Further Assessment of Air Quality in Redhill.

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Reigate & Banstead
BOROUGH COUNCIL
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Document Control

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Contents

Reigate and Banstead Borough Council confirms that it accepts the recommendations made in this report.

1 Introduction

1.1 This report is the Further Assessment of nitrogen dioxide concentrations in Redhill town centre. The report is one of a series produced by, and on behalf of, Reigate and Banstead Borough Council (RBBC), which periodically review and assess air quality within the Borough.

The Air Pollutant of Concern

1.2 Nitrogen dioxide is associated with adverse effects on human health. At high levels nitrogen dioxide causes inflammation of the airways. Long-term exposure may affect lung function and respiratory symptoms. Nitrogen dioxide also enhances the response to allergens in sensitive individuals (Defra, 2007).

The Air Quality Objectives

1.3 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air Quality Regulations, 2000 (Stationery Office, 2000) and the Air Quality (England) (Amendment) Regulations 2002, (Stationery Office, 2002). The relevant objectives for this assessment are provided in Table 1.

Table 1: Relevant Air Quality Objectives

Pollutant	Time Period	Objective
Nitrogen Dioxide	1-hour mean	200 $\mu g/m^3$ not to be exceeded more than 18 times a year
	Annual mean	40 $\mu g/m^3$

1.4 The objectives for nitrogen dioxide were to be achieved by 2005, and continue to apply in all future years thereafter. The air quality objectives only apply where members of the public are likely to be regularly present for the averaging time of the objective (i.e. where people will be exposed to pollutants). For the annual mean objective, relevant exposure is mainly limited to residential properties, schools and hospitals. The 1-hour objective applies at these locations as well as at any outdoor location where a member of the public might reasonably be expected to stay for 1 hour or more, such as shopping streets, parks and sports grounds, as well as bus stations and railway stations that are not fully enclosed.

1.5 Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded where the annual mean concentration is below 60 $\mu g/m^3$ (Defra, 2009). Therefore, 1-hour nitrogen dioxide concentrations will only be considered if the annual mean concentration is above this level.

1.6 The European Union has also set limit values for nitrogen dioxide. Achievement of these values is a national obligation rather than a local one. The limit values for nitrogen dioxide are the same levels as the UK objectives, and were to be achieved by 2010 (Stationery Office, 2007). The Government is currently seeking a time extension from the European Commission to extend the date for achievement of the limit value to 2015.

Introduction to Review and Assessment

1.7 The Air Quality Strategy (Defra, 2007) provides the policy framework for air quality management and assessment in the UK. As well as providing the air quality objectives listed above, it also sets out how the different sectors: industry, transport and local government can contribute to achieving the air quality objectives. Local authorities are seen to play a particularly important role. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular Reviews and Assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date.

1.8 Review and Assessment is carried out as a series of rounds. Local Air Quality Management Technical Guidance (LAQM.TG(09); Defra, 2009) sets out a phased approach to the current round of Review and Assessment. This prescribes an initial Updating and Screening Assessment (USA), which all authorities must undertake. It is based on a checklist to identify any matters that have changed since the previous round. If the USA identifies any areas where there is a risk that the objectives may be exceeded, which were not identified in the previous round, then the Local Authority should progress to a Detailed Assessment.

1.9 The purpose of the Detailed Assessment is to determine whether an exceedence of an air quality objective is likely and the geographical extent of that exceedence. If the outcome of the Detailed Assessment is that one or more of the air quality objectives are likely to be exceeded, then an Air Quality Management Area (AQMA) must be declared. Subsequent to the declaration of an AQMA, a Further Assessment should be carried out, 1) to confirm that the AQMA declaration is justified and that the appropriate area has been declared, 2) to ascertain the sources contributing to the exceedence, and 3) to calculate the magnitude of reduction in emissions required to achieve the objective. This information can be used to inform an Air Quality Action Plan, which will identify measures to improve local air quality.

Scope

1.10 Guidance within LAQM.TG(09) (Defra, 2009) explains that a Further Assessment report allows authorities to:

- confirm their original assessment, and thus ensure they were correct to designate an AQMA in the first place;
- calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA;
- refine their knowledge of sources of pollution, so that the air quality Action Plan may be appropriately targeted;
- take account of any new guidance issued by Defra and the Devolved Administrations, or any new policy developments that may have come to light since declaration of the AQMA;
- take account of any new local developments that were not fully considered within the earlier Review and Assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc, that were not committed or known of at the time of preparing the Detailed Assessment;
- carry out additional monitoring to support the conclusion to declare the AQMA;
- corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way; and
- respond to any comments made by statutory consultees in respect of the Detailed Assessment.

Key Findings of Previous Review and Assessment Reports

1.11 In 2009, the Council completed an Updating and Screening Assessment, which concluded that a Detailed Assessment was required due to measured exceedences of the annual mean nitrogen dioxide objective (RBBC, 2009). In August 2010, a Detailed Assessment was undertaken which confirmed that exceedences of the annual mean objective were likely at locations of relevant exposure and that an AQMA would be required (RBBC, 2010a).

1.12 The conclusions of this Further Assessment will be used to inform the Air Quality Action Plan for the area to be declared as an AQMA.

2 Study Area and AQMA Location

2.1 The Redhill AQMA has not yet been formally declared, however, the proposed AQMA is shown in Figure 1. The study area for this Further Assessment encompasses the AQMA and extends beyond it, particularly to the West. The study area is approximately the extent of the map shown in Figure 1.

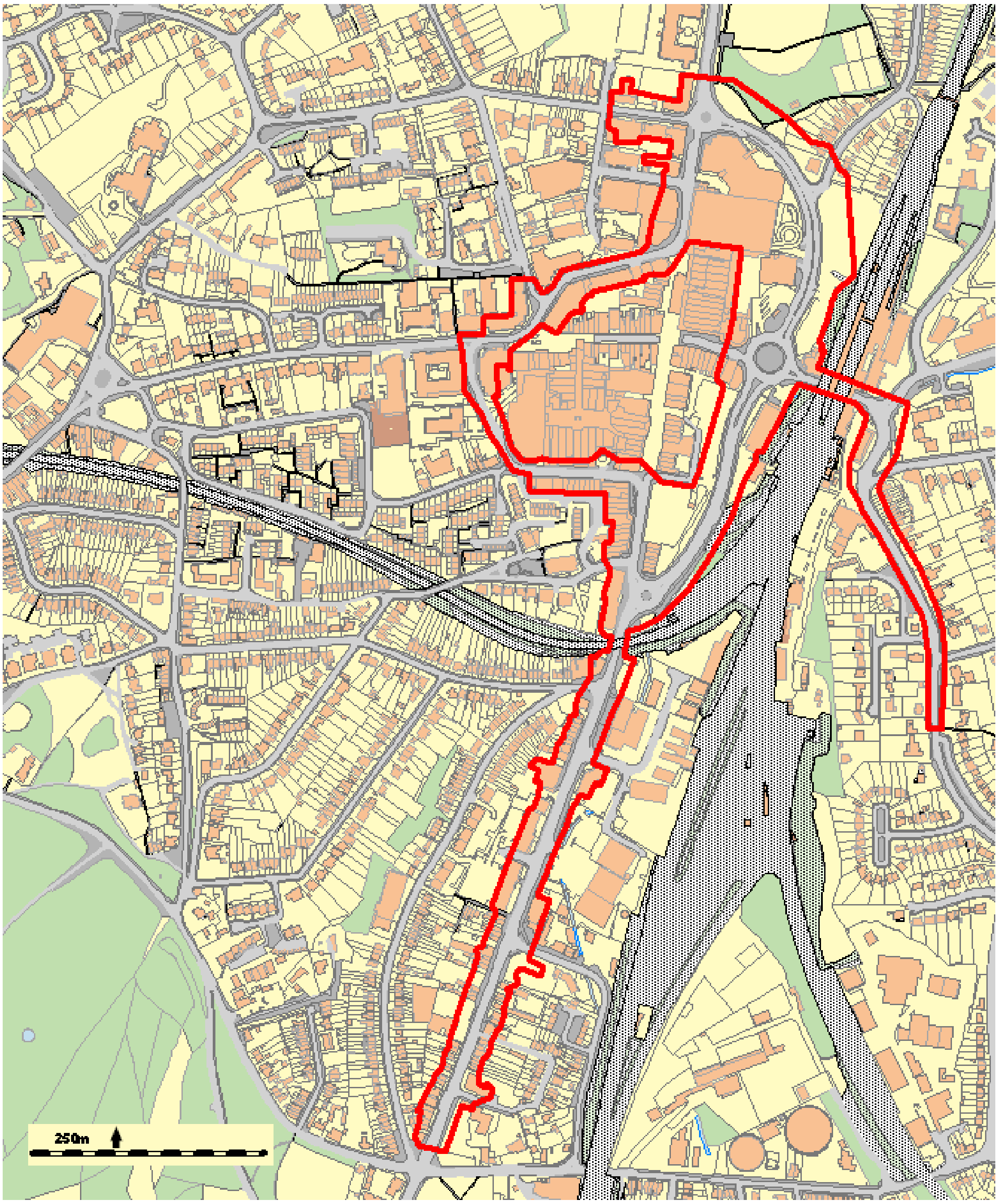

Figure 1: Proposed Redhill AQMA. © Crown Copyright 2011. Reigate & Banstead Borough Council. Licence no. 100019405.

3 Local Developments since Declaration of the AQMA

New and Proposed Local Developments

3.1 The Government's South East Plan, which sets out planning policies for the Southeast region, has identified Redhill/Reigate as a 'centre for significant change' in addition to being at the heart of the Borough's New Growth Point proposals. The Redhill Area Action Plan is a Development Plan Document forming part of the Local Development Framework. Redhill is proposed to undergo significant redevelopment. The Area Proposals (which form part of the Area Action Plan) set out specific areas of the town centre where new development will be brought forward. RBBC has presented detailed Area Proposals for 15 sites (RBBC, 2008). These are summarised in Table 2. The key areas within the model study area are highlighted in Figure 2. These developments are taken into account in the 2016 modelling, as well as in the choice of receptors.

Table 2: Redhill Area Action Plan Developments

Area	Proposals
Town Centre	
AP1 - Railway Station and Car Park	Residential development with ground floor provision of convenience retail, cafe/restaurant and /or community facilities facing onto Princess Way. railway station and transport improvements Station Square - high quality gateway space.
AP2 - Marketfield Way	Redevelopment of existing retail units fronting onto High Street and surface car park to provide for comparison retail/food and drink at ground and first floor. This could include a mid-sized department store anchor unit at southern end above retail: mixed tenure residential, small scale office/business space and potential for hotel or small scale leisure/food and drink function.
AP3 - Cromwell Road	Redevelopment to provide a supermarket and supplementary retail/cafe/restaurants facilities at street level, plus reprovision of affordable housing as part of new mixed tenure housing with community facilties new public square.
AP4 - Warwick Quadrant / Bus Station	Bus station expansion. Long-term redevelopment of library, theatre, cinema with facilities on both ground and upper levels and improvement of existing offices and retail uses plus mixed tenure residential and/or office space above. New station square. Short-term improvements to appearance, entrance space and retail units. Ground floor activity onto Princess Way.
AP5 - Liquid and Envy Nightclub	Mixed use development e.g. leisure, food and drink, hotel, retail, housing. Railway embankment to be landscaped to form a positive continuation of the upgraded Marketfield Way. Improved pedestrian link.
AP6 - Belfry Centre	Enhancement of main entrance fronting High Street and Marketfield Way development site. Creation of new public square and 'cafe quarter' at northern entrance of centre. Improved pedestrian access across Cromwell Road and opening of the Centre's southern facade to face Cromwell Road development.
AP7 - Existing Office Areas	Consolidation and enhancement of existing town centre office belt.

Area	Proposals
AP8 - Memorial Park	Major enhancement of key town centre park, looking at facilities for recreation and play and pedestrian / cycle links with wider area. Opportunity for pavilion building as 'gateway' to park, potentially providing a cafe focus at the entrance to the town centre.
Edge of Centre	
AP9 - East of Railway Station: Colebrook/Royal Mail	Redevelopment of Colebrook Centre. Redevelopment of Royal Mail site to provide high quality commercial floor space. Housing.
AP10 - Reading Arch Road/Brighton Road	Redevelopment to provide appropriate edge of centre mixed use development possibly including leisure, small business units, energy centre and housing. High quality public space with emphasis on accentuating the Redhill Brook. Landscape buffer.
AP11 - Gloucester Road	Opportunity for multi-storey car park alongside residential or office-led development.
AP12 - Donyngs/Hatchlands Road	Retention and enhancement to Donyngs leisure facilities unless alternative, town centre site can be brought forward. Retention and enhancement of allotments. Enhancement to Hatchland's Road local centre.
AP13-Esitng Edge of Centre Housing Areas	Ongoing process of enhancement and refurbishment to existing housing areas. Enhancement of existing recreation ground.
AP14 - Copyhold	Opportunity for leisure/recreation facility which utilises existing countryside setting.
AP15 - Longmead Block	Retention of Longmead Centre if possible. Provision of community facilities as part of comprehensive plan including mixed-tenure residential and/or offices facing onto Holland Close, the recreation ground and St. Matthew's Road.

