Further Assessment (Stage 4) of Air Quality within Four Air Quality Management Areas in Reigate & Banstead

Air Quality Consultants

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Report by

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On Behalf of

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1 Introduction and Background

1.1 On 30th April 2002, Reigate and Banstead Borough Council declared five Air Quality Management Areas (AQMAs). One of these areas has two sections and so there are effectively six separate AQMAs. These are all areas of the Borough where concentrations of nitrogen dioxide are likely to exceed the Government's air quality objective in 2005. Four of these areas are located in the more northern part of the Borough, close to busy roads. Two are close to Gatwick Airport, where the exceedences are influenced by emissions from the airport. This document represents the Stage 4 further assessment report for the four AQMAs that are predominantly influenced by road vehicle emissions. A separate report provides the further assessment for the remaining two areas.

Policy Context

1.2 The Government's Air Quality Strategy for England, Scotland, Wales and Northern Ireland sets out a framework for air quality improvements, which includes a series of air quality objectives. These are ambient air pollutant concentrations averaged over a defined time period, occasionally with a set number of exceedences allowed. They are based on an assessment of health effects and of the practicality of improving ambient air quality. Only one air quality objective is relevant to this report and this is shown in Table 1.

Table 1 The Air Quality Objective Relevant to This Report

Pollutant	Time Period	Objective	To be achieved by[1]
Nitrogen Dioxide	Annual mean	40 $\mu g/m^3$	2005

[1] The end of the specified year.

1.3 National and international measures are likely to achieve the Governments objectives in most locations, but it is recognised that management at a local level will be necessary in some areas. Part IV of the Environment Act 1995 requires local authorities to periodically review and assess the current, and likely future, air quality in their area. The role of this process is to identify areas where it is unlikely that the air quality objectives will be achieved.

1.4 Air Quality Review and Assessment is a multi-stage process, with each stage requiring progressively more complex assessment. This negates the need for very detailed assessments in areas where air quality is unlikely to be a problem. If the possibility that an air quality objective will be exceeded cannot be discounted during Stage 1 and 2 of Review and Assessment, a Stage 3 assessment becomes necessary. Following this more detailed assessment, if there still appears to be a risk of an objective exceedence, an Air Quality Management Area (AQMA) must be designated. Following this, Sections 84(1) and 84(2)a of the Environment Act 1995 require the local authority to carry out a Stage 4 Review and Assessment of existing and likely future air quality within the AQMA.

Scope

1.5 This report represents one part of the Stage 4 further assessment for the borough of Reigate and Banstead. It covers all AQMAs apart from the two that are near to Gatwick Airport. The AQMAs considered in this report are shown in Appendix 1 and are identified by Defra[1] as Reigate and Banstead AQMA 1, 2a, 3 and 4. AQMAs 2b and 5 are assessed in a separate report.

1.6 The Stage 4 guidance note[2] issued by Defra states that the main purpose of this further assessment is to allow local authorities to supplement the information they have already gathered from their earlier Review and Assessment work. The assessment should provide the technical justification for the measures to be included in the action plan. It allows authorities:

- to confirm their original assessment of air quality against the prescribed objectives, and thus to ensure that they were right to designate the AQMA;
- to calculate more accurately how much of an improvement in air quality would be needed to deliver the air quality objectives within the AQMA;
- to refine their knowledge of the sources of pollution so that air quality action plans can be properly targeted;
- to take account of national policy developments which may come to light after the AQMA declaration;
- to take account as far as possible of any local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into earlier calculations;
- to carry out real-time monitoring where this has not been done as part of the Stage 1-3 Reviews and Assessments;
- to carry out further monitoring in problem areas to check earlier findings;
- to corroborate other assumptions on which the designation of the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way;

- to respond to any comments made by statutory consultees in respect of authorities' Stage 1-3 reports, particularly where these have highlighted that insufficient attention has been paid to, e.g., the validation of modelled data.

Key Findings of Previous Review and Assessments Conducted by this Authority

1.7 The second stage of Review and Assessment for Reigate and Banstead indicated a risk of exceeding the annual mean NO_2 objective at a number of major roads in the area, as well as a risk of exceeding the 24-hour PM_{10} objective along certain stretches of road.

1.8 Stage 3 of Review and Assessment involved detailed modelling work focusing on the potential exceedence areas highlighted in the Stage 2 report. Results indicated a likely exceedence of the annual average NO_2 objective in 2005 at a number of residential properties that were within 30 m of the M25, A217 or M23, and for an area of Horley alongside Gatwick Airport.

1.9 Following the Stage 3 assessment, a number of AQMAs were declared within the borough. Those relevant to this report are described in Appendix 1.

Report Structure and Issues Addressed

1.10 Section 2 assesses the impact of new developments since the Stage 3 report was produced. Section 3 provides responses to the comments of consultees on the Stage 3 report. Section 4 comprises a review of the monitoring data collected since the Stage 3 report was produced. These monitoring data are used to reassess the likelihood of objective exceedences within the AQMAs.

1.11 For areas where it still appears likely that the NO_2 objectives will be exceeded in 2005, section 5 estimates the relative contribution of the most significant pollution sources to the likely ambient concentrations.

1.12 Section 6 estimates the reduction in local emissions necessary to achieve the Government's NO_2 objective in 2005. Section 7 appraises a range of nominal traffic control measures for their ability to bring about the necessary changes. An appraisal of the costs and feasibility of these measures is not included in this report and will instead form a part of the action plan.

2 Developments since Declaration of the AQMAs

National Developments

2.1 The vehicle emission factors provided by Defra have been revised since the AQMAs were designated. The new factors have been used in this report.

2.2 The Government published an addendum to its Air Quality Strategy Document in February 2003[3]. This sets out new air quality objectives for certain pollutants. No new objectives are relevant to this report.

Local Developments

2.3 Since the AQMAs were designated, a road widening program has taken place to west of the borough, but within the borough, developments have been mainly related to the provision of new housing. The most notable new developments are listed below:

- New junction on the A23 close to Star Bridge for a housing estate with 400 houses.
- Royal Earlswood Hospital 400 new homes accessing the A23 (joining close to Three Arch Road).
- 180 new homes at Goods Yard, near Redhill. The development is accessed via Hooley Lane / Mill Street.
- 400 new houses at Homethorpe Industrial Estate, near Battle Bridge Lane. These access onto the A23 via a new junction.

Additional traffic related to these developments will not have a material effect on the AQMAs under consideration.

2.4 Reigate and Banstead Borough Council aim to produce supplementary planning guidance related to AQMAs in due course.

3 Response to Consultees Comments

3.1 The Stage 3 Review and Assessment Appraisal Report accepted the conclusions reached for all pollutants, but did offer a series of comments. These comments, along with the responses offered, are set out below.

3.2 Comment 1

The section on continuous monitoring is brief. A more substantial discussion and analysis of the data from Horley could be provided. Data from this site could also be used to predict 2004/5 concentrations.

The site had not been operating for a long period when the report was prepared. The data were used to validate the model. The model was used as the basis for the declaration of an AQMA. Further analysis of the monitoring data from the Horley site, and other monitoring sites hat have been set up in the area, is included in the separate Stage 4 report for AQMAs 2a and 5.

3.3 Comment 2

The discussion of bias in measurements made by analytical laboratories on page 15 is brief. It is not clear how the conclusions reached on page 15 are carried forward into the assessment, nor is it made clear what the implications of an incorrect conclusion may be.

Understanding of the performance of diffusion tubes has improved since the Stage 3 report was prepared. The current assessment includes an adjustment for diffusion tube bias using the results of a year's inter-comparison with the Horley automatic monitor (see section 4).

3.4 Comment 3

In the case of traffic information, it is not clear if any of the assumptions have been validated by traffic counting. Page 18 refers to 'assumptions' that are used to generate traffic flow and speed information. These assumptions should be made explicit.

The current assessment utilises measured traffic flows, thus improving the accuracy of the assessment (see Appendix 3).

3.5 Comment 4

In the case of PM_{10} modelling validation,, it is not clear what approach has been taken. On page 5, section 2.2, it states that monitored data from the TEOM is used in model validation. However, on page 32, section 4.1, it states that no validation could be undertaken for PM_{10} due to a lack of roadside monitoring. This is potentially confusing and it should be made clear what validation has been attempted for PM_{10}.

There was no direct validation of the PM_{10} model output due to the absence of monitoring data for roadside locations. Background is an important component of PM_{10}. The national maps used at that time gave higher background concentrations than the measured value in Horley. This suggests that the model results will have over-predicted concentrations, reinforcing the decision not to declare any AQMAs for PM_{10}. Monitoring carried out at the Reigate South site alongside the NO_x monitor (see section 4), 13 m from the edge of the M25, during the winter period November 2002 – February 2003, gave a period mean of 19 $\mu g/m^3$ (gravimetric equivalent), with no exceedences of the 24-hour objective of 50 $\mu g/m^3$. This is considerably lower than the modelled values for this location, further supporting the decision not to declare any AQMAs for PM_{10}.

