₂ concentration of 45.51 µg/m³, compared to a bias corrected monitored concentration of 51.72 µg/m³.

Figure 5.1 Windsor, 2005 Predicted Concentrations of NO₂ (µg/m³)



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 exceedences of $40 \mu\text{g}/\text{m}^3$ extend into residential areas on either side of the A308, and that widescale exceedences are shown across the modelling domain. As the model verification was based on continuous monitoring data from a roadside site, it is possible that there may be some over-estimation in NO_2 concentrations at locations where ambient concentrations are close to background levels.

The locations of diffusion tubes at Broadway (1), South Road (2) and Frascati Way (20) are also shown in Figure 5.2. On the basis of the 2004 baseline, the model predicted an annual mean NO_2 concentration of $58.87 \mu\text{g}/\text{m}^3$ at Broadway compared to a bias corrected monitored concentration of $56.72 \mu\text{g}/\text{m}^3$. At the South Road diffusion tube site, the model gives a concentration of $47.87 \mu\text{g}/\text{m}^3$ compared to a monitored annual average of $37.28 \mu\text{g}/\text{m}^3$. At the location of the continuous analyser in Frascati Way, the model gives a concentration of $48.67 \mu\text{g}/\text{m}^3$ compared to a monitored annual average of $53.20 \mu\text{g}/\text{m}^3$.

Figure 5.2 Maidenhead (North), 2005 Predicted Concentrations of NO₂ (µg/m³)

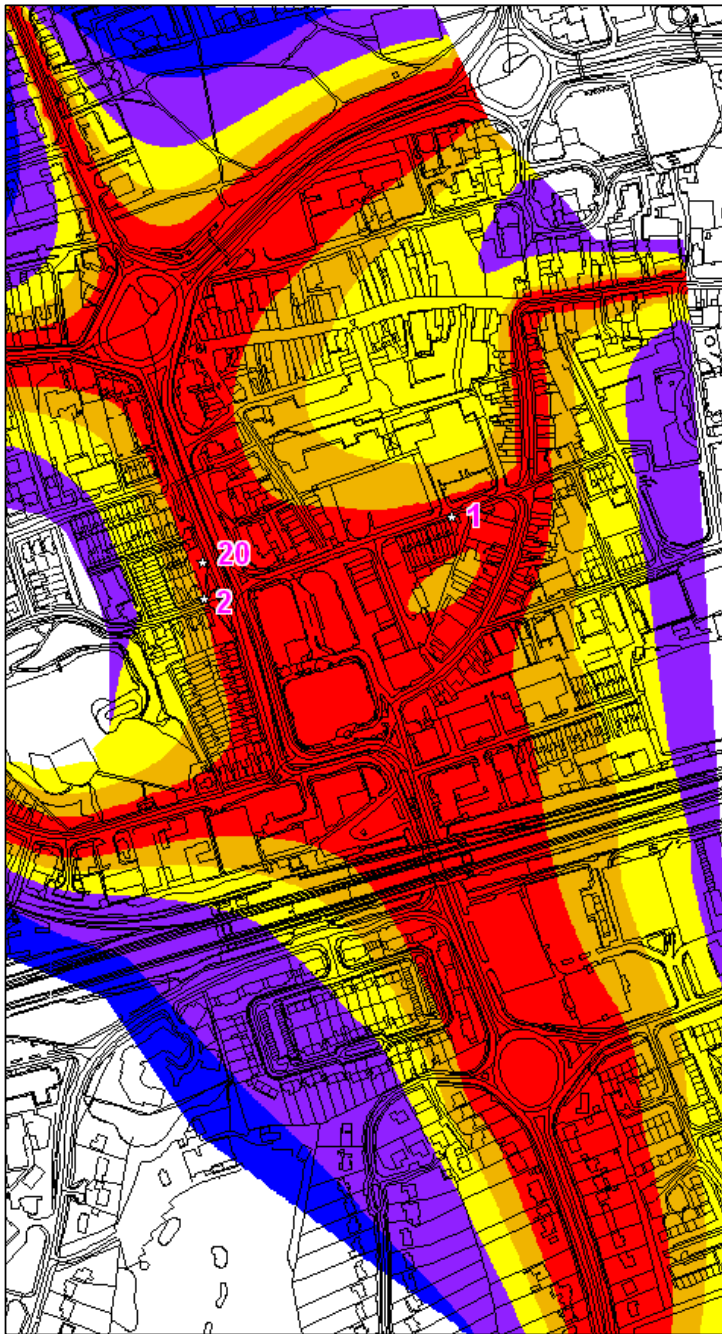
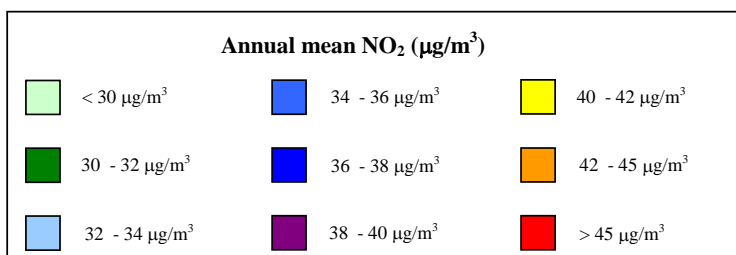


Figure 5.3 Key for Maidenhead NO₂ (µg/m³) Contour



5.5 Emission Reduction Requirements

One of the aims of the Further Assessment is to provide an indication in terms of the emission reductions required in order to meet the AQOs.

