Stage 4 Review and Assessment for the London Borough of Newham

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February 2003

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ERG File Ref Z:\erg\Air Quality Management\Stage_4_Review_assessment\London\Newham\Newham_st4_draft_v8.doc

Executive Summary

This is the Stage 4 report for the London Borough of Newham, which fulfils the next step of the Local Air Quality Management (LAQM) process. Section 84(1) of the Environment Act 1995 requires the London Borough of Newham to undertake the Stage 4 assessment following the designation of its air quality management area (AQMA). The earlier Stage 3 report produced by the London Borough of Newham identified areas within the borough where the annual mean nitrogen dioxide and daily mean PM10 concentrations were predicted to exceed government objectives.

The report follows the guidance produced by the Department of Environment, Food and Rural Affairs (DEFRA) and this allows the London Borough of Newham to:

- Confirm the original assessment of air quality against the prescribed objectives and thus to ensure that they were right to designate the AQMA in the first place;
- Calculate more accurately how much of an improvement in air quality would be needed to deliver air quality objectives within the AQMA;
- Refine the knowledge of the sources of pollution so that air quality action plans can be properly targeted;
- Take account of any new national policy developments, which have come to light since the AQMA declaration and the Stage 3 report, were prepared;
- Take account as far as possible of any new local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into the stage 3 report;
- Respond to comments from statutory consultees in respect of the Stage 3 report;
- Check the other assumptions previously made on which the designation of the AQMA has been based and to check that the designation is still correct;
- Carry out further monitoring in problem areas to check earlier findings.

New modelling predictions have been made for the Stage 4, and these incorporate a series of improvements over and above that undertaken in Stage 3. These improvements include both improved modelling methods and treatment of emissions.

The Stage 4 modelling predictions confirm the Stage 3 findings that the AQS objectives for nitrogen dioxide and PM10 will be exceeded within the London Borough of Newham's AQMA. The area where the 24-hour PM10 AQS objective is predicted to exceed however is smaller than the area where the annual mean NO_2 objective is predicted to exceed. Thus the modelling confirms that the annual mean NO_2 is the more stringent of the objectives that need to be met.

A series of locations have been chosen across the borough to help understand the source contribution of oxides of nitrogen, (NO_x) and PM10. This assessment is for NO_x rather than nitrogen dioxide because the latter is mostly a secondary pollutant formed as a result of

complicated atmospheric chemistry from the oxides of nitrogen. Based on the average façade result, approximately 44% of the total contribution is derived from background sources of NO_x and 56% from local road transport. The range of contributions related to background varies considerably and is between 22 and 85%. This is dependant on exact position chosen of the location relative to the road. The lower the background contribution the closer the location is to the kerbside. A significant proportion (47 to 63%) of the background contribution also arises from roads; these include roads outside the borough.

A possible intervention measure was also tested using the same modelling techniques. The scenario is based on a highly ambitious London wide low emission scenario to reduce traffic emissions (for different categories of vehicle). The result of this for NO_2 at the identified locations was that fewer sites were predicted to exceed the AQS objective, than the base case scenario.

Three other scenarios were examined these were based on an expected traffic reduction. These scenarios were borough based only. These all showed only a very small reduction in pollutant concentrations close to roadsides within the borough.

Appendix F provides an update on the current pollution levels as determined by the high quality continuous monitoring sites both within the Council's area and across the wider London Air Quality Network. These results confirm that the annual mean NO_2 objective is widely exceeded at roadside and urban sites, whereas the daily mean PM10 objective is mainly exceeded at the busiest roadside sites.

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1 Introduction to Stage 4 further assessment of air quality

1.1 Overview to Stage 4

This is the Stage 4 report for the London Borough of Newham. This report is intended to fulfil the statutory requirement for this, the Council's next step, of the Local Air Quality Management (LAQM) process.

1.2 Background – national perspective

Section 84(1) of the Environment Act 1995 requires local authorities to undertake a further assessment, where the local authority has designated an air quality management area (AQMA); this is now termed the Stage 4 assessment. The L.B of Newham designated its Air Quality Management Area by order in October 2001, following the production of its Stage 3 report. That report confirmed that areas close to major roads across the borough are likely to exceed the relevant future AQS objectives for nitrogen dioxide and PM10 (DETR, 2000).

Section 84(1) also requires the local authority to undertake the Stage 4 to supplement the information it has on the AQMA. The Department of Environment, Food and Rural Affairs (DEFRA) has produced specific guidance on the Stage 4 assessment (see www.defra.gov.uk/environment/airquality/laqm/stage4/index.htm).

The following provides a check list of the requirements for the Stage 4, as given in the DEFRA guidance:

- L.B of Newham to confirm the original assessment of air quality against the prescribed objectives and thus to ensure that they were right to designate the AQMA in the first place;
- To calculate more accurately how much of an improvement in air quality would be needed to deliver air quality objectives within the AQMA;
- To refine the knowledge of the sources of pollution so that air quality action plans can be properly targeted;
- To take account of any new national policy developments, which have come to light since the AQMA declaration and the Stage 3 report, were prepared;
- To take account as far as possible of any new local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into the Stage 3 report;
- To respond to comments from statutory consultees in respect of the Stage 3 report;
- To check the other assumptions previously made on which the designation of the AQMA has been based and to check that the designation is still correct;
- To carry out further monitoring in problem areas to check earlier findings.

1.3 Background – The London Borough of Newham perspective

The London Borough of Newham has undertaken the earlier stages of review and assessment of the Local Air Quality Management (LAQM) process within its area (see the individual Stage 1, 2 and 3 reports prepared between 1998 and 2000). These reports present the staged approach whereby the seven air pollutants in the Government's Air Quality Strategy (AQS) related to LAQM, were assessed and screened as to their relative importance to air quality within the L.B of Newham's area.

The Stage 3 report assessed air quality across the whole of the L.B of Newham's area in accordance with DEFRA (formerly DETR) guidance. The findings of the Stage 3 report were that the statutory objectives for nitrogen dioxide (NO_2), PM10 and sulphur dioxide (SO_2) only were exceeded, specifically the annual mean objective for NO_2, 24-hour mean objective for PM10 and the 15 minute objective for SO_2. Subsequent predictions of SO_2 based on revised emission data (from the Environment Agency) for the largest industrial processes confirmed that the SO_2 objective would not be exceeded within the Council's area. The area predicted to exceed therefore relates mainly to those areas that are adjacent to major roads.

The other four AQS pollutants (benzene, 1,3 butadiene, carbon monoxide, and lead) were only considered at earlier stages of the review and assessment. The finding for all these pollutants was that none were found likely to lead to the AQS objectives being exceeded and therefore no further action was required in respect of these pollutants.

Table 1 Table of air quality objectives relevant to Stage 4

	Concentration	Measured as	Date to be achieved by
Nitrogen dioxide (NO_2)	40µg/m^3 (21ppb)	Annual mean	31-Dec-05
	200µg/m^3 (105ppb) not be exceeded more than 18 times a year	1 hour mean	31-Dec-05
Particles (PM10)[1]	40 µg/m^3	Annual mean	31-Dec-04
	50 µg/m^3 not to be exceeded more than 35 times a year	24 hour mean	31-Dec-04

1.4 National Policy Developments

There are a number of key developments that have taken place since the Stage 3 report was first produced.

The government released its revised Air Quality Strategy in January 2000. This revision included a reappraisal of the objective pollutants (DETR, 2000). As a result many of these were changed to reflect both the U.K's commitments to the EU and also

[1] PM10 to be measured using the European gravimetric system or equivalent

that the objectives for many of the pollutants were already being met or close to being met. One principal change however was the amendment of the previous PM10 objective to equate with both the EU Daughter Directive and an improved scientific understanding.

Both the NO_2 and PM10 objectives however remained provisional, with the PM10 objective subject to a further review. The Environment Minister subsequently announced in January 2001 that the PM10 objective would remain to give local authorities a period of stability (ENDS, 2001), however consultation on a new objective for the longer term is already underway, following release of the latest Air Quality Strategy consultation for: particles, benzene, carbon monoxide and PAHs (polycyclic aromatic hydrocarbons) (DEFRA, 2001).

The latest health evidence shows that particles are likely to have significant long-term effects on health: probably many times more severe than the short-term effects on which policy has previously concentrated. The above mentioned consultation document explains the changes that the government proposes for the Strategy's objectives to take account of the latest health evidence. The proposals also seek to set a longer-term focus to the Strategy to reflect recent developments at the European Union (EU) level and to influence the development of wider policies that impact on air quality.

Of key importance for London and therefore to the London Borough of Newham are the proposals to strengthen substantially the AQS objectives for particles by supplementing the present objectives with new provisional objectives. These are:

- For all parts of the UK, except London and Scotland, a 24-hour mean of 50µg/m^3 not to be exceeded more than 7 times per year and an annual mean of 20µg/m^3, both to be achieved by the end of 2010;
- For London, a 24-hour mean of 50µg/m^3 not to be exceeded more than 10-14 times per year and an annual mean of 23-25µg/m^3, both to be achieved by the end of 2010.

It is also proposed that the Mayor and London boroughs should work towards a target of 20µg/m^3 after 2010, with the aim of achieving it by 2015 where cost effective and proportionate local action can be identified.

In addition the government's Expert Panel on Air Quality Standards (EPAQS) separately reported on an appropriate measurement upon which to base the airborne particle standard. The Panel concluded that the metric PM10 should remain, although it should be kept under active review due to the likelihood of important advances in the understanding of particles and health in the next few years (EPAQS, 2001).

The Mayor of London published the Mayor's Air Quality Strategy (September 2002) with section 5B of the strategy highlighting partnerships with the London Boroughs. The Mayor is a statutory consultee and the Council is required to have regard to the Mayor's Air Quality Strategy when carrying out its duties (GLA, 2002).

The government also revised the road traffic emission factors at the end of February 2002 and required their use by local authorities when reviewing and assessing local air quality. These are briefly discussed further in the next section.

1.5 Use of New Emission Factors

On initial inspection the new factors as released appear to be quite different from the previous factors. Briefly, these cover:

- Petrol cars (small, medium and large) Euro I, Euro II and Euro II.
- Diesel cars: (small and large) Euro I, Euro II and Euro II.
- LGVs (petrol and diesel) Euro I
- HGVs (rigid and articulated) Euro I and Euro II.
- Buses: Euro I and Euro II

To provide a complete breakdown of Euro classes it is necessary to use the old factors for pre-Euro I vehicles. As a result the new factors for NO_X and PM10 were considered in detail.

By way of an example, initial calculations were made of the total road transport emissions in London based on the new factors for NO_X and PM_{10}. These have been based on the same flows and vehicle stock, with only the emissions factors changed.

For NO_X, the following observations can be made:

- Total emissions for 1999 have increased by over 25 %.
- All vehicle types show an increase in NO_X except motorcycles.
- The most significant increase is for HGV emissions.
- LGV are also significantly higher than previous estimates
- Re-calculated 2005 total emissions have increased significantly.

For PM_{10}, the following observations can be made:

- There has been a small increase in total emissions for 1999.
- The change for different vehicle types is variable. HGVs, and to a lesser extent cars, have increased compared with the previous factors. Conversely, LGVs and buses have shown a decrease.
- For 2005, total emissions have increased by 15 %.
- The variation between different vehicle types is more pronounced than for 1999. HGVs in particular show a large increase.

In summary the outcome is that there are increases in emissions of both pollutants.

These findings therefore have important implications for dispersion modelling and the management of emissions from road traffic sources. The application of the new factors would be expected to increase predicted concentrations for the future, although detailed modelling is required to quantify the magnitude of this increase. The effect on individual links could be large. For example, the increase in emissions for HGVs is likely to have a larger impact where the flows of HGVs are highest. Another important aspect is the allocation of emissions between the different vehicle classes. Compared with the previous inventory there are marked differences between the shares of emissions for different vehicle classes, particularly for PM10.

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2 Predictions of Nitrogen Dioxide (NO_2) and Particles (PM10) in the London Borough of Newham's area

2.1 Outline of modelling developments

The Stage 4 review represents significant progress beyond the Stage 3 report. As a summary the developments include:

- Major roads on an exact geographic basis Ordnance Survey (OS), to allow an improved assessment of exposure;
- Predictions plotted on OS base maps;
- Improved modelling methods;
- A best estimate of model uncertainty, using Monte Carlo techniques;
- Detailed estimates of effects of traffic management scenarios;
- Additional monitoring data for assisting the modelling.

A detailed explanation of the methods used, including the developments undertaken is given in the appendices.

