Further Assessment of Air Quality in the Cross Street AQMA – Babergh District Council

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Document Control

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Executive Summary

This report is the Further Assessment of nitrogen dioxide concentrations within the Cross Street Air Quality Management Area (AQMA), Sudbury.

Nitrogen dioxide concentrations within and around the Cross Street AQMA have been assessed through diffusion tube monitoring and detailed dispersion modelling. The results indicate that the annual mean nitrogen dioxide objective was exceeded in 2009 within the AQMA, and also at locations of relevant exposure outside of the AQMA. It is therefore recommended that the AQMA should be extended, and should also be amended to include the 1-hour objective due to the measured exceedence at 87 Cross Street.

Source apportionment of the local traffic emissions has been undertaken. This shows Heavy Goods Vehicles contribute the largest proportion to the overall concentration. In most cases, the ambient background concentration and emissions from cars also contribute a significant proportion to the overall concentration.

The effectiveness of four potential Action Plan measures has been assessed. Removing the parking bays or making Cross Street one-way both have the potential to bring about air quality improvements within the AQMA that are great enough for the annual mean objective to be met at some locations. However, these measures would not result in sufficient improvements for the objective to be met at all receptors.

Contents

1 Introduction

1.1 This report is the Further Assessment of nitrogen dioxide concentrations within the Cross Street Air Quality Management Area (AQMA), Sudbury. The report is one of a series produced by, and on behalf of, Babergh District Council, which periodically review and assess air quality within the District. Babergh District Council accepts the conclusions of this report and intends to implement all recommendations.

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 are to be achieved by 2010 (Stationery Office, 2007). The objectives are the same as, or more stringent than, the limit values, thus it is appropriate to focus on the objectives.

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.

Key Findings of Previous Review and Assessment Reports

1.10 In May 2008 a Detailed Assessment was undertaken for the Cross Street/Ballingdon Street area of Sudbury due to monitored exceedences of the annual mean objective for nitrogen dioxide. Following this, an AQMA was designated in November 2008 (Babergh District Council, 2008).

1.11 In April 2009 an Updating and Screening Assessment was undertaken. The report concluded that Babergh District Council was correct in its designation of the Cross Street Air Quality Management Area (Babergh District Council, 2009). However, the report identified that the boundary of the current AQMA may need to be amended to incorporate properties in Ballingdon Street due to monitored exceedences of the annual mean objective for nitrogen dioxide.

1.12 The Air Quality Action Plan is currently being drafted. The conclusions of this Further Assessment will be fully taken into account in the final document.

Scope

1.13 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.

2 Study Area and AQMA Location

2.1 The Cross Street AQMA encompasses properties along Cross Street from the junction with Church Street to 5/89 Cross Street (Figure 1). The majority of properties along Cross Street are residential and therefore represent relevant exposure for the annual mean objective. There are no additional locations that are relevant for the 1-hour objective.

2.2 Cross Street is extremely narrow and 'canyon'-like. A build-out was installed in the narrowest section of Cross Street in July 2005. It reduced the road to single carriageway width, so that north-bound vehicles have to give-way to southbound traffic. This was installed to prevent lorries mounting the kerb and causing damage to properties. The build-out has led to an increase in congestion, as vehicles wait for on-coming traffic to pass, and queue on Ballingdon Street, which is increasing emissions.

2.3 There are six parking bays in Cross Street, to the north of the build-out, which effectively reduce the road to single carriageway when they are occupied. These also lead to congestion and queues, as vehicles are required to give-way to on-coming traffic. In combination with the build-out, these bays lead to significantly increased vehicle emissions, as vehicles are required to accelerate and decelerate several times in this short section of road. Currently parking for up to 1-hour is allowed 8am to 6pm Monday to Saturday, with unrestricted parking outside these hours.

Figure 1: Cross Street AQMA.

3 Local Developments since Declaration of the AQMA

New and Proposed Local Developments

3.1 There have been no new road or housing developments close to the Cross Street AQMA since the Detailed Assessment was carried out. The 'build-out' has recently been removed which will allow two-way traffic to flow more freely. However, traffic will still need to stop to allow two HGVs to pass at the southern end of Cross Street.

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) have been used for this assessment.

4 New Monitoring and Modelling Data

New Monitoring

4.1 The Council maintains one automatic air quality monitor within its district and 15 roadside diffusion tube sites. There are no real time analysers situated within the Cross Street study area, and this assessment therefore relies on diffusion tube monitoring.

Bias Adjustment of Diffusion Tubes

4.2 Diffusion tube measurements may exhibit substantial bias compared to the reference method (real time chemiluminescent analyser) for measuring nitrogen dioxide. As a result, LAQM.TG(09) recommends that Local Authorities should apply a 'bias adjustment factor', which is calculated by undertaking a co-location study with a real time analyser. If this cannot be undertaken within the local authority area, then a default factor made available within a spreadsheet on the Review and Assessment helpdesk website should be used (Defra, 2010a). The Council uses Harwell Scientifics Ltd for analysis of diffusion tubes (50% TEA in acetone method). For this study, the 2009 data have been adjusted using the national factor provided on the Review and Assessment Helpdesk website (0.81; spreadsheet version 03/10). The 2007 and 2008 data have been bias adjusted by the Council using national factors.

Diffusion Tube Data

4.3 The diffusion tube monitoring locations in close proximity to the Cross Street AQMA are shown in Figure 2. Each of the diffusion tube sites has duplicate tubes in order to increase the confidence in the results. Monitoring data are presented in Table 2.

Table 2: Diffusion Tube Data within the Cross Street Study Area[a]

	Within AQMA	OS Grid Coordinates[b]		Annual mean nitrogen dioxide (µg/m^3)		
		X	Y	2007[c]	2008[d]	2009[e]
9 Cross Street	Y	586848	241133	34.0	36.0	35.6
17 Cross Street	Y	586836	241089	36.2	38.3	36.6
30 Cross Street	Y	586808	241015	**56.0**	**59.2**	**57.6**
36 Cross Street	Y	586790	240944	39.8	**40.4**	38.4
58 Cross Street	Y	586798	241010	**42.5**	**41.4**	39.1
70 Cross Street	Y	586818	241068	**43.2**	38.7	35.4
78 Cross Street	Y	586829	241104	**59.5**	**58.7**	**57.8**
82 Cross Street	Y	586835	241123	**56.1**	**59.3**	**57.2**
87 Cross Street	Y	586842	241148	**64.0**	**62.6**	**60.3**
5 Ballingdon Street	N	586721	240879	39.9	**43.0**	**40.5**
7 Ballingdon Street	N	586723	240941	**47.1**	**47.0**	**46.1**
30 Church Street	N	586822	240952	29.8	31.6	30.3
54 Church Street	N	586930	241058	31.1	30.3	29.6

[a] Values in bold are exceedences of the objective.

[b] As reported in Babergh District Council's 2009 Updating and Screening Assessment.

[c] Bias adjusted by the Council using a national factor of 0.81 (using national factors in version 03/08 of the spreadsheet available at www.uwe.ac.uk/aqm/review).

[d] Bias adjusted by the Council using a national factor of 0.80 (using national factors in version 03/09 of the spreadsheet available at www.uwe.ac.uk/aqm/review).

[e] Bias adjusted using the national factor of 0.81 (using national factors in version 03/10 of the spreadsheet available at www.uwe.ac.uk/aqm/review).