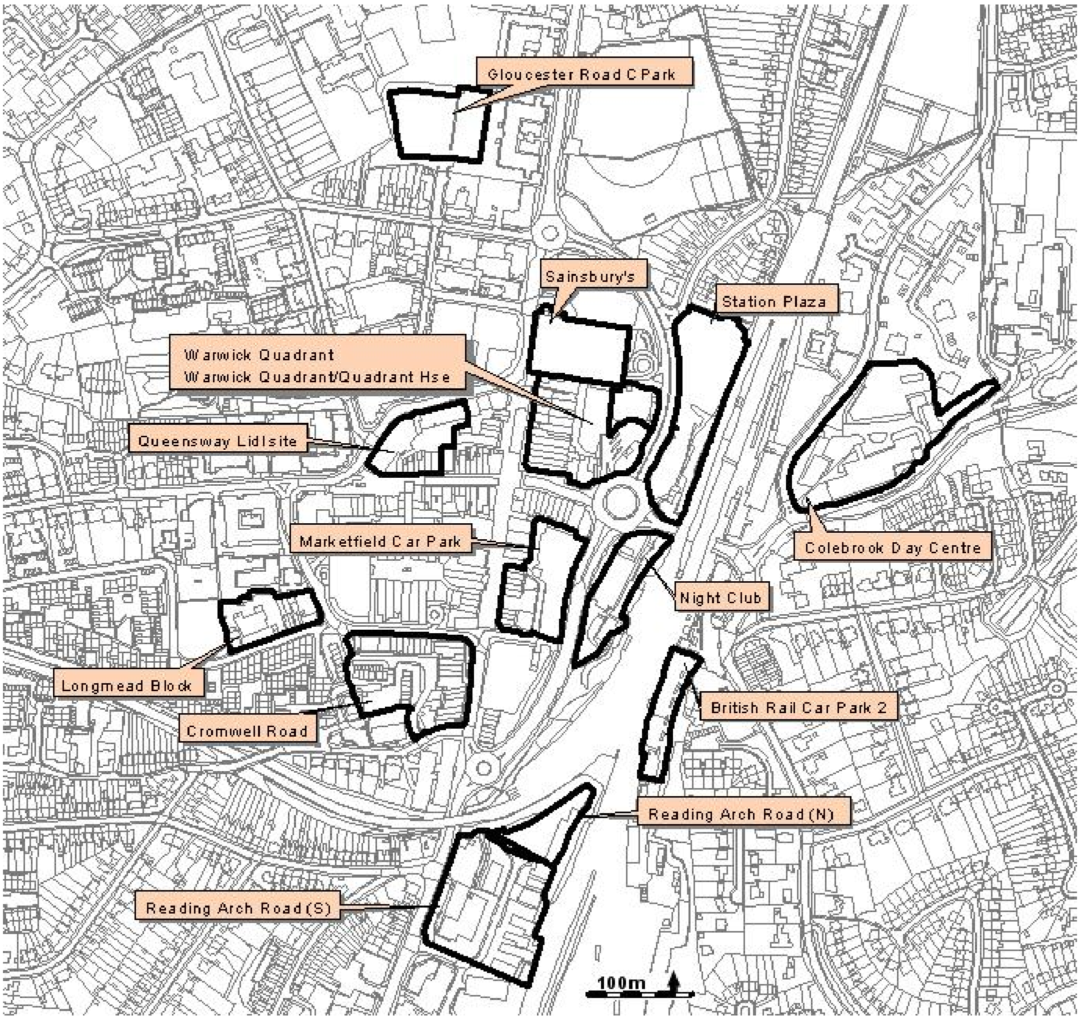

Figure 2: Key Development Areas within Redhill Town Centre

National Developments

3.2 The latest guidance from Defra in LAQM.TG(09) (Defra, 2009) has been followed regarding NOx to NO_2 relationships. All the latest tools associated with the release of LAQM.TG(09) (Defra, 2009), and those subsequently updated, have been used for this assessment. The most recent version of ADMS-Roads (v3), has been used, and vehicle emissions have been calculated using Defra's latest emission factor toolkit (EFT) (Version 4.2.2). A recent report by Defra (Carslaw et al., 2011) has demonstrated that technological improvements in new vehicles have not delivered the reductions in emissions that Defra previously forecast. Defra has yet to update its forecasts to take this into account and so the uncertainty as to future vehicle emissions is only taken into account in a qualitative manner.

4 Responses to Consultees Comments

4.1 Defra's Appraisal Report accepted the conclusions reached within the Detailed Assessment. The Appraisal report made four comments but two were specific to the Reigate Hill area and thus addressed in the Further Assessment for Reigate Hill (RBBC, 2011a). Of relevance to the Redhill assessment, Defra commented that:

1. "It is worth noting that current evidence seems to be suggesting that it is unlikely that reductions in concentrations will be achieved in line with current predicted emissions reductions and that over the next five years actual reductions in concentrations may be negligible".
2. "All data used in calculations should be clearly included in the report, including the background values used in the modelling".
3. "The report does not include an assessment of population exposure to the exceedences nor the magnitude of reduction required. This issue will need to be considered within the Further Assessment".

4.2 Responses are as follows:

1. This point is recognised, but the future year predictions are made using the latest suite of tools that Defra has provided. Once Defra updates the tools that it provides for local authorities to predict future year concentrations it will be possible to take this into account quantitatively. The uncertainty in future projections is taken into account in a qualitative manner. It is also noted that the AQMA boundary, and key conclusions of the assessment, were based on 2009 concentrations and thus not subject to this uncertainty.
2. Appendix 3 of the Detailed Assessment explained the Redhill modelling methodology. This explained that background concentrations were taken from: "*national maps of ambient background concentrations published by Defra during 2010 (Defra, 2010). These maps are published on a 1km x 1km grid resolution. For the Redhill work, these concentrations were interpolated across the study area before a site-specific background value being assigned to each receptor location and intelligent grid point*". It is clearly not practical to tabulate the interpolated background concentrations for each of the (>5,000) receptor points used in the assessment. Full details of the data used in this Further Assessment are provided in Appendix 1.
3. These estimates are included in this Further Assessment.

5 Assessment Methodology

Monitoring

5.1 Monitoring for nitrogen dioxide is carried out using passive diffusion tubes. The monitoring sites are shown in Figure 3. The diffusion tubes are prepared and analysed by Lambeth Scientific Services using 50% TEA in Acetone. It is necessary to adjust diffusion tube data to account for laboratory bias. RBBC has co-located triplicate diffusion tubes with three of its automatic monitoring sites: Michael Crescent (RG1), The Crescent (RG2), and Poles Lane (RG3). Results from these three local surveys have been combined using orthogonal regression[1]. The adjustment factor for 2010 calculated in this way was 1.050 (further details available in RBBC, 2011b).

Modelling

5.2 Annual mean nitrogen dioxide concentrations have been assessed by detailed dispersion modelling (using ADMS-Roads version 3 and ADMS-4.2). The model outputs have been verified against the diffusion tube measurements described in Table 2. Full details of the modelling methodology are set out in Appendix 1.

5.3 Concentrations have been predicted for the year 2009, since this is the year for which detailed traffic flows were available. In addition, concentrations have been predicted for 2016. A series of new developments is planned for Redhill (see Section 3). Air quality was modelled for 2016 assuming all of the development work had been completed. Predictions have been made for each of the receptor locations shown in Figure 4.

Uncertainty

5.4 There is an element of uncertainty in all measured and modelled data. All values presented in this report are the best possible estimates, but uncertainties in the results might cause over-predictions or under-predictions. All of the measurements presented have an intrinsic margin of error. Defra (2009) suggests that this is of the order of plus or minus 20% for diffusion tube data, provided that appropriate QA/QC procedures are applied. The model results rely on a traffic model which has its own inherent uncertainty. There will be additional uncertainties introduced because the modelling has simplified real-world processes into a series of algorithms. For example, it has been assumed the emissions per vehicle conform to the factors published in Defra's latest Emission Factor Toolkit (EFT V4.2.2); it has been assumed that wind conditions measured at Gatwick Airport during 2009 will occur throughout the study area, and it has been assumed that the subsequent dispersion of emitted pollutants will conform to a Gaussian distribution over flat terrain. An important step in the assessment is verifying the dispersion model against the measured data. By comparing the model

1 Using the same method as is used in Defra's national co-location database.

results with measurements, data have been corrected for any under- or over-prediction (see Appendix 1 for details of the model verification).

5.5 Predicting pollutant concentrations in future years will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future, and it is necessary to rely on a series of projections as to what will happen to background pollutant concentrations, and to vehicle emissions. These projections are based on emission factors published by DfT.

5.6 Recently however, a disparity between the road transport emission projections and measured annual mean concentrations of nitrogen oxides and nitrogen dioxide has been identified (Carslaw et al, 2011). This applies across the UK, although there is considerable inter-site variation. Whilst the emission projections suggest that both annual mean nitrogen oxides and nitrogen dioxide concentrations should have fallen by around 15-25% over the past 6 to 8 years, at many monitoring sites levels have remained relatively stable, or have even shown a slight increase. This is reflected in the monitoring data presented in Section 6.

5.7 The precise reason for this disparity is not known, but is thought to be related to the actual on-road performance of diesel vehicles when compared to the calculations based on the Euro standards. It may therefore be expected that nitrogen oxides and nitrogen dioxide concentrations will not fall as quickly in future years as the current projections indicate. However, at this stage, there is no robust evidence upon which to carry out any revised predictions.

5.8 The implications for this assessment are that the nitrogen dioxide concentrations in 2016 may be higher than predicted.

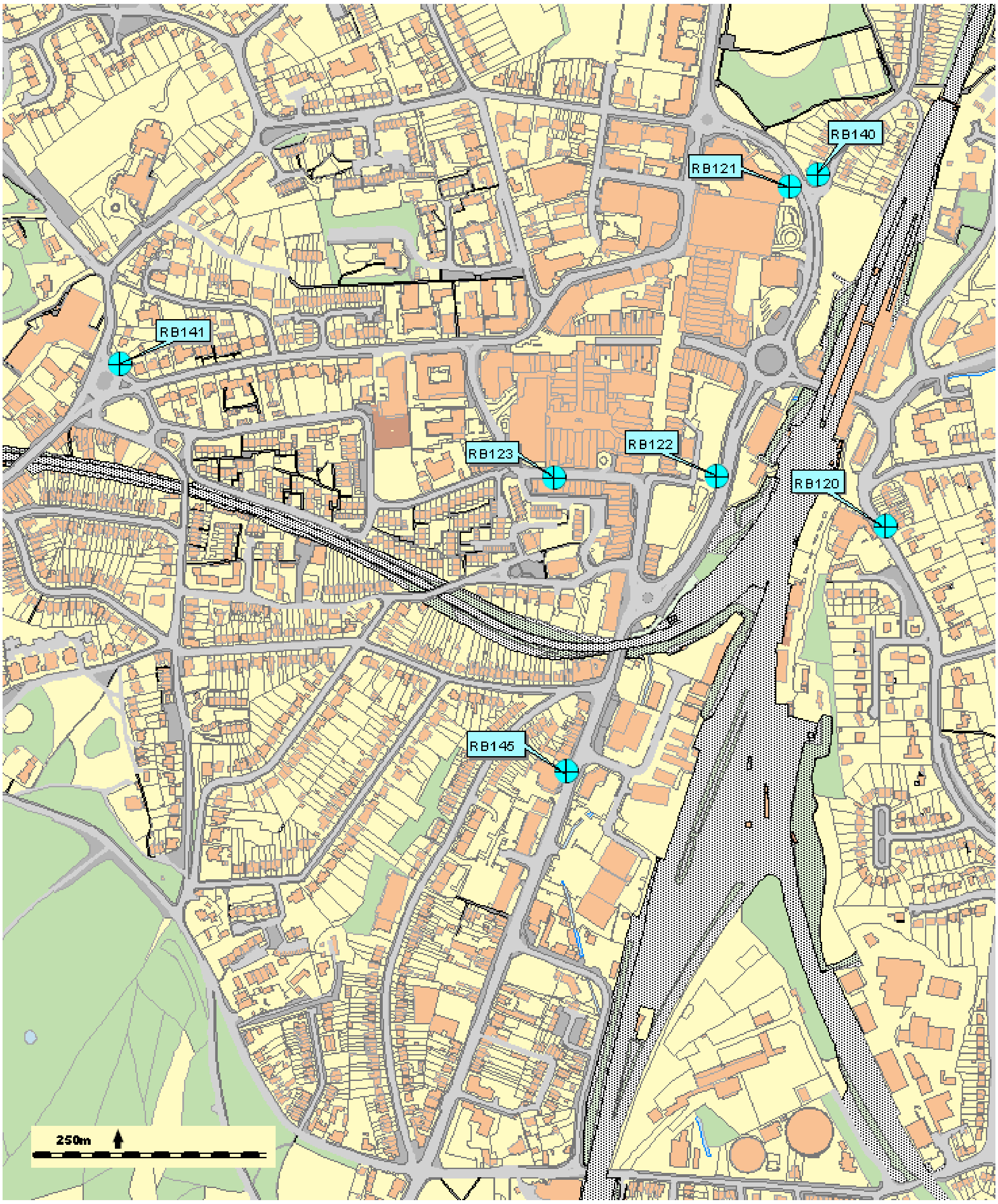

Figure 3: Diffusion Tube Locations. © Crown Copyright. Reigate & Banstead Borough Council. Licence no 100019405