4 Corroboration of Previous Findings

New Automatic Monitoring Data

4.1 Real-time chemiluminesence NO_2 monitors were operated for a period of almost four months during the period 22 October 2002 to 20 February 2003, at two locations within AQMA 1. These locations are shown in figures A1.2 and A1.3. Both analysers were housed in purpose-built glass-fibre enclosures. Instruments were supplied and operated by staff of AEA Technology, which is the company responsible for quality assurance of the Government's UK Automatic Urban and Rural Network. Calibrations were carried out at two-week intervals, using methods set out in the site operators' manual available on the internet[1]

4.2 The first monitor, Reigate North, was 13 m horizontally from the northern hard shoulder of the M25. In addition, the monitor was approximately 15 m above the motorway, which is in a cutting at this point. The monitor was directly adjacent to a house, but was 1 m closer to the motorway than the house facade, or any other nearby property. It therefore represented a worst-case location. The second monitor, Reigate South, was approximately 20 m from the southern hard shoulder of the motorway. This monitor also represented a worst-case location, as the closest dwelling to the motorway in this area is 69 m from the hard shoulder. 1-hour mean concentrations measured at each of these sites are presented in Appendix 2.

4.3 Data for the entire year were unavailable from either site, therefore annual mean concentrations have been estimated following the procedure set out in the Local Air Quality Management Technical Guidance (TG(03))[4]. This involves identifying large-scale temporal patterns in NO_2 concentration, which are likely to have influenced the entire region. Data from twelve other continuous monitors operating at background locations in south-east England during the whole of 2002 and early 2003 are described in Appendix 2. These were all sites with at least 90% data capture over the period 1 January 2002 to 20 February 2003. The regional data indicate that the annual mean concentration for 2002 was lower by, on average, just under 20% (by 17% for the matched period at Reigate north and 18% at Reigate south). As a result, the predicted 2002 mean concentrations at Reigate North and Reigate South are lower than the measured period means. The monitoring results are set out in Table 2, together with projections to 2005. In both 2002 and 2005, predicted annual mean NO_2 concentrations at both sites are below the objective.

Table 2 Annual Mean Chemiluminescence Monitor Data for Sites Inside AQMA 1 (μg/m^3)

Site	Data collection period	Period mean	Estimated 2002 mean	Projected 2005 mean	2005 Annual Mean Objective
Reigate North	24/10/02 - 20/2/03	46.9	38.7	35.7	40
Reigate South	30/10/02 - 20/2/03	41.2	33.6	31.0	40

2005 data are projected forward using the projection factors supplied by defra[1].

4.4 No AQMAs were declared for the 1-hour NO_2 objective, which is for no more than 18 exceedences of 200 μg/m^3 NO_2 as a 1-hour mean in 2005. It is nevertheless worthwhile to assess the new monitoring data in relation to this objective. Table 3 shows that during the four month period for which chemiluminesence data are available, 1-hour mean concentrations exceeded 200 μg/m^3 six times at Reigate South. It was explained above that long-term mean concentrations are likely to have been lower earlier in 2002. Considering this, as well as the point that concentrations are likely to fall by 2005, it seems highly unlikely that there will be more than 18 1-hour mean exceedences in 2005. There were no such exceedences at Reigate North. These data support the decision not to declare this AQMA for the 1-hour NO_2 objective.

Table 3 1-Hour Mean Chemiluminescence Monitor Data for Sites Inside AQMA 1

Site	Data collection period	Exceedences of 200 μg/m^3 as a 1-Hour Mean During the Measurement Period	Exceedences of 200 μg/m^3 as a 1-Hour Mean permissible in the 2005 Objective
Reigate North	24/10/02 - 20/2/03	0	18
Reigate South	30/10/02 - 20/2/03	6	18

New Diffusion Tube Data

4.5 Monthly average nitrogen dioxide concentrations have been measured at a range of sites within the three relevant AQMAs throughout 2002 using passive diffusion tubes. The locations used are shown in Appendix 1. In addition, triplicate diffusion tubes have been co-located with a chemiluminesence analyser at the Horley air monitoring station. Following the procedure set out in TG(03)[4], concurrent data from these two methods have been compared in order to produce a bias adjustment factor for all diffusion tubes used in this study. Table 4 describes the data used to generate this factor. Table 5 sets out the mean measured concentration at each site, as well as the adjusted concentration and the predicted 2005 concentration.

Table 4 Co-located Diffusion Tube (DT) and Automatic Monitor Data (μg/m^3) Used to Calculate the Diffusion Tube Bias Adjustment Factor.

Measurement Period	DT 1	DT 2	DT 3	DT Mean (a)	Automatic Data Mean (b)	Automatic Data Capture	Bias Adjustment Factor (b/a)
08/01/02 – 03/04/02 + 01/05/02 – 03/12/02	27	26	25	26	30	99.8%	**1.17***

* Calculation based on un-rounded values

4.6 Support for the use of this bias adjustment factor comes from a comparison of the results for Tube RB27, which was positioned near to, but not alongside, the Reigate North chemiluminesence sampler. The estimated adjusted diffusion tube concentrations in 2005 is 38 μg/m^3 at RB27, compared with 36 μg/m^3 at Reigate North.

Assessment of Diffusion Tube Data for AQMA 1

4.7 The Locations of diffusion tubes within, or close to, AQMA 1 are described in Figures A1.1 to A1.5. The data presented in Table 5 suggest that in 2005, the only likely objective exceedence at any of the monitoring locations will be at Highlands, Brighton Road (RB49). This tube was attached to a post beside the pavement, approximately 1.5 m the kerb, while the façade of the adjacent residential property is 6 m from the kerb. Following the methodology set out in Appendix 4, the monitored value has been used to predict a concentration in 2005 of 36.6 μg/m^3 at the façade of the nearby house. It is thus unlikely that the objective will be exceeded at this location.

4.8 Elsewhere alongside the M25, there are a few locations with concentrations close to the objective, RB27, RB28 (Figure A1.2) and RB39 (Figure A1.5). Sites RB27 and RB28 are close to the automatic monitoring site. This area has already been assessed. Site RB39, on the other hand, is not worst-case, as there are residential properties between monitoring site and the motorway. The methodology set out in Appendix 4 has been used to predict the NO_2 concentration profile along Ashcombe Road. Figure 1 shows this profile, along with the data used to validate it. This analysis shows that the annual mean NO_2 concentration in 2005 at number 20 Ashcombe Road, which is the property closest to the motorway, is likely to be 43 μg/m^3. This will constitute an exceedence of the annual mean nitrogen dioxide objective. The indications are that properties out to 23 m from the carriageway, i.e. four properties in Ashcombe Road, are likely to experience concentrations above the objective.

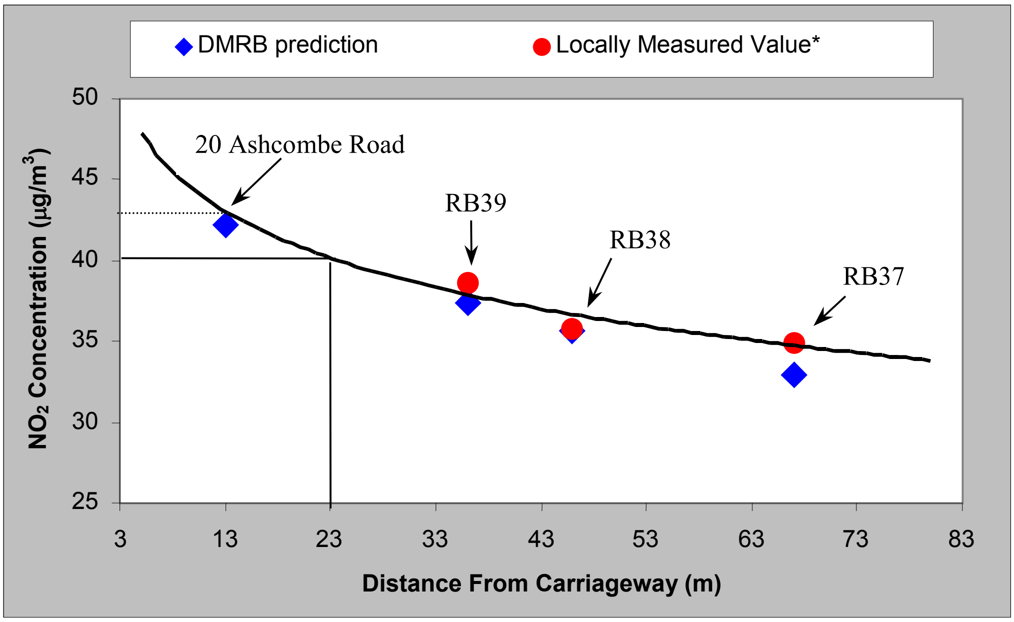
Table 5 Measured 2002 and Projected 2005 Annual Mean Concentrations at Each Diffusion Tube Monitoring Site (μg/m^3). Values in bold are >40 μg/m^3