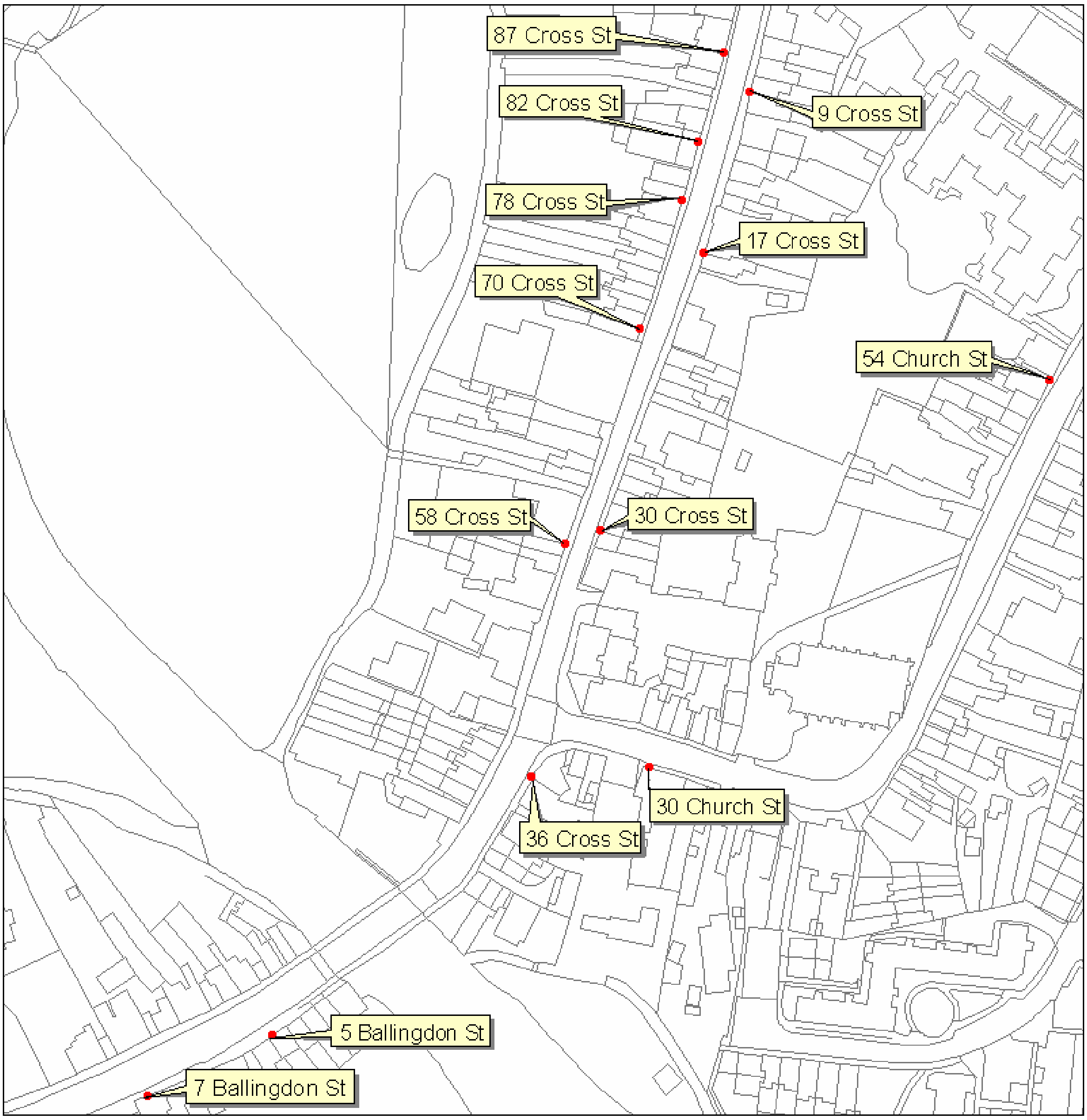

Figure 2: Monitoring locations in close proximity to the Cross Street AQMA.

4.4 There are six monitoring sites which measured an exceedence of the annual mean objective within the Cross Street study area in 2009. The majority of the diffusion tubes are attached to the facades of the properties (on drainpipes etc), the exceptions are 36 Cross Street, 30 Church Street and 7 Ballingdon Street which are located on lamp posts at the rear of the pavement. There is relevant residential exposure at ground floor level near to all the diffusion tube sites. Traffic flows are lower on Church Street and therefore the results are lower, as would be expected. Concentrations of nitrogen dioxide exceed 60 µg/m^3 at one location within the AQMA (87 Cross Street). The Technical Guidance TG(09), issued by the Department for Environment Food and Rural Affairs (DEFRA), regards this as being indicative of a potential failure of the 1-hour objective.

4.5 The exceedences in Cross Street occur in the canyon sections where traffic flows are interrupted by obstructions (build-out and parking bays). Measured concentrations at 9 and 17 Cross Street have been consistently below the objectives. These sites are adjacent to parking bays. The highest concentrations are measured opposite these sites (78, 82, 87) where traffic is reduced to single file. Measured concentrations in Ballingdon Street exceed the objective, confirming the findings of the USA that the AQMA needs to be extended to include this area.

4.6 Figure 3 shows measured concentrations at the four long term diffusion tube sites in the Cross Street area. The 21 Cross Street diffusion tube site ceased monitoring in 2007. 58 Cross Street had poor data capture in 2004 (33.3%) which could account for the increased concentration. The build-out on Cross Street was built in 2005. This does not appear to have had a significant impact on concentrations at these specific locations, although it does appear to have had an impact elsewhere on Cross Street, which is discussed in more detail later. There is little evidence of a downward trend which is consistent with monitoring at other locations in the UK over the same period.

Figure 3: Measured NO_2 Concentrations (2003 – 2009) (Bias adjusted using national factors in version 03/10 of the spreadsheet available at www.uwe.ac.uk/aqm/review).

New Modelling

4.7 Annual mean concentrations of nitrogen dioxide from road sources in 2009 have been modelled within the study area using ADMS Roads (version 2.3). Details of the input parameters are set out below and in Appendix 1, whilst further details of the dispersion modelling methodology are set out in Appendix 2.

Road Traffic Impacts

4.8 The contribution of emissions from road traffic to the annual mean concentrations of nitrogen dioxide within each study area has been modelled using ADMS Roads (version 2.3). The following input data were used:

- Suffolk County Council provided classified turning counts, split into a number of vehicle classes, for Cross Street, Ballingdon Street and Church Street. These flows were adjusted to Annual Average Daily Traffic (AADT) flows by comparing them with typical national diurnal flow profiles published by the Department for Transport (DfT, 2009). There will be uncertainty associated with these traffic data, however, the conclusions of the assessment are unlikely to be particularly sensitive to this uncertainty. All of the traffic flows used in this assessment have been assumed to have the national diurnal flow profiles published by the Department for Transport (DfT, 2009).
- Detailed fleet composition data were provided, and therefore the emissions from each vehicle class were calculated using the Emission Factor Toolkit (EFT), Version 4.0 (Defra, 2010b) and entered into the model for each vehicle class individually. This enabled data to be determined for detailed source apportionment. The EFT provided car and LGV emissions split into petrol and diesel, however the traffic data provided by the Council did not include this split. An average emission rate was therefore calculated based on the average UK petrol/diesel split provided in the EFT. The Council provided data for Other Goods Vehicles (OGV) 1 and 2, these broadly correspond to Rigid and Articulated Heavy Goods Vehicles (HGVs) respectively. The EFT does not include the OGV 1 and 2 categories and therefore Rigid HGV and Articulated HGV emission factors were used respectively;
- Speeds are based on the speed limit, but also take into account the proximity to a junction and traffic speeds observed during the site visit;
- The locations of roads and buildings (including road width) were obtained using OS Landline mapping information;
- Meteorological data from Wattisham in 2009 were used.

4.9 The model has been verified by comparing the predicted results with local measurements (within the study area), and the model output adjusted accordingly. Details of model verification are presented in Appendix 2.