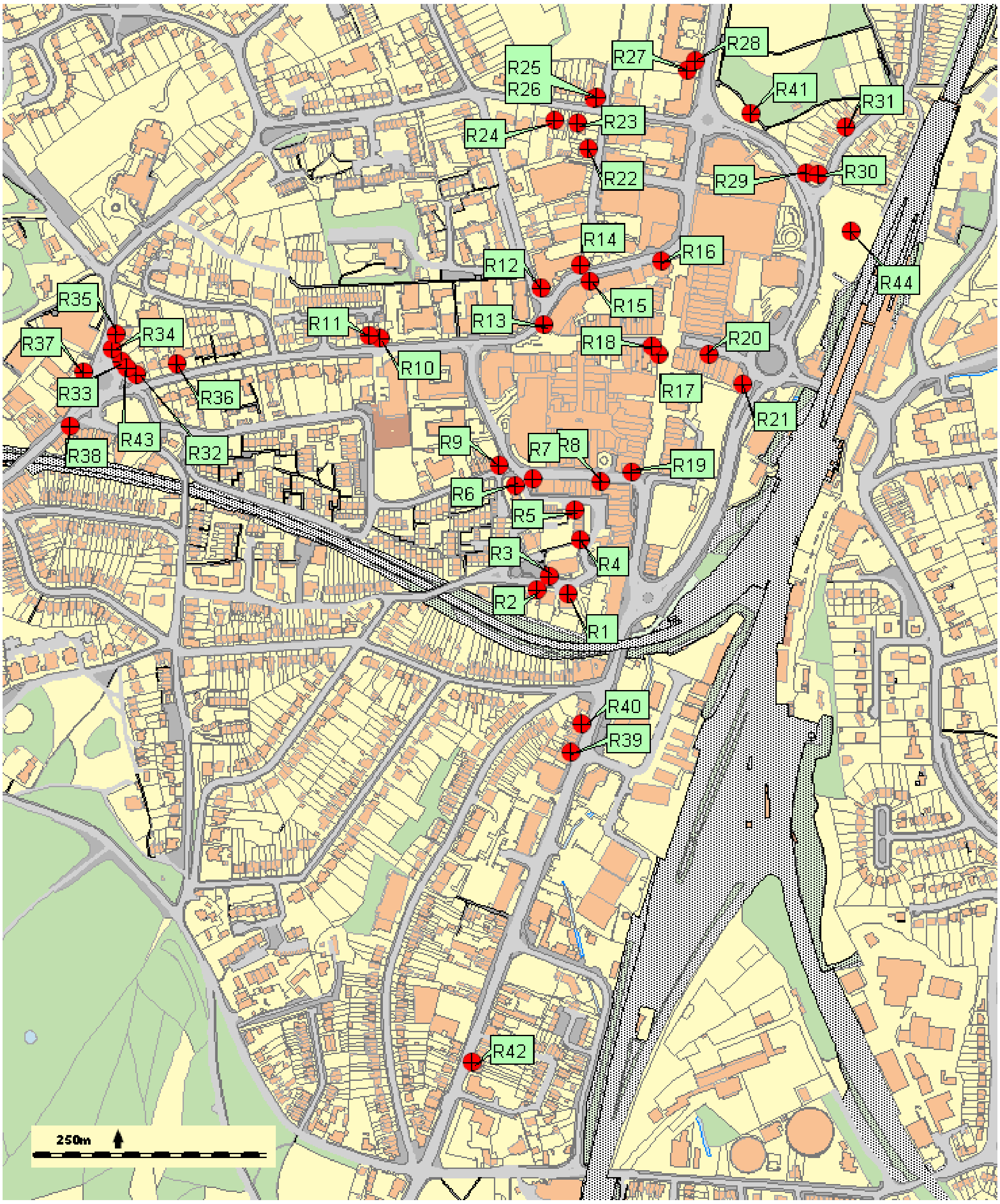

Figure 4: Receptor Locations. © Crown Copyright. Reigate & Banstead Borough Council. Licence no 100019405

6 Results

Monitoring

6.1 Monitoring data for the diffusion tube sites in Figure 2 are summarised in Table 2. In 2007, the objective was exceeded at every operational site except RB122, next to Marketfield Way. In 2008, the objective was exceeded at all four operational sites. In 2009, two additional sites were added. The objective was only exceeded at one site in 2009 (Site RB121, next to Princess Way). Concentrations at the two new sites (RB140 and RB141) were less than 30 μg/m^3 and thus well below the objective level. In 2010 a further additional site was added. Measured concentrations in 2010 were higher than those in 2009, and at one location (RB123) higher than those in 2008. The objective was exceeded at five of the seven sites in 2010.

6.2 There are no clear trends in monitoring results for the past four years. This contrasts with the expected decline due to the progressive introduction of new vehicles operating to more stringent standards, discussed in Section 5.

Table 2: Annual Mean Nitrogen Dioxide Concentrations Measured at Diffusion Tube Sites in Redhill (μg/m^3)

Site	Site Description	2007[a]	2008[b]	2009[c]	2010[d]
RB120	Lamp post Outside 21, Redstone Hill Redhill	**51.1**	**41.9**	36.5	**40.7**
RB121	Lamp Post 271, Opposite Ladbrook Grove, Redhill	**47.6**	**47.0**	**42.9**	**45.3**
RB122	Roundabout Sign 5158 near Carpark, Marketfield Way, Redhill	38.7	**46.5**	39.8	**44.7**
RB123	Lamp post 3, outside Age Concern Cromwell Road, Redhill	**48.6**	**43.4**	39.9	**47.7**
RB140	Flat 2, 45 Ladbrook Grove, Redhill, RH1 1JQ	-	-	29.4	30.9
RB141	Near Roundabout outside 105 Station Road, Redhill, opposite Donyngs	-	-	29.6	35.1
RB145	Lampost outside Brewers, 33 Brighton Road, Redhill	-	-	-	**46.5**
Objective		**40**			

[a] Data available for June to December, annual adjustment factor of 1.02 applied as described in Appendix B of RBBC, 2009. Bias adjusted using a local factor of 1.145.
[b] All > 90% data capture. Bias adjusted using a local factor of 1.02 (RBBC, 2009).
[c] All > 90% data capture. Bias adjusted using a local factor of 1.014 (RBBC, 2010b).
[d] All > 90% data capture. Bias adjusted using a local factor of 1.050 (RBBC, 2011b).

Modelling

6.3 Predicted annual mean nitrogen dioxide concentrations in 2009[2] and 2016 at each of the receptor locations are summarised in Figures 5 and 6 and set out in Table 3. In 2009, the annual mean objective is predicted to have been exceeded at eight of the 44 receptors. All predicted concentrations are below 60 µg/m^3 and therefore the hourly mean objective is unlikely to have been exceeded at any of these receptors in 2009. The suite of tools that Defra currently provides to local authorities for use in their Review and Assessment reports predict that technological improvements will reduce vehicle emissions such that total road traffic emissions will fall despite concurrent increases in traffic volumes. Defra also predicts reductions in emissions from other sectors which are included in its background pollution maps. Using Defra's methodology, concentrations in 2016 are predicted to be markedly lower than those in 2009 and there are no predicted exceedences at any of the receptors in 2016. The limitations to the assessment set out in the uncertainty section should be borne in mind when considering the results for 2016.

[2] Model results are nominally presented for 2009 since they are based on 2009 traffic flows and use 2009 meteorological data. The model has, however, been adjusted to match 3-year average conditions (assuming no year-on-year change in concentrations) and so the results are higher than those measured in 2009, which was a low-pollution year.

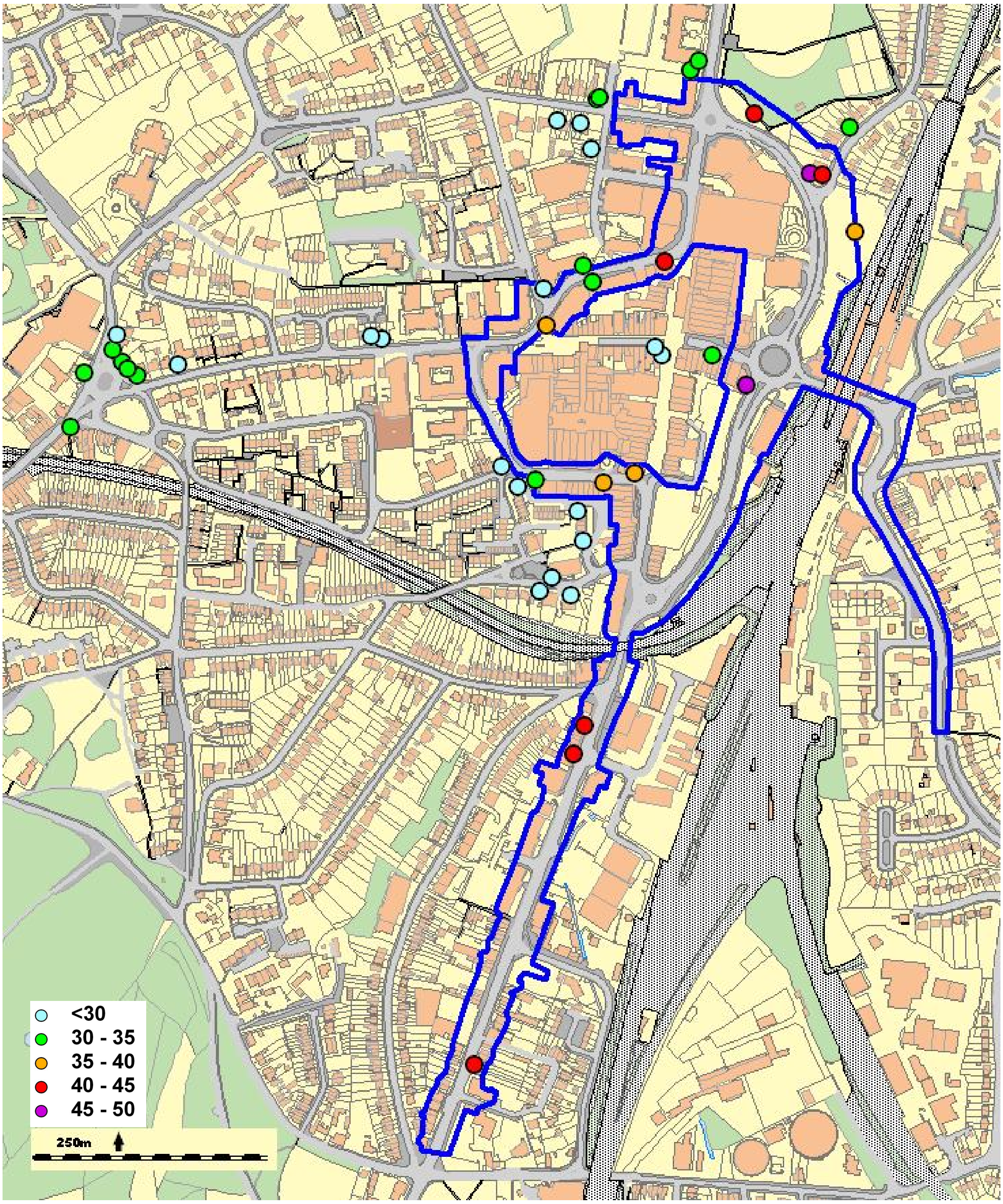

Figure 5: Predicted Annual Mean NO_2 in 2009 ($\mu g/m^3$) © Crown Copyright. Reigate & Banstead Borough Council. Licence no 100019405