2.2 Annual mean NO_2 ($\mu g/m^3$) in 2005

The predicted concentrations of annual average NO_2 for the 2005 base case, assuming that the meteorology of the year 1999 was repeated, are shown in Figure 1 below. The areas coloured yellow to red are those that exceed the AQS objective of 40 $\mu g/m^3$ (21ppb). The predictions confirm the Stage 3 findings that the AQS objective will be exceeded adjacent to major roads across the borough. The predicted concentrations at specific locations are given in the next section.

It is clearly illustrated by Figure 1 that the major roads provide the most important contribution to concentrations of NO_2. It is also important to note that the locations of the major roads are modelled to a high degree of accuracy and in this case it is within 1m. This enables the concentration contours to be plotted with OS Landline data[2], which gives details of individual houses and allows easy estimation of the exposure of the local population to concentrations above the AQS objective. The pollution contours also show the rapid fall off in concentration from the road and the effect of increased concentrations close to road junctions, where the emissions of two or more roads combine and where slow moving, congested traffic is more likely to occur.

The one-hour mean has not been modelled in this report, as the predictions in the Stage 3 report were below the objective level. This previous analysis is further confirmed by the most recent monitoring results from the London Air Quality Monitoring Network sites, which are presented in Appendix F.

[2] Note – these are reproduced from the Ordnance Survey map with the permission of Her Majesty's Stationery Office, Crown Copyright reserved. Unauthorised production infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence No LA

Specific areas, which exceed the AQS objective and are associated with major roads include:

- Across the borough (North to South):

  - A406 (North Circular Road)
  - A117 (Forest Drive / Station Road / High Street North / Ron Leighton Way / High Street South / Woolwich Manor Way)

- Across the borough (East to West):
  - A118 (Romford Road),
  - A124 (Barking Road)
  - A13 (Newham Way)
  - B165 (Densham Road / Portway / Plashet Road / Plashet Grove / East Avenue)

- Other roads and parts of roads including:
  - A1020 (Royal Albert Way/ Royal Docks Road)
  - B109 (Katherine Road)
  - A11 (High Street / Broadway / Great Eastern Road / The Grove / Leytonstone High Road)
  - A1011 (Manor Road)
  - A114 (Upton Lane / Stopford Road / Terrace Road / Perry Road / Clegg Street)
  - A112 Leyton High Road / part of Chobham Road / Leyton Road Angel Lane / Tram Avenue / West Ham Lane / New Plaistow Road / Plaistow Road / High Street / Greengate Street / Prince Regent Lane / Victoria Dock Road Connaught Bridge / Hart Road / Connaught Road / Albert Road)
  - A115 Carpenters Road
  - B164 Water Lane / Vicarage Lane
  - Forest Lane E15 / E7
  - Abbey Lane / Abbey Road E15
  - Freemasons Road E16

2.3 Daily mean PM10 ($\mu g/m^3$) Concentrations in 2004

The prediction for the number of days exceeding the 24 hour mean of 50 $\mu g/m^3$ for 2004, assuming that the meteorology of the year 1996 was repeated, are given in Figure 2 below. The areas coloured yellow to red exceed the AQS objective, in this case where PM10 concentrations greater than 50 $\mu g/m^3$ occur for more than 35 days each year. Once again it is clear that major roads provide a significant proportion of PM10 concentrations in the London Borough of Newham's area although the PM10 concentrations differ markedly from that of NO_2, with the areas predicted to exceed being much smaller.

Specific areas, which exceed the AQS objective and are associated with major roads include:

- Across the borough (North to South):
    - A406 (North Circular Road)
- Across the borough (East to West):
    - A13 (Newham Way)
- Other roads and part roads including:
    - Forest Lane E15 / E7
    - A11 (High Street / Broadway / Great Eastern Road / The Grove / Leytonstone High Road)
    - Part B164 Water Lane
    - A1020 (Royal Docks Road)
    - Part A118 (Romford Road – near A406)

The modelling confirms that the annual mean NO_2 is the more stringent of the two objectives that are predicted to exceed.

The annual mean concentration for PM10 has also not been modelled in this report, as the predictions in the Stage 3 report were below the objective level.

Figure 1 Annual mean nitrogen dioxide (µg/m^3) for 2005 (based on 1999 meteorology.)

See end of report

Figure 2 Number of days with daily mean PM10 >50(µg/m^3) for 2004 (based on 1996 meteorology.)

See end of report

2.4 Source Apportionment for NO_X and PM10 in the London Borough of Newham's area

2.4.1 Methodology

To better understand the improvement needed at a location to achieve the AQS objectives, it is necessary to determine the individual source emissions that contribute to the overall predicted pollution concentration. Both pollutant emissions and atmospheric processes, including meteorology, determine the pollution concentration at any given location. Traditionally pollution is determined only from an understanding of emissions derived from local sources and background influences. This however provides only a simplistic understanding within London, as the pollution climate is further complicated by the actual size of London itself and the huge numbers of varying activities contributing to the source of emissions.

The pollutants under investigation in this stage of the LAQM process, i.e. PM10 and NO_2, further complicate the understanding of source apportionment. For NO_2, the contribution that the different sources make to the predicted concentrations can only be understood by examining the contribution of NO_x sources as the primary emission. This reflects the fact that the relationship between NO_2 and NO_x is non-linear and determined by photochemistry that is highly location dependent. The modelling undertaken to derive the predictions of NO_2 reflect this aspect and this is explored more fully in the model description given in Appendix A. The uncertainty associated with the modelling undertaken is explained in Appendix E.

For PM10 it is necessary to understand the influence of the primary, secondary and coarse components, which contribute to the total concentration. It is the 24-hour mean objective, which is predicted to be exceeded. However the source apportionment undertaken is based on annual mean PM10, which is averaged over a longer timescale and therefore less affected by specific events.

The source apportionment methodology used here is based on both:

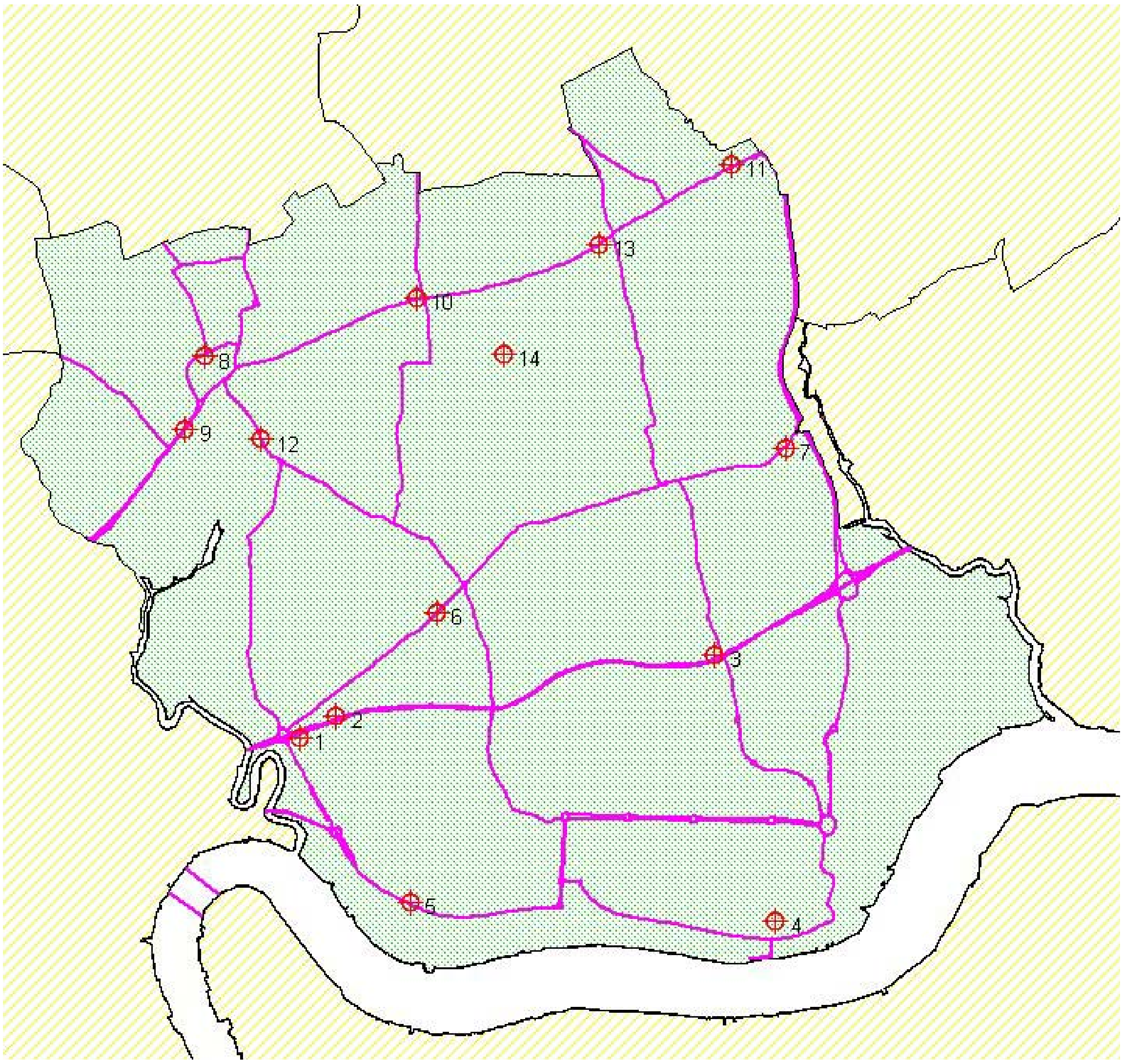
a) Determining the source apportionment for individual categories of the vehicle fleet, which of course recognises the major influence of road transport (as the dominant local source) and

b) Further determining the source apportionment in relation to the so called background sources, this recognises that this is influenced by both near and far sources, including road transport beyond the immediate location, which is therefore not considered as a local source. This contribution is specifically determined by deriving the pollution from all roads outside the borough, but within the Greater London area.

In all instances the determination of the influences of the different sources is undertaken by modelling sources independently of one another and establishing the predicted concentration at a given point. This is necessary since the influence of the different sources varies between locations due to their proximity to the sources; hence the apportionment is location dependent.

A series of specific point locations were selected for investigation to provide a representative understanding. The selection of these locations was undertaken by the London Borough of Newham, with the points chosen considered to be those representative of areas with predicted high concentrations of pollution. The specific locations are shown in Figure 3 below and listed in Table 2.

Figure 3 The location of facades identified across the London Borough of Newham's area



Note – 1) the numbered points refer to the locations given in Table 2.

Table 2 Location of sites used for source apportionment

Locations	Road Name	Easting	Northing
1	1 Hughes Terrace E16	539568	181517
2	19 Aviary Close E16	539864	181690
3	2 Roman Road E6	542891	182176
4	65 Claremont Close E16	543377	180066
5	8 Kennacraig Close E16	540460	180210
6	486 Barking Road E13	540669	182510
7	53 Dukes Court E6	543461	183824
8	Gerry Raffles Square E15	538815	184551
9	High Street Stratford E15	538656	183973
10	325 Romford Road E7	540502	185015
11	1019 Romford Road E12	543020	186079
12	81 West Ham Lane E15	539267	183891
13	Salisbury School, Romford Road E	541965	185438
14	49 South Esk Road (background site) E7	541206	184567

2.4.2 Annual mean NO_2 at identified locations within the Council's area

To calculate more accurately how much improvement in air quality would be needed to deliver the air quality objective within an AQMA; it is necessary first to confirm the concentration of NO_2 at specific sites. This can be established from the modelling undertaken above and the concentrations are given in Table 3 below.

Table 3 Predicted NO_2 concentration ($\mu g/m^3$) at identified locations within the AQMA

Location	Concentration
1	51.0
2	57.0
3	48.2
4	32.4
5	47.4
6	45.0
7	47.0
8	46.7
9	53.3
10	44.0
11	44.3
12	50.1
13	45.0
14	32.0

The predicted results for the 2005 base year (from Table 3 above) show that for those locations exceeding the objective, the amount is between 4 and 17 $\mu g/m^3$.

2.4.3 Source apportionment of NO_x at the identified locations

The understanding of NO_x is undertaken for the base case of 1999 (for which accurate traffic estimates are available, including; vehicle flows and stock information. This is described more fully in Appendix D). The method for calculating the emissions incorporates the many different categories in the vehicle fleet using the road, however for the purposes of understanding source contributions more straightforwardly the following grouping has been applied to the sources:

- HGV (i.e. all HGVs and LGVs other than cars, taxis and motorcycles)
- Cars (including all cars, taxis and motorcycles) and
- Buses and coaches.

A series of model runs for the base case were undertaken for each of the components described above, plus a separate run to determine the gross background contribution. The individual contribution for each category is given in Table 4 below.