Modelling Uncertainty

4.10 Uncertainty is inherent 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- or under-predictions. All of the measured concentrations presented have an intrinsic margin of error. Defra (2010b) suggests that this is of the order of plus or minus 20% for diffusion tube data and plus or minus 10% for automatic measurements. The model results rely on traffic data provided by Suffolk

County Council and any uncertainties inherent in these data will carry into this assessment. 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 that wind conditions measured at Wattisham during 2009 will have occurred throughout the study areas during 2009; and it has been assumed that the 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 results with measurements, and correcting for the apparent under-prediction of the model, the uncertainties can be reduced.

4.11 The UK Government's Air Quality Expert Group (AQEG) has published a report on trends in primary nitrogen dioxide in the UK (AQEG, 2007). This examines evidence that shows that while NOx emissions have fallen in line with predictions made a decade previously, the composition of NOx has, in some urban environments, changed. This may have caused nitrogen dioxide levels at some locations to fall less rapidly than was expected. The latest guidance from Defra (Defra, 2010b) has been followed regarding NOx to NO_2 relationships, which should minimise the uncertainty associated with primary nitrogen dioxide emissions.

4.12 Conditions such as those introduced by the build-out and parking bays are particularly difficult to model, as demonstrated by the scatter of results shown in Appendix 2. Therefore where relevant, greater reliance is placed on the measured rather than modelled results.

4.13 The limitations to the assessment should be borne in mind when considering the results set out in the following sections. While the model should give an overall accurate picture, i.e. one without bias, there will be uncertainties for individual receptors. The results are 'best estimates' and have been treated as such in the discussion.

Concentrations at Specific Receptors

4.14 Locations representing worst-case residential exposure along the roads within the study area were selected for modelling. In total sixteen residential receptor locations were selected. The receptors have been modelled at a height of 1.5 m.

4.15 Receptor locations are shown in Figure 4. Annual mean nitrogen dioxide concentrations predicted for each of these receptors are presented in Table 3. The highest predicted concentration in 2009 is 58.6 µg/m^3, at Receptor 16. Concentrations are also predicted to exceed the annual mean objective at Receptors 1 and 2, 7 – 12 and Receptor 14. There are no predicted annual mean concentrations greater than 60 µg/m^3.

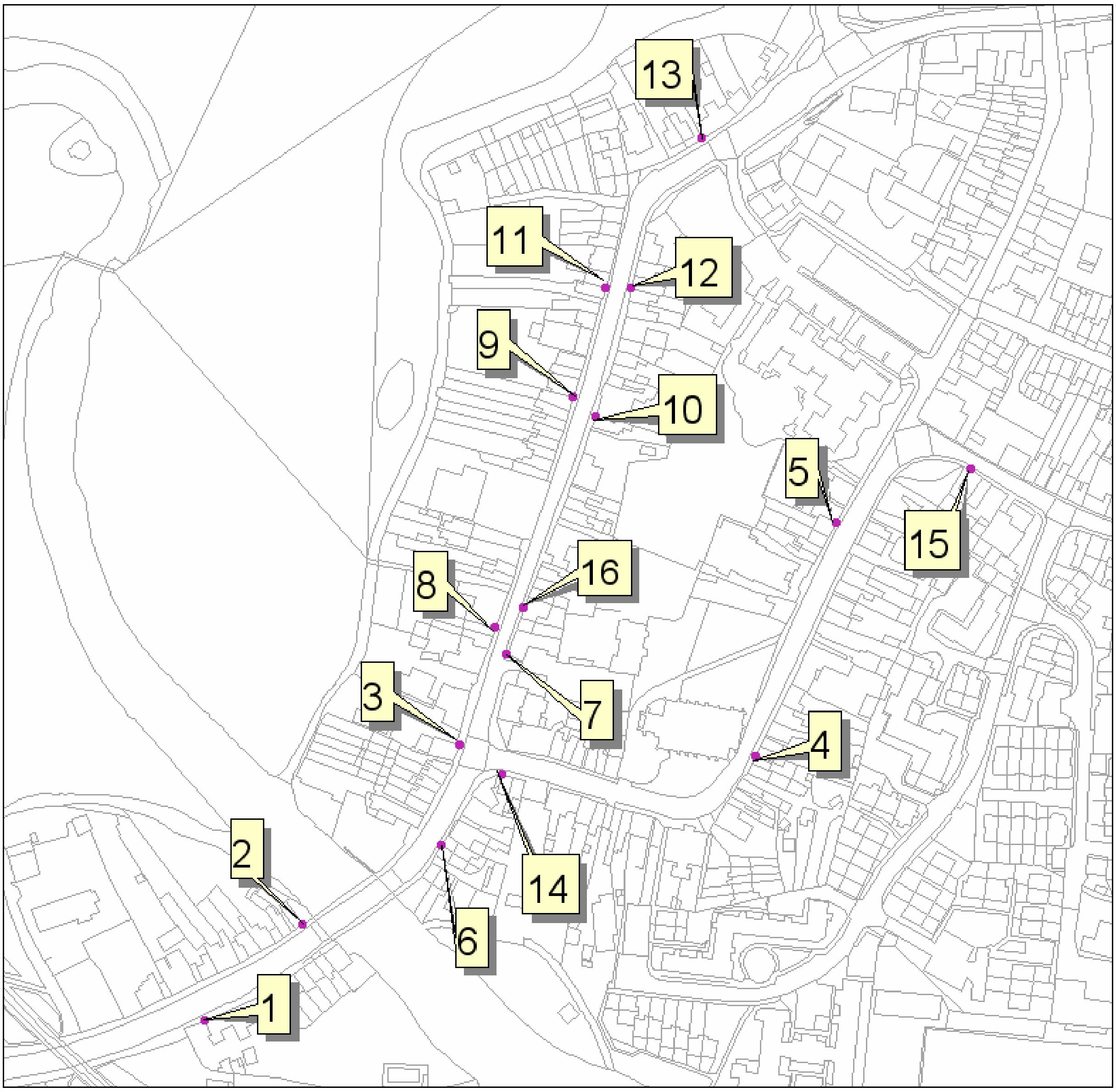

Figure 4: Receptor Locations.

Table 3: Predicted Annual Mean Concentrations of Nitrogen Dioxide (μg/m^3) in 2009[a]

Receptor	Location	Annual Mean (μg/m^3)
1	Ballingdon Street	**44.4**
2	Ballingdon Street	**48.2**
3	Cross Street	33.3
4	Church Street	24.5
5	Church Street	23.5
6	Cross Street	32.0
7	Cross Street	**49.3**
8	Cross Street	**55.2**
9	Cross Street	**42.7**
10	Cross Street	**42.4**
11	Cross Street	**42.5**
12	Cross Street	**42.1**
13	Mill Hill	26.5
14	Church Street	**40.5**
15	Friars Street	20.0
16	Cross Street	**59.1**
Objective		**40**

[a] Values in bold are predicted exceedences of the objective.

4.16 Concentrations have also been predicted for a number of additional receptors to enable the extent of the exceedence area to be to be determined (Figure 5). These confirm that there are relevant locations outside of the current AQMA at which concentrations are likely to have exceeded the annual mean nitrogen dioxide objective in 2009.