Site Location	Site Description	Site Ref.	% (of 2002) Data Capture	2002 Unadjusted Mean[1]	2002 Adjusted Mean[1]	2005 mean[2]
Sites within or close to AQMA 1						
60, Brook Road, Merstham	Urban Background	RB18	58	25	29	27
Village Hall, Station Road, Merstham	Intermediate Site	RB19	92	20	24	22
Corner of London Road, Merstham	Near Road	RB20	92	29	34	31
White Lodge, Sturts Lane, WotH[3]	Near M25	RB27	92	35	**41**	38
Badgers Cottage, Sturts Lane, WotH[3]	Near M25	RB28	92	36	**42**	39
April Cottage, Sturts Lane, WotH[3]	Near M25	RB29	92	29	34	31
Linden Lea, Chequers Lane, WotH[3]	Near M25	RB30	92	33	39	36
Margery Hall, Reigate Hill	Near M25	RB31	92	26	30	28
South Gable, Margery Hall, Reigate Hill	Near M25	RB32	75	29	34	31
Rose Cottage, Margery Grove	Near M25	RB33	92	26	30	28
Stagholt, Merrywood Grove	Near M25	RB34	92	19	23	21
Applewood Cottage, Merrywood Grove	Near M25	RB35	92	19	22	20
Old Church House, Gatton Bottom	Near M25	RB36	92	29	33	31
14 Ashcombe Road, Merstham	Near M25	RB37	83	32	38	35
16 Ashcombe Road, Merstham	Near M25	RB38	92	33	39	36
17 Ashcombe Road, Merstham	Near M25	RB39	92	36	**42**	39
Bridge Cottage, Mogador Road	Near M25	RB48	58	31	36	33
Highlands, Brighton Road	Near A217	RB49	92	39	**46**	**42**
Yew Cottage, Brighton Road	Near A217	RB50	92	30	35	33
Sites Within or Close To AQMA 2						
Dilkusha, Shepherds Hill	Near M23	RB40	92	29	34	31
Upalond, Shepherds Hill	Near M23	RB41	92	25	29	27
Outside Rhydlanfair, Shepherds Hill, Merstham	Near M23	RB42	92	26	31	28
Sites Within or Close To AQMA 3						
Outside 1 Deans Lane Hooley	Beside A23	RB82	42	25	29	27
Sites Within or Close To AQMA 4						
Outside Flying Scud Public House, Brighton Road, Redhill.	Beside A23	RB81	33	28	33	30

[1] Adjusted 2002 mean values have been multiplied by 1.169 to correct for bias (see text).
[2] 2005 data are projected forward using the projection factors supplied by defra[1].
[3] Walton on the Hill.

4.9 Concentrations alongside the M25 at Ashcombe Road seem to be a little higher than elsewhere alongside the M25. Several factors probably contribute to this. The area is located in close proximity to junction 7 on the motorway, a major junction with the M23. The manoeuvring of the traffic to the inside lane to leave the M25, can result in flow breakdown on this section of the motorway. The disrupted flow will lead to higher emissions. In addition, the background will be higher than along other sections of the M25 due to emissions from the nearby M23 and the junction itself, as well as emissions from Redhill.

Figure 1 Predicted NO_2 Concentration Profile in 2005 Along Ashcombe Road with Distance from the M25 Carriageway Edge



The line is derived from a monitoring study carried out alongside the M25 between junctions 13 and 14[5]
This is further described in Appendix 4
* Measured values have been scaled forward to 2005 using the projection factors provided by defra[1]

Assessment of Diffusion Tube Data for AQMA 2a

4.10 The locations of diffusion tubes specific to AQMA 2a are shown in Figures A1.6 and A1.7. The tubes have been positioned outside of cottages identified in the previous modelling study[6] as likely to experience exceedences of the annual mean NO_2 objective in 2005. The data presented in Table 5 do not support these conclusions; they suggest that exceedences of the annual mean NO_2 objective at these cottages are unlikely.

Assessment of Diffusion Tube Data for AQMA 3

4.11 The location of the diffusion tube within AQMA 3 is shown in Figure A1.8. The tube was located outside of the property at 1 Deans Lane, Hooley; affixed to a post on the grass verge approximately 10 m from the centre of the A23. The property is further from the road than this. The data in Table 5 suggest that at this location, the annual mean concentration in both 2002 and 2005 is likely to be well below the 2005 objective.

Assessment of Diffusion Tube Data for AQMA 4

4.12 The location of the diffusion tube site in AQMA 4 is shown in Figure A1.9. The tube was positioned approximately one metre from the wall of the Flying Scud public house, beside the A23. The data presented in Table 5 suggests that at this location, the annual mean concentration in both 2002 and 2005 is likely to be well below the 2005 objective.

Summary

4.13 These monitoring data suggest that the Stage 3 modelling results tended to over-predict ambient NO_2 concentrations. The only area where monitoring data suggest a likely exceedence of the annual mean objective is for the four properties on Ashcombe Road closest to the M25. There are other locations alongside the motorway where concentrations are likely to be just below the objective. It is therefore considered advisable to retain the whole of AQMA 1 as designated. This position will be reviewed in future years.

4.14 There does not appear to be a necessity for the continued designation of AQMAs 2a, 3 and 4. It would therefore be appropriate to revoke these AQMAs.

5 Source Apportionment

5.1 To develop an appropriate action plan it is necessary to identify the sources contributing to the exceedences of the annual mean nitrogen dioxide objective alongside the M25. The principal local sources will be emissions from vehicles using the motorway. These emissions are primarily nitric oxide (NO) with a small component of NO_2, jointly being termed nitrogen oxides (NO_x). The NO emission is important, because it is converted in the atmosphere to NO_2, mainly by reaction with ozone. Close to the source there is usually insufficient ozone to convert more than a small proportion of the NO to NO_2. The relationship between NO_2 and NO_x is not linear, the proportion decreasing as NO_x concentrations increase. In order to calculate the contributions of the various sources, and how changes in emissions will affect NO_2 concentrations, it is necessary to consider NO_x concentrations. The methodology set out in Appendix 5 has been used to predict that the total NO_x concentration in 2005 at 20 Ashcombe Road will be 134.1 $\mu g/m^3$. This is likely to be made up as follows: 40.3 $\mu g/m^3$ is the background concentration, 93.4 $\mu g/m^3$ will come from local traffic on the M25, 0.33 $\mu g/m^3$ will come from local traffic using the A23 and just 0.09 $\mu g/m^3$ from vehicles on Rockshaw Road. The contribution of the different vehicle categories to NO_x concentrations is set out in Table 6 and Figures 2 and 3.

5.2 The results show that goods vehicles (HGV and LGV) account for the largest proportion (48%) of the NO_x emissions from the M25, with articulated HGVs accounting for 69% of the goods vehicle emissions. Background NO_x imported into the area is the next most important component. This will be even more important than shown, as the NO_2 content of this background air will be greater, relative to the NO_x, than that produced by the fresh emissions from the local traffic.

Table 6 Source Apportionment of Ambient NO_x at 20 Ashcombe Road*

	Annual Average Speed Modeled		**NO_x**	
	kph	**mph**	**($\mu g/m^3$)**	**%**
Artic. HGVs on M25	95	59	44.5	33.2
Rigid HGVs on M25	95	59	12.7	9.5
Buses on M25	110	68	2.8	2.1
Cars on M25	110	68	26.1	19.5
LGVs on M25	110	68	7.2	5.4
Total From M25	-		93.4	69.7
Total From A23	-		0.3	0.2
Total From Rockshaw Road	-		0.1	0.1
Background Concentration	-		40.3	30.0
Total	-		134.1	100

*See Appendix 5 for methodology.

Figure 2 Ambient NO_x at 20 Ashcombe Road, Apportioned by Source in $\mu g/m^3$.

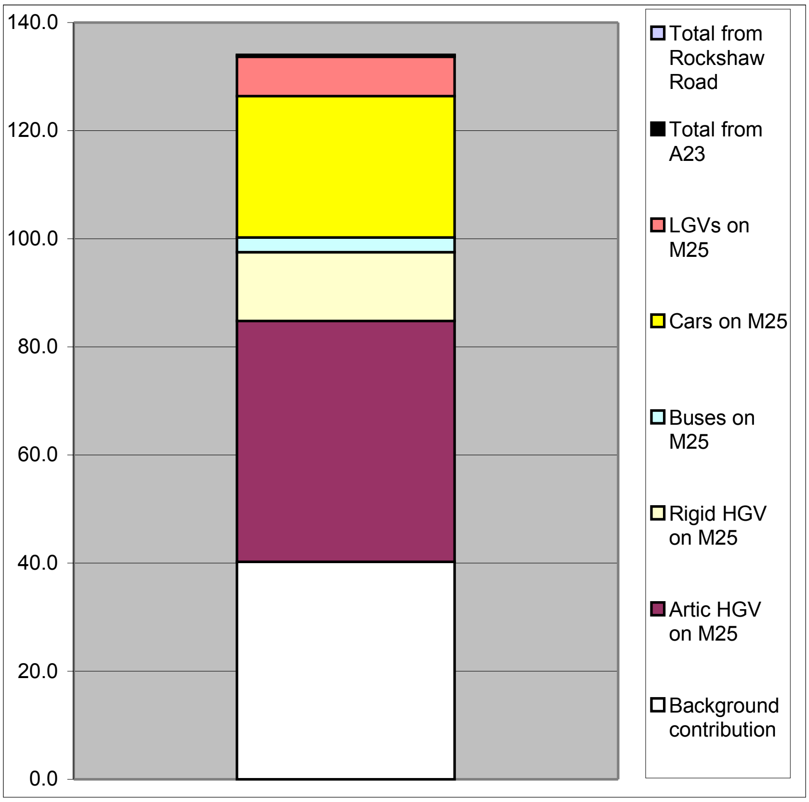
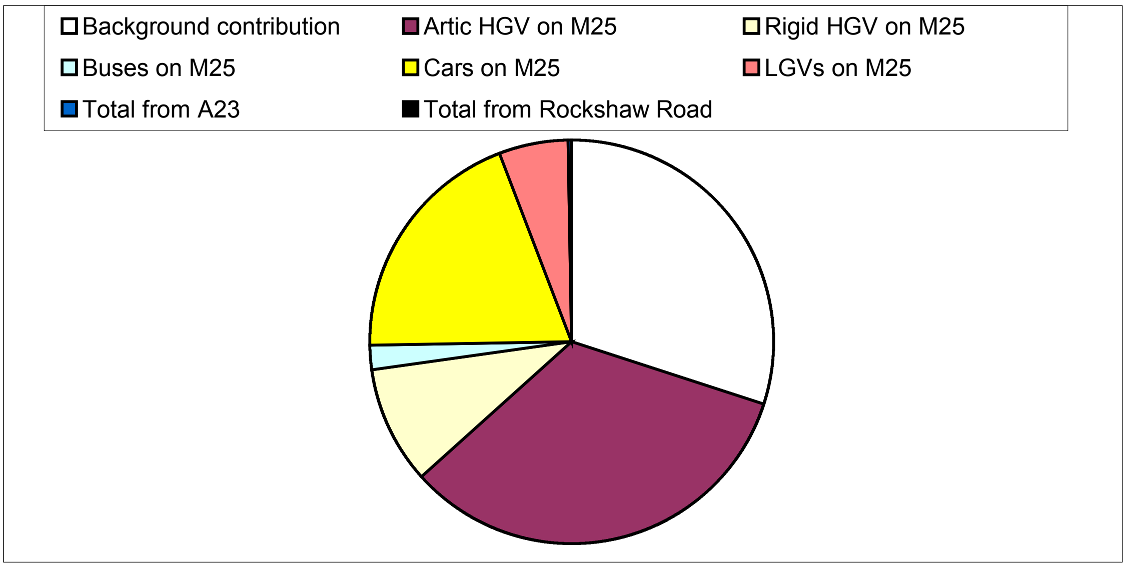