Table 4 Predicted NO_x concentration ($\mu g/m^3$) for the different sources

Location	Base case	Buses	Cars	HGVs	Background
1	182.4	5.0	40.1	69.8	67.5
2	287.6	3.8	78.1	141.6	64.1
3	183.5	5.5	53.7	66.3	58.0
4	70.5	1.0	2.7	6.5	60.3
5	146.3	6.3	33.1	43.5	63.4
6	129.3	17.9	25.7	28.0	57.6
7	160.9	16.7	44.7	38.9	60.6
8	144.2	9.4	33.1	41.1	60.6
9	234.0	22.5	62.3	87.6	61.5
10	125.6	9.5	30.0	27.5	58.5
11	138.9	9.3	36.7	24.0	69.0
12	192.2	37.4	36.1	59.2	59.5
13	146.7	11.2	37.4	38.3	59.7
14	69.0	2.0	4.2	5.3	57.5

The results highlight that the vehicle related contributions vary by location, with the background contribution between 57.5 and 69 $\mu g/m^3$. The Car and HGV categories together dominate at locations 1, 2, 3, 5, 7, 8, 9, 12 and 13. For each of these locations the combined contributions exceed the background. In addition the individual Car and HGV contributions at locations 2 and 9 also exceed the background. However the background contribution is greater than the contributions from the Car and HGV categories at location 4, 6, 10, 11 and 14. Locations 1, 2 and 3 are close to the A13. For these locations the HGV contribution exceeds the Car contribution. HGV contributions exceed car contributions at other locations (5, 6, 8, 9, 12 and 13), which are also close to major roads.

Buses and coaches form only a minor contribution (less than 10 $\mu g/m^3$) at most locations (apart from locations 6, 7, 9, 12, 13). At these five locations the contribution is greater than 10 $\mu g/m^3$, with location 12 approximating that of cars.

The background component comprises emissions from the following sectors:

- Domestic (including heating and cooking)
- Commercial/ industrial sources (termed industrial for both gas and oil)
- Other transport sources (railways, airports and shipping)
- Part B industrial processes (which are authorised by the L.B of Newham)
- Background roads

Background roads include the contribution to the total pollutant concentration, which is derived from those roads beyond those modelled as directly influencing the location. This includes those roads that are outside the borough, which contribute to the overall background concentration for London. In addition a separate contribution termed "Other background" is also included. This is the contribution which is that derived from natural/ rural emissions outside of London. This contribution is considered constant for all locations across London. The method for deriving this contribution is also more fully explained in Appendix A on the model development.

Part A sources are included within the categories rather than specifically included as a separate category. The predicted NO_x contribution in the L.B of Newham for all Part A sources was predicted as just over 1 $\mu g/m^3$ for 2005 and therefore can be considered as a minor source (Carslaw, Beevers and Hedley, 2000).

Table 5 below gives the individual contributions for the 14 identified locations.

Table 5 Predicted NO_x concentration ($\mu g/m^3$) for the different background sources

Location	Background roads	Domestic	Industrial Gas	Industrial Oil	Other Transport	Part Bs	Other Background
1	41.66	2.81	2.23	1.02	0.56	0.26	19.0
2	38.18	2.81	2.23	1.02	0.56	0.26	19.0
3	29.65	2.98	5.45	0.26	0.53	0.14	19.0
4	28.60	3.26	6.85	0.55	1.78	0.22	19.0
5	36.43	2.82	2.27	0.62	1.27	0.96	19.0
6	31.25	4.08	2.21	0.58	0.38	0.14	19.0
7	35.54	3.41	1.94	0.24	0.37	0.09	19.0
8	33.10	3.83	2.44	1.41	0.62	0.22	19.0
9	34.18	3.74	2.72	1.11	0.46	0.33	19.0
10	31.08	4.90	2.56	0.48	0.39	0.12	19.0
11	43.59	3.90	1.63	0.23	0.61	0.07	19.0
12	32.14	3.74	2.72	1.11	0.46	0.33	19.0
13	32.22	5.01	2.41	0.40	0.59	0.10	19.0
14	30.03	4.76	2.59	0.48	0.58	0.10	19.0

The contribution to the background component from domestic, commercial/ industrial, other transport and Part B sources for all locations is small (approximately 6 to 13 μg/m^3) compared to the contributions from the Other background and Background roads.

Table 6 demonstrates the relative importance within the background component of NO_x from road transport and non-road transport related sources.

Table 6 Predicted NO_x contributions (%) for the different background sources

Location	% Non-road related	% Road related
1	38.3	61.7
2	40.4	59.6
3	48.9	51.1
4	52.5	47.5
5	42.5	57.5
6	45.8	54.2
7	41.3	58.7
8	45.4	54.6
9	44.5	55.5
10	46.9	53.1
11	36.8	63.2
12	46.0	54.0
13	46.0	54.0
14	47.8	52.2

The above proportions indicate that for all locations, approximately 47-63% of the background component is from road transport related sources. This is in addition to the road transport related sources modelled locally to the identified locations and therefore this confirms the major influence of this sector in the L.B of Newham area.

2.4.4 Source apportionment of PM10 at the identified locations

The source apportionment for PM10 has been derived using the same methodology as that described earlier (sections 2.4.1 and 2.4.3). The locations given in the following tables are therefore those identified in Table 2 and Figure 3.

Table 7 provides the results for the 1999 base case, along with the relative contributions for the separate road transport source categories, plus the background contribution. As explained in the modelling methodology (Appendix A) and the previous Stage 3 report, the PM10 fraction can be considered as comprising different components: primary – relating to emissions direct from combustion sources: secondary which are formed in the atmosphere from smaller particles; and coarse components such as those from natural sources. In this instance the road transport sources provide the major proportion of the primary component, whereas the background contribution includes the remainder of the primary, plus the secondary and coarse components. As a result the background contribution remains almost constant for all the locations investigated (between 24.2 and 24.6 μg/m^3).

Highest concentrations are predicted at locations 2, 9 and 12 (all approximately 33 - 36 μg/m^3), these locations also exhibit the highest contributions from the HGV category (which also includes all LGVs other than cars, taxis and motorcycles), thus reflecting the relatively higher proportion of these vehicles close to these locations. Location 12 has the highest contribution from Buses with the contribution marginally greater than that of Cars.

For all locations the HGV category contribution exceeds that of cars and in most locations (apart from locations 12 and 14) the contribution from Cars exceeds that of Buses.

Table 7 Predicted annual mean PM10 concentration (µg/m^3) for different sources

Location	Base case	Buses	Cars	HGVs	Background
1	30.4	0.3	1.4	4.1	24.6
2	34.8	0.2	2.6	7.6	24.5
3	30.4	0.3	1.7	4.2	24.3
4	24.7	0.0	0.1	0.3	24.2
5	29.1	0.3	1.2	3.0	24.5
6	28.8	1.0	1.4	2.2	24.2
7	30.1	0.9	1.9	2.9	24.3
8	29.4	0.5	1.5	3.0	24.4
9	36.1	1.2	3.5	6.8	24.5
10	28.3	0.5	1.5	2.1	24.3
11	29.5	0.6	2.0	2.3	24.6
12	33.4	2.3	2.2	4.6	24.3
13	30.4	0.7	2.2	3.3	24.3
14	24.7	0.1	0.1	0.3	24.2

Table 8 provides the same information in relative terms for the sites however as previously explained the variation between proportions can be partly explained by both the contributions themselves, i.e. proximity of the individual locations as well as by the actual magnitude of the local sources investigated.

Table 8 Proportions of source contributions (%)

Location	All road transport	Background
1	18.9	81.1
2	29.7	70.3
3	20.2	79.8
4	1.8	98.2
5	15.7	84.3
6	15.8	84.2
7	19.1	80.9
8	16.8	83.2
9	32.0	68.0
10	14.4	85.6
11	16.6	83.4
12	27.2	72.8
13	20.0	80.0
14	2.0	98.0

In all instances it can be clearly seen that the Background contribution greatly dominates even when compared with the All road transport total. Locations 2, 9 and 12 have the greatest increases in contribution from the All road transport category when compared to the other locations.

The proportion of vehicle category contributions to the total for All road transport can be seen below in Table 9. This highlights the expected dominance of the HGV category (including Buses) for all locations, although the Car is almost equally significant at location 11. The similar contribution of PM10 from Cars and HGVs at this location reflects a proportionally lower number of HGVs.

Table 9 Proportion (%)of vehicle category contributions to predicted PM10 concentrations

Location	Buses	Cars	HGVs
1	4.4	25.1	70.5
2	1.8	24.7	73.5
3	4.4	27.9	67.7
4	9.9	18.3	71.9
5	6.8	26.5	66.7
6	21.9	29.8	48.3
7	16.2	33.3	50.5
8	9.7	29.9	60.4
9	10.7	30.0	59.3
10	12.4	35.7	51.9
11	11.8	41.3	46.9
12	24.8	24.3	50.9
13	10.7	35.8	53.5
14	16.5	28.7	54.7

The background component for PM10 varies from that of NO_x as it includes both secondary and coarse components. These are in addition to the other primary components, which also include the influence of traffic beyond the borough boundary. The background contribution comprises emissions from the following sectors:

- Commercial/ industrial sources (termed industrial for both gas and oil)
- Other transport sources (railways, airports and shipping)
- Part B industrial processes (which are authorised by the L.B of Newham)
- Background roads
- Rural background primary
- Secondary and coarse

It should also be noted that other sectors were considered, including contributions from the domestic sector, however these found to comprise very small proportions (i.e. less than 0.01 $\mu g/m^3$). As a consequence these contributions have not been included in Table 10 of the predicted contributions to background PM10.

Background roads include the contribution to the total pollutant concentration, which is derived from those roads outside of those modelled as directly influencing the location. This includes those roads that are outside the borough, which contribute to the overall background concentration for London. In addition separate contributions termed “Secondary/ Coarse” and “Rural background primary” are also included. These are the contributions that are derived from natural/ rural emissions outside of London (including transboundary contributions). These contributions are therefore considered constant for all locations across London.

Table 10 Predicted PM10 concentration (μg/m^3) at the identified locations for the different background sources

Location	Background roads	Industrial Oil	Other Transport	Part Bs	Rural Background primary	Secondary/ coarse
1	1.93	0.26	0.02	0.29	1.17	20.93
2	1.83	0.26	0.02	0.29	1.17	20.93
3	1.82	0.05	0.02	0.32	1.17	20.93
4	1.62	0.09	0.05	0.35	1.17	20.93
5	1.77	0.14	0.03	0.46	1.17	20.93
6	1.78	0.12	0.02	0.17	1.17	20.93
7	2.02	0.04	0.02	0.12	1.17	20.93
8	1.62	0.11	0.03	0.54	1.17	20.93
9	1.73	0.10	0.02	0.55	1.17	20.93
10	1.89	0.09	0.03	0.19	1.17	20.93
11	2.23	0.04	0.03	0.20	1.17	20.93
12	1.53	0.10	0.02	0.55	1.17	20.93
13	1.87	0.08	0.03	0.23	1.17	20.93
14	1.79	0.09	0.03	0.19	1.17	20.93

Table 10 demonstrates that the secondary/ coarse contributions are of greatest significance, totally dominating the overall background contribution. This apportionment was based on 1999 meteorology and therefore it would be expected to be even greater for the worst-case meteorology scenario i.e. for 1996. The PM10 measurements in London for that year were dominated by the transboundary secondary episodes, due to the higher than normal frequency of easterly winds from Europe.

The relative proportions for the above categories are given in Table 11. In this instance the local commercial/ industrial and other transport categories have been combined. The second most significant contribution to the background is that from the Background roads, these approximate to about 7-9% of the total for all locations. The Other transport/ commercial contribution approximates to 0 – 2.8% for all locations. As indicated above the secondary/ coarse component greatly dominates at all locations (about 85% of the total).

Table 11 Proportion (%) of source category contributions

Location	Background roads	Other transport/ commercial	Rural Background primary	Secondary/ coarse
1	7.9	2.3	4.76	85.1
2	7.5	2.3	4.78	85.4
3	7.5	1.6	4.81	86.1
4	6.7	2.0	4.83	86.5
5	7.2	2.6	4.78	85.4
6	7.4	1.3	4.83	86.5
7	8.3	0.7	4.81	86.1
8	6.6	2.8	4.80	85.8
9	7.1	2.7	4.78	85.4
10	7.8	1.3	4.81	86.1
11	9.1	1.1	4.76	85.1
12	6.3	2.8	4.81	86.1
13	7.7	0.0	4.81	86.1
14	7.4	0.0	4.83	86.5

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3 The Effectiveness of Possible Interventions

3.1 Overview to Air Quality Action Plans

The Council having declared an AQMA is required to produce an action plan following the production of its Stage 4 report. The purpose of the action plan is to allow the Council to work towards the statutory air quality objectives that have been identified as being likely to be exceeded and where the public are exposed for the relevant years.