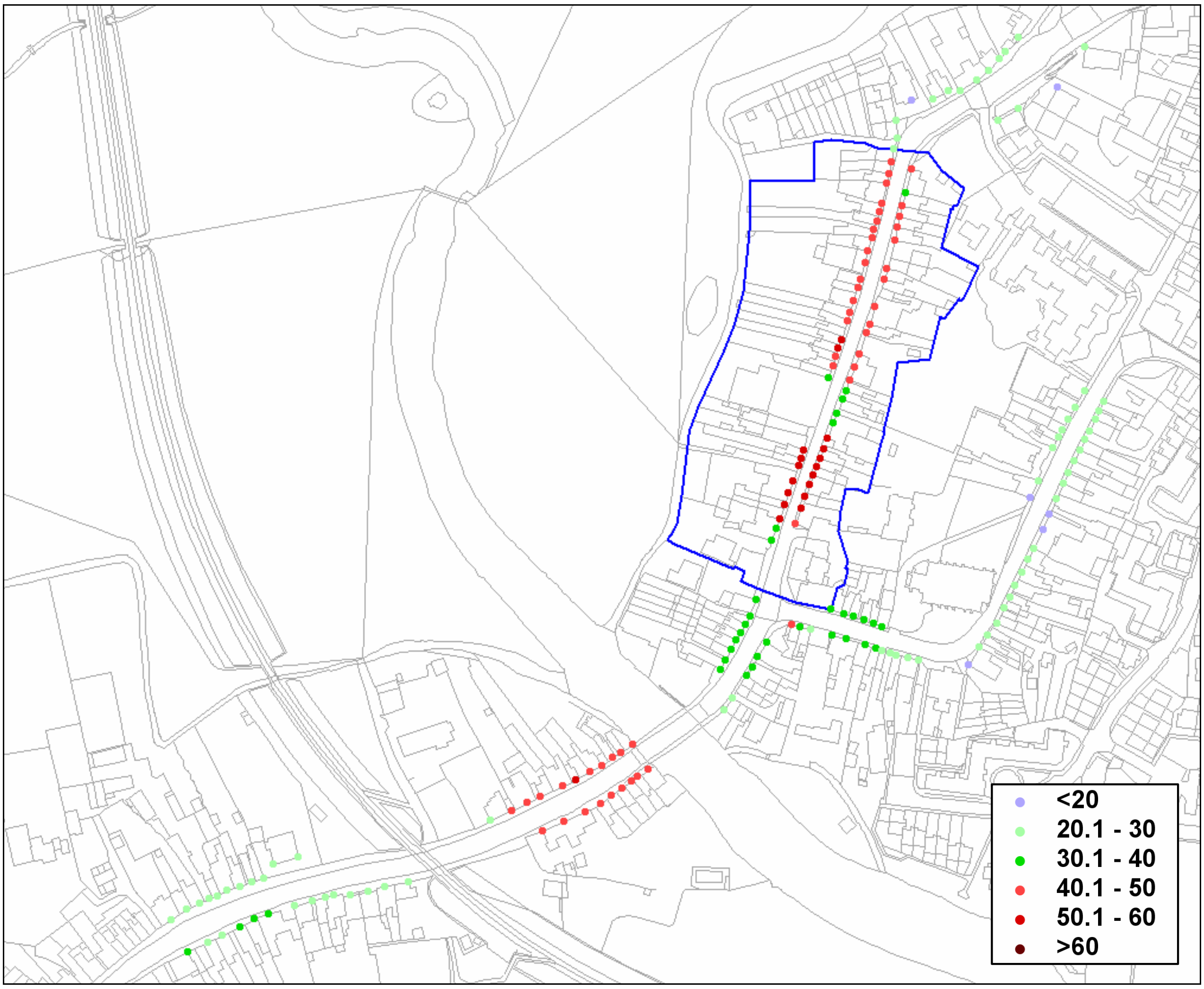

Figure 5: Predicted Concentrations of Nitrogen Dioxide (µg/m^3) at Ground Floor Level in 2009. The blue line represents the existing AQMA boundary.

4.17 The AQMA boundary should therefore be amended to include, as a minimum, those relevant locations where exceedences have been predicted alongside Ballingdon Street and Church Street. Due to uncertainties associated with the modelling it is advised that the entire area from the north of Cross Street to the railway bridge across Ballingdon Street should be included in the amended AQMA. The Council should also amend the AQMA to include the 1-hour objective due to the measured exceedence at 87 Cross Street.

5 Source Apportionment

5.1 In order to develop an appropriate action plan it is necessary to identify the sources contributing to the objective exceedences within the AQMA. The data presented here can be used to inform future traffic management decisions, and have been calculated in line with guidance provided in LAQM.TG(09) (Defra, 2009).

5.2 Figure 6 and Table 4 set out the relative contributions of traffic emissions. The following categories have been modelled:

- Ambient Background (Bkgd);
- Motorcycle (MCL);
- Cars;
- Light Goods Vehicles (LGV);
- Public Service Vehicle (PSV)
- Other Goods Vehicles 1 (OGV1);
- Other Goods Vehicles 2 (OGV2).

5.3 Three receptor locations identified previously have been used to provide an overview of source contributions. Table 4 and Figure 6 show, the most significant component for Receptor 2 is from Other Goods Vehicles 1 and background concentrations. For Receptor 9 the most significant component is from Other Goods Vehicles 2 and background concentrations and for Receptor 16 the most significant component is from Other Goods Vehicles 2 followed by Cars and background concentrations. Other Goods Vehicles (1 and 2) despite making up a relatively small proportion of the total traffic volume (7.0% on Cross Street) have the largest impact on concentrations (45.8% at Receptor 16). In most cases, the ambient background concentration and emissions from cars also contribute a significant proportion to the overall concentration.

Table 4: Predicted Annual Mean (2009) Nitrogen Dioxide Concentrations and the Contribution of Each Source Type to the Total

Receptor	Annual Mean Concentration (µg/m³)							
	Bkgd	MCL	Car	LGV	PSV	OGV1	OGV2	Total
2	11.4	<0.1	9.3	5.7	2.4	11.6	7.8	48.2
9	10.8	<0.1	7.3	4.1	1.9	7.5	11.0	42.7
16	10.8	<0.1	11.4	6.6	3.1	11.2	15.9	59.1
	% Contribution to Total							
	Bkgd	MCL	Car	LGV	PSV	OGV1	OGV2	Total
2	23.6	0.1	19.2	11.8	5.0	24.1	16.1	100.0
9	25.4	0.1	17.0	9.6	4.5	17.6	25.9	100.0
16	18.4	0.1	19.3	11.2	5.3	18.9	26.9	100.0