At the location of the Windsor continuous monitor, the dispersion modelling has demonstrated that a 59 percent reduction in NO_x road traffic emissions would be required to bring about a 16 percent reduction in total NO₂ concentrations of 8 µg/m³, thus meeting the 40 µg/m³ AQO. There are sensitive receptors with the same predicted NO₂ concentrations as the location of the continuous monitoring station and, therefore, this level of reduction will also be required at the receptor locations that are closest to the roads included in the modelling assessment.

At the location of the Maidenhead continuous monitor, the dispersion modelling has demonstrated that a 64 percent reduction in NO_x road traffic emissions would bring about a 19 percent reduction in total NO₂ concentrations of 9 µg/m³, thus meeting the 40 µg/m³ AQO. Similar percentage reductions in emissions will be required in order to meet the AQOs at sensitive receptor locations.

The percentage reduction in NO_x from road traffic that is required to meet the NO₂ AQO is particularly high, partly because the background NO₂ concentrations in 2005 are estimated to be in the order of 30-32 µg/m³, and therefore, on their own, represent 75% of the AQO. With a total monitored concentration of approximately 50 µg/m³, a 10 µg/m³ reduction is sought to meet the 40 µg/m³ AQO. Assuming a contribution to total concentrations of 20 µg/m³ is attributable to the road traffic, a 10 µg/m³ reduction equals 50 percent. The difference between 50 and 59 or 64 percent is likely to be attributable to the NO_x:NO₂ conversion and the method of model verification.

6. Conclusions and Recommendations

6.1 Summary of Road Traffic Impacts

The Further Assessment builds on the data gathered and the conclusions reached in the Detailed Assessment, submitted to Defra in August 2004. The Detailed Assessment concluded that on the basis of detailed dispersion modelling and passive diffusion tube monitoring, the annual mean nitrogen dioxide (NO₂) air quality objective was unlikely to be met by the required date at locations in Maidenhead town centre and at the junction of the A332 and Clarence Road in Windsor.

This led to RBWM declaring two Air Quality Management Areas (AQMAs) at these locations. Following this declaration, continuous monitoring of NO_x/NO₂ commenced within the AQMAs in March 2005.

The Further Assessment has focused on air quality within these two AQMAs and, has primarily involved the updating of the dispersion modelling with revised estimates of traffic flows for 2004 and 2005, year 2004 hourly meteorological data from Heathrow Airport, and most significantly, the incorporation of local continuous monitoring data into the model verification process.

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.

These enhancements to the Detailed Assessment methodology will serve to reduce the uncertainty of the Further Assessment in terms of the modelled estimates and the associated zones of exceedence.

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. Local continuous monitoring has shown the exceedence of the 1-hour mean Objective is unlikely to occur.

The Further Assessment, incorporating model verification against local continuous monitoring, has demonstrated that exceedences of the annual mean NO₂ AQO remain likely to occur in Maidenhead town centre and at the junction of the A332 and Clarence Road in Windsor, thus confirming the conclusions of the 2004 Detailed Assessment report.

In the case of the AQMA in Windsor, the Further Assessment modelling suggests that the zone of the highest concentrations is narrower than that identified in the 2004 Detailed Assessment report. The modelling indicates that the pollution hotspots are more confined to the roundabout and its environs, and that concentrations above $45 \mu\text{g}/\text{m}^3$ do not extend as far along Clarence Road to the east and west of the roundabout and, along Imperial Way and Goslar Way to the south-west and south-east respectively.

In Maidenhead, the dispersion modelling suggests that the zone of exceedence may be wider than that reported in the Detailed Assessment report, although this may in part be an artefact of the dispersion modelling.

When considering the effects of the random error of the model, as discussed in Section 4.4, a level of increased uncertainty 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 $36 \mu\text{g}/\text{m}^3$ contour be used to define the extent of the likely exceedence.

On the basis of the Further Assessment it is recommended that the Council retain the AQMA in Maidenhead town centre and at the junction of the A332 and Clarence Road in Windsor. There is evidence to suggest that the AQMA in Maidenhead could be extended, although it is recommended that the Council introduce additional diffusion tube monitoring at residential property façades to further quantify NO_2 concentrations in more suburban areas, and continue to develop an Action Plan on the basis of the current AQMA. When more monitoring data is available, the Council could then make a judgement in relation to modifying the extent of the AQMA.