To test the effectiveness of possible measures to improve air quality within the AQMA a series of scenario tests have been considered. This reflects the fact that road transport is the main source of emissions (as discussed above in section 2).

3.2 Scenario selection

The Council having declared an AQMA is required to produce an action plan following the production of its Stage 4 report. The purpose of the action plan is to allow the Council to work towards the statutory air quality objectives that have been identified as being likely to be exceeded and where the public are exposed for the relevant years.

To test the effectiveness of possible measures to improve air quality within the AQMA a series of scenario tests have been considered. This reflects the fact that road transport is the main source of emissions (as discussed above in section 2). There are a variety of mitigation measures available and the numerous strategies being considered by the varying levels of government will, when implemented provide an overall benefit.

The first possible intervention tested is based on a low emissions scenario. This reflects that specific vehicles will be excluded from a specific geographic area. This is intended to lead to an improvement in air quality, based on the two pollutants, i.e. NO_2 and PM10. The scenario is based on a re-adjustment of vehicle stock only; hence the total traffic volume is not altered. The intention is that the most polluted vehicles are removed thus reducing emissions in the area of interest; these vehicles however are replaced on a one for one basis by “cleaner” vehicles. The scenario is also based on a London wide approach (i.e. using the M25 as the boundary). Clearly if this were not the case then the resulting impact would be reduced.

To test this specific scenario a series of assumptions have been made. Those vehicles that have been modelled in the scenario are those given below. The assumptions were first agreed at an LAQN workshop on the 12th February 2002 and are tested on the basis of their potential at this stage. The scenario should therefore be considered as indicative.

A separate definitive Low Emission Zone (LEZ) project is also currently underway across London, funded by local and central government (see www.london-lez.org). The final report from this study will not be available until the autumn. In comparison with the scenarios being investigated in that project, the scenario agreed below is possibly too ambitious.

It is also important to note that this approach provides a scenario for modelling and it clearly does not take into account the complexity involved with instigating such measures in practice.

3.3 Scenario testing

The low emission scenario specification investigated will include only the following categories of vehicle and prohibit all other categories outside of these:

- Petrol cars – Euro III and Euro IV
- Diesel cars - Euro III and Euro III (with particle trap)
- Petrol taxis – Euro III
- Diesel LGVs - Euro III
- HGVs Rigid - Euro III, Euro III (with particle trap) and Euro II (with particle trap)
- HGVs Articulated - Euro III, Euro III (with particle trap) and Euro II (with particle trap)
- Non LT buses - Euro III, Euro III (with particle trap) and Euro II (with particle trap)
- LT buses - Euro III, Euro III (with particle trap) and Euro II (with particle trap)

Three further separate scenarios tested are based on an emphasis in reducing the need to travel and encouraging a switch to less to polluting forms of transport. The scenarios therefore model traffic reduction scenarios to see what the impact is. The scenarios are as follows:

Scenario 1) 10% reduction in vehicles (borough wide)

Scenario 2) 15% reduction in vehicles (borough wide)

Scenario 3) 20% reduction in vehicles (borough wide)

The scenarios are not modelled outside of the Council's area and no changes have been made to either taxi or bus flows.

Additionally to support the Council action planning further a number of scenarios have also been tested based on increases in traffic flows on the North Woolwich Road/ Royal Albert Way and on the A11/ Romford Road. The met year used for testing all the scenarios is 1999.

3.4 Results of low emissions scenario test

The results of the modelling for the scenario test undertaken are given in each of the following tables: Table 12, Table 13 and Table 14 with the results representing the predicted concentrations at the same locations as used for the earlier source apportionment (see Table 2 and Figure 3). The results for NO_2 are also mapped in Figure 4.

Table 12 Predicted 2005 concentrations (µg/m^3) of NO_2 at the identified locations

Location	Base case	Lower emissions	Improvement (µg/m^3)	Improvement (%)
1	51.0	45.1	5.9	11.5
2	57.0	54.2	2.8	5.0
3	48.2	43.2	5.0	10.3
4	32.4	29.0	3.3	10.3
5	47.4	42.0	5.4	11.4
6	45.0	39.6	5.4	12.0
7	47.0	41.2	5.9	12.4
8	46.7	41.5	5.2	11.0
9	53.3	51.5	1.8	3.4
10	44.0	39.0	5.0	11.4
11	44.3	38.4	5.9	13.3
12	50.1	47.7	2.4	4.8
13	45.0	40.3	4.7	10.4
14	32.0	28.4	3.6	11.3

Table 13 Predicted 2005 concentrations (µg/m^3) of NO_x at the identified locations

Location	Base case	Lower emissions	Improvement (µg/m^3)	Improvement (%)
1	122.4	95.8	26.6	21.7
2	189.7	145.5	44.2	23.3
3	120.7	92.9	27.8	23.0
4	49.5	41.9	7.6	15.3
5	98.8	78.2	20.7	20.9
6	89.1	72.0	17.1	19.1
7	107.8	84.5	23.2	21.6
8	99.2	78.6	20.5	20.7
9	161.8	126.7	35.1	21.7
10	86.3	68.6	17.7	20.5
11	92.4	72.1	20.3	22.0
12	135.5	109.4	26.1	19.3
13	99.7	78.6	21.0	21.1
14	47.9	40.1	7.8	16.3

Table 14 Predicted (2004) number of days exceeding the AQS daily PM10 mean of 50μg/m^3 at the identified locations

Location	Base case	Lower emissions	Improvement (days)	Improvement (%)
1	7	5	2	23.4
2	14	9	4	32.2
3	7	5	2	24.6
4	4	4	0	2.4
5	6	5	1	19.7
6	5	4	1	18.1
7	6	5	1	23.8
8	6	5	1	21.0
9	13	8	5	36.3
10	5	4	1	17.3
11	6	5	1	22.6
12	8	6	3	31.6
13	6	5	2	24.8
14	4	4	0	2.3

The results in the three tables above confirm the expected reduction in concentrations as a result of the continuing uptake of technology.

For NO_2 the predicted improvement is insufficient to ensure that all locations will meet the AQS annual mean objective. The predicted improvement varies between 1.8 and 5.9 μg/m^3 (between approximately 3 and 13% improvement). This is sufficient for locations 6, 10 and 11 to meet the annual mean NO_2 objective. For locations 5, 7, 8 and 13 the margin predicted to exceed is less than 2 μg/m^3. However for those locations nearest the busy A11 and A13 roads the margin is much greater (up to 14.2 μg/m^3 for location 2).

Figure 4 Predicted 2005 annual mean NO_2 concentration in the LB Newham based on a low emissions scenario

See end of report.

3.5 Results of traffic reduction scenarios

The results of the modelling for these scenario tests undertaken are given in the following tables: Table 15 to Table 20, with the results representing the predicted concentrations at the same locations as used for the earlier source apportionment (see and Figure 3).

Table 15 Predicted 2005 concentrations (µg/m^3) of NO_2 at the identified locations

Location	Base case	10% reduction	15% reduction	20% reduction
1	50.9	49.4	49.0	48.6
2	56.0	53.8	53.1	52.3
3	47.4	45.9	45.4	44.9
4	32.4	31.7	31.6	31.4
5	47.4	46.1	45.6	45.1
6	45.0	43.8	43.4	43.1
7	46.9	45.5	45.1	44.7
8	46.4	45.2	44.8	44.5
9	53.3	51.5	50.9	50.3
10	44.0	42.9	42.6	42.4
11	47.9	46.5	46.1	45.7
12	50.1	48.6	48.2	47.8
13	45.0	43.8	43.5	43.1
14	32.0	31.4	31.2	31.1

Table 16 Predicted NO_2 improvement from base case at the identified locations (%)

Location	10% reduction	15% reduction	20% reduction
1	2.9	3.8	4.7
2	3.9	5.2	6.6
3	3.2	4.3	5.3
4	2.1	2.5	3.0
5	2.7	3.6	4.7
6	2.7	3.5	4.3
7	2.9	3.8	4.6
8	2.6	3.3	4.0
9	3.4	4.5	5.6
10	2.5	3.1	3.7
11	2.9	3.8	4.6
12	2.9	3.7	4.6
13	2.7	3.5	4.3
14	2.1	2.6	3.0

Table 17 Predicted 2005 concentrations (µg/m^3) of NO_x at the identified locations

Location	Base case	10% reduction	15% reduction	20% reduction
1	122.0	113.6	110.1	106.7
2	179.2	164.2	157.8	151.4
3	112.4	104.5	101.2	97.9
4	49.5	48.3	48.0	47.7
5	98.8	92.8	90.5	88.1
6	89.1	84.6	82.9	81.2
7	106.1	99.8	97.3	94.8
8	96.2	90.6	88.3	86.0
9	161.8	150.1	145.2	140.3
10	86.3	81.6	79.7	77.9
11	128.4	120.3	117.0	113.7
12	135.5	127.5	124.4	121.17
13	99.7	93.7	91.4	88.97
14	47.9	46.7	46.4	46.12

Table 18 Predicted NO_x improvement from base case at the identified locations (%)

Location	10% reduction	15% reduction	20% reduction
1	6.9	9.7	12.6
2	8.4	11.9	15.5
3	7.0	10.0	12.9
4	2.5	3.1	3.7
5	6.0	8.5	10.9
6	5.0	6.9	8.8
7	5.9	8.3	10.7
8	5.9	8.3	10.6
9	7.3	10.3	13.3
10	5.5	7.6	9.8
11	6.3	8.9	11.5
12	5.9	8.3	10.61
13	6.0	8.4	10.74
14	2.5	3.1	3.77

Table 19 Predicted number of days exceeding the AQS daily PM10 mean of 50µg/m^3 at the identified locations

Location	Base case	10% reduction	15% reduction	20% reduction
1	7	6.4	6.1	5.9
2	12	11.0	10.3	9.7
3	6	5.9	5.7	5.5
4	4	3.6	3.6	3.6
5	6	5.5	5.4	5.2
6	5	4.9	4.8	4.7
7	6	5.7	5.5	5.4
8	6	5.4	5.2	5.1
9	13	11.6	11.0	10.3
10	5	4.8	4.7	4.6
11	10	8.8	8.3	7.9
12	8	7.6	7.3	7.05
13	6	5.9	5.8	5.58
14	4	3.6	3.6	3.59

Table 20 Predicted PM10 improvement from base case at the identified locations (%)

Location	Improvement (%)	Improvement (%)	Improvement (%)
1	6.9	10.2	13.4
2	11.3	16.6	21.7
3	6.6	9.7	12.7
4	0.2	0.3	0.4
5	5.5	8.1	10.6
6	4.0	5.9	7.8
7	6.1	8.9	11.7
8	5.1	7.5	9.9
9	10.6	15.7	20.5
10	4.2	6.1	8.0
11	9.5	14.0	18.3
12	7.6	11.3	14.78
13	6.3	9.2	12.05
14	0.2	0.3	0.35

The results in the above tables confirm a reduction in concentrations at the chosen locations as a result of the reduced numbers of vehicles. The scenarios are incremental and therefore the greatest reduction in concentrations relates to the greatest reduction in vehicle flows. The scenarios modelled have assumed an equal reduction in all types of vehicle (i.e. not just the most polluting category).

For NO_2 the predicted improvement is however not sufficient to ensure any additional locations will meet the AQS annual mean objective, with the improvement being less that that predicted for the low emissions scenario. The predicted improvement varies between 0.8 and 3.7 µg/m^3 (i.e. between approximately 2 and 6.6 % improvement). All locations meet the PM10 objective (based on the met year used).
Figures 5 to 7 represent the predicted concentration for the three scenarios.

Figure 5 Predicted 2005 annual mean NO_2 concentrations for LB Newham based on a 10% reduction in traffic flows

Figure 6 Predicted 2005 annual mean NO_2 concentrations for LB Newham based on a 15% reduction in traffic flows

Figure 7 Predicted 2005 annual mean NO_2 concentrations for LB Newham based on a 20% reduction in traffic flows

See end of report for these figures.

Figure 8 Predicted 2005 annual mean NO_2 concentrations based on a 10% increase in traffic flows along the North Woolwich Road/ Royal Albert Way only

Figure 9 Predicted 2005 annual mean NO_2 concentrations based on a 20% increase in traffic flows along the North Woolwich Road/ Royal Albert Way only

Figure 10 Predicted 2005 annual mean NO_2 concentrations based on a 30% increase in traffic flows along the North Woolwich Road/ Royal Albert Way only

Figure 11 Predicted 2005 annual mean NO_2 concentrations based on a 5% increase in traffic flows along the A11/ Romford Road only

Figure 12 Predicted 2005 annual mean NO_2 concentrations based on a 10% increase in traffic flows along the A11/ Romford Road only

Figure 13 Predicted 2005 annual mean NO_2 concentrations based on a 15% increase in traffic flows along the A11/ Romford Road only

See end of report for these figures.