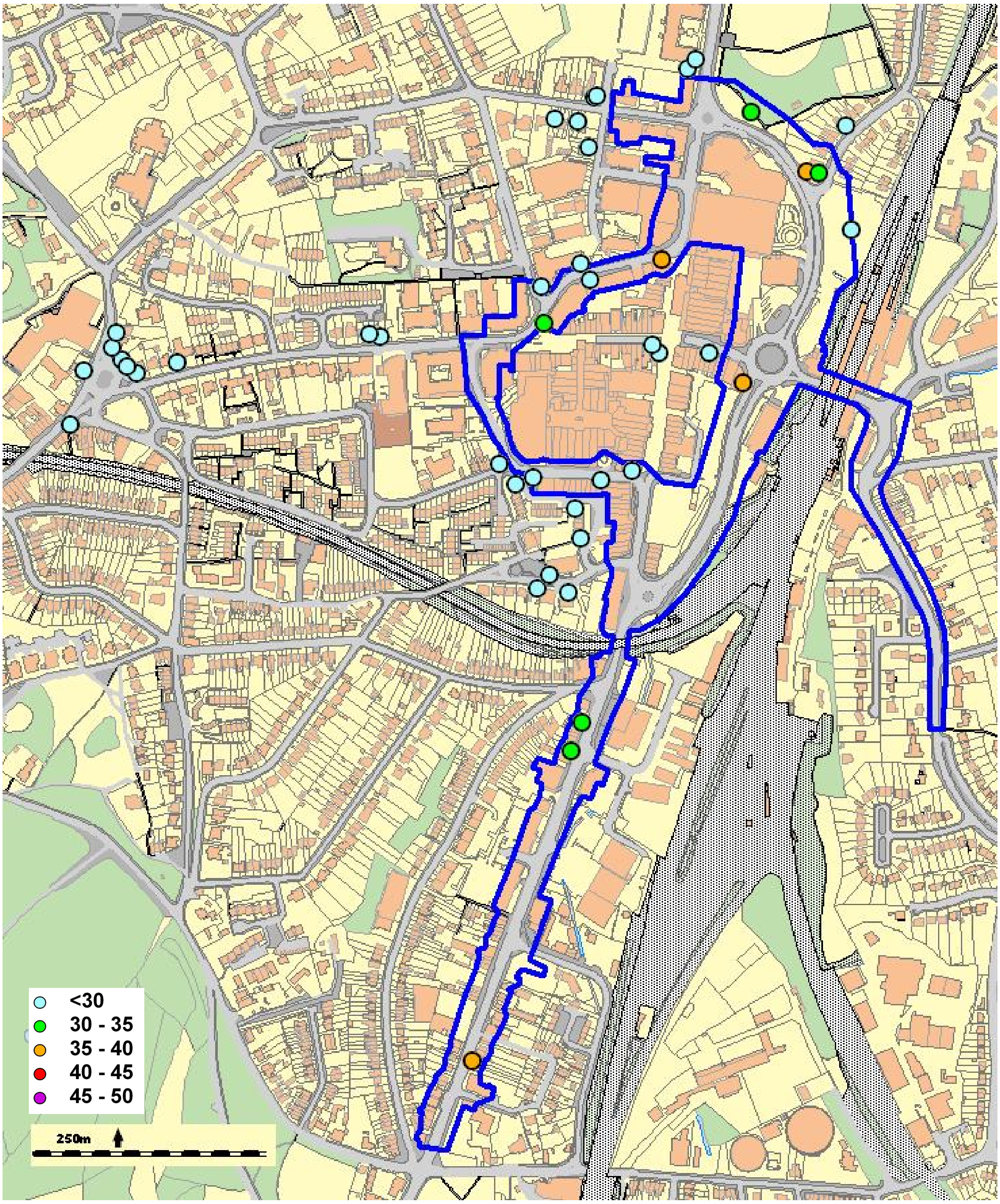

Figure 6: Predicted Annual Mean NO_2 in 2016 ($\mu g/m^3$) © Crown Copyright. Reigate & Banstead Borough Council. Licence no 100019405

Table 3: Modelled Annual Mean Nitrogen Dioxide Concentrations at Selected Worst-Case Receptors in Redhill in 2009[2] and 2016 (µg/m^3)

Receptor	Concentration		Receptor	Concentration		Receptor	Concentration	
	2009	2016		2009	2016		2009	2016
1	26.1	18.9	**16**	**44.9**	39.5	**31**	30.5	22.7
2	24.8	17.9	**17**	25.7	18.6	**32**	31.9	22.6
3	26.5	19.1	**18**	25.4	18.5	**33**	32.0	22.6
4	26.4	19.1	**19**	37.8	26.4	**34**	30.9	21.8
5	26.1	18.7	**20**	31.8	22.8	**35**	28.0	19.8
6	26.4	18.9	**21**	**48.7**	38.0	**36**	27.0	19.1
7	32.3	22.9	**22**	25.9	19.3	**37**	30.2	21.5
8	36.1	25.5	**23**	26.2	19.0	**38**	32.0	22.6
9	28.1	19.8	**24**	24.8	17.9	**39**	**40.0**	32.7
10	29.0	20.7	**25**	31.2	22.4	**40**	**41.4**	34.0
11	27.6	19.7	**26**	31.3	22.5	**41**	**42.0**	31.8
12	29.2	23.4	**27**	32.4	23.0	**42**	**43.1**	36.2
13	37.0	31.1	**28**	34.9	24.8	**43**	32.0	22.7
14	31.6	26.9	**29**	**49.4**	39.8	**44**	35.6	27.4
15	32.3	27.4	**30**	**42.7**	33.5			
Objective	40							

Confirmation of the AQMA Boundary

6.4 As explained in Appendix 2, contour isopleths have not been re-modelled for this Further Assessment and this section re-interprets the contours presented in the Detailed Assessment (RBBC, 2010a). Appendix 2 explains that the methodology for the Detailed Assessment and Further Assessment are largely the same, with the most significant difference being that model results in Detailed Assessment were adjusted to match measurements made in 2009, whereas those for this Further Assessment have been adjusted using data for three years (2008-2010). The effect of this change is that the current model results are approximately 10% higher than those in the Detailed Assessment. The "36 µg/m^3" contour from the Detailed Assessment is thus used in Figure 7 to indicate concentrations of 40 µg/m^3, while the "32 µg/m^3" contour from the Detailed Assessment is taken to indicate concentrations of 35 µg/m^3. The only locations where either of these contours extend beyond the AQMA boundary are those where there is no relevant exposure to the objectives. Thus, using the latest data, it is highly unlikely that locations with relevant exposure outside of the AQMA would experience concentrations greater than 35 µg/m^3. The AQMA boundary is thus considered to be appropriate.

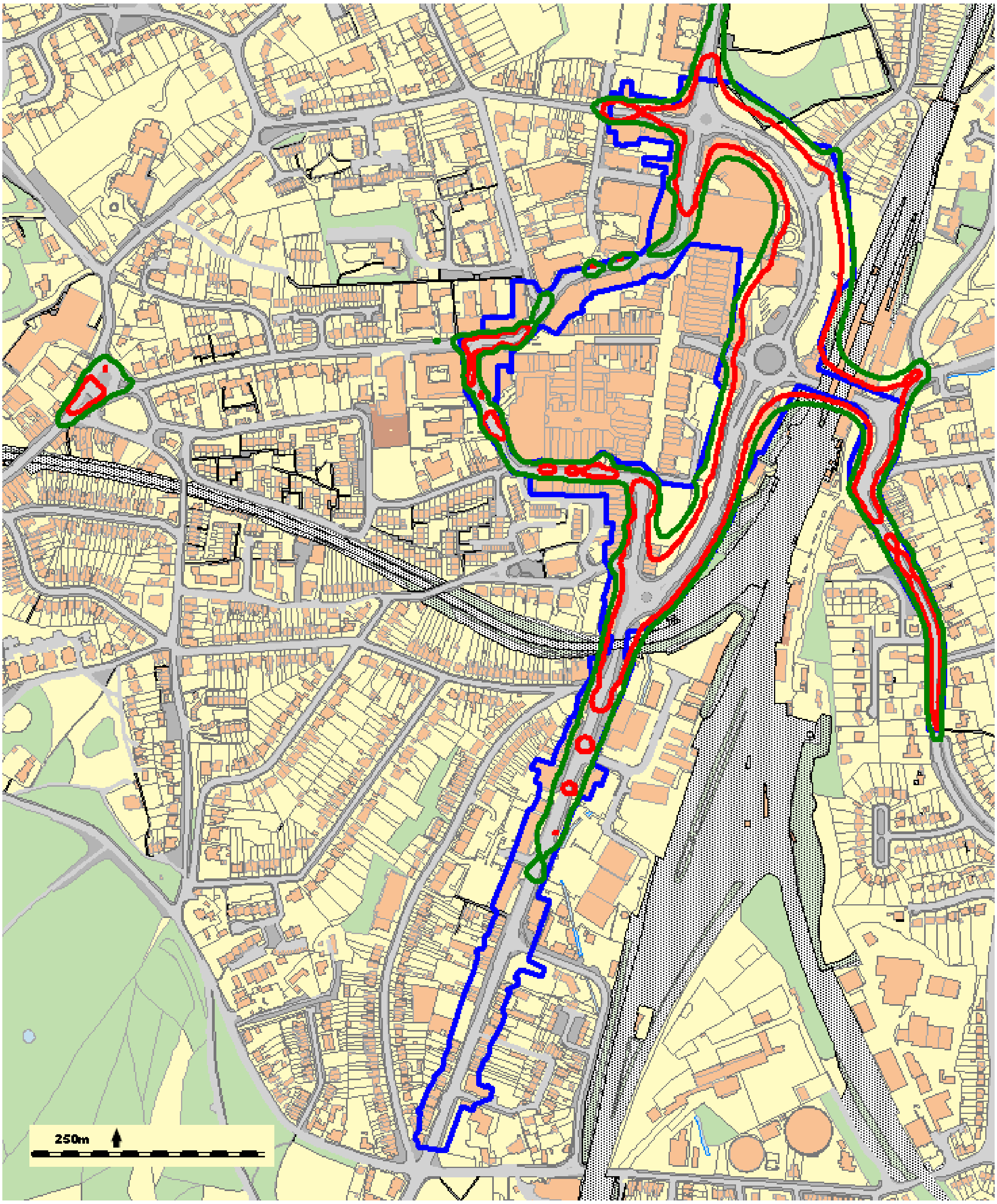

Figure 7: Nitrogen Dioxide Concentration Contours 2009[2]. The Red line is Indicative of 40 µg/m³, the Green Line is indicative of 35 mg/m³, and the Blue Line shows the AQMA Boundary (note: where the blue line is obscured, it follows the 35 mg/m³ contour).

Population Exposure

6.5 The AQMA is centred on the town centre, where most of the buildings do not represent relevant exposure in terms of the annual mean objective. Where there is relevant exposure in the form of residential flats, they often occupy the upper floors; where concentrations are likely to be lower than those shown in Figure 7 (which are based on ground-level (1.5 m) concentrations). As explained in Section 3, this area is undergoing significant local redevelopment and it is difficult, at this stage, to show precisely where new residential properties will be located. The number of existing residential properties within the 35 μg/m^3 and 40 μg/m^3 contours (Figure 7) are set out in Table 4. The average household size in Redhill during the 2001 census was 2.3 (RBBC, 2011c), suggesting that approximately 90 people live within the 40 μg/m^3 contour.

Table 4: Number of Listed Addresses within the AQMA

Area	Number of Residential Properties
35 mg/m^3 contour	138
40 mg/m^3 contour	35

7 Source Apportionment

7.1 In order to develop an appropriate action plan it is necessary to identify the sources contributing to the objective exceedences within the AQMA. These data can be used to inform future traffic management decisions. Source apportioned nitrogen dioxide concentrations have been calculated taking account of the different proportions of primary nitrogen dioxide (f-NO_2) emitted by different vehicle types. The methodology used is explained in Appendix 1. Table 5 sets out the relevant contribution of different vehicle types to total annual mean nitrogen dioxide concentrations at each of the eight receptors where objective exceedences are predicted in 2009. These data are repeated in Table 6 for 2016 using the same subset of receptors. Source-apportioned concentrations at all 44 Receptors are summarised in Figures 8 and 9 for 2009 and 2016 respectively.

Table 5: Predicted Annual Mean (2009) Nitrogen Dioxide Concentrations and the Contribution of Each Source to the Total

Receptor	Annual Mean Concentration (µg/m^3)					
	Background	**Car**	**LGV**	**HGV**	**Bus**	**Total**
16	18.0	7.3	2.6	8.7	8.2	44.9
21	17.9	7.9	3.1	10.4	9.4	48.7
29	18.0	8.7	3.2	10.3	9.1	49.4
30	17.9	6.6	2.3	8.2	7.5	42.7
39	17.4	5.7	2.1	8.3	6.5	40.0
40	17.5	6.3	2.3	8.2	7.1	41.4
41	18.0	6.5	2.3	8.1	7.1	42.0
42	16.5	7.0	2.6	9.6	7.4	43.1
	% Contribution to Total					
	Background	**Car**	**LGV**	**HGV**	**Bus**	**Total**
16	40%	16%	6%	19%	18%	100%
21	37%	16%	6%	21%	19%	100%
29	36%	18%	7%	21%	18%	100%
30	42%	16%	5%	19%	18%	100%
39	44%	14%	5%	21%	16%	100%
40	42%	15%	6%	20%	17%	100%
41	43%	16%	5%	19%	17%	100%
42	38%	16%	6%	22%	17%	100%

7.2 The largest single contribution to total concentrations at each receptor is the ambient background. In terms of local traffic, in 2009 HGVs make the largest contribution to the objective exceedences, followed by buses and then cars. By 2016, cars are expected to be the largest contributor[3], followed by buses. The limitations of the 2016 emission factors should, however be recognised when interpreting these data.