6.2 Recommendations for Further Work

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

- Continue the continuous NO_x/NO_2 monitoring in Windsor and Maidenhead. Continue the co-location of triplicate diffusion tubes alongside the monitoring stations;
- Site diffusion tubes at residential property façades in all areas where high levels of NO_2 are forecast;
- Proceed with the development of an Air Quality Action Plan;
- Undertake a 2006 Updating and Screening Assessment.

Appendix A Road Traffic Data

1 Page

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Table A.1 Traffic Data Provided by RBWM on 03/10/2005 for use in the Further Assessment

Ref	Road	AADT 2003	AADT 2004	AADT 2005	HGV %	Speed (km/hr)
1	A308 Craufurd Road	16,605	14,257	13,997	3	50
2	A4 Saint Cloud Way	26,568	25,977	25,266	3	40
3	A4 Bath Road	20,129	22,108	21,270	3	55
4	Roundabout (A4) / 2	11,674	11871*	12072*	2	25
5	A308 Fra. Way	16,605	16886*	17171*	3	50
6	Grenfell Road	17,388	17682*	17980*	3	40
7	Grenfell Road (A308)	38,240	35,814	36,134	3	40
8	Broadway	10000*	10169*	10340*	3	35
9	Queen Street	10000*	10169*	10340*	3	40
10	High Street	10000*	10169*	10340*	3	40
11	A308 King Street	38,240	35,814	36,134	3	40
12	A308 Roundabout	19,120	19443*	19772*	3	25
13	A308 Roundabout / 2	9,560	9722*	9886*	3	25
15	A308 Braywick Road (N) / 2	19,120	17,326	17,440	3	40
16	A308 Braywick Road (S) / 2	19,120	18,488	18,694	3	40
20	A308 Braywick Road	38,240	35,814	36,134	3	40
21	B3024 Clarence Road (west)	5740*	5837*	5936*	3	30
22	B3173 Imperial Road	5740*	5837*	5936*	3	30
23	A308 Goslar Way	20,019	22,344	23,479	3	80
24	Clarence Road (east)	5035*	5120*	5207*	3	30
25	A332 W&E relief (slip on from Maidenhead Arthur Road)	5766*	5863*	5962*	3	30
26	A332 W&E relief south	28828*	30,301	32,144	3	80
27	A332 W&E relief north	28828*	30,589	30,754	3	80
28	A332 W&E relief (slip off to A308)	5766*	5863*	5962*	3	30
29	roundabout	28,828	30,589	30,754	3	25
30	M4 (J7-J8)	134,184	136452*	138758*	9	112
31	M25 (based on flows from J15-J16)	184,290	187405*	190571*	13	96
32	B376 Wraysbury Road	7000*	7118*	7238*	3	60
33	A308 slip road	18429*	18740*	19057*	3	80

* Identified by RBWM as estimated traffic flows.

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Appendix B Model Verification

2 Pages

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Table B.1 Model Verification Process - Windsor

Element	Value
[No2]TotMon (Roadside total monitored NO2 concentration)	48.90
[Nox]TotMon (Roadside total monitored NOx concentration)	120.90
[Nox]Bkgd (Background NOx)	57.97
[No2]Bkgd (Background NO2)	31.61
[Nox]RoadsMod (Modelled roadside NOx contribution)	15.70
[Nox]RoadsMon (Monitored NOx roadside contribution)	62.93
[No2]RoadsMon (Monitored NO2 roadside contribution)	17.29
NOx[AdjustmentRoadsMod] (adjustment factor for modelled roadside contribution)	4.01
Nox[CorrRoadsMod]	62.93
F (proportion of NOx converted to NO2)	0.20
[NO2]RoadsMod (Modelled Roadside NO2 =Nox[CorrRoadsMod] x F)	12.83
[NO2]TotMod	44.44
Additional NO2 correction	1.100
FINAL NO2	48.9

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Table B.2 Model Verification Process - Maidenhead

Element	Value
[No2]TotMon (Roadside total monitored NO2 concentration)	51.31
[Nox]TotMon (Roadside total monitored NOx concentration)	144.58
[Nox]Bkgd (Background NOx)	63.36
[No2]Bkgd (Background NO2)	33.58
[Nox]RoadsMod (Modelled roadside NOx contribution)	4.78
[Nox]RoadsMon (Monitored NOx roadside contribution)	81.22
[No2]RoadsMon (Monitored NO2 roadside contribution)	17.73
NOx[AdjustmentRoadsMod] (adjustment factor for modelled roadside contribution)	16.99
Nox[CorrRoadsMod]	81.22
F (proportion of NOx converted to NO2)	0.19
[NO2]RoadsMod (Modelled Roadside NO2 =Nox[CorrRoadsMod] x F)	15.58
[NO2]TotMod	49.15
Additional NO2 correction	1.044
FINAL NO2	51.31