Figure 3 Relative Contributors the Total NO_x at 20 Ashcombe Road



6 Statement of Air Quality Improvements Needed

6.1 Section 4 concludes that maximum air quality improvements required will be defined by concentrations at 20 Ashcombe Road. Both the total NO_x concentration and the roadside NO_x increment at 20 Ashcombe Road in 2005 have been predicted in section 5. Using the calculator supplied by Defra[1] to derive NO_x concentrations from NO_2, it has been estimated that the total NO_x concentration would need to be below 114.4 $\mu g/m^3$ in 2005 in order for the NO_2 concentration to meet the 40 $\mu g/m^3$ objective. The reduction required in 2005 would thus be 19.7 $\mu g/m^3$ (134.1-114.4). This reduction would have to be obtained from the local traffic contribution of 93.4 $\mu g/m^3$. It represents a 21% reduction in NO_x from the local traffic. The roadside incremental NO_x concentration would therefore need to be below 74.1 $\mu g/m^3$. This represents a 21% reduction in the 2005 roadside incremental NO_x concentration, which means a 21% reduction in NO_x emissions from traffic on the M25.

6.3 This 21% is an estimate of the minimum reduction necessary to achieve the objective. In order to ensure with confidence that the objective is achieved, management measures should aim for a reduction somewhat greater than this. The question of how much greater needs to be assessed in relation to an appraisal of the costs and feasibility of the measures considered in the action plan

7 Management Planning

7.1 Section 6 showed that the NO_x emissions from the local traffic would need to be reduced by more than 21% in order for the annual mean NO_2 objective to be achieved. This reduction has essentially to be derived from the traffic on the M25, as the source apportionment has shown that any measures applied to either the A23 or Rockshaw Road are unlikely to bring about a perceptible change in air quality at number 20 Ashcombe Road.

7.2 To help with the preparation of the action plan, the effectiveness of a number of possible measures has been explored. These cover: reductions in HGV traffic alone; reductions in car traffic alone; reductions in all traffic; and reduced speeds. The method used to carry out these illustrative calculations is described in Appendix 6. The likely effects on air quality of emission reduction scenario are set out in Table 7.

Table 7 Potential Traffic Control Measures to Bring About the Necessary Improvements. Approaches likely to achieve the necessary improvements are shown in bold.

Option	Measure	% reduction in Roadside Incremental NO_x at 20 Ashcombe Road
	Reducing HGV Traffic	
1	20% reduction in the number of HGVs	12
2	**35% reduction in the number of HGVs***	**21**
3	**50% reduction in the number of HGVs**	**31**
	Reducing Car Traffic	
4	20% reduction in the number of Cars	6
5	50% reduction in the number of Cars	14
6	**76% reduction in the number of Cars***	**21**
	Reducing All Traffic	
7	20% reduction in the number of vehicles	20
8	**21% reduction in the number of vehicles***	**21**
9	**50% reduction in the number of vehicles**	**50**
	Reducing Speeds	
10	Imposing an average speed of 90 kph (56 mph) for all vehicles	20
11	**Imposing an average speed of 85 kph (53 mph) for all vehicles**	**22**
12	**Imposing an average speed of 80 kph (50 mph) for all vehicles**	**24**

* These values give the precise reduction in traffic necessary to achieve the objective.

7.3 The results in Table 7 show that if the only approach employed was the reduction of HGV traffic on the M25, HGV traffic volume would need to be reduced by 35%, at the very least, in order to achieve the objective. Similarly, if only car traffic was targeted, a 76% reduction in traffic volume would be the minimum required to achieve the objective. If the numbers of all vehicles using this section of the M25 were reduced, the very minimum reduction in volume necessary would be 21% (assuming the split of vehicles remains constant). Reducing the average speed to 85 kph (53 mph) would be sufficient to bring about required improvements in local air quality.

7.5 The traffic reduction figures are straightforward to interpret. The speed figures, however, require a more cautious interpretation. For the base case it has been assumed that the vehicle speeds on the motorway can be assumed to be close to the relevant legal speed limits for each vehicle class, 95 kph (59 mph) for HGVs and 110 kph (68 mph) for all other vehicles. It is known that many vehicles often exceed these limits on motorways, but it is reasonable to assume these speeds on this section of motorway, as there is a busy junction nearby. The average speed will on occasions be much less than this, as it is a common phenomenon on motorways, especially near to busy junctions, for flow-breakdown to occur. The sheer volume of traffic and the weaving of traffic exiting and joining the main carriageway lead to periods when traffic slows, often with stop-start driving. Under these conditions the average speed during the day could reduce to around 80 kph (50 mph). The optimum speed in terms of minimising emissions of NO_x is in the range 50-80 kph (31-50 mph), with higher emissions at both lower and higher speeds. If an average speed of 80 kph (50 mph) is made up of periods of flow at 30 kph (19 mph) (daytime congestion) and at 120 kph (75 mph) (night-time free flow), then the emissions will be much greater than if a constant average of 80 kph (50 mph) were assumed. Imposition of a speed limit of 85 kph (53 mph), as suggested above to improve air quality alongside the motorway, should be an effective way to minimise emissions, as it would avoid the high speeds with their greater emissions and reduce the incidence of flow breakdown, with slower speeds and stop-start driving.

8 Conclusions

8.1 Nitrogen dioxide concentrations have been measured during 2002/03 at two sites using chemiluminesence samplers, and at a further twenty-four sites using passive diffusion tubes. The data have been used to reassess the current, and likely future air quality within four of the six AQMAs declared in 2002: 1, 2a, 3 and 4. The further review of the other two AQMAs: 2b and 5, is presented in a separate report.

8.2 The monitoring data have shown that ambient nitrogen dioxide concentrations at the worst-case receptors in three of the AQMAs: 2a, 3 and 4, are likely to be below the 2005 annual mean objective for nitrogen dioxide. As this is the objective for which each AQMA was declared, it now seems appropriate to revoke the AQMA designations.

8.2 In AQMA 1, which runs alongside the M25 motorway, the reassessment confirms that the annual mean nitrogen dioxide objective is likely to be exceeded in 2005, although the evidence is that the exceedence should be confined to four properties on Ashcombe Road. These properties lie between 13-23 m north of the M25, close to junction 7. Elsewhere the predicted concentrations are below the objective, although only just in some cases. It is therefore appropriate to retain the AQMA designation for area 1.

8.3 A source apportionment exercise has been carried to identify the contributions of the different sources to nitrogen oxides concentrations at the worst-case receptor on Ashcombe Road. It has been estimated that almost 70% of the nitrogen oxides concentration at this receptor will come from vehicles using the M25, with a very small proportion, <1%, from other local roads. The remaining 30% will be due to background NO_x imported into the area from elsewhere. Around half of the NO_x from the M25 comes from goods vehicles, with two thirds of this being due to articulated lorries.

8.4 It has been calculated that 21% reduction in the nitrogen oxides emissions from the M25 in 2005 will be required if the annual mean NO_2 objective is to be achieved at the worst case receptor on Ashcombe Road. Modelling suggests that this would be achieved if traffic on the adjacent section of the M25 were to flow smoothly at an average speed of 85 kph (53 mph). Alternatively, it could be achieved by reducing the number of HGVs on the M25 by 35%, or by reducing total traffic volume on the M25 by 21%. Further assessment of the costs and feasibility of different control options will be provided as part of the action plan.

References

[1] www,airquality.co.uk

[2] Guidance to local authorities on the further ("Stage 4") assessments of air quality required under section 84 of the Environment Act 1995.

[3] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum, February 2003.