Table 6: Predicted Annual Mean (2016) Nitrogen Dioxide Concentrations and the Contribution of Each Source to the Total

Receptor	Annual Mean Concentration (µg/m³)					
	Background	Car	LGV	HGV	Bus	Total
16	13.1	10.1	2.7	5.9	7.7	39.5
21	13.0	9.0	2.3	6.2	7.5	38.0
29	13.0	10.0	2.5	6.5	7.9	39.8
30	13.0	7.4	1.8	5.0	6.2	33.5
39	12.7	6.8	1.8	5.3	6.0	32.7
40	12.8	7.2	2.0	5.6	6.4	34.0
41	13.1	6.8	1.6	4.7	5.6	31.8
42	12.1	8.4	2.3	6.2	7.2	36.2
	% Contribution to Total					
	Background	**Car**	**LGV**	**HGV**	**Bus**	**Total**
16	33%	26%	7%	15%	19%	100%
21	34%	24%	6%	16%	20%	100%
29	33%	25%	6%	16%	20%	100%
30	39%	22%	5%	15%	19%	100%
39	39%	21%	6%	16%	18%	100%
40	38%	21%	6%	17%	19%	100%
41	41%	21%	5%	15%	18%	100%
42	33%	23%	6%	17%	20%	100%

[3] This point is interesting, since it is only the case for NO_2 and not for NOx. In terms of NOx, buses and HGVs remain the most significant contributors in 2016, but predicted f-NO_2 for cars in 2016 is much higher than that for buses or HGVs and this alters the relative distribution in terms of NO_2.

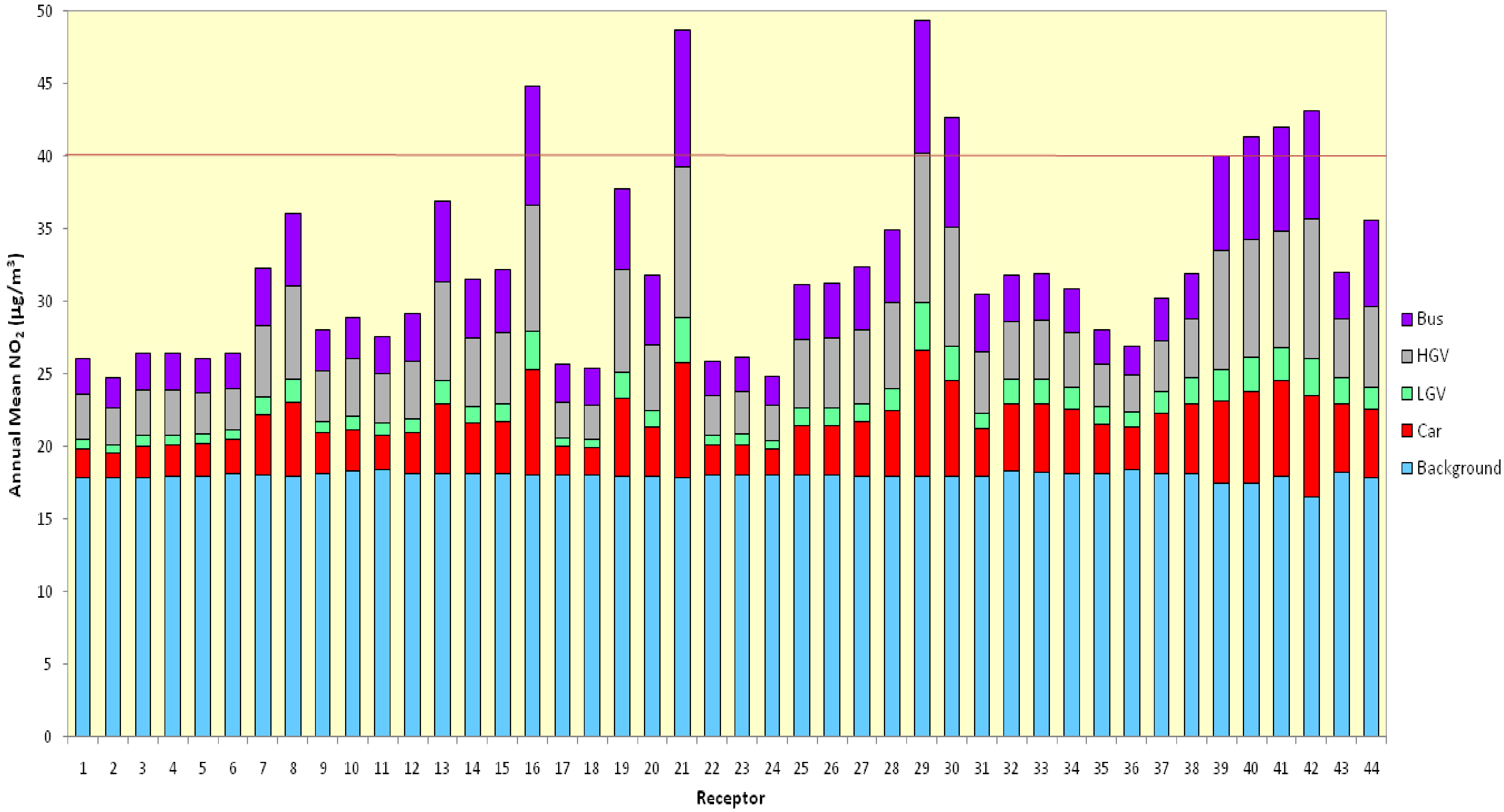

Figure 8: Contribution of Each Source to the Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m³) at Each Receptor in 2009

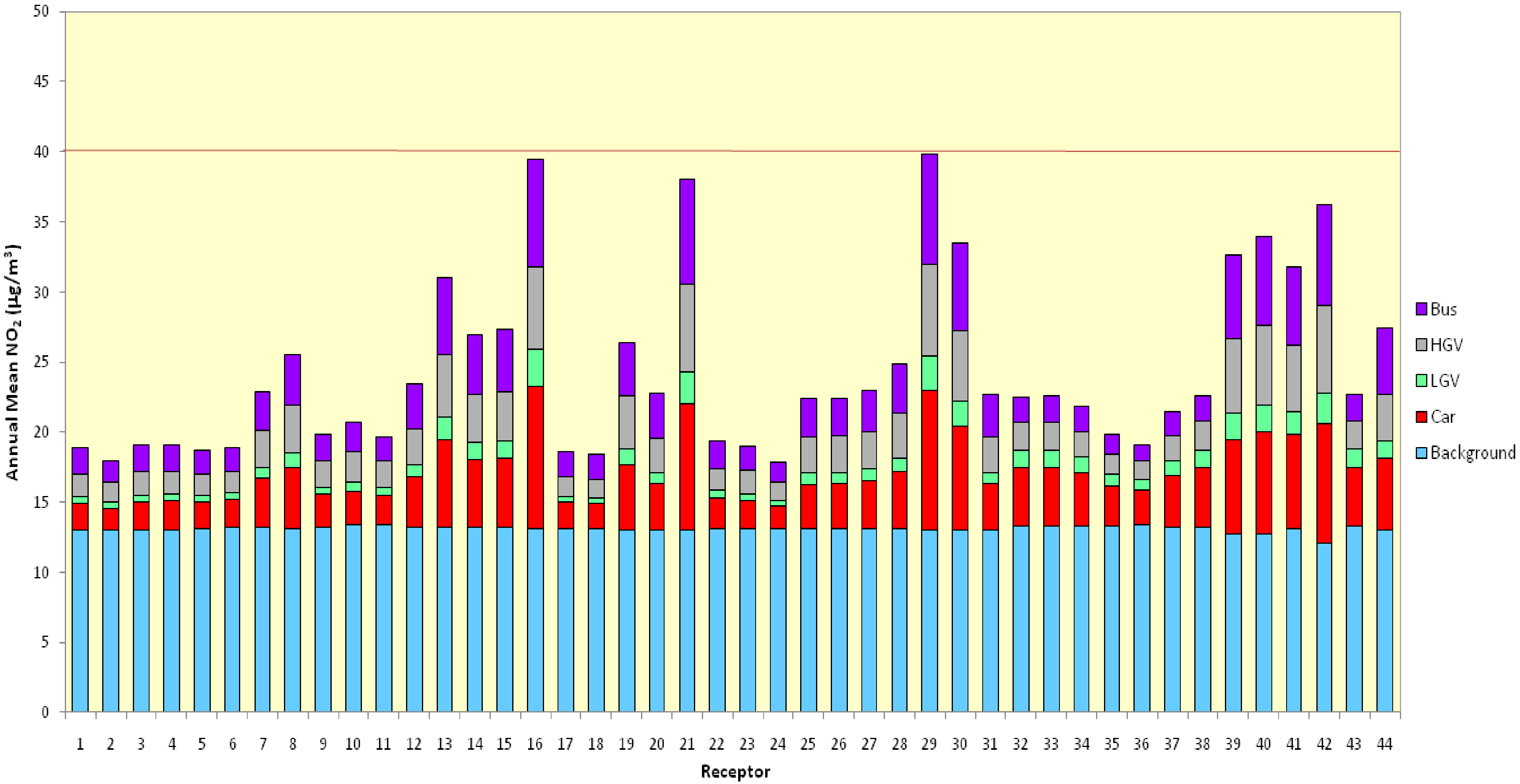

Figure 9: Contribution of Each Source to the Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m³) at Each Receptor in 2016.

8 Air Quality Improvements Required

8.1 The degree of improvement needed in order for the annual mean objective to be achieved is defined by the difference between the highest predicted concentration and the 40 µg/m^3 objective level. The highest nitrogen dioxide concentration is that measured at Receptor 29 (49.3 µg/m^3), requiring a reduction of 9.3 µg/m^3 in order for the objective to be achieved.

8.2 It is conventional to consider the improvement required in terms of the primary pollutant nitrogen oxides (NOx). Different vehicle types are characterised by different f-NO_2 values, and so the reduction in NOx required to achieve the nitrogen dioxide objective depends upon the types of vehicle being managed. For example, the degree of reduction required will be different if it is brought about through reducing car emissions than if it is achieved through reducing bus emissions. For the purposes of calculating the indicative data in Table 7, it has been assumed that any emission reductions are achieved without altering the composition of the vehicle fleet (which in practice is unlikely). Table 7 shows that, at Receptor 29, a reduction of 32.4 µg/m^3 in NOx would be required in order to achieve the objective. This equates to a reduction of 37% in emissions from local roads.

Table 7: Improvement in Annual Mean Nitrogen Dioxide Concentrations and in Emissions of Oxides of Nitrogen in 2009.

Receptor	Required reduction in annual mean nitrogen dioxide concentration (µg/m^3)		Required reduction in annual mean nitrogen oxides (NOx) concentration (µg/m^3)[a]	
	mg/m^3	% of total from local roads	mg/m^3	% of total from local roads
16	4.9	18%	16.1	22%
21	8.7	28%	30.3	35%
29	9.4	30%	32.4	37%
30	2.7	11%	8.5	13%
39	<0.1	<1%	<0.1	<1%
40	1.4	6%	4.4	7%
41	2.0	8%	6.4	10%
42	3.1	12%	10.3	15%

[a] Assuming these reductions are brought about without altering the vehicle fleet composition.

9 Management Planning

9.1 In order to inform the focus of potential measures within the Action Plan, a number of simple and hypothetical measures to deliver the required reductions at each receptor have been explored. The measures that have been examined involve stepped reductions in emissions from each of the vehicle categories defined in Section 7. It is not within the remit of this report to speculate on how these reductions might be achieved, and the intention is simply to inform future management decisions. Table 8 sets out the results.

Table 8: Modelled Annual Mean Nitrogen Dioxide Concentration During 2009 Assuming Hypothetical Emission Reductions from Different Vehicle Classes.

Vehicle Type	% Reduction in Emissions	Predicted Annual Mean Concentration (µg/m^3)							
		16	21	29	30	39	40	41	42
Car	10%	**44.3**	**48.1**	**48.7**	**42.1**	39.6	**40.9**	**41.5**	**42.6**
	25%	**43.4**	**47.2**	**47.7**	**41.3**	38.8	**40.1**	**40.7**	**41.7**
	50%	**41.9**	**45.6**	**46.0**	39.9	37.6	38.9	39.3	**40.3**
LGV	10%	**44.7**	**48.5**	**49.1**	**42.5**	39.8	**41.2**	**41.8**	**42.9**
	25%	**44.4**	**48.1**	**48.7**	**42.2**	39.6	**40.9**	**41.5**	**42.6**
	50%	**43.8**	**47.5**	**48.1**	**41.7**	39.1	**40.4**	**41.1**	**42.0**
Bus	10%	**44.2**	**48.0**	**48.6**	**42.0**	39.4	**40.7**	**41.4**	**42.4**
	25%	**43.2**	**46.8**	**47.5**	**41.1**	38.4	39.7	**40.4**	**41.3**
	50%	**41.5**	**44.8**	**45.5**	39.4	36.6	37.9	38.8	39.4
HGV	10%	**43.6**	**47.3**	**47.9**	**41.4**	38.9	**40.2**	**40.8**	**41.8**
	25%	**41.6**	**45.0**	**45.7**	39.5	37.0	38.2	38.9	39.8
	50%	37.9	**40.8**	**41.6**	36.0	33.7	34.8	35.6	36.1
All Vehicles	10%	**42.8**	**46.4**	**47.0**	**40.7**	38.2	39.5	**40.1**	**41.0**
	25%	39.4	**42.7**	**43.2**	37.5	35.3	36.4	37.0	37.7
	50%	33.2	35.7	36.1	31.8	29.9	30.8	31.4	31.5
Do Nothing	-	**44.9**	**48.7**	**49.4**	**42.7**	**40.0**	**41.4**	**42.0**	**43.1**

9.2 The results presented in Table 9 highlight that targeting vehicle types in isolation would achieve very little. The only effective measure for improving air quality would be to reduce total vehicle emissions by between 25 and 50% (in practice by 37% as set out in Section 8). This is the only measure that, in 2009, would reduce the concentrations to a level where the annual mean objective would be met.