3.6 Commentary on possible interventions

The relationship between NO_x and NO_2 is one of a number of critical factors relevant to understanding the outcomes from the scenario tests undertaken. This relationship, which is location dependent, provides the understanding between the photochemical processes that lead to the formation of NO_2 from NO_x. This relationship is non linear which means that a reduction of the primary emission (i.e. NO_x) does not lead to a corresponding reduction in the secondary pollutant. (Appendix A further describes this relationship).

The results and the contour plots produced from the emission and traffic reduction scenario tests undertaken highlight that to achieve the annual mean AQS objective at all the locations identified further interventions would be needed.

It should also be noted that the scenarios have been modelled separately and thus do not overlap; this means that the removal of the most polluting vehicles from the low emissions scenario and replacement by less polluting vehicles was not included for the traffic reduction scenarios. It is therefore important to note that adding the results of the low emissions and traffic reduction scenarios together would overestimate the combined impact.

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4 Conclusion

This report fulfils the requirements of the DEFRA guidance for Stage 4 and permits the London Borough of Newham to review and update its Stage 3 report and address relevant issues as part of the continuing LAQM process. The Stage 4 has used both improved modelling techniques and also an improved treatment of emissions.

The predictions for the 2005 take into account a predicted vehicle growth, improvement in vehicle technology leading to lower emission releases and changes to background concentrations. However even with these improvements, it is predicted that the concentrations of the annual mean NO_2 and daily mean PM10 will still exceed the objectives. In the case of NO_2 the area predicted as likely to exceed is greater than the equivalent area for PM10. This confirms that the annual mean nitrogen dioxide objective is more stringent than the daily mean objective for PM10.

The extent to which the predicted concentrations exceed the objectives has been derived from a selection of locations identified within the AQMA and all of these (apart from locations 4 and 14) are predicted to exceed the NO_2 objective in the modelled 2005 base case.

For the first time an accurate source apportionment has been undertaken within the L.B of Newham's area. To determine the separate contributions from the road and background sources a series of detailed tests were run, based on NO_x as the primary pollutant rather than NO_2. These confirm that approximately 14 to 78% of the concentrations relate to the road transport with the remainder relating to the background sources. However the tests further confirm that the background can also be partly ascribed to road transport sources, such as those outside the borough. For NO_x approximately 47-63% of the background contribution arises from such road transport sources.

For PM10 the proportions vary from that of NO_x as a result of the different components that contribute to total PM10. In this instance the contribution from the background sources is most significant (approximately 68 - 98%), whereas road transport as a primary emission constitutes the other 2 - 32%. For the total background sources, road transport contribute between 7 and 9%, with the remainder arising mostly from secondary and coarse components, which are beyond the control of local authorities.

The Council is also required to consider actions that might be undertaken to reduce pollutant concentrations in order to work towards the prescribed objectives. To aid this process an agreed highly ambitious low emissions scenario was tested and the results of this highlight the complexity in dealing with this issue. The result for PM10 was that no location was predicted to exceed the AQS objective, however for NO_2, areas close to the major roads were still predicted to exceed the AQS objective. Therefore to ensure complete compliance additional pollution reduction measures would be required.

Three traffic reduction scenarios were also tested, based on reductions in traffic flows across the borough only. These scenarios showed only small reductions in concentrations, which were insufficient to ensure that the objectives were met at all locations.

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5 Recommendations

The Council is recommended to undertake the following actions, in respect of the findings for the statutory objectives relating to annual mean nitrogen dioxide and 24 hour mean PM10:

a. Assess the potential for relevant public exposure at the sites identified as exceeding the statutory objectives.

b. Amend the its designated Air Quality Management Areas as necessary.

c. Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

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Appendix A

1 Model Development

1.1 Model Overview

The modelling approach adopted in this Stage 4 report is refined from that used in the Stage 3 report. The previous approach used receptor based modelling and relied on a modified mapping method to predict a background concentration that was combined with other models (CAR International and ADMS) to predict the fall off in concentration from emission source. The ERG recognised that this earlier approach did not differentiate fully between different emission sources, such as those from road traffic and fixed combustion sources; instead they were all mixed in the same way.

Our new receptor based approach has been developed by combining both modelling and measurement further. Separate modelling was undertaken of two categories of sources: 1) the road network close to measurement sites and 2) all sources, including roads further away. These were combined with a constant representing emission sources from outside London. A multiple regression analysis was then undertaken with the monitoring results from the LAQN and this established the modelling relationship that has been used.

This approach better describes the balance between the local road contribution and the background since it provides a good comprise between the most robust aspects of both modelling and measurements. Importantly it permits all background emission sources to be identified accurately within the modelling e.g. this means that if any such emission source becomes less significant over time, it will feature less prominently in the final predictions and thus reflect the actuality of the measurements. The validation for the modelling is given in Appendix C.

1.1.1 Model Dilution

The ERG modelling approach used the full detail of the London Atmospheric Emissions Inventory for road traffic (LAEI) to model all roads within 500m of road centre lines (see Appendices B and D for descriptions of the road network and LAEI). This initial part was undertaken using ADMS 3 with hourly sequential meteorological data from Heathrow. Modelling of all other sources from the LAEI (based on 1kn grid squares) within London (I.e. beyond the 500m) was also undertaken. The mixing heights of each source were treated differently: roads sources used release heights of less than 5m; other sources 50m; with Part A sources modelled explicitly, dependant on specific release heights. (It is however worth noting here that the annual means NO_2 and daily mean PM10 concentrations from such sources is very small in comparison to other sources).

To allow for urban meteorological effects a surface roughness length of 1m was assumed, together with an anthropogenic heat flux of $15Wm^{-2}$. Both these were based on examples given in the available literature.

The derived relationship for NO_x, established by using all the monitoring sites in the LAQN, can be described as:

$$Concentration = a.\ [road] + b.\ [other] + c$$

Where *a*, *b* and *c* are constants derived through multiple regression, *[road]* represents the contribution from the nearby road network and *[other]* represents the contribution from other sources and roads further than 500m from each point. The modelling was repeated for every point in the Borough based on a 20m x 20m grid and contributions from nearby road network and those sources further away were not delineated.

The new approach provides improved predictions and produces a continuous and smooth fall off away from roads.

1.2 NO_X and NO_2 Relationships

1.2.1 The Adopted Method

To determine the predicted NO_2 the ERG method builds on the approach described by Carslaw et al. (2001). In summary, the relationship between hourly NO_x and NO_2 can be described by plotting NO_2 against NO_x in different NO_x 'bins', for example 0-10 ppb, 10-20 ppb etc, (Derwent and Middleton, 1996). The resulting NO_x to NO_2 relationship describes the main features of NO_x chemistry, first the NO_x -limited regime where NO_2 concentrations increase rapidly with NO_x and second the O_3-limited regime where a change in NO_x concentration has little effect on the concentration of NO_2. A third and final regime also exists where, once again NO_x and NO_2 increase pro-rata, related to extreme wintertime episodes. In all cases, the precise relationship is always both year and site dependent.

1.2.2 Roadside/ Background Concentrations

Of more use than the hourly relationship discussed earlier is the relationship between the annual mean NO_x and NO_2 concentrations. The construction of these curves described in Carslaw et al. (2001) and is both site and year specific. The relationship for a site relates annual mean concentrations of NO_x to NO_2 whilst implicitly including the full distribution of concentrations measured each hour of the year.

When using these relationships it is important to differentiate between those applicable to background locations and those applicable to roadside locations for any given predicted year.

The NO_x and NO_2 relationships described above are year and site dependent. However, analysis of 1999, the year for which there are most sites shows that the roadside concentrations of NO_2 for any NO_X concentration lies within a range of values that can be related to location. The range is from a central London, busy street canyon, at Marylebone Road to an outer London suburb with an open road location, i.e. the A3 dual carriageway. The contrast between the two locations relates specifically to the background concentration of NO_x and NO_2, with Marylebone Road (70,000 vehicles per day) in a region of very high background concentration and the A3 site (120,000 vehicles per day) in an area with a low background concentration of NO_X and NO_2, and thus it is similar to a rural motorway. For all years Marylebone Road provides the upper limit of NO_2 concentrations and A3, the lower limit for any given concentration of NO_x. The hierarchy of NO_x and NO_2 relationships, for 1999, is summarised in Figure 14, below.

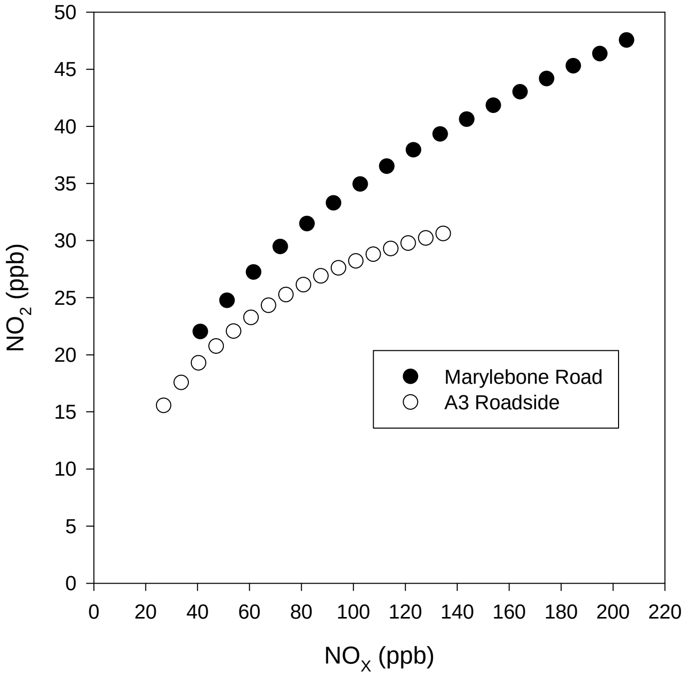

Figure 14 NO_x and NO_2 Relationships at Roadside Sites across London (1999)

The range of NO_2 concentrations, for a given NO_x concentration at the roadside are much larger than for background locations. This is because of a number of factors, including the relative contribution of the road to total NO_x concentrations, the rapid fall-off in concentration away from a road and the rapid reaction between NO and O_3 to form NO_2. The sites used within the ERG model are for background: central London (Bloomsbury), Inner London (Kensington) and Outer London (Teddington). For roadside: central London (Marylebone Road) and outer London (A3) are used.

The use of the roadside/ background curves is decided within the model itself by examination of the ratio of the other source NO_x contribution and local roadside NO_x contribution made at each prediction point. The determination of which background/ roadside curve to use is dependant on geographical location and relates to distance from central London. For example for roadsides, beyond 20km from the centre of London the A3 curve is used.

It is recognised that the approaches developed here are new and perhaps unfamiliar. However, confidence can be gained in their application through comprehensive validation, which is described in Appendix C.

1.3 The ERG PM10 Model

1.3.1 Model Description

The ERG has developed a new PM10 model specifically for the Stage 4 modelling study (Fuller et al., 2002). It uses the comprehensive PM10, PM2.5 and NO_x measurements to derive a model to predict daily concentrations of PM10. The model splits PM10 into 4 component parts and relates each to the likely source/s of the particles. To achieve this, regression analysis of NO_x with PM10 was employed. Stedman (2000, 2001) and APEG (1999) used a similar analysis, however the ERG model has extended this to include PM2.5, which can be related to combustion sources.

The four component parts are summarised as:

- PM2.5 that is related to NO_X
- PM2.5 that is not related to NO_X
- Coarse particles that are related to NO_X
- Coarse particles that are not related to NO_X.

1.3.2 Measurements used in the PM10 Model

To determine the relationship between NO_x and PM10, regression analysis was undertaken for co-located rolling annual mean concentrations of NO_x, PM10 and PM2.5 at monthly intervals. Rolling annual means have been chosen to test the stability of the derived relationships over time. A total of over 10 million, 15 minute mean measurements from November 1995 to March 2000 have been averaged to produce the rolling annual means at each site. Data have been used from all site types: kerbside, roadside, urban background, suburban and rural. A maximum of 22 sites have been used for PM10 and maximum of 5 sites for PM2.5. The sites used in each regression are not consistent and depend on the operational start date for each site and at least 75% annual data capture.

1.3.3 Modelling Daily Particle Concentrations

Since the EU Limit values refer to daily mean concentration it is necessary to model and understand the particle concentrations with a daily time resolution. Time series of daily means for each of the components were calculated by applying the factors derived from regression analysis, to the daily mean NO_x, PM10 and PM2.5 measured at each of the sites with co-located measurements. This allowed the calculation of the NO_x dependent components. The non-NO_x dependent components can be calculated by subtraction. Time series of each of the components has been calculated for the four years 1996 to 1999, inclusive. An example of the relationship between annual mean NO_x and number of days greater than 50 $\mu g/m^3$ for 1999 (using the TEOM to gravimetric scaling factor of 1.3) is summarised in Figure 15 below.