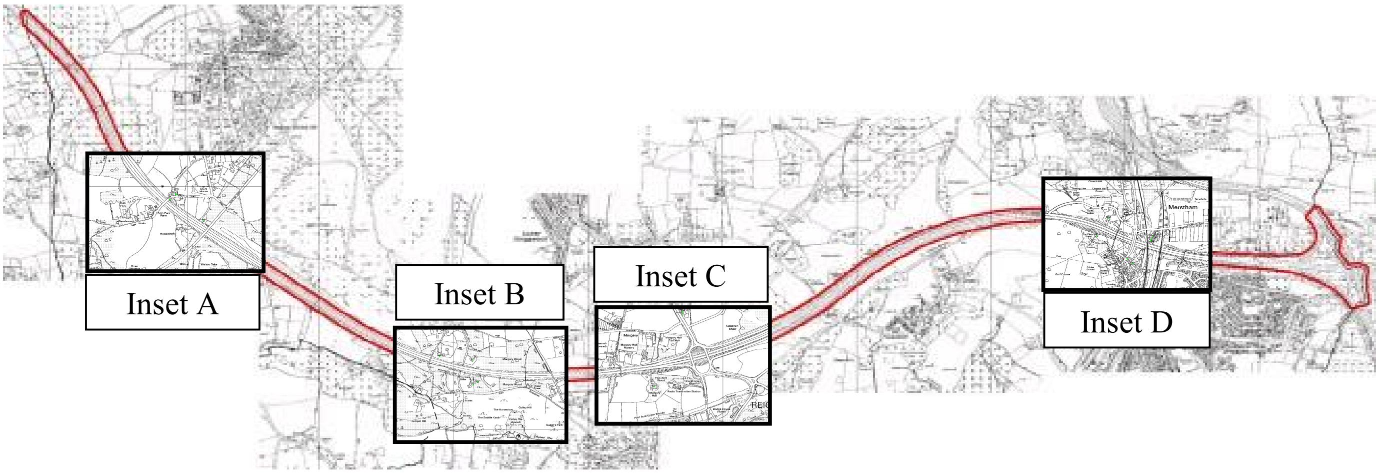
[4] Local Air Quality Management Technical Guidance TG(03)

[5] Hickman, A.J., McCrae, I.S., Cloke, J. and Davies, G.J. 2002. Measurements of Roadside Air Pollution Dispersion. TRL Ltd Project report PR/SE/445/02. Available from www.trl.co.uk

[6] Stage 3 Local Air Quality Review and Assessment NO_2 and PM_{10}. Reigate and Banstead Borough Council, June 2001. Report ref: A36030100/yb/1711/Rev1.

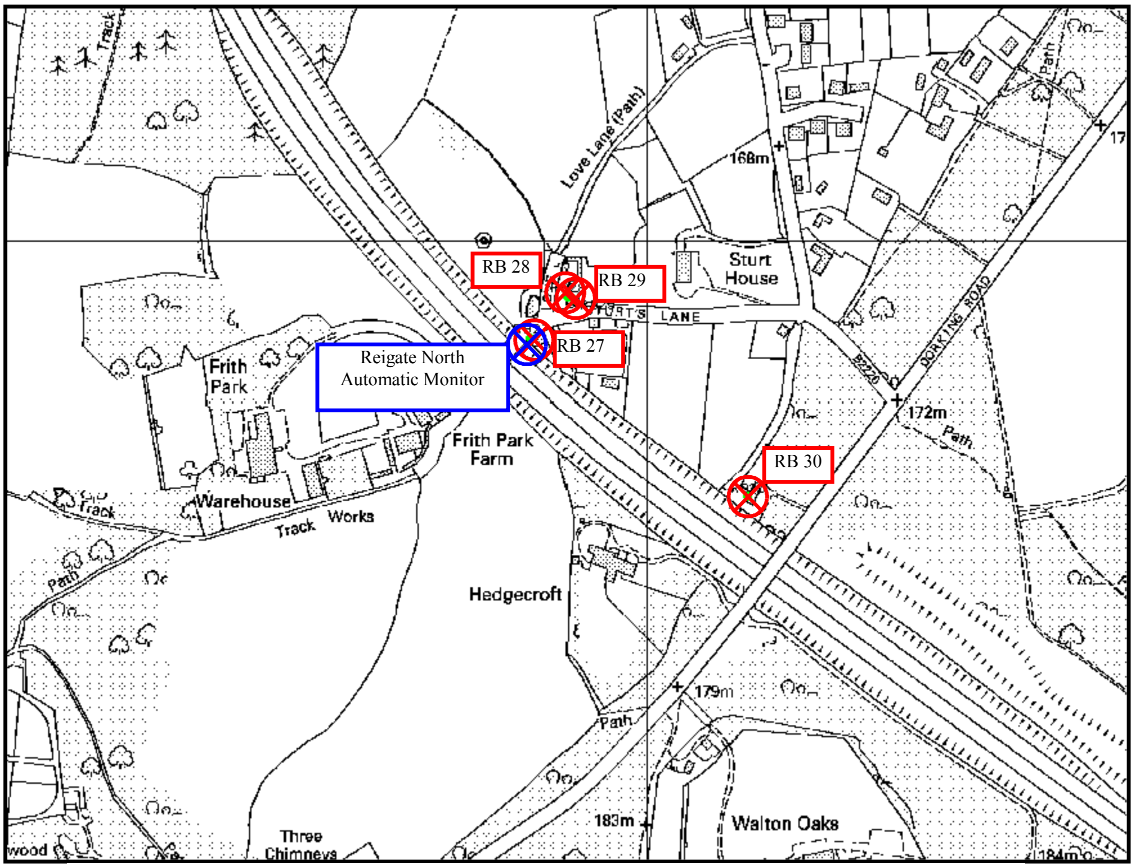
Appendix 1 Locations of AQMAs and Monitoring Sites

Figure A1.1 AQMA1 with Inset Figures Marked.



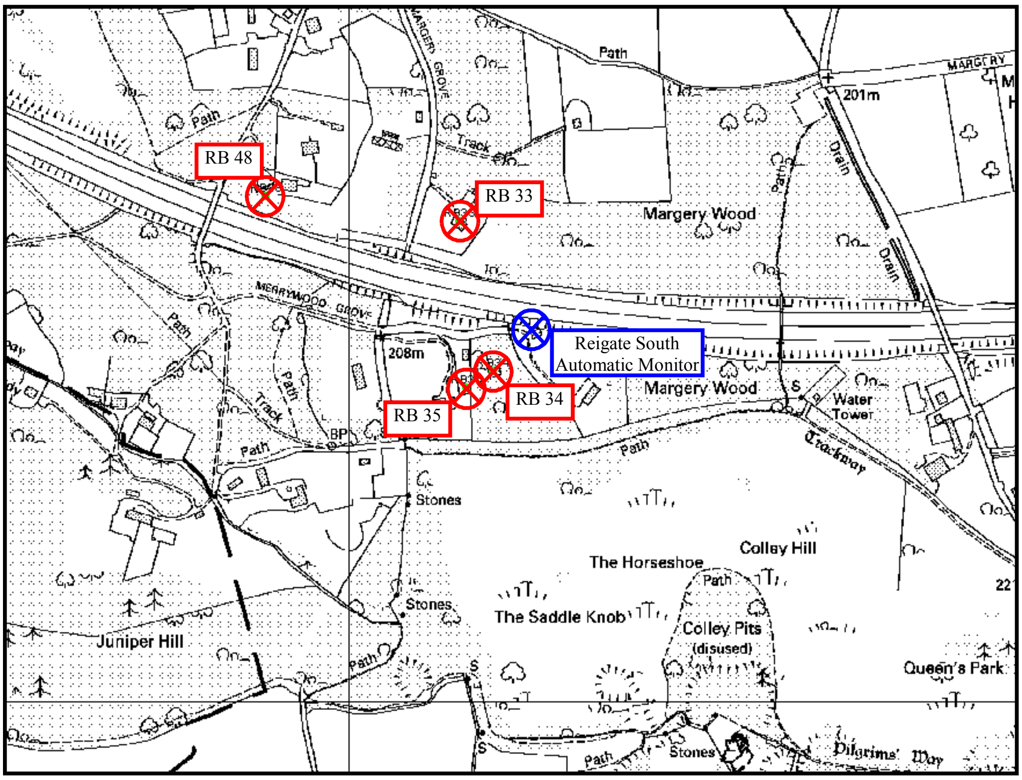
Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.2 AQMA 1 Inset A Monitoring Locations.



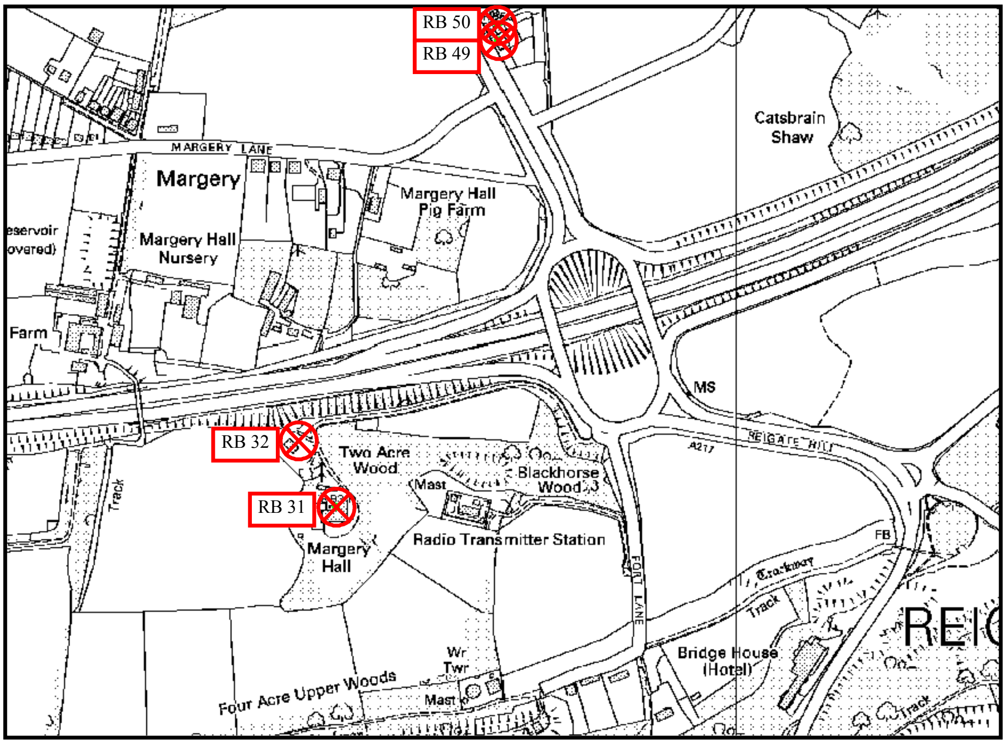
Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.3 AQMA 1 Inset B Monitoring Locations.