10 Summary and Conclusions

10.1 Nitrogen dioxide concentrations within and around Redhill town centre have been assessed through diffusion tube monitoring and dispersion modelling. The results indicate that the annual mean nitrogen dioxide objective continues to be exceeded within the AQMA, but that there are no exceedences outside of the AQMA. It is therefore recommended that the AQMA, as proposed, is appropriate, and should be declared as soon as possible.

10.2 It has been shown that ambient background concentrations contribute the largest proportion to existing nitrogen dioxide concentrations, followed by emissions from HGVs and buses on local roads. By 2016, Defra's current vehicle emission factors suggest that cars will become the most important local contributor; principally because of expected shifts in the relative proportion of primary nitrogen dioxide (f-NO_2) emitted by different vehicles.

10.3 A reduction in the volume of traffic within the AQMA would result in a decrease in the concentrations of nitrogen dioxide. However, assuming no change in vehicle fleet composition, a reduction in total vehicle emissions of 37% would be required to achieve the annual mean objective at the worst-case location.

11 References

AQC, 2009. Assessment of Air Quality in Redhill.

AQC/TRL, 2010. Local Measures for NO_2 Hotspots in London http://www.aqconsultants.co.uk/getattachment/355ae820-d090-4f60-97bc-28d51ad05c0a/Local-Measures-for-NO2-Hotspots-in-London---Produc.aspx

Carslaw, D, Beevers, S, Westmoreland, E and Williams, M, 2011. Trends in NOx and NO_2 emissions and ambient measurements in the UK. Available at: http://uk-air.defra.gov.uk/library/reports?report_id=645

Defra, 2007. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007.

Defra, 2009. Review & Assessment: Technical Guidance LAQM.TG(09).

Defra, 2010. Defra Air Quality Website accessed during 2010 at: www.airqaulity.co.uk

Defra, 2011. Defra Air Quality Website at: www.defra.gov.uk/environment/quality/air/airquality/

DfT, 2007. English Regional Traffic Growth and Speed Forecasts. Available at http://www.dft.gov.uk/pgr/economics/ntm/AF07_Annex_Baseline_summary.xls

DfT, 2008 DfT (2008) Regional Tranport Statistics. Available at: http://www.dft.gov.uk/pgr/statistics/datatablespublications/regionaldata/rts/regtranstats2008

DfT, 2009. TEMPRO (Version 6.2) System. Available at www.tempro.org.uk

RBBC, 2008. Redhill Area Action Plan. Details available at www.reigate-banstead.gov.uk/planning/planning_policies/local_development_framework/redhill_area_action_plan/

RBBC, 2009. Updating and Screening Assessment of Air Quality within the Borough of Reigate and Banstead. Available at: www.reigate-banstead.gov.uk/Images/2009_03999_RPR_005_RBBC_final_050809incl%20consult1a_tcm9-37188.pdf

RBBC, 2010a. Detailed Assessment of Air Quality on Reigate Hill and in Redhill Town Centre. Available at: www.reigate-banstead.gov.uk/Images/2010_03097_RPR_005a_Reigate%20Hill%20and%20Redhill%20DA%20250810FINALwcover1_tcm9-41449.pdf

RBBC, 2010b. Progress Report (2010) on Air Quality within the Borough of Reigate and Banstead. Available at: www.reigate-banstead.gov.uk/Images/2010%20Progress%20Report%20110111%20FINALwithfront_tcm9-42553.pdf

RBBC, 2011a. Further Assessment of Air Quality in the Reigate Hill AQMA

RBBC, 2011b. Progress Report (2011) on Air Quality within the Borough of Reigate and Banstead

RBBC, 2011c. 2001 Census Town / Village Profile – Redhill. Available at: www.reigate-banstead.gov.uk/Images/Redhill_tcm9-20822.pdf

Stationery Office, 2000. Air Quality Regulations, 2000, Statutory Instrument 928.

Stationery Office, 2002. Air Quality (England) (Amendment) Regulations, 2002, Statutory Instrument 3043.

Stationery Office, 2007. The Air Quality Standards Regulations, 2007 (No.64).

12 Glossary

Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal.
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date, taking into account costs, benefits, feasibility and practicality. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides.
Exceedence	A period of time where the concentration of a pollutant is greater than the appropriate air quality objective.
AQMA	Air Quality Management Area
ADMS Roads	Atmospheric Dispersion Modelling System for Roads.
NOx	Nitrogen oxides
NO_2	Nitrogen dioxide.
mg/m^3	Microgrammes per cubic metre.
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
TEA	Triethanolamine – used to absorb nitrogen dioxide

A1 Dispersion Modelling Methodology Used for Receptor Locations

Background Concentrations

A1.1 Sources not included explicitly were accounted for using the national maps of ambient background concentrations published by Defra (Defra, 2011). These maps are published on a 1km x 1km grid resolution. Concentrations were interpolated across the study area before a site-specific background value was assigned to each receptor location. The background concentrations used in this assessment are set out in Table A1.1.

Table A1.1: Background Nitrogen Dioxide Concentrations (μg/m^3)

Receptor	Concentration		Receptor	Concentration		Receptor	Concentration	
	2009	2016		2009	2016		2009	2016
1	17.8	13.0	**16**	18.0	13.1	**31**	18.0	13.0
2	17.9	13.0	**17**	18.0	13.1	**32**	18.3	13.3
3	17.9	13.0	**18**	18.0	13.1	**33**	18.2	13.3
4	17.9	13.1	**19**	17.9	13.1	**34**	18.2	13.3
5	18.0	13.1	**20**	17.9	13.1	**35**	18.2	13.3
6	18.1	13.2	**21**	17.9	13.0	**36**	18.4	13.4
7	18.1	13.2	**22**	18.0	13.1	**37**	18.1	13.2
8	18.0	13.1	**23**	18.0	13.1	**38**	18.1	13.2
9	18.2	13.2	**24**	18.0	13.1	**39**	17.4	12.7
10	18.4	13.4	**25**	18.0	13.1	**40**	17.5	12.8
11	18.4	13.4	**26**	18.0	13.1	**41**	18.0	13.1
12	18.1	13.2	**27**	18.0	13.1	**42**	16.5	12.1
13	18.2	13.2	**28**	18.0	13.1	**43**	18.3	13.3
14	18.1	13.2	**29**	18.0	13.0	**44**	17.9	13.0
15	18.1	13.2	**30**	17.9	13.0			
Diffusion Tubes								
RB120	17.5	-	**RB123**	18.1	-	**RB145**	17.4	-
RB121	18.0	-	**RB140**	17.9	-			
RB122	17.8	-	**RB141**	18.2	-			

Meteorological Data

A1.2 A full year of hour-by-hour meteorological data from Gatwick Airport in 2009 were used in the model. These data are summarised in Figure A1.1.

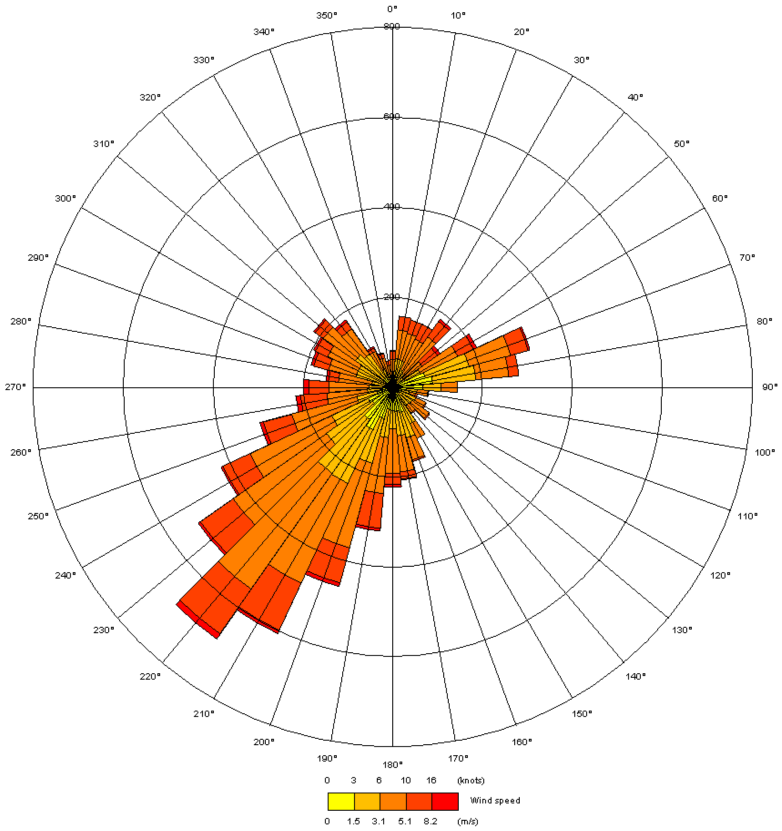

Figure A1.1: Wind Rose for Gatwick Airport in 2009

Traffic Data

2009

A1.3 RBBC provided the results from Surrey County Council's micro-simulation traffic model for 2007. The model provided the hourly flow of cars, LGVs, HGVs, and buses/coaches, as well as modelled hourly average speeds. These data were provided for the following time periods:

- Weekday AM peak hour
- Weekday PM peak hour
- Saturday peak hour

A1.4 For each remaining hour of the week, traffic volumes were interpolated from the modelled data based upon the results of traffic counts carried out on key roads in the town. Speeds during other hours were interpolated from the modelled speeds based upon the typical urban diurnal speed profile published in the 2008 edition of the Department for Transport's Regional Transport Statistics (DfT, 2008)[4].

A1.5 These traffic flows for 2007 were factored to represent 2009 conditions using the average ratio of change from two long-term traffic counters situated on key routes into Redhill which provided counts in both 2007 and 2009. It was assumed that flows into and out of the car parks and bus station did not change between 2007 and 2009.

A1.6 The micro-simulation model did not include flows around Hatchlands Roundabout. These were calculated using annual average daily traffic (AADT) flows for the three roads serving the roundabout (Station Road, Hatchlands Road and Linkfield Lane)[5]. The AADT flow for Station Road was taken from the micro-simulation model (with modelled flows used to calculate AADT following the approach given in paragraph A1.4). The flows for Hatchlands Road and Linkfield Lane were taken from short-term (12-hour and 7-day respectively) counts conducted in 2005, factored to represent conditions in 2009 using the approach recommended by Defra (2011) (using a combination of the National Traffic Model and TEMPRO (DfT 2007 and 2009)). The vehicle fleet composition around Hatchlands Roundabout was assumed to be the same as that on Station Road.

A1.7 The 2009 traffic dataset as included in the dispersion model is made up of more than 45,000 individual traffic flows. It was not considered helpful to tabulate these data within this report, but spreadsheets can be made available to Defra on request.

2016

A1.8 As explained in Section 3, Redhill is expected to undergo significant redevelopment over the next five years. In addition to the traffic data described in paragraph A1.3, micro-simulation traffic model data were provided for scenarios relating to a range of future development options, including the effect of road junction alterations. The results from the micro-simulation traffic model have been used to predict traffic flows in 2016 with the Action Plan developments (see Section 3) in place. The precise method taken is presented in detail in AQC (2009).

A1.9 As with the 2009 data, the 2016 traffic dataset is made up of more than 45,000 individual traffic flows. Spreadsheets can be made available to Defra on request.

Emissions Calculations

A1.10 Nitrogen dioxide is predominantly a secondary pollutant and emissions are more conveniently quantified in terms of nitrogen oxides (which is the sum of nitrogen dioxide and nitric oxide). Emissions were calculated for each vehicle class included in the traffic model (cars, LGVs, HGVs,

4 The calculation was carried out before data for subsequent years became available.

5 Apportioning turning movements to the link flows based upon the relative volumes on each link. While this is an approximation, it is unlikely to add significant additional error to the assessment.

Buses/Coaches) separately. For most of the road network, emissions of nitrogen oxides from each road link during each hour of the week (i.e. each hour was treated separately) were calculated using EFT V4.2.2. For road links in and around Hatchlands roundabout (for which only AADT flows were available), annual average emission rates were calculated using EFT V4.2.2.

ADMS Model Set-up

Inputting Emissions into ADMS

A1.11 The hour-by-hour emissions data described in paragraph A1.10 were used to calculate an annual average hourly emission, and a weekly diurnal emissions profile for each vehicle type on each road. The annual average hourly emissions for each link were input directly into ADMS-Roads V3. The vehicle-specific and link-specific diurnal emissions profiles were assigned within ADMS using ".fac" files. For the links around Hatchlands roundabout, the annual average emission rate was accompanied in the model by a national diurnal flow profile published in the 2008 edition of the Department for Transport's Regional Transport Statistics (DfT, 2008)[4].