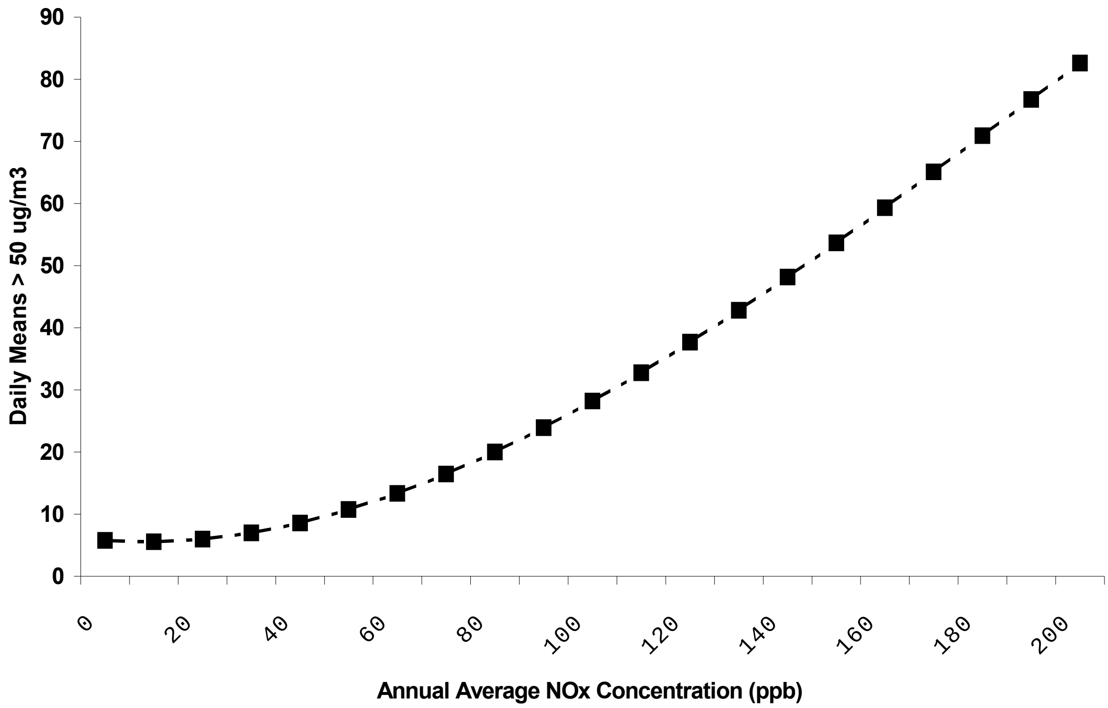

Figure 15 The relationship between annual mean NO_X and days where PM10 > 50 μg/m^3

A comprehensive validation of the PM10 model for roadside and background locations is described in Appendix C.

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Appendix B

1 Modelling Detailed Road Networks

1.1 Geographic Accuracy of Model Predictions

Significant progress has been made towards improving the geographic accuracy of predictions. All major roads have been split up into 10 m sections, as shown in Figure 16, below. There are several benefits, which result from this development. First, each 10 m point can act as a source of emissions, thus allowing emissions to be varied along each link. This approach allows, for example, emissions near junctions where vehicle idling is important to be increased. Second, the emissions sources are geographically accurate, enabling roundabout and complex road junctions be modelled thoroughly. Third, maps of concentration will also be geographically accurate allowing more accurate assessments to be made of population exposure.

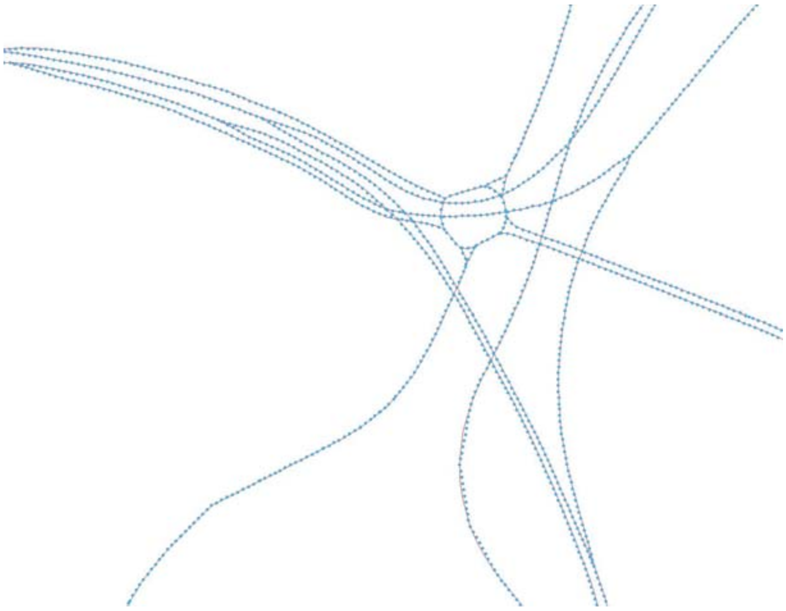

Figure 16 10m sections of road, showing complex junction details

This is further demonstrated in Figure 17 overleaf which shows that features such as roundabouts and curved roads are accurately represented.

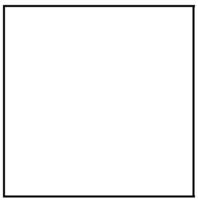

Figure 17 Modelled example showing concentrations near complex road junctions.

1.2 Emissions at Major Road Junctions

The new approach of separating road links into 10 m sections allows emissions near to junctions to be explicitly accounted for. Within a short distance of each junction it is assumed that vehicle idling is increased and the average speed of vehicle is reduced significantly. The assumption used in the model predictions is that 30 m[3] from a major road junction vehicles travel on average at 5 km/hr and that this includes significant periods of idling. Having made significant improvements in the predictions of average link speed, using ‘floating car’ data, care was taken to keep the link emissions constant, by increasing the emissions at the ends of the links and reducing the emissions elsewhere on the link. In summary the effect of junctions is accounted for through a redistribution of the emissions along each of the road links.

A further set of assumptions is required for the application of such a scheme. First, the road junctions are assumed to be congested on one side of the road only and second, that there is a combination of periods of free flowing traffic and traffic travelling at 5 km/hr. The assumption for the proportion of time spent at the average link speed was assumed to be 50 % on the side of the road affected by the queue. The application of the emissions redistribution was taken only on roads that were greater than 150 m in length as it is assumed that the congested nature of such short links would be well reflected in the measured average speed. Motorways were further exempted as the simplistic assumptions were not thought applicable.

The assumptions used in the emission model are a first estimate and it is accepted that individual road links should be treated independently, for example, using detailed traffic models. However, data on delay times and average speeds are not available, for specific road junctions and at the same time over a large area such as London. Furthermore, emission factors of the type used to develop large-scale emissions inventories are not a suitable method by which to represent emissions for specific driving characteristics (idling, acceleration/deceleration), which are unique to each junction separately.

Figure 18 Emissions NO_X (g/hr) for Euro 2 and 3 Vehicles at different Average Speeds (km/hr)

The detailed DMRB emission factors are applicable down to a speed of 5 km/hr, although factors at this speed are highly uncertain. These data were employed in the redistribution of junction emissions described above. It is worth therefore investigating the effect of low speeds on the emissions of, in this case NO_X, from different vehicle

[3] 30 m was assumed as being a typical length for queuing traffic. In practice, road traffic activity is more variable and there is a lack of quality data available from which to improve the predictions made here.

types. By multiplying the g/km results for different average speeds by the speed the emissions may be expressed in g/hr. A sample of the g/hr vehicle emissions for Euro 2 and 3 vehicles is summarised in Figure 18 above. It shows that as LGV (petrol and diesel), cars (petrol and diesel) and motorcycles increase their speed so the emissions increase steadily and are at a maximum at 110 km/hr. This increase in emissions is related to the additional work, which is being done by the engine. It is important to note however, that for these vehicle types the g/hr emissions approaches zero at 5 km/hr. Also plotted in black are rigid HGVs, and buses in the Euro 2 and 3 technology categories. These vehicles contrast significantly with the cars, LGVs and motorcycles by showing emissions up to a factor 40 times greater than for smaller vehicles at very slow speeds. It is therefore these specific vehicle types, which provide the majority of the emissions close to road junctions. Since comparatively little work has been carried out on emissions from heavy vehicles, the emission factors derived at such slow speeds should be treated with considerable caution. It is important to considered these effects when considering the results from the modelling.

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Appendix C

1 Model Validation

A comprehensive validation exercise has been undertaken for the NO_x-NO_2 and PM10 models at measurement sites in London. A very extensive data set exists for the years 1996, 1997, 1998 and 1999 and these were used in the exercise. Comparisons were made with sites located at roadside and kerbside in both open locations and street canyons, as well as in background locations. All sites were not available for every year and for NO_X, NO_2 and PM10. However, Figure 19 below summarises those sites used during the validation exercise as a whole. The validation exercise goes beyond the sites available in the London Borough of Newham's area. This is beneficial since it is only through a comparison with many sites types in different locations can the approaches used can be properly tested.

Figure 19 Sites used to Validate Model Predictions

To ensure the validity of the exercise care was taken to locate the site locations as accurately as possible, particularly in relation to roadside sites, where a steep concentration gradient exists and poor site locations may lead to significant changes to the model performance.

1.1 Predictions of Annual Average NO_2 in London

The column plots in Figure 20 show predicted against measured concentrations of NO_2 for 1996 (first plot) to 1999 (last plot). Additionally Table 21 and Table 22 provide the actual results and a summary of the overall model performance. The average for all sites used was 94 % for 1999 and those sites with low data capture rates were not included.

1996

1997

1998

1999

Figure 20 Predicted and Measured Annual Average NO_2 for 1996, 1997, 1998 and 1999

Overall the model performed very well with the average modelled and measured predictions showing close agreement. A summary of the overall performance of the model is given in Table 22, which gives the standard deviation of the measured minus the predicted NO_2 concentrations as 12 % (1996), 9 % (1997), 11 % (1998), and 11 % (1999). The percentages were calculated by dividing the standard deviation by the all site average measured NO_2 concentration.

Table 21 Annual Mean NO_x and NO_2 (ppb) Validation Results for 1999

Site	Predicted NO_X	Measured NO_X	Predicted NO_2	Measured NO_2
A3	160.4	134	32	31
Barnet	78.7	95	27.8	27.6
Bexley 1	36.4	35	20.5	19.1
Bloomsbury	73.7	71	34	35
Brent 1	32	34	18.9	19.4
Bridge Place	60	55	30.3	31
Bromley 7	77.9	94	27.3	34
Camden 1	110.7	109	33.4	34.2
Cromwell Road	151	134	38.2	48
Croydon 2	107.6	91	29.7	20.3
Ealing 1	44.9	47	23.4	24.1
Ealing 2	82.4	91	28.9	31.1
Ealing 5	90.1	88	27.3	33.8
Enfield 1	32.4	32	19.2	17.6
Enfield 2	61.8	51.8	25.2	23.6
Enfield 3	35.2	37	20.3	19.7
Greenwich	36.4	33	21	18.5
Hackney 4	58.9	70	28.4	31.2
Haringey	53.6	70.2	25.8	26.6
Havering	50.6	70.6	25.8	22.9
Havering 3	53.7	66	24.4	23.2
Hillingdon	110.7	86.8	28.9	26.3
Islington	48.9	50	27.2	25.6
Kensington	46.9	42	25.1	23.8
Kingston 2	78.4	66	26.9	25.4
Marylebone Road	188.3	205	42.2	47.5
Southwark 1	64.9	62	32	29.1
Sutton 2	40.3	39	21.9	19.8
Teddington	31.1	26	18.6	16.7
Tower Hamlets 1	55.2	39	29	23.8
Tower Hamlets 2	88.2	124	31.6	36.4
Waltham Forest	42.9	41	23.9	22.8
West London	62.7	52	29.7	28.6

This level of accuracy does not apply to all sites and certain roadside sites are not as well predicted. The most obvious example of this is the Croydon 2, which is poorly predicted for all years and has not been included in the summary above. This site exhibits a very low NO_2 to NO_x ratio, which is more typical of a rural motorway site, as thus the model over predicts by a large margin, typically 10 ppb. Other sites, included in the summary above, that also identify poor model performance are Bromley 7, which is under predicted by 9 ppb and Wandsworth 4, which is over predicted by 7 ppb. The first full year of operation of Bromley 7 was during 1999 and so it is difficult to draw firm conclusions from this result alone. Over prediction at Wandsworth 4 occurred in both 1998 and 1999, which might be a result of the very low vehicle speeds at this site (approximately 10 km/hr throughout the day) and the uncertainty in emission factors at this speed, as described in Appendix E.