Receptor 2 = Ballingdon Street

Receptor 9 = Cross Street near parking bays

Receptor 16 = Cross Street near build-out

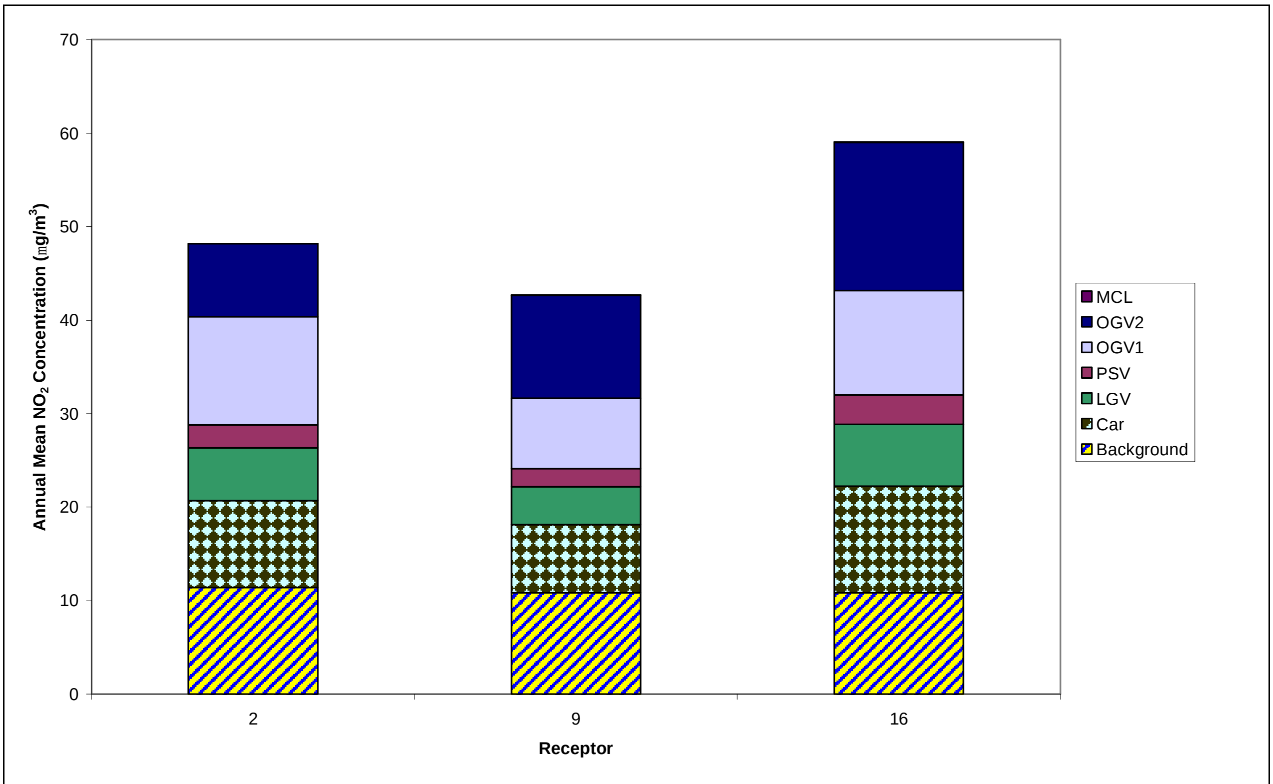

Figure 6: Relative Contribution of Each Source Type to the Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m³) at Receptor Locations.

6 Air Quality Improvements Required

6.1 The degree of improvement needed in order for the annual mean objective for nitrogen dioxide to be achieved is defined by the difference between the highest measured or predicted concentration and the objective level (40 $\mu g/m^3$).

6.2 The highest nitrogen dioxide concentration is that measured at 87 Cross Street (60.3 $\mu g/m^3$), requiring a reduction of 20.3 $\mu g/m^3$ in order for the objective to be achieved.

6.3 In terms of describing the reduction in emissions required, it is more useful to consider nitrogen oxides (NOx). This has been calculated in line with guidance presented in LAQM.TG(09) (Defra, 2009). Table 5 sets out the required reduction in local emissions of NOx that would be required at three of the diffusion tubes where an exceedence was measured in 2009, in order for the annual mean objective to have been achieved. At 87 Cross Street, local emissions would need to have been 51.8% lower in order to meet the objective.

Table 5: Improvement in Annual Mean Nitrogen Dioxide Concentrations and in Emissions of Oxides of Nitrogen at Receptors in 2009.

Receptor	Required reduction in annual mean nitrogen dioxide concentration ($\mu g/m^3$)	Required reduction in emissions of oxides of nitrogen from local roads (%)
87 Cross Street	20.3	51.8
30 Cross Street	17.6	47.8
7 Ballingdon Street	6.1	21.8

7 Specific Action Plan Measures

7.1 Four potential Action Plan measures have been identified by Babergh District Council for investigation. These are:

a) Removing the build-out (completed April 2010);

b) Removing the build-out and the car parking spaces;

c) Removing the build-out and allowing only one-way HGV movements on Cross Street; and

d) Removing the build-out and allowing only one-way movements on Cross Street for all vehicles.

7.2 Table 6 shows that in Do-Nothing scenario, ten of the receptors are predicted to exceed the annual mean objective. The greatest reduction is brought about when the build-out and the parking bays are removed, however, these measures would not result in sufficient improvements within the AQMA for all predicted concentrations to meet the objective. By making Cross Street one-way for either HGVs or all vehicles the concentrations are significantly reduced at all receptors on Cross Street. Concentrations at receptors on Church Street would increase, however only one receptor would exceed the objective.

7.3 It is important to note that there are uncertainties associated with these predictions. The removal of the build-out and parking bays have been represented in the model as increases in speed. In reality, the changes will be more complex and therefore these model results represent a best estimate of the changes. The model predictions for the one way scenarios do not take into account any changes outside the immediate study area.

Table 6: Predicted Annual Mean Nitrogen Dioxide Concentration During 2009 for Potential Action Plan Measures [a]

	Scenario				
	Do Nothing	Remove build-out	Remove build-out and car parking spaces	Removing build-out and making Cross Street one way for HGVs	Removing build-out and making Cross Street one way for all vehicles
Receptor 1	**44.4**	32.0	31.9	32.0	32.0
Receptor 2	**48.2**	33.0	32.9	33.0	33.1
Receptor 3	33.3	25.2	25.1	25.0	25.0
Receptor 4	24.5	23.9	23.8	30.6	34.4
Receptor 5	23.5	23.1	22.8	29.2	32.8
Receptor 6	32.0	23.3	23.2	23.4	23.6
Receptor 7	**49.3**	34.2	33.9	29.2	26.2
Receptor 8	**55.2**	**40.2**	39.9	33.3	29.2
Receptor 9	**42.7**	**42.2**	32.6	34.4	29.5
Receptor 10	**42.4**	**41.9**	33.1	34.1	29.4
Receptor 11	**42.5**	**42.3**	32.6	34.3	29.4
Receptor 12	**42.1**	**41.9**	33.1	34.1	29.2
Receptor 13	26.5	26.3	24.8	22.1	19.7
Receptor 14	**40.5**	36.1	36.0	**45.5**	**50.5**
Receptor 15	20.0	19.7	19.5	24.4	26.9
Receptor 16	**59.1**	**42.4**	**42.0**	35.0	30.5

[a] Values in bold are predicted exceedences of the objective.

8 Summary and Conclusions

8.1 Nitrogen dioxide concentrations within and around the Cross Street AQMA have been assessed through diffusion tube monitoring and detailed dispersion modelling. The results indicate that the annual mean nitrogen dioxide objective was exceeded in 2009 within the AQMA, and also at locations of relevant exposure outside of the AQMA.

8.2 It is therefore recommended that:

- The AQMA should be extended to include, as a minimum, the entire area from the north of Cross Street to the railway bridge across Ballingdon Street, and monitoring should continue.
- The Council should also amend the AQMA to include the 1-hour objective due to the measured exceedence at 87 Cross Street.

8.3 Source apportionment of the local traffic emissions has been undertaken. This shows Heavy Goods Vehicles contribute the largest proportion to the overall concentration (45.8%). In most cases, the ambient background concentration and emissions from cars also contribute a significant proportion to the overall concentration. This highlights the importance of keeping all sources under consideration when contemplating measures to include within the action plan.

8.4 The effectiveness of four potential Action Plan measures has been assessed. Removing the parking bays or making Cross Street one-way both have the potential to bring about air quality improvements within the AQMA that are great enough for the annual mean objective to be met at some locations. The removal of the parking bays in association with the removal of the build-out would deliver the greatest improvement to all properties. However, these measures would not result in sufficient improvements for the objective to be met at all receptors.