A1.12 Emissions from cars using car parks were calculated assuming an average speed of 5 kph across the distances described in paragraph A1.16. It was assumed that all of the vehicles exiting car parks would have cold engines. Emissions from these vehicles were thus adjusted using the EXEMPT tool for cold-start emissions published by Defra (2011). These aggregated emissions were then spread equally across the area and volume sources described in paragraph A1.16.

A1.13 For the bus station, the traffic model predicted the number of buses entering and exiting the station. It was assumed that on average buses would spend 5 minutes in the bus station with their emissions equivalent to those of a bus travelling at 5kph. Since emissions (expressed as grammes per second) are likely to be considerably lower from an idling bus than from one travelling at 5kph, this assumption may have caused emissions from the bus station to be over-predicted.

ADMS Source Geometry

A1.14 Each road link in the traffic model was assigned a real-world geometry using Ordnance Survey Mastermap data. Road widths were determined using a combination of Ordnance Survey data and aerial photographs. Canyon heights were estimated based on details of the number of storeys of each roadside building provided by RBBC.

A1.15 Redstone Hill was estimated to have a gradient of 6.25% and the emissions for this road were adjusted to account for this following the method set out by Defra (2009). None of the other roads are sufficiently steep for this method to be required.

A1.16 Emissions from surface car parks and top floors of multi-storey car parks were modelled as area sources. Emissions from other storeys of multi-storey car parks were modelled as volume sources with an initial dispersion depth of 2m positioned along those edges of the carparks which are not enclosed. The traffic model provided flows into, and out of, each car park. A number of assumptions were made regarding the relative proportion of vehicles accessing each floor, and the distance travelled by a typical car on each floor. These assumptions were based on observations made by RBBC, details of car park surveys provided by RBBC, a detailed examination of aerial photographs, and experience of other multi-storey car parks. The assumptions made were specific to each car park and professional experience suggests that they will have had a negligible impact on the predicted concentrations. They are thus not set out in detail.

A1.17 The bus station was entered into the model as an area source, with the emissions described in paragraph A1.13 spread evenly.

Primary NO_2

A1.18 Nitrogen dioxide (NO_2) was calculated from NOx using Defra's NOx to NO_2 calculator. This includes year-specific estimates of the proportion of primary NO_2 in NOx emissions (f-NO_2) within typical vehicle fleets. The fleet-weighted f-NO_2 values in the NOx to NO_2 calculator were derived from those in the NAEI and relate to national average fleet composition data. In order to take account of the influence of the local fleet composition on f-NO_2 values, a disaggregated f-NO_2 database (which matches the breakdown of vehicle types available to this assessment – i.e. "urban cars", "LGV", "HGV", and "buses") was obtained from the NAEI (Tim Murrells, AEA pers. comm.) (Table A1.2). For each receptor, a weighted-average f-NO_2 was calculated (with f-NO_2 weighted by the relative contribution of each vehicle class to modelled road-NOx - i.e. total-NOX minus background-NOx). Table A1.3 sets out the receptor-specific f-NO_2 values used when calculating total NO_2 concentrations without any fleet manipulation. f-NO_2 values used for source-apportionment and management planning are described subsequently.

Table A1.2: Values of f-NO_2 Provided by AEA

Year	Cars (urban)	LGV	HGV	Bus
2009	0.206	0.345	0.129	0.128
2016	0.362	0.441	0.107	0.110

Table A1.3: Receptor-Specific f-NO_2 Values Used to Calculate Total NO_2 Concentrations Without any Emissions Reduction Measures

Receptor	Concentration		Receptor	Concentration		Receptor	Concentration	
	2009	2016		2009	2016		2009	2016
1	0.163	0.205	16	0.165	0.216	31	0.166	0.213
2	0.163	0.205	17	0.168	0.222	32	0.178	0.251
3	0.163	0.206	18	0.168	0.223	33	0.178	0.251
4	0.164	0.210	19	0.164	0.208	34	0.178	0.251
5	0.165	0.212	20	0.167	0.219	35	0.178	0.250
6	0.166	0.214	21	0.164	0.209	36	0.178	0.250
7	0.166	0.213	22	0.165	0.214	37	0.178	0.251
8	0.165	0.210	23	0.165	0.212	38	0.179	0.253
9	0.165	0.212	24	0.165	0.212	39	0.163	0.204
10	0.165	0.209	25	0.165	0.211	40	0.163	0.204
11	0.166	0.210	26	0.165	0.211	41	0.165	0.211
12	0.164	0.212	27	0.164	0.212	42	0.164	0.205
13	0.163	0.208	28	0.164	0.211	43	0.178	0.251
14	0.165	0.213	29	0.166	0.211	44	0.168	0.220
15	0.164	0.211	30	0.166	0.213			
Diffusion Tube Sites								
RB120	0.159	-	RB123	0.166	-	RB145	0.163	-
RB121	0.165	-	RB140	0.166	-			
RB122	0.165	-	RB141	0.178	-			

Model Verification

A1.19 The model has been run to predict the annual mean NOx concentrations during 2009 at all of the Redhill diffusion tube monitoring sites described in the main report. The model was set up differently around Hatchlands Roundabout than across the rest of the model domain (i.e. AADT flows and speeds were used instead of hour-by-hour flows and speeds). The results were first tested separately (i.e. comparing the model results for diffusion tube site RB141, which is on Hatchlands Roundabout, separately from the other sites). In the end, it was found that site RB141 fits very well with all of the other data and a single verification approach was used across the entire model domain.

A1.20 The monitoring data presented in the main report show that concentrations during 2009 were lower than those in either 2008 or 2010. It was not, therefore, considered appropriate to base the verification on 2009, even though this is the year for which traffic data were available. Instead, all of the measurements made during 2008, 2009, and 2010 were treated as though they were made in 2009 (i.e. used alongside 2009-specific background concentrations and not adjusted using Defra's year projections).

A1.21 The model output of road-NOx (i.e. the component of total NOx coming from road traffic entered into the model as road sources but not including the car parks and bus station which were modelled as area and volume sources) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated first by calculating measured local-NOx (i.e. road-NOx, car park NOx and bus station NOx) from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator available from Defra (2011)[6]. Car park NOx and bus station NOx were then both subtracted from the calculated local-NOx to give the measured road-NOx.

A1.22 A primary adjustment factor was determined as the slope of the best fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A1.2). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. Car park and bus station NOx was then added to the adjusted road-NOx to give total modelled local-NOx. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled local-NOx concentrations with the background NO_2 concentration within the NOx from NO_2 calculator available from Defra (2011)[7]. A secondary adjustment factor was finally calculated as the slope of the best fit line applied to the adjusted data and forced through zero (Figure A1.3).

A1.23 The following primary and secondary adjustment factors have been applied to all model results:

- Primary adjustment factor : 2.6543
- Secondary adjustment factor: 1.0007

A1.24 The results imply that the model was under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is extremely small.

A1.25 Figure A1.4 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship. Some scatter is unavoidable since data from three separate years are included, while the model is only able to provide one value for each location. Despite this, the majority of data are within +/- 25%.