Table 22 All Site Average NO_2 (ppb)

Year	Predicted Average (ppb)	Measured Average (ppb)	Average difference (measured - predicted) (ppb)	Standard Deviation (measured - predicted) (ppb)
1996	26.6	25.8	-0.8	3.2
1997	27.0	27.8	0.8	2.4
1998	25.7	25.7	0.0	2.7
1999	25.5	25.9	0.4	2.9

1.2 Predictions of the 24 hour mean AQS PM10 Objective

The map in Figure 21 shows the sites used to validate the model, these include sites both in London and the other surrounding areas.

Table 23 and Table 24 provide the results and a summary of the overall model performance. Those sites with low data capture rates were not included and by way of example, the all site 1999 data capture rates averaged 96 %. The insistence of a very high data capture rate for measurements is essential in this case, as the PM10 pollution is episodic in nature and therefore loss of data can lead to a bias in the measured results. In addition, sites with instruments other than the TEOM were not included in the analysis as the relationship between the measurements and European gravimetric standards are not well understood at present.

Furthermore, care should be taken to avoid very localised particle effects, which are not covered in the inventory or the model calculations. One such example is Marylebone Road. This site was removed from the comparison in 1999 due to localised building works, which increased the days greater than 50 $\mu g/m^3$ significantly and invalidated any model comparison made.

Overall the model performed well with the average modelled and measured predictions showing close agreement. A summary of the overall performance of the model is given in Table 25, which gives the standard deviation of the measured minus the predicted PM10 days greater than 50 $\mu g/m^3$ as 16 % (1996), 21 % (1997), 24 % (1998), and 22 % (1999). The percentages were calculated by dividing the standard deviation by the all site average measured PM10 days greater than 50 $\mu g/m^3$.
Much of the inaccuracy of the PM10 predictions is associated with the error in predicting annual average NO_x correctly, and highlights the difficulty in dispersion calculations in urban areas as well as the error in estimating emissions of NO_x themselves. With this in mind only those sites, which have a complete dataset of NO_x measurements for the year, were chosen for prediction of PM10. The results given above indicate that overall the predictions for 1996 represent the best model performance and those for 1998, the worst. Care should be taken interpreting the results in this way as there are relatively few site predictions in 1996, although it is reasonable to assume that the existence of a large source of secondary particles during many of the PM10 episodes in 1996 would reduce the model sensitivity to NO_x predictions, thereby improving the overall performance.

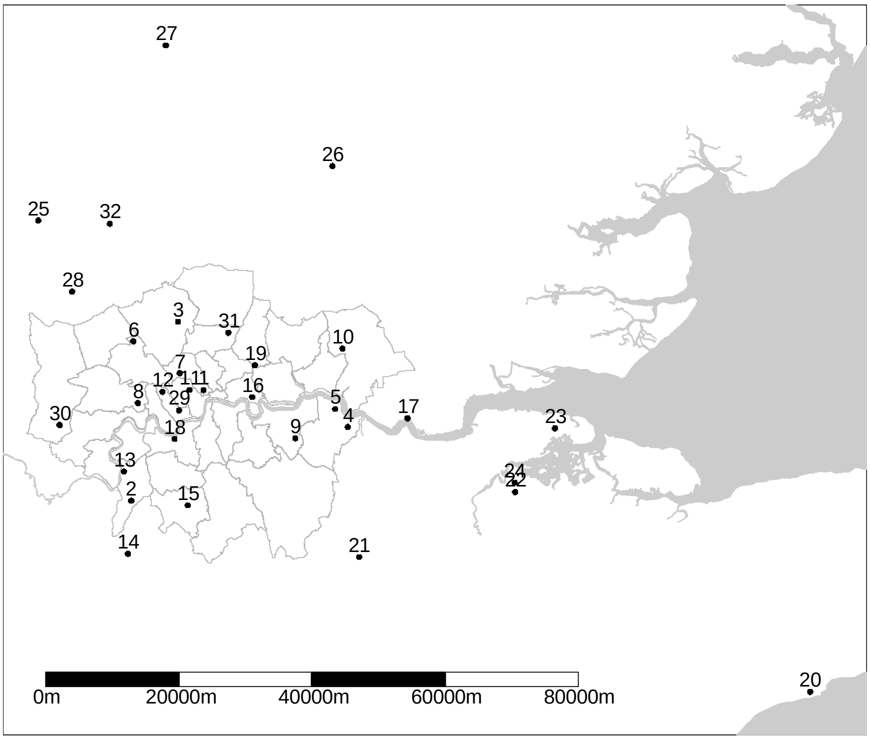

Figure 21 Monitoring sites in used to derive the model.

Several sites in the PM10 validation are not well predicted. First is the Wandsworth 4 site, which the model over predicts by 24 days (i.e. those extra days greater than 50 μg/m^3). This is consistent with the difficulty in predicting for NO_x at this location, which is assumed to be due to the effect of low vehicle speeds. Second is the A3 site, which is predicted well for NO_X and should show good performance for PM10. However, the PM10 model relationships calculated from the London sites do not perform well at the A3 site and here too the PM10 model over predicts the days greater than 50 μg/m^3 by approximately 27.

Table 23 Predicted and measured number of days where PM10 > 50 µg/m³ (TEOM*1.3)

Site code	Site name	Site type	Annual Mean NO_X (ppb)	Annual mean PM_{10} µg m^{-3} TEOM *1.3			Daily means >50 µg m^{-3} TEOM *1.3		
				Measured	Modelled	Difference	Measured	Modelled	Difference
1996									
9	Greenwich 4	U	41	29.9	31.2	1.3	38	46	8
31	Haringey 1	R	89	37.7	36.4	-1.3	67	63	-4
12	Kens & Chelsea 1	U	53	32.5	32.5	0	46	54	8
15	Sutton 1	R	79	35.1	36.4	1.3	50	60	10
16	Tower Hams 1	U	50	35.1	32.5	-2.6	61	51	-10
1	Bloomsbury	U	80	39	36.4	-2.6	65	63	-2
1997									
6	Brent	U	46	28.6	28.6	0	26	30	4
4	Bexley 1	S	48	29.9	29.9	0	32	30	-2
7	Camden 1	K	153	41.6	40.3	-1.3	86	78	-8
9	Greenwich 4	U	43	27.3	28.6	1.3	24	29	5
31	Haringey 1	R	96	33.8	33.8	0	50	46	-4
12	Kens & Chelsea 1	U	57	31.2	29.9	-1.3	33	32	-1
13	Kingston 2	R	90	35.1	33.8	-1.3	48	44	-4
15	Sutton 1	R	77	31.2	32.5	1.3	34	37	3
16	Tower Hams 1	U	54	32.5	32.5	0	36	31	-5
17	Thurrock	U	40	29.9	28.6	-1.3	31	29	-2
24	Medway Chatham	R	53	28.6	29.9	1.3	23	22	-1
22	Medway Luton	U	30	23.4	27.3	3.9	16	22	6
23	Medway Stoke	RU	19	24.7	26	1.3	19	18	-1
1998									
2	A3	R	153	31.2	36.4	5.2	38	62	24
31	Haringey 1	R	75	28.6	28.6	0	22	24	2
12	Kens & Chelsea 1	U	42	26	26	0	16	13	-3
11	Marylebone Road	K	197	41.6	41.6	0	83	89	6
15	Sutton 3	S	62	27.3	27.3	0	13	19	6
6	Brent	U	32	23.4	24.7	1.3	8	10	2
4	Bexley 1	S	36	24.7	24.7	0	18	12	-6
5	Bexley 2	S	31	24.7	24.7	0	19	10	-9
8	Ealing 2	R	96	29.9	31.2	1.3	22	33	11
13	Kingston 2	R	71	29.9	28.6	-1.3	28	22	-6
14	Mole Valley 2	S	26	22.1	23.4	1.3	8	8	0
32	St Albans	S	36	23.4	24.7	1.3	4	10	6
16	Tower Hams 1	U	43	27.3	26	-1.3	23	14	-9
17	Thurrock	U	37	24.7	24.7	0	14	11	-3
18	Wandsworth 4	R	56	24.7	27.3	2.6	12	18	6
24	Medway Chatham	R	51	27.3	26	-1.3	15	15	0
22	Medway Luton	U	25	18.2	23.4	5.2	2	8	6
23	Medway Stoke	RU	16	22.1	22.1	0	3	7	4
21	Sevenoaks 2	U	23	24.7	23.4	-1.3	10	8	-2

Key to Site Types: K= Kerbside, R = Roadside, U = Urban Background, S = Suburban, RU = Rural.

Table 24 Comparison of measurements and modelled results for 1999 to EU Limit Values

Site code	Site name	Site type	Annual Mean NO_X (ppb)	Annual mean PM_{10} µg m^{-3} TEOM *1.3			Daily means >50 µg m^{-3} TEOM *1.3		
				Measured	Modelled	Difference	Measured	Modelled	Difference
1999									
2	A3	R	134	29.9	35.1	5.2	22	45	23
7	Camden 1	K	110	33.8	32.5	-1.3	33	33	0
9	Greenwich 4	U	33	22.1	24.7	2.6	5	10	5
31	Haringey 1	R	71	28.6	28.6	0	17	16	-1
12	Kens & Chelsea 1	U	42	26	26	0	16	12	-4
11	Marylebone Road	K	206	45.5	42.9	-2.6	111	88	-23
15	Sutton 3	S	61	24.7	27.3	2.6	4	15	11
1	Bloomsbury	U	71	28.6	28.6	0	21	25	4
3	Brent	S	32	23.4	24.7	1.3	6	6	0
6	Barnet 1	K	96	28.6	31.2	2.6	16	26	10
4	Bexley 1	S	38	24.7	24.7	0	17	11	-6
5	Bexley 2	S	31	23.4	24.7	1.3	17	8	-9
25	Dacorum	U	30	20.8	24.7	3.9	2	6	4
8	Ealing 2	R	92	29.9	29.9	0	25	26	1
26	East Herts 2	U	22	20.8	23.4	2.6	6	6	0
10	Havering 3	R	67	28.6	27.3	-1.3	22	16	-6
29	Kens & Chelsea 2	R	134	39	35.1	-3.9	51	45	-6
13	Kingston 2	R	66	28.6	27.3	-1.3	15	16	1
30	Heathrow	U	71	28.6	28.6	0	27	25	-2
14	Mole Valley 2	S	26	22.1	23.4	1.3	1	6	5
27	North Herts	R	61	28.6	27.3	-1.3	8	15	7
16	Tower Hams 1	U	39	27.3	24.7	-2.6	21	7	-14
17	Thurrock	U	37	24.7	24.7	0	3	11	8
18	Wandsworth 4	R	63	26	27.3	1.3	17	15	-2
28	Watford	R	54	26	26	0	7	13	6
19	Waltham Forest	U	41	24.7	26	1.3	12	12	0
24	Medway Chatham	R	51	24.7	26	1.3	7	12	5
20	Folkestone	S	19	27.3	23.4	-3.9	15	6	-9
22	Medway Luton	U	27	18.2	23.4	5.2	1	6	5
23	Medway Stoke	RU	16	23.4	22.1	-1.3	6	6	0
21	Sevenoaks 2	U	24	22.1	23.4	1.3	2	6	4

Key to Site Types: K= Kerbside, R = Roadside, U = Urban Background, S = Suburban, RU = Rural.

Table 25 All Site Average Number of Days where PM10 > 50 μg/m^3 (TEOM*1.3)

Year	Predicted Average (days)	Measured Average (days)	Average difference (measured - predicted) (days)	Standard Deviation (measured - predicted) (days)
1996	61.6	55.4	6.2	8.7
1997	39.2	42.2	-3.0	8.8
1998	24.6	24.2	0.4	5.7
1999	15.5	17.8	2.6	3.9

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Appendix D

1 Emissions from Road Transport in London

1.1 Overview of the London Atmospheric Emissions Inventory

The revised London Atmospheric Emissions Inventory for road traffic (LAEI) uses a considerable number of data sources available in London. This therefore enables the dependence upon modelled transport vehicle flow and speed data used in the earlier Stage 3 modelling to be reduced. The use of the activity data in the inventory follows a hierarchy, which is summarised as follows:

- Data available from DTLR/LT/TfL;
- Data from local authorities;
- Data from transport models.

The total vehicle km represented by each category for Greater London per annum is: DTLR manual counts 20.75 billion vehicle km (bvkm), LTS 4.48 bvkm, minor roads 2.47 bvkm. The DTLR manual counts therefore account for an estimated 75 % of total traffic activity in Greater London.