9 References

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10 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.
$\mu g/m^3$	Microgrammes per cubic metre.
Roadside	A site sampling between 1 m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5 m of the road, but could be up to 15 m (Defra, 2009).
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
OGV 1	Other Goods Vehicles 1 (this broadly correspond to Rigid Heavy Goods Vehicles).
OGV 2	Other Goods Vehicles 2 (this broadly correspond to Articulated Heavy Goods Vehicles).
PSV	Public Service Vehicles
MCL	Motorcycles
TEA	Triethanolamine – used to absorb nitrogen dioxide

A1 Appendix 1: ADMS Roads Model Set Up

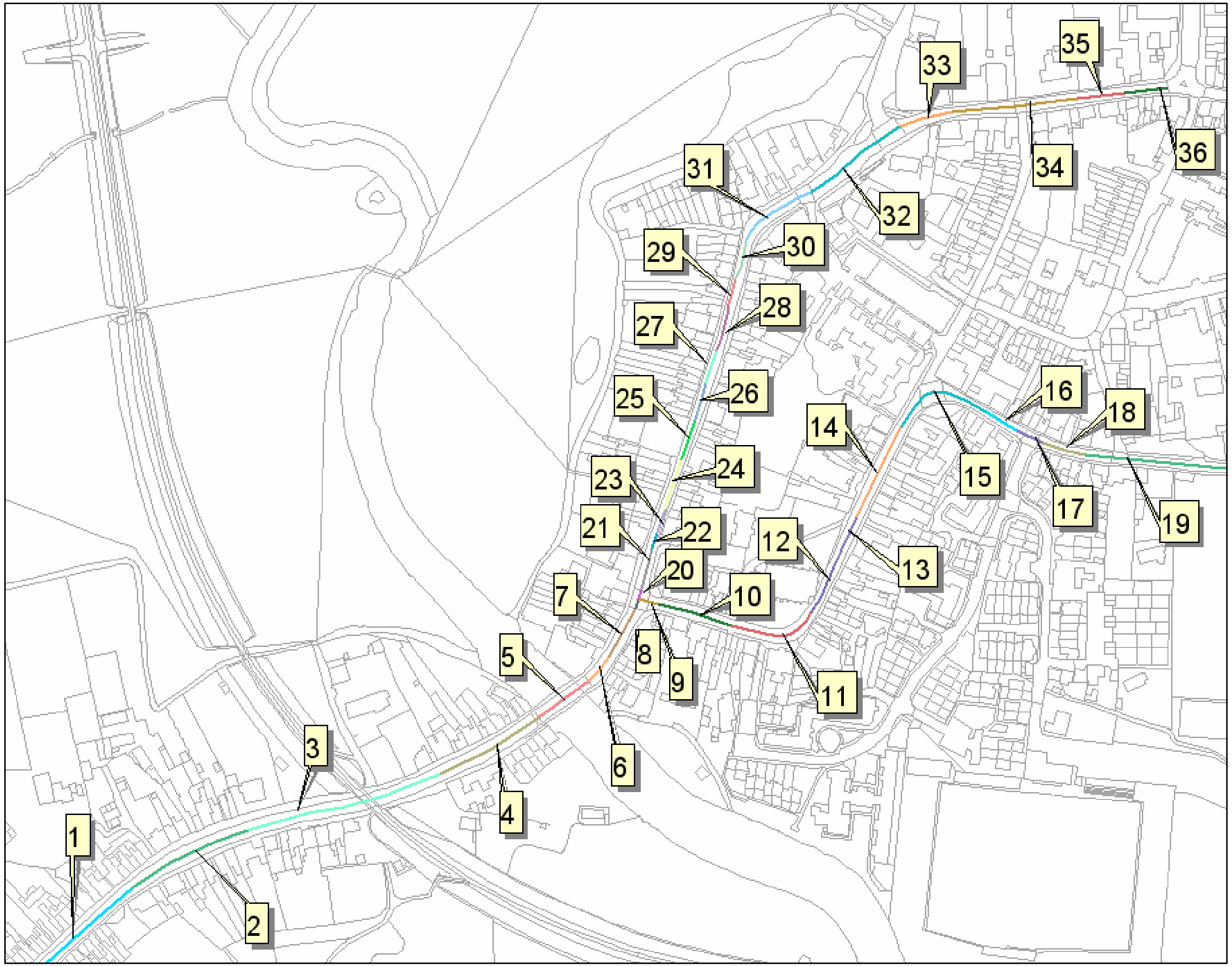

Figure A1.1 Road Sections (with Build-Out and Parking Bays)

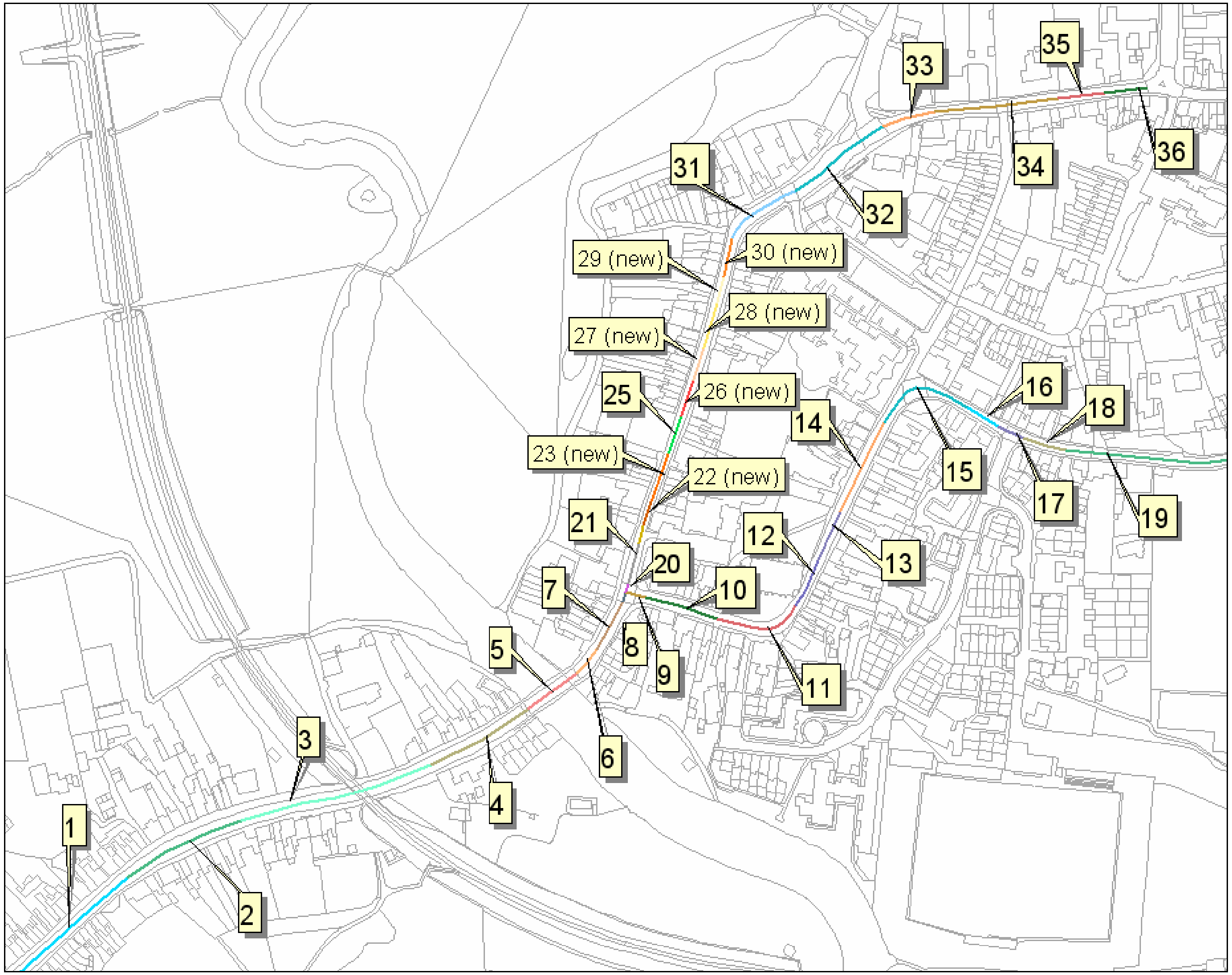

Figure A1.2 Road Sections (without Build-Out and Parking Bays)