6 Treating 2008, 2009, and 2010 measurements as if they were made during 2009.

7 Using the receptor-specific f-NO_2 values described previously.

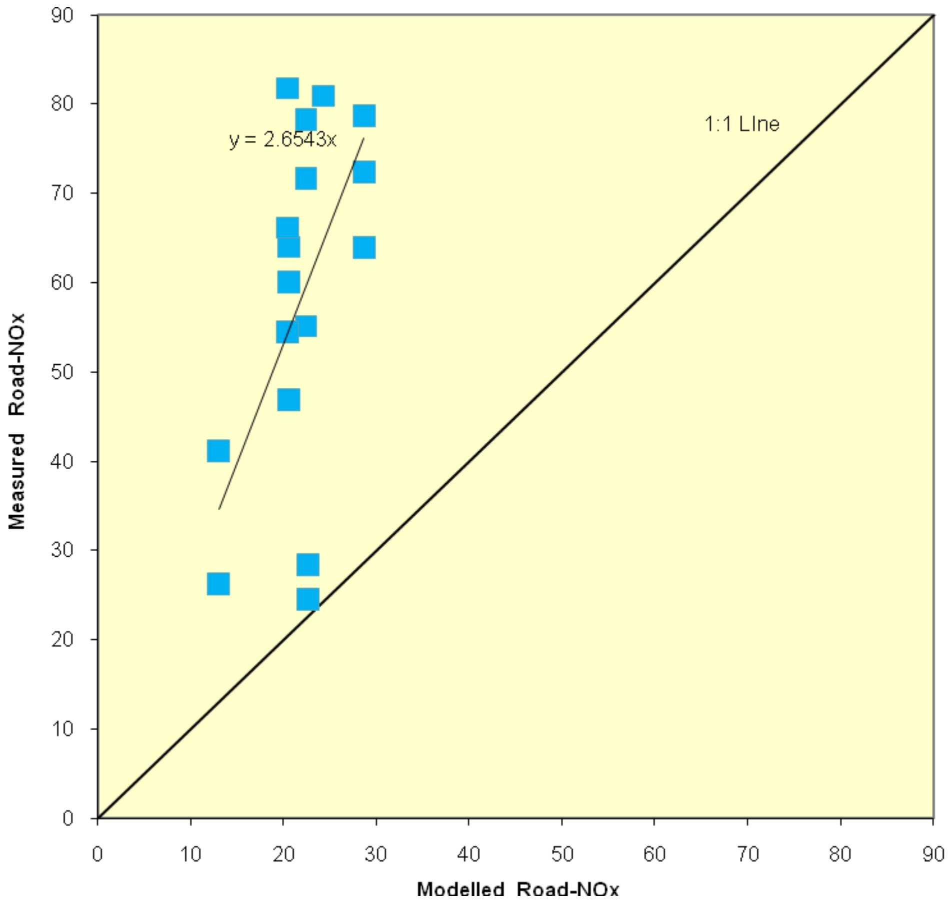

Figure A1.2: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

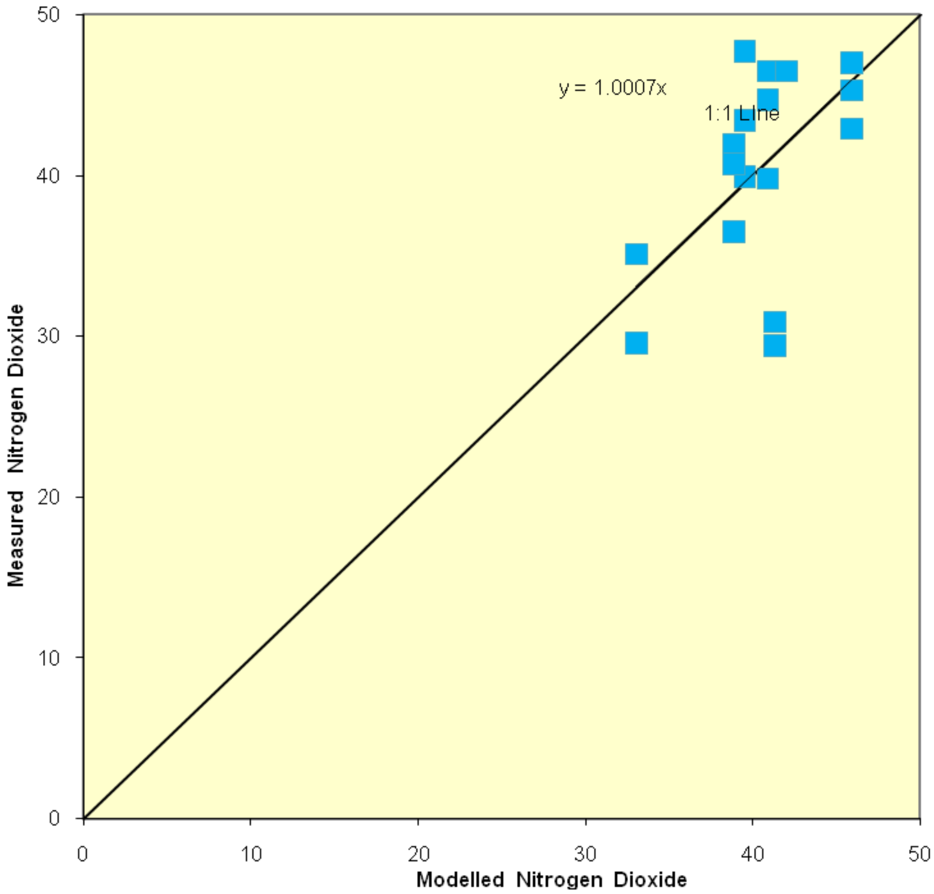

Figure A1.3: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

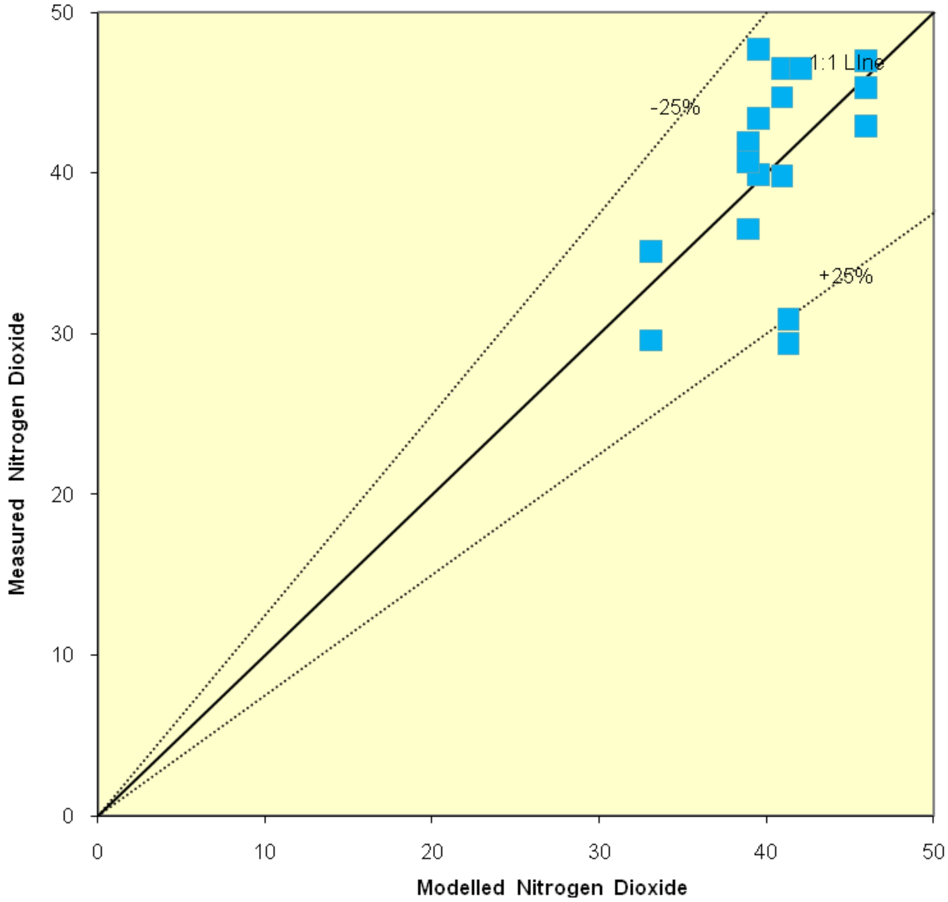

Figure A1.4: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

Source Apportionment

A1.26 The model was run for each vehicle type separately. The relative contribution from each source to road-NOx concentrations was thus implicit in the model results. The source apportionment calculation has also taken account of the different proportions of primary NO_2 (f-NO_2) emitted by different vehicle types, following the method developed for a report on Local Measures for NO_2 Hotspots in London (AQC/TRL, 2010). The method relies on removing the NOx contribution from each vehicle type in turn and then recalculating the f-NO_2 for the remaining vehicle mix (Table A1.4) and using the NOx to NO_2 calculator (Defra 2011) to derive a new NO_2 concentration. The difference between this NO_2 concentration and the total NO_2 concentration derived from the calculator is then assigned to the vehicle type. The results for each vehicle type calculated in this way are then summed. This sum was then scaled to match the measured road NO_2 (total minus background) and this factor used to adjust the contribution from each vehicle type.

Table A1.4: Receptor-Specific f-NO_2 Values Used for Source-Apportionment

	2009					2016				
		All Vehicles Except Listed Vehicle Types					All Vehicles Except Listed Vehicle Types			
R	All vehicles	Cars	LGV	HGV	Bus	All vehicles	Cars	LGV	HGV	Bus
R1	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.25
R2	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.25
R3	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.25
R4	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.26
R5	0.16	0.15	0.15	0.19	0.18	0.21	0.14	0.19	0.26	0.26
R6	0.17	0.15	0.15	0.19	0.18	0.21	0.14	0.20	0.26	0.26
R7	0.17	0.15	0.15	0.19	0.18	0.21	0.14	0.20	0.26	0.26
R8	0.17	0.15	0.15	0.19	0.18	0.21	0.14	0.19	0.26	0.25
R9	0.17	0.15	0.15	0.19	0.18	0.21	0.14	0.20	0.26	0.26
R10	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.25
R11	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.25
R12	0.16	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.25	0.26
R13	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.26
R14	0.16	0.15	0.15	0.18	0.18	0.21	0.15	0.19	0.25	0.26
R15	0.16	0.15	0.15	0.18	0.18	0.21	0.15	0.19	0.25	0.26
R16	0.17	0.15	0.15	0.18	0.18	0.22	0.15	0.20	0.26	0.27
R17	0.17	0.15	0.16	0.19	0.18	0.22	0.16	0.21	0.26	0.26
R18	0.17	0.16	0.16	0.19	0.18	0.22	0.16	0.21	0.27	0.26
R19	0.16	0.15	0.15	0.19	0.18	0.21	0.14	0.19	0.25	0.25
R20	0.17	0.15	0.15	0.19	0.18	0.22	0.16	0.20	0.26	0.26
R21	0.16	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.26
R22	0.17	0.15	0.15	0.18	0.18	0.21	0.15	0.20	0.26	0.26
R23	0.16	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.26
R24	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.26
R25	0.16	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.26
R26	0.16	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.26
R27	0.16	0.15	0.15	0.18	0.18	0.21	0.15	0.19	0.26	0.26
R28	0.16	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.26	0.26

	2009					2016				
		All Vehicles Except Listed Vehicle Types					All Vehicles Except Listed Vehicle Types			
R	All vehicles	Cars	LGV	HGV	Bus	All vehicles	Cars	LGV	HGV	Bus
R29	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.19	0.25	0.26
R30	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.20	0.26	0.26
R31	0.17	0.15	0.15	0.19	0.18	0.21	0.15	0.20	0.26	0.26
R32	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R33	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R34	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R35	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R36	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R37	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R38	0.18	0.16	0.16	0.20	0.19	0.25	0.18	0.23	0.30	0.29
R39	0.16	0.15	0.15	0.18	0.18	0.20	0.14	0.19	0.25	0.25
R40	0.16	0.15	0.15	0.18	0.18	0.20	0.14	0.19	0.25	0.25
R41	0.17	0.15	0.15	0.18	0.18	0.21	0.14	0.19	0.25	0.26
R42	0.16	0.15	0.15	0.18	0.18	0.20	0.14	0.19	0.25	0.25
R43	0.18	0.16	0.16	0.20	0.19	0.25	0.17	0.23	0.30	0.29
R44	0.17	0.15	0.15	0.19	0.18	0.22	0.16	0.20	0.26	0.26

Management Planning

A1.27 In order to calculate the effect of reducing emissions from each vehicle class, it was assumed that there is a direct relationship between NOx emissions from a vehicle category and f-NO_2 from that vehicle category[8]. Receptor-specific f-NO_2 was thus recalculated for each emission-reduction scenario and used in the NOx to NO_2 calculator to determine total NO_2 concentrations. The f-NO_2 values used are set out in Table A1.5.

[8] i.e. that emissions reduction measures do not affect vehicle class specific f-NO_2 values.

Table A1.5: Values of f-NO_2 Used to Calculate the Effect of Hypothetical Emission Reduction Measures

Vehicle Type	% Reduction in Emissions	f-NO_2							
		R16	R21	R29	R30	R39	R40	R41	R42
Car	10%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	25%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	50%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
LGV	10%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	25%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	50%	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Bus	10%	0.17	0.17	0.17	0.17	0.16	0.16	0.17	0.16
	25%	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	50%	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
HGV	10%	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	25%	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	50%	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

A2 Dispersion Modelling Methodology Used for Isopleths

A2.1 The isopleths presented in this Further Assessment were originally prepared for the Detailed Assessment (RBBC, 2010a). Full details of the methodology are set out in RBBC (2010a). The traffic data used are the same as those described above. The only differences to the methodology described above for individual receptor locations are:

- The model was run for all vehicle types together, rather than each vehicle type separately. This is unlikely to have a significant effect on the results.
- Emissions were calculated using EFT V4.1 rather than EFT V4.2.2. Defra updated the EFT after the Detailed Assessment was prepared owing to some minor issues with the previous calculator. When issuing the update, Defra confirmed that it was not necessary to redo any work carried out using the previous version.
- The NOx to NO_2 calculation used national average f-NO_2 values, rather than the location-specific data set out in Appendix A1.
- The model was verified using the 2009 diffusion tube measurements, rather than those for 2008, 2009 and 2010.

A2.2 Of these factors, it is the latter which has the greatest effect on predicted concentrations, with the first three points having only a relatively minor combined influence (on the 2009 results) in comparison. Figure A2.1 shows the modelled annual mean NO_2 concentrations in 2009 at each of the receptor locations; comparing the results from the Detailed Assessment with those from this Further Assessment. On average, the latest results are approximately 10% higher than those from the Detailed Assessment, with this divergence higher at higher concentrations and lower at lower concentrations (which is to be expected since the model adjustment factor has increased). In locations where the previous modelling predicted concentrations of 36 $\mu g/m^3$, the latest results predict that concentrations are approximately 40 $\mu g/m^3$. Thus, those locations where concentrations were predicted to be >36 $\mu g/m^3$ in the Detailed Assessment can be considered to experience an exceedence of the objective. The discussion in the main report thus treats the 36 $\mu g/m^3$ contour from the Detailed Assessment as indicative of 40 $\mu g/m^3$.

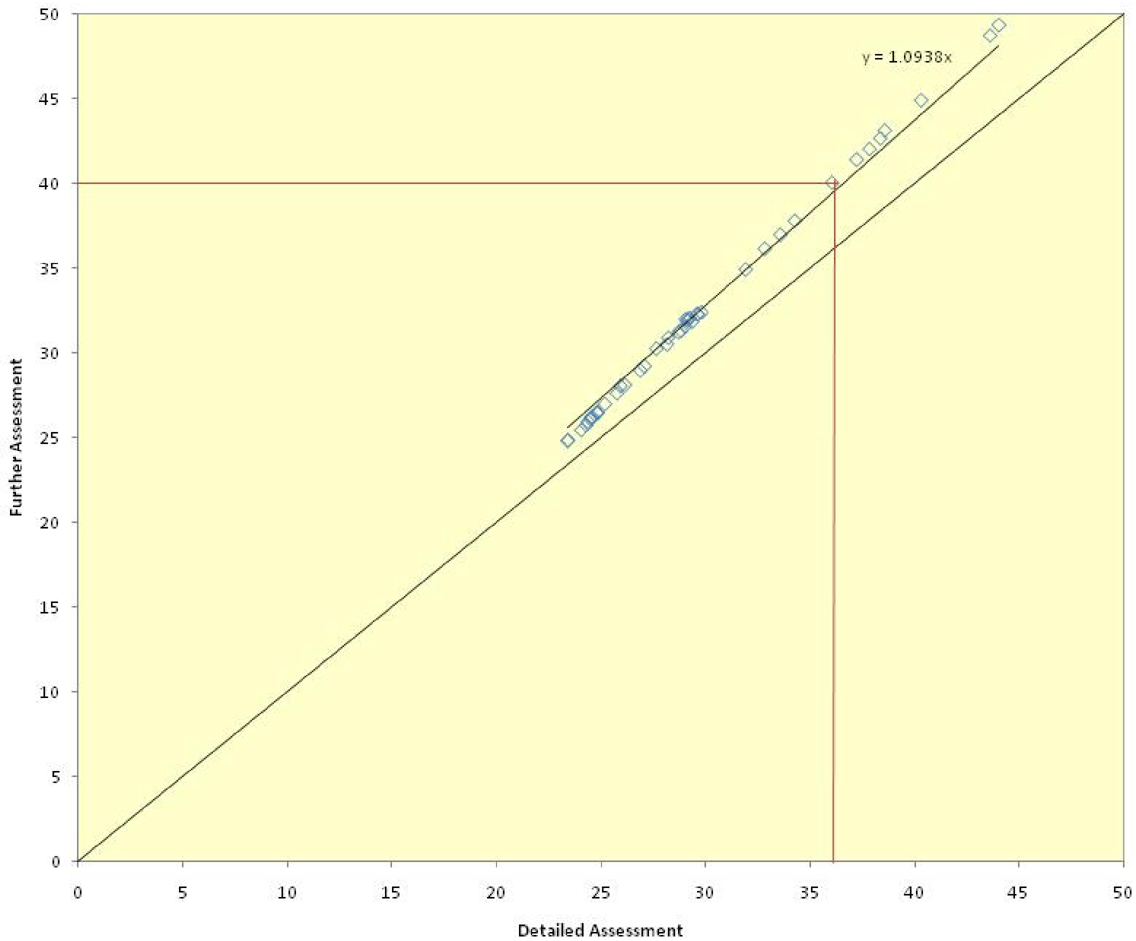

Figure A2.1: Comparison of Model Results from the Detailed Assessment and the Further Assessment