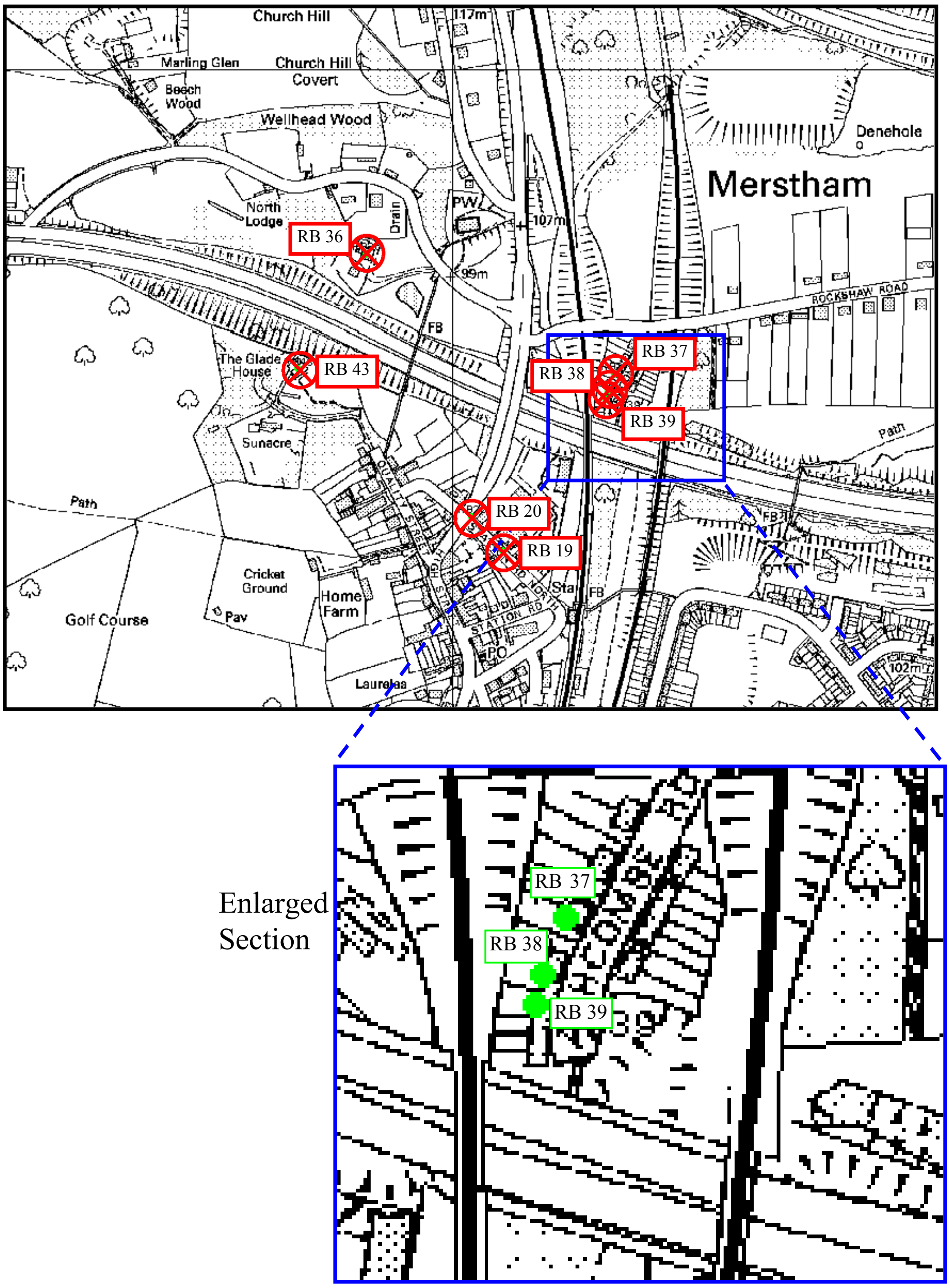
Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.4 AQMA 1 Inset C Monitoring Locations.



Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.5 AQMA 1 Inset D Monitoring Locations.



Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.6 AQMA2a With Inset

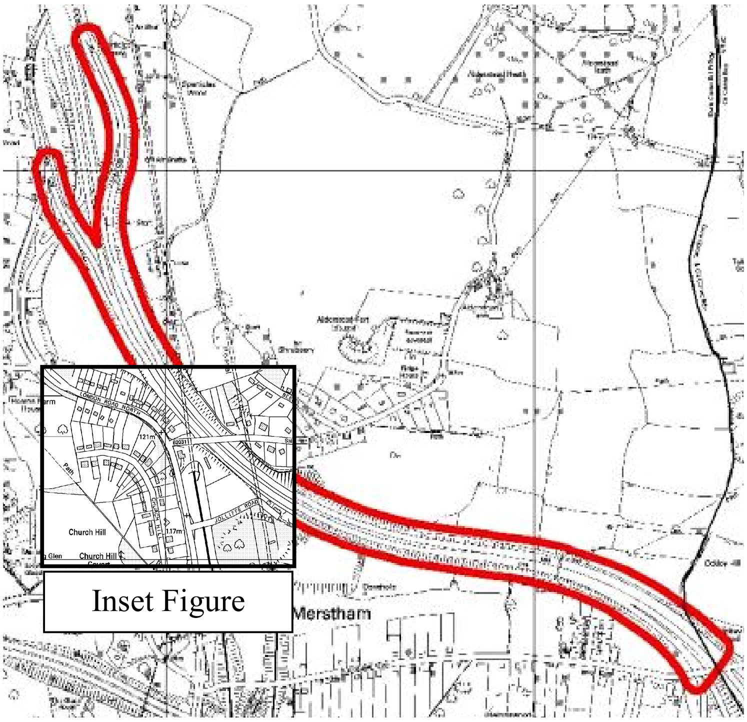
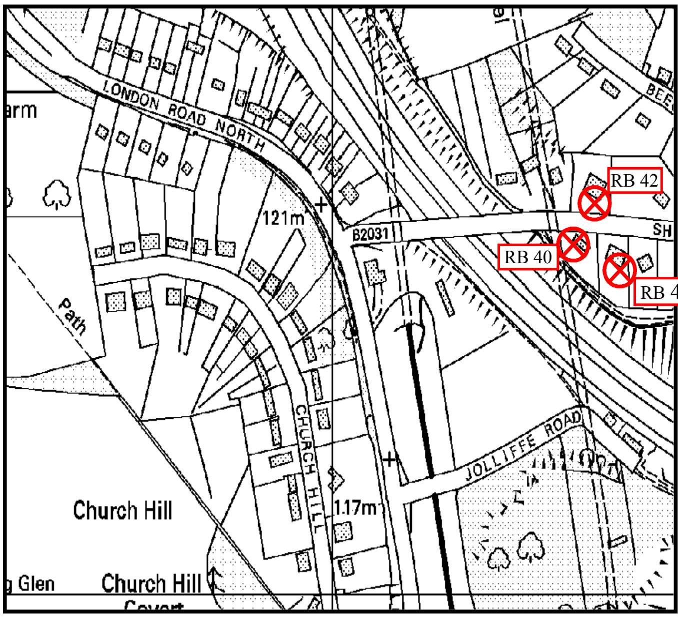
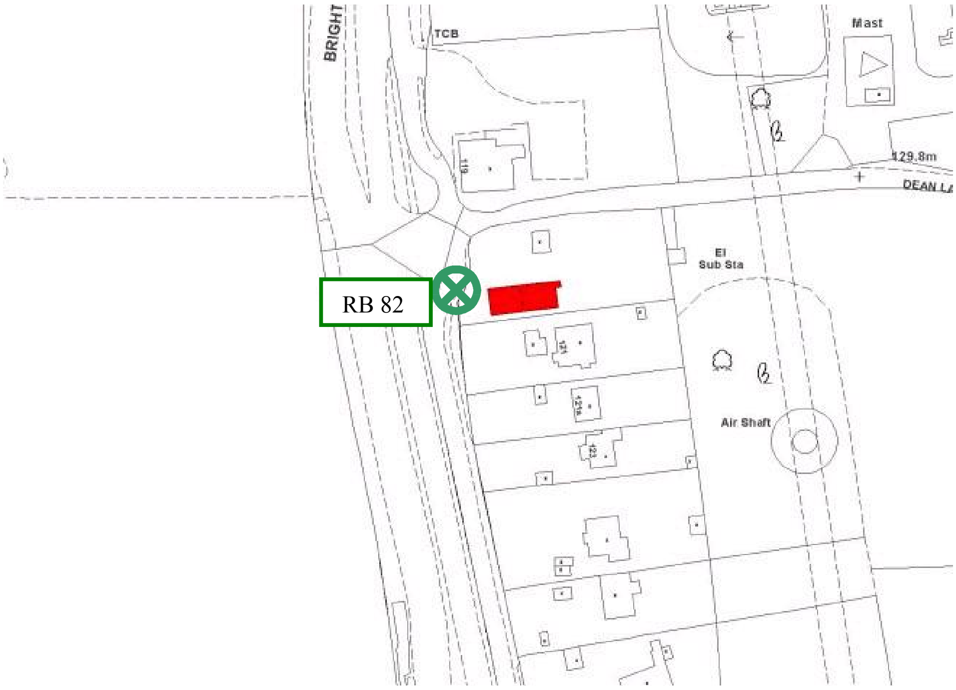