Table A1.1: Summary ADMS Roads Model Set Up

Road Section	Scenario									
	Do Nothing		Remove build-out		Remove build-out and car parking spaces		Removing build-out and making Cross Street one way for HGVs		Removing build-out and making Cross Street one way for all vehicles	
	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments
1 [a]	50		50		50		50		50	
2 [a]	50		50		50		50		50	
3	50		50		50		50		50	
4 [a]	10		40	Speed increased	40		40		40	
5	10		40	Speed increased	40		40		40	
6	10		40	Speed increased	40		40		40	
7 [a]	10		40	Speed increased	40		40		40	
8	10		40	Speed increased	40		40		40	
9	10		10		10		10	Plus half of Cross Street HGV AADT flows	10	Plus half of Cross Street AADT flows
10 [a]	10		10		10		10	Plus half of Cross Street HGV AADT flows	10	Plus half of Cross Street AADT flows
11	30		30		30		30	Plus half of Cross Street HGV AADT flows	30	Plus half of Cross Street AADT flows
12 [a]	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows

Road Section	Scenario									
	Do Nothing		Remove build-out		Remove build-out and car parking spaces		Removing build-out and making Cross Street one way for HGVs		Removing build-out and making Cross Street one way for all vehicles	
	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments
13	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
14 [a]	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
15	30		30		30		30	Plus half of Cross Street HGV AADT flows	30	Plus half of Cross Street AADT flows
16 [a]	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
17	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
18 [a]	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
19	50		50		50		50	Plus half of Cross Street HGV AADT flows	50	Plus half of Cross Street AADT flows
20	10		30	Speed increased	30		30	HGV AADT flows halved	30	AADT flows halved
21	10		30	Speed increased	30		30	Half HGV AADT flows	30	AADT flows halved
22	10		30	Speed increased Road alignment changed to centre of the road	30		30	HGV AADT flows halved	30	AADT flows halved

Road Section	Scenario									
	Do Nothing		Remove build-out		Remove build-out and car parking spaces		Removing build-out and making Cross Street one way for HGVs		Removing build-out and making Cross Street one way for all vehicles	
	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments
23 [a]	10		30	Speed increased Road alignment changed to centre of the road	30		30	HGV AADT flows halved	30	AADT flows halved
24 [a]	10		30	Speed increased Road alignment changed to centre of the road	30		30	HGV AADT flows halved	30	AADT flows halved
25	15		15		40	Speed increased	15	HGV AADT flows halved	15	AADT flows halved
26 [a]	15		15		40	Speed increased Road alignment changed to centre of the road	15	HGV AADT flows halved	15	AADT flows halved
27 [a]	15		15		40	Speed increased Road alignment changed to centre of the road	15	HGV AADT flows halved	15	AADT flows halved
28 [a]	15		15		40	Speed increased Road alignment changed to centre of the road	15	HGV AADT flows halved	15	AADT flows halved
29 [a]	15		15		40	Speed increased Road alignment changed to centre of the road	15	HGV AADT flows halved	15	AADT flows halved
30 [a]	15		15		40	Speed increased Road alignment changed to centre of the road	15	HGV AADT flows halved	15	AADT flows halved

Road Section	Scenario									
	Do Nothing		Remove build-out		Remove build-out and car parking spaces		Removing build-out and making Cross Street one way for HGVs		Removing build-out and making Cross Street one way for all vehicles	
	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments	Speed (kph)	Comments
31	30		30		40	Speed increased	30	HGV AADT flows halved	30	AADT flows halved
32	50		50		50		50	HGV AADT flows halved	50	AADT flows halved
33	50		50		50		50	HGV AADT flows halved	50	AADT flows halved
34	50		50		50		50	HGV AADT flows halved	50	AADT flows halved
35	50		50		50		50	HGV AADT flows halved	50	AADT flows halved
36	50		50		50		50	HGV AADT flows halved	50	AADT flows halved

[a] These road sections have been included as canyons in the model. The canyon width has been taken as the longest distance between the road centre line and the buildings for any of the five scenarios, and then multiplied by two.

A2 Appendix 2: Dispersion Modelling Methodology

A2.1 Annual mean concentrations of nitrogen dioxide during 2009 have been modelled using the Atmospheric Dispersion Modelling System (ADMS). ADMS is one of the dispersion models accepted for modelling within LAQM.TG(09) (Defra, 2009). Road sources were modelled using ADMS Roads (version 2.3).

Traffic Data:

A2.2 Traffic data were provided by Suffolk County Council. A summary of the Annual Average Daily Traffic (AADT) flows entered into the model is provided in Table A2.1.

Table A2.1: Summary of AADT Flows (2009)

	MCL	Cars	PSV	LGV	OGV1	OGV2	Total
Ballingdon Street	65	7,305	51	1,583	480	175	9,659
Cross Street	90	11,157	79	2,260	564	465	14,615
Church Street	25	4,345	28	771	91	295	5,555

Background Concentrations:

A2.3 Background concentrations of nitrogen dioxide have been taken from the national maps of background concentrations available from the Air Quality Archive (Defra, 2010b). The background concentrations used in the modelling are presented in Table A2.2.

Table A2.2: Background Concentrations (µg/m^3)

	NOx	NO_2
2009	15.6 – 16.4	10.8 – 11.4

Model Verification:

A2.4 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The models have been run to predict annual mean road-NOx concentrations during 2009 at the roadside diffusion tube sites within the study area. Initial model runs showed that the model significantly underestimated the concentrations along Ballingdon Street and therefore two bias adjustment factors were calculated, one for Cross Street and Church Street and one for Ballingdon Street.

A2.5 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated from the measured

NO_2 concentrations and the predicted background NO_2 concentration using the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010b).

A2.6 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 A2.1). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010b). 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 A2.2).

A2.7 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

Cross Street and Church Street

- Primary adjustment factor : 2.10
- Secondary adjustment factor: 1.01

A2.8 The results imply that the model for Cross Street and Church Street is slightly under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.9 Figure A2.3 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