1.2 Base Year and Pollutants Covered

The base year for the inventory is 1999, but includes predictions for 2004 and 2005.

The pollutants covered include:

- Benzene;
- 1-3 Butadiene;
- Carbon dioxide CO_2;
- Carbon monoxide CO;
- Hydrocarbons HC[4];
- Oxides of nitrogen NO_X;
- Particles PM10;
- Sulphur dioxide SO_2;

The km^2 emissions have been calculated over the same geographic area as the previous inventory i.e. the area bounded by the M25 (see Figure 22). Details of individual road flows and emissions cover all local authorities in Greater London.

Figure 22 NO_x Emissions for 2005 (tonnes/annum), showing area covered by new LAEI

[4] Note, any reference to hydrocarbons excludes methane.

1.3 Major Road Flows

Use has been made of manual count data for all “A” and “M” roads in London from the DTLR rotating census programme. Two principal data sources are available: hourly variation for 12 hours between 7 am and 7 pm for weekdays and annual average daily flows (AADF). In total 11 vehicle types are considered:

Table 26 Vehicle Categories on Major Roads in London

Vehicle Category
Pedal cycles (not used)
Motorcycles
Cars
Light Goods Vehicles (LGV)
Buses
Taxis (derived)
Rigid HGVs with 2 axles
Rigid HGVs with 3 axles
Rigid HGVs with >=4 axles
Articulated HGVs with 3 & 4 axles
Articulated HGVs with 5 axles
Articulated HGVs with >=6 axles

Expansion factors have been derived to determine vehicle flows for each hour of the day. These factors have been derived from an assessment of continuous count data from fixed traffic counters. The DTLR operates 56 such sites in London and the TfL operate approximately another 30. It should be noted that the TfL sites are mostly in central and inner London on “A” roads.

Figure 23 Map showing road network and the locations of the automatic traffic counters[5]

Data from the automatic traffic counters (ATC) have been used to derive the profiles of vehicles throughout each day, by location in London. An analysis of the data from ATC sites showed that there were differences between inner and central London compared with outer London. The ATC data serves two main purposes: i) to calculate the 12 to 24 hour expansion factors by vehicle type and ii) to derive realistic hourly profiles by vehicle type. These profiles have been applied in two different ways:

[5] Bold lines show the principal road network (A and M roads); thin lines show the LTS roads

- Where 12 hourly data were available, the factors were used to "fill-in" the non-peak hours i.e. after 7pm to 7 am.
- Where an AADF has already been calculated by the DTLR, the profiles were used to estimate the hourly flow by vehicle type.

1.4 Local Authority Traffic Counts

A request was made to all 33 London local authorities for traffic count data. Table 4 shows that 21 authorities responded to the request and of those 15 were used in the inventory development. It should be noted that data were only used for non A and M roads, since DTLR manual count data were available for these roads and it was considered important to maintain consistency.

Table 27 Responses to Request for Local Authority Traffic Count Data

LA	Data Available?
Barking and Dagenham	Sent Count data
Barnet	Sent Count data
Bexley	Sent Count data
Brent	Saturn Data
Bromley	Sent Count data
Camden	Sent Count data
City of London	Sent Count data
Croydon	No Data Sent
Ealing	Sent Count data
Enfield	No Data Sent
Greenwich	No Data Sent
Hackney	No Data Sent
Hammersmith	Sent Count data
Haringey	No Data Sent
Harrow	No Data Sent
Havering	Sent Count data
Hillingdon	No Data Sent
Hounslow	Sent Count data
Islington	Count Data Unavailable
Kensington and Chelsea	Sent Count data
Kingston	No Data Sent
Lambeth	Sent Count data
Lewisham	Sent Count data
Merton	Sent Count data
Newham	No Data Sent
Redbridge	Sent Count data
Richmond	Sent Count data
Southwark	Sent Count data
Sutton	Sent Count data
Tower Hamlets	No Data Sent
Waltham Forest	Sent Count data
Wandsworth	Sent Count data
Westminster	Count Data Unavailable

1.5 LTS Road Flows

LTS version B1.5 has been obtained from MVA (via TfL) for base years 1996 and 2011. All "A" and "M" roads were removed from the output using the LTS definition of road number. A later examination of the remaining links suggested that around 150 links out of 4200 were misclassified or could not be adequately identified. These links were also removed. Checks were also made on the remaining links to ensure that none contained anomalous flows.

LTS provides the split between light, HGV and buses. These were summed to give a 12 hour flow and expanded to 24 hour flows as described in the previous section. Most remaining LTS roads are either "B" roads or unclassified. The rotating census data for "B" roads was used to derive the breakdown of 11 vehicle types.

Table 28 Vehicle breakdown assumed for LTS roads

Vehicle	%
Motorcycles	1.8
Cars	84.1
Bus and coaches	1.3
LGV	10.7
Rigid 2 axle	1.4
Rigid 3 axle	0.2
Rigid >=4 axle	0.2
Artic 3 & 4 axle	0.1
Artic 5 axle	0.2
Artic >=6 axle	0.1

1.6 Minor Road Flows

Minor roads are those for which there are no individual road link details and are represented as total vehicle km in grid squares. The original LRC inventory estimated the total vehicle km by vehicle type. The current inventory uses the same total vehicle km estimates, but apportions the vehicle km differently. Use has again been made of the rotating census data, for "unclassified roads". These roads typically have very little HGV or bus traffic, as shown in the table below.

Table 29 Vehicle breakdown assumed for minor roads

Vehicle type	%
Motorcycles	1.20
Cars	86.5
Bus and coaches	0.97
LGV	9.79
Rigid 2 axle	1.15
Rigid 3 axle	0.13
Rigid >=4 axle	0.10
Artic 3 & 4 axle	0.05
Artic 5 axle	0.07
Artic >=6 axle	0.03

1.7 Vehicle Age By Road Type

The analysis of DTLR on road vehicle age data highlights significant variations in vehicle age by road type in London. These data are from 20 sites in London, from motorways to rural B roads and total approximately 200,000 vehicles. This agrees well with the conclusions drawn from the manual counts, which suggest that the mix of traffic varies from place to place, and from hour to hour. The DTLR data therefore supports the idea of developing methods of estimating vehicle stock in a more spatially disaggregated way.

A comparison was made of the breakdown of vehicle ages in the national model with those described above. It was found that in London, there is a slightly newer vehicle stock on motorways on average and older vehicle stock on minor roads compared with national data. A small correction has therefore been made to motorway traffic and minor road traffic to account for this effect. The effect is more apparent on minor roads, however, these roads only account for 8.9 % of the total estimated vehicle km. Overall the effect is therefore very small.

1.8 Vehicle Speed Estimates

With the use of speed-dependent vehicle emission factors, it is essential that realistic speeds be used in the inventory. The previous inventory used vehicle speed estimates directly from the LTS model for three periods of the day (am peak, inter-peak and pm peak). The current inventory uses data from actual measurements of speed. Vehicle speed estimates are derived from the "floating-car" technique (Roland, 1998). The technique involves the use of an instrumented car driven at the prevailing traffic speed in such a way as to make equal the number of vehicles overtaken and the number of vehicles overtaken by the car itself. Journey times between successive junctions are recorded, and the speed calculated by weighting the speed against vehicle flow. Surveys are conducted throughout the year but are timed to avoid holiday periods or periods of particularly adverse weather. Each road link is surveyed in both directions on four separate occasions: once in the morning peak period between 7.45 am and 9.15 am, one in the morning off-peak period between 10 am and 12 noon, once in the afternoon off-peak period between 2 pm and 4 pm, and one in the evening peak period between 4.45 pm and 6.15 pm. The estimated speed on an individual link is subject to wide sampling variation. On average the 7.45 am to 6.15 pm speed on a single link has a 95 per cent confidence interval of about ± 10 kmh^{-1}. Compared with fixed measurements of speed in one location, the floating-car technique should produce representative *mean* vehicle speeds.

The floating car data does not cover all major road links in the inventory. Mean am peak, inter-peak and pm-peak speeds have therefore been calculated by area of London (central, inner and outer). Neither does the database consider speeds from 7pm to 7am. For these hours the inter peak speed has been applied.

The speed estimates provided in the LTS model have been used for all remaining LTS links by 3 periods of the day.

For minor roads and local authority roads, a constant speed of 30 km/h has been assumed.

1.9 Bus Data and Assumptions

A summary of the key assumptions for the estimate of emissions from buses in London is as follows:

- Data for the study were provided by:
    - ***DTLR:*** Manual count information, split by hour of day (7am-7pm) for all major roads in London. Total number of roads is 1992;
    - ***TfL:*** LTS model data, split for three period of the day am peak, inter peak and pm peak;
    - ***TfL and DTLR:*** automatic count data for 86 sites throughout London;
    - ***LT Buses:*** Information from environmental audit 2000 and through personal communication with Mike Weston and Simon Thomas of LT buses;
- Bus and coach numbers were taken from the rotating census of traffic counts from 7am to 7pm;
- Other periods of the day were factored from the automatic count data;
- The remaining bus numbers were taken from LTS B1.5, although these were a small proportion of the total bus vehicle km and applied to minor roads only;
- The bus vehicle stock was broken into two parts, central London (defined by LTS) and other London stock representing all other locations in London. LT bus services are assumed to represent 90 % of the bus vehicle km in London (personal communication, LT Buses);
- The central London bus vehicle stock is given in Table 30 below. The top row of figures show the proportion of buses in each Euro class and the final two rows show the proportions within each class which have been fitted with either an oxidation catalyst or particle trap. For example, the figures show that 67 % of buses in 1999 were pre Euro 1 and 74 % of those buses were fitted with an oxidation catalyst;
- The central London stock is made up of Routemaster buses (assumed to account for 60 % of the bus km and the outer London bus stock accounting for the remaining 40 %). The proportions within each Euro class were obtained through personal communication with LT buses and the proportion of oxidation catalysts and particle traps from the results of LT's environmental audit in 2000.
- The outer London bus stock is given in Table 31 below;
- The number of in service Routemaster buses were assumed to be 515 and of those 448 had oxidation catalysts. The factors for reducing emissions for buses through retrofitting oxidation catalysts and particle traps is summarised in Table 32 below.

These are consistent with the assumptions of the LTEM emissions model developed by LT Buses;

- The emission reduction factors summarised in Table 32 are applied to the vehicle emission according to the Euro class and whether an oxidation catalyst or particle trap has been fitted. For example for emissions of particles a factor of 0.11 is applied to the particle emissions of a Euro 2 bus if it is fitted with a particle trap.

- The assumptions for 2005 are that 400 buses will come into service, replacing pre Euro 1 vehicles with Euro 2. This will take place during 2001. By 2005 LT's policy of having all buses at Euro 2 standard or above will be achieved. Euro 3 vehicles will replace all the pre Euro 1 and Euro 1 vehicles remaining after 2001. The total number of in-service buses will remain the same (approximately 5651) and Euro 3 buses will not be retrofitted with either oxidation catalysts or particle traps. The resulting bus vehicle stock in 2005 will be 48 % Euro 2 and 52 % Euro 3;

Table 30 Central London Bus Vehicle stock by Euro Class (1999)

	pre Euro 1	Euro 1	Euro 2
	67 %	6 %	27 %
Catalyst fitted	74 %	8 %	11 %
RPT fitted	0 %	0 %	23 %

Table 31 Outer London Bus Vehicle stock by Euro Class (1999)

	pre Euro 1	Euro 1	Euro 2
	18 %	14 %	68 %
Catalyst fitted	17 %	7 %	11 %
RPT fitted	0 %	0 %	23 %

Table 32 Emission Reduction Factors by Euro Class and Technology

	CO	HC	NO_X	PM
Pre Euro 1 with Catalyst fitted	0.08	0.19	0.72	0.46
Euro 1 with Catalyst fitted	0.16	0.25	0.88	0.3
Euro 2 with Catalyst fitted	0.22	0.37	1	0.33
Euro 1/2 with Particle Trap Fitted[6]	0.10	0.10	0.90	0.10

1.10 Taxi Data and Assumptions

A summary of the key assumptions for the estimate of emissions from taxis in London is as follows:

Data for the study was provided by:

[6] Factors supplied by GLA for 2005 BAU case.

- ***London Borough of Camden:*** Manual and Video traffic count information, split by hour of day for 50 sites;

- ***Corporation of London:*** Manual traffic counts from 13 sites in the borough, given as a proportion of total daily flow (7am-7pm);

- ***Transport for London (World Squares Taxi Counts):*** Manual traffic counts from 20 sites around Parliament square and Victoria Embankment. Information for the periods 7-9am, 12, 1pm, 4, 5 and 6pm;

- ***MVA taxi survey data:*** Information collected for the DETR looking at the effect of "Supply and Demand for London Taxis";

- The proportion of taxis as percentage