Figure A1.7 AQMA 2a Diffusion Tube Monitoring Locations



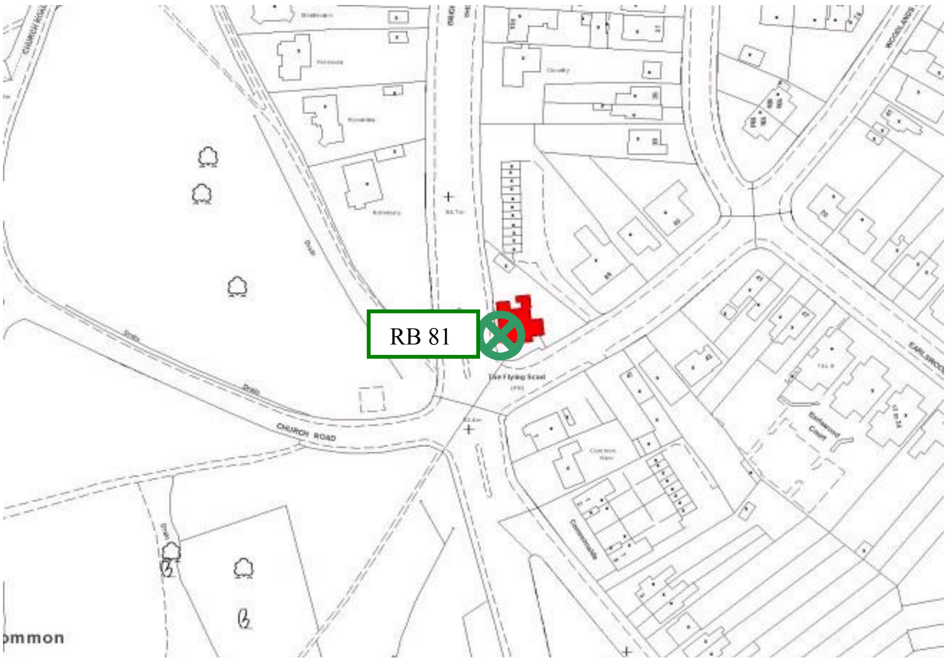
Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Figure A1.8 AQMA 3 With Diffusion Tube Location



Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

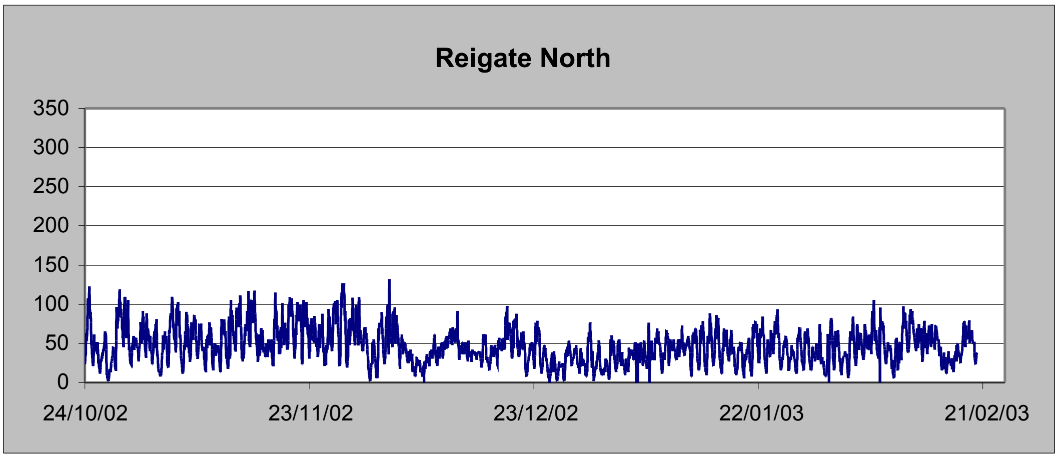
Figure A1.9 AQMA 4 With Diffusion Tube Location



Reigate & Banstead BC: OS Licence No. LA 079065 (2002)

Appendix 2 Results of Automatic Monitoring in AQMA 1

Nitrogen dioxide 1-hour results for Reigate North and Reigate South (μg/m^3)



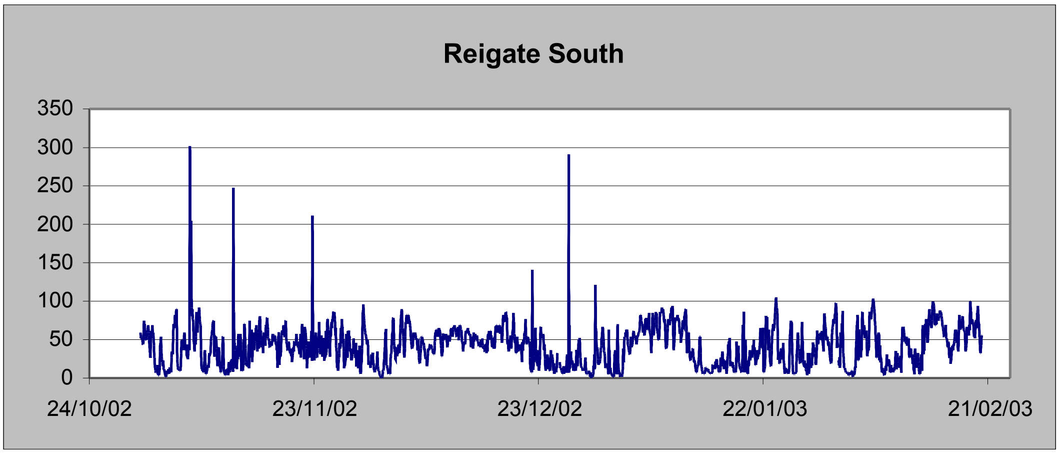


Table A2.1 Data for Estimation of Annual Mean from Period Mean for Reigate North

Site	Period Mean ($\mu g/m^3$)	2002 Annual Mean ($\mu g/m^3$)	Ratio Annual Mean / Period Mean
London Eltham	38.8	29.6	0.763
Thurrock	39.9	35.7	0.895
Teddington	32.8	25.4	0.776
West London	52.6	45.6	0.886
Rochester	23.3	21.2	0.909
London Brent	40.8	29.1	0.714
Lullington Heath	14.0	10.8	0.774
Harwell	19.5	14.7	0.756
London Hillingdon	48.4	45.3	0.935
London Westminster	49.4	43.2	0.875
London N. Kensington	48.0	39.7	0.827
Portsmouth	31.3	25.6	0.819
Average			**0.826**

Table A2.1 Data for Estimation of Annual Mean from Period Mean for Reigate South

Site	Period Mean ($\mu g/m^3$)	2002 Annual Mean ($\mu g/m^3$)	Ratio Annual Mean / Period Mean
London Eltham	39.5	29.6	0.748
Thurrock	40.1	35.7	0.889
Teddington	33.3	25.4	0.765
West London	53.1	45.6	0.859
Rochester	23.6	21.2	0.889
London Brent	41.0	29.1	0.710
Lullington Heath	14.3	10.8	0.758
Harwell	19.7	14.7	0.746
London Hillingdon	48.1	45.3	0.941
London Westminster	50.0	43.2	0.864
London N. Kensington	48.4	39.7	0.819
Portsmouth	31.7	25.6	0.808
Average			**0.817**

Appendix 3 DMRB Calculations

The Design Manual for Roads and Bridges, Volume 1.1 (February 2003) has been used to predict the impacts of roads on local air quality in the vicinity of Ashcombe Road.

Step 1

Background concentrations have been taken from the national background concentration maps supplied by defra[1] Data used are the average of mapped concentrations in the 4th 1x1 km grid square away from the M25 both north and south, and also transposed 1 square west, to avoid bias from the A23 emissions. This procedure has been adopted following the recommendation in TG(03)[i] in order to avoid the double counting of local emission sources. The data used are set out in Table A3.1.

Table A3.1 Local Background Concentrations in 2005

NOx µg/m^3	NO_2 µg/m^3
40.25	24.6

Step 2

M25 traffic flow data are based on traffic counts on the stretch of motorway adjacent to Ashcombe Road. A23 traffic flow data were also taken from the adjacent link. Both counts were obtained from the National Atmospheric Emissions Inventory[ii] and were conducted in 2000. Traffic data for Rockshaw Road are estimates based on direct observation at the site. As is shown in the source apportionment section of the report, any error introduced by the estimates for Rockshaw Road is unlikely to be significant.

Step 3

Traffic flow data have been adjusted to predict 2005 conditions by generating a local traffic growth factor for Reigate and Banstead using TEMPRO[iii]. This has been used to weight the National TEMPRO traffic growth factor which has then been applied to a National Road Traffic Forecast factor. This procedure is summarised in Equation A3.1 and the values used are described in equations A3.1 to A3.6. Table A3.2 sets out the traffic flow data used for the two major roads. In addition, the estimated annual average daily flow on Rockshaw road was 5000 vehicles, of which only 1% were assumed to be HDVs.

(Reigate and Banstead TEMPRO factor / GB TEMPRO factor) x NRTF factor. (Equation A3.1)

Cars: (1.072 / 1.043) x 1.085 (Equation A3.2)
Buses: (1.072 / 1.043) x 1.055 (Equation A3.3)
LGVs: (1.072 / 1.043) x 1.125 (Equation A3.4)
Rigid HGVs: (1.072 / 1.043) x 1.039 (Equation A3.5)
Articulated HGVs: (1.072 / 1.043) x 1.135 (Equation A3.6)

Table A3.2 Annual Average Traffic Flow in 2005.

	M25	**A23**
Articulated HGV	12,164	39
Rigid HGV	7,215	396
Bus	1,304	189
Car	13,0779	14,452
LGV	18,642	1,847
Total	170,104	16,923

Two way flows

The DMRB calculations do not take into account traffic flow along Ashcombe Road, which in these circumstances will be insignificant.

Appendix 4 Extrapolation of the Monitoring Data

Ashcombe Road

Step 1

Nitrogen dioxide concentrations for 12 monitoring locations on a transect across the M25 between junctions 13 and 14[iv] have been used to derive a relationship between the roadside NO_2 concentration and distance from the road (Equation A4.1).

A = -0.1253Ln (d) + 1.38321 (Equation A4.1)

Where d is the distance from the M25 carriageway edge (m) and A is the NO_2 concentration as a percentage of the concentration at 20 m from the carriageway.

Step 2

The horizontal distance between each diffusion tube site and the edge of the carriageway has been measured from maps and verified using GIS technology. The distance between the motorway and number 20 Ashcombe Road has also been measured. It should be noted that the M25 at this point sits within a cutting and there is a significant vertical distance between the road and the receptors. As little is known about how this topography will influence local meteorology and dispersion, this factor cannot be accounted for. The use of local monitoring data negates the need for more detailed modelling.

Step 3

The value 'd' in Equation A4.1 has been substituted with the measured distance to each diffusion tube. This predicts the concentration at each site, as a percentage of the concentration at 20m.

Step 4

Dividing the predicted concentration in 2005 at each monitoring point (based on diffusion tube data and set out in Table 4) by the relevant value obtained in step 3, gives the concentration at 20 m from the carriageway based on each individual measured datum. The three predicted concentrations in 2005 at 20 m from the carriageway are 39.6, 40.7 and 41.4 μg/m^3. The coefficient of variation between the three values is just 0.02, suggesting that the measured data fit the predicted relationship well. The mean of these three values is. 40.6.

Step 5

Reworking equation A4.1, incorporating the mean NO_2 concentration at 20 m gives an estimate of the NO_2 concentration at each point along a continuous transect away from the M25 along Ashcombe Road. This is the basis for the curve in Figure 1, with the equation:

C = 40.249x(-0.1253xLn(d)+1.3832) (Equation A4.2)

Step 6

In order to support these estimates, the DMRB has been used to predict concentrations at each notable point along the transect. GIS data provided the distance between the carriageway edge and the centre of the road.

Step 7

The transect line, the monitoring data (scaled forward to 2005), and the DMRB data are all shown in Figure 1. The DMRB values are consistent with the shape of the curve fitted to the monitoring data, although they lie slightly below the line, suggesting the DMRB is under-predicting slightly.

Highlands, Brighton Road

Equation A4.1 was derived from monitoring around the M25. It is therefore less applicable to the A240, beside which tube RB49 was situated. General patterns are, however, likely to be fairly representative. Tube RB49 was approximately 1.5 m from the edge of the road. The nearest house was approximately 6 m from the road. The methodology described above has been applied to the data from this tube to estimate the concentration at the building façade.

Appendix 5 Source Apportionment Methodology

Source apportionment has been carried out for the worst-case location, 20 Ashcombe Road. At its closest, this property is 10 m horizontally from the edge of the motorway and 13 m from the edge of the carriageway. All data described in this Appendix refer to the year 2005.

Step 1

The NO_x from NO_2 calculation spreadsheet supplied by Defra[v] has been used along with the predicted NO_2 concentration at the receptor, and the local background concentrations set out in Table A3.1 to estimate the total NO_x concentration at the receptor in 2005. This is estimated as 131.9 $\mu g/m^3$.

Step 2

The total NO_x concentration at the receptor, minus the local background concentration is the roadside increment. This is 91.6 $\mu g/m^3$.

Step 3

The DMRB has been used to predict, for 2005, the NO_x concentration at the receptor. The relative influence of each road on the DMRB prediction has been used to apportion the roadside NO_x increment arrived at in Step 2 between the M25, A23 and Rockshaw Road. The DMRB predicts that 99.5% of the roadside increment comes from the M25, while just 0.4% and 0.09% come from the A23 and Rockshaw Road respectively.

Step 4

Emissions factors for each vehicle class have been obtained from the emission factor toolkit available on the internet[vi]. The data collected are summarised in Table A5.1.

Step 5

Traffic flow estimates for 2005 on each road are described in Appendix 3. The emission factor, multiplied by the traffic volume, gives an emission estimate for each vehicle class in g/km.

Step 6

The roadside NO_x increment from the M25 has been apportioned by the relative contribution of each vehicle class to the total emissions from all vehicle classes.

Table A5.1 Emissions Factors Used for Each Vehicle Type on the M25

	Annual Average Speed		Emission Factor
	mph	kph	g*/veh/km
Articulated HGV	59	95	10.3
Rigid HGV	59	95	5.0
Buses and Coaches	68	110	6.0
Cars	68	110	0.6
LGV	68	110	1.1

*grammes of NO_x as NO_2

Appendix 6 Management Planning

Measure 1 (20% reduction in HGV traffic)

The HGV traffic volumes in Table A3.2 were multiplied by 0.8. The other traffic volumes in Table A3.2 remained unchanged. Total emissions from each vehicle class were calculated by multiplying the traffic volume by the appropriate emission factor in Table A5.1. These values were then summed. The difference between this value and the value obtained using unmodified traffic data (as a % of the latter value) is the change in emissions likely to result from this change in traffic flow. This % change was then multiplied by 0.995, which is the relative contribution of the M25 to the total roadside incremental NO_x concentration. Assuming a direct, linear relationship between emissions and the roadside incremental NO_x concentration, this gives an estimate of the likely reduction in the roadside incremental NO_x concentration at the receptor. This was then compared with the necessary reduction in roadside incremental NO_x concentration arrived at in section 6.

Measures 2 and 3 (35 and 50% reductions in HGV traffic)

The HGV traffic volumes in Table A3.2 were multiplied by 0.65 and 0.5 respectively. The same methodology as described for option 1 was then followed.

Measures 4, 5 and 6 (20 and 50 and 76% reductions in car traffic)

The car traffic volumes in Table A3.2 were multiplied by 0.8, 0.5, and 0.24 respectively. The other traffic volumes in Table A3.2 remained unchanged. The methodology descried for option 1 was then followed.

Measures 7, 8 and 9 (20 and 21 and 50% reductions in car traffic)

All traffic volumes in Table A3.2 were multiplied by 0.8, 0.79, and 0.5 respectively. The methodology described for option 1 was then followed.

Measure 10 (Using an average speed of 90 kph (56 mph))

Traffic volumes were taken from Table A3.2. These were then multiplied by the appropriate emission factors from Table A6.1 and the resultant vehicle-class-specific emission estimates were summed. The difference between this value and the value obtained using the emission factors from Table A5.1 (as a % of the latter value) is the change in emissions likely to result from this change in traffic speed. This % change was then multiplied by 0.995, which is the relative contribution of the M25 to the total roadside incremental NO_x concentration. Assuming a direct, linear relationship between emissions and the roadside incremental NO_x concentration, this gives an estimate of the likely reduction in the roadside incremental NO_x concentration at the receptor. This was then compared with the necessary reduction in roadside incremental NO_x concentration arrived at in section 6.

Measures 11 and 12 (Using average speeds of 85 and 80 kph (53 and 50 mph))

Traffic volumes were taken from Table A3.2. These were then multiplied by the appropriate emission factors from Table A6.1. The methodology described for option 10 was then followed.

Table A6.1 Emissions Factors for Each Vehicle Type and Speed

	Annual Average Speed		Emission Factor
	mph	kph	g*/veh/km
Articulated HGV	56	90	10.1
	53	85	9.9
	50	80	9.8
Rigid HGV	56	90	4.9
	53	85	4.8
	50	80	4.7
Buses and Coaches	56	90	5.4
	53	85	5.3
	50	80	5.2
Cars	56	90	0.4
	53	85	0.4
	50	80	0.4
LGV	56	90	0.8
	53	85	0.8
	50	80	0.7

*grammes of NO_x as NO_2

References for Appendices

[i] Local Air Quality Management Technical Guidance TG(03)

[ii] www.naei.co.uk

[iii] Trip End Model Presentation Program v4. produced by the Department of Transport. Available from www.tempro.org.uk

[iv] Hickman, A.J., McCrae, I.S., Cloke, J. and Davies, G.J. 2002. Measurements of Roadside Air Pollution Dispersion. TRL Ltd Project report PR/SE/445/02. Available from www.trl.co.uk

[v] available from www.airquality.co.uk

[vi] www.casellastanger.com