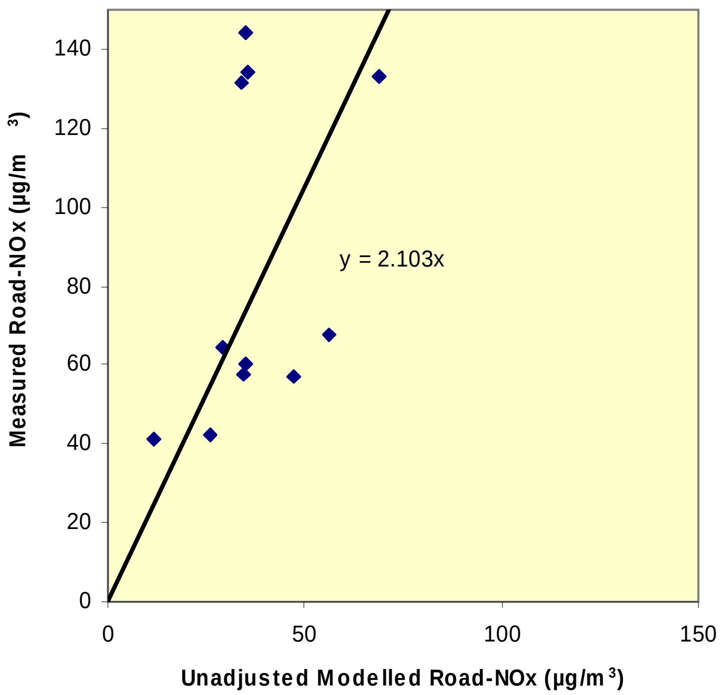

Figure A2.1: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

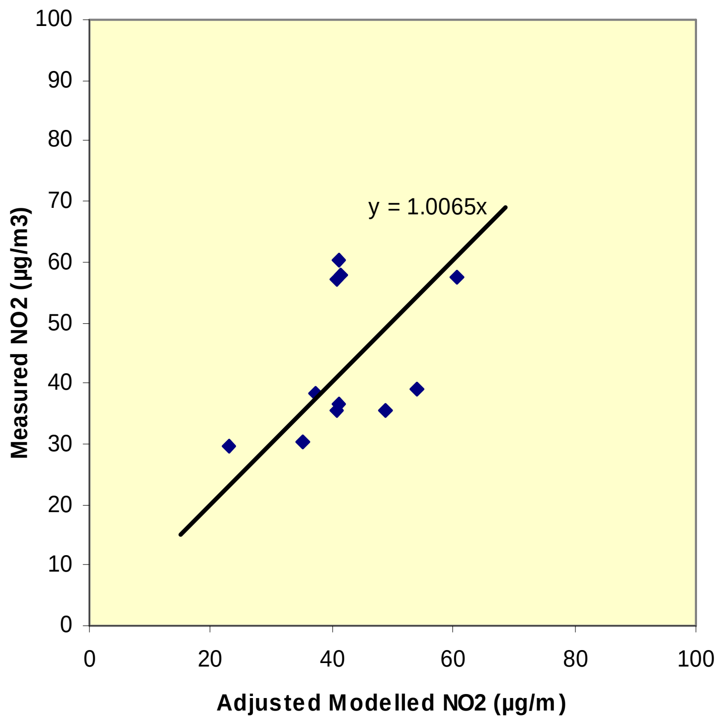

Figure A2.2: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

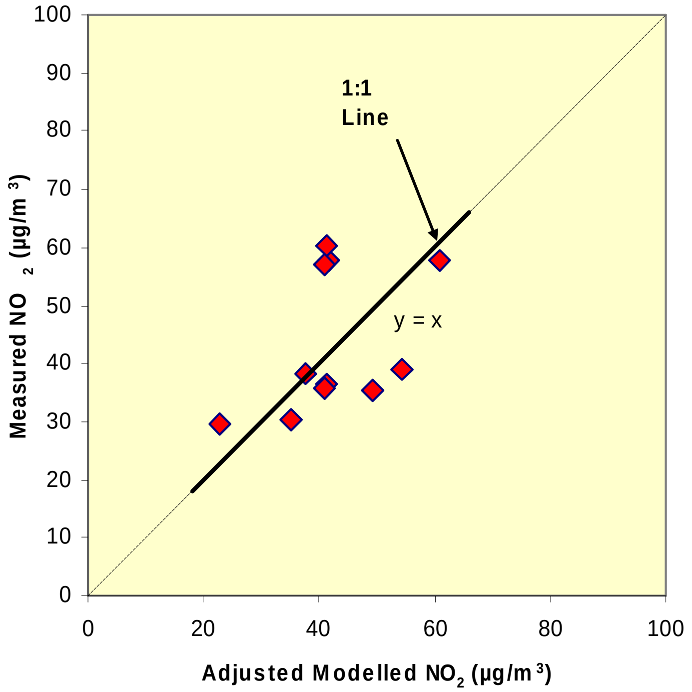

Figure A2.3: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

Ballingdon Street

- Primary adjustment factor : 4.20
- Secondary adjustment factor: 1.00

A2.10 The results imply that the model for Ballingdon Street is under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.11 Figure A2.6 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

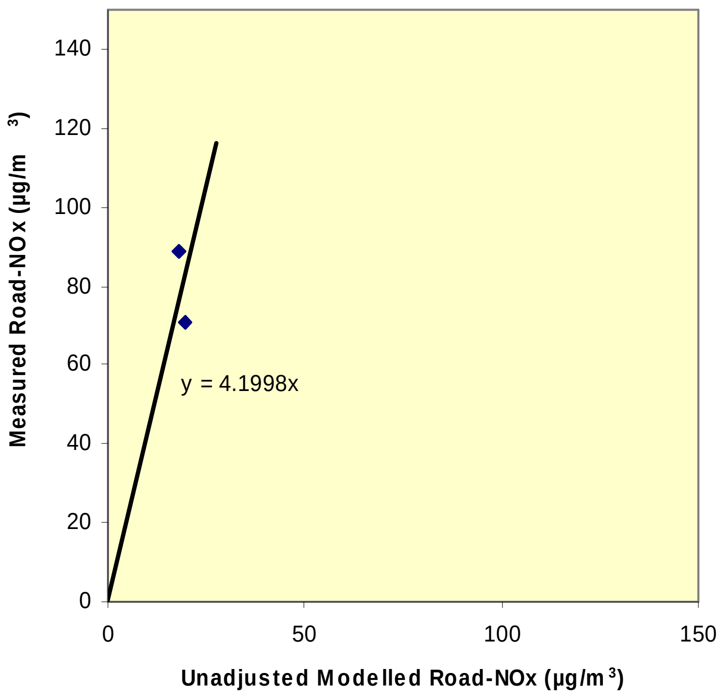

Figure A2.4: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

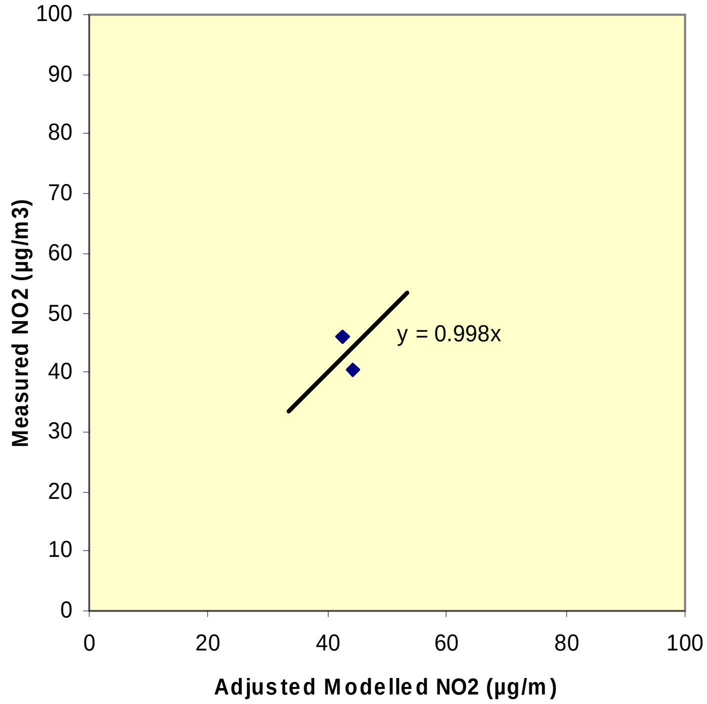

Figure A2.5: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

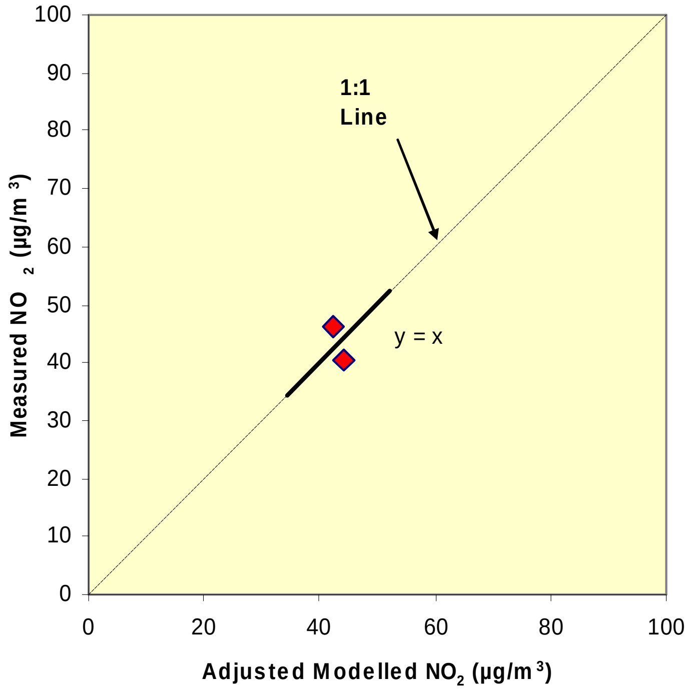

Figure A2.6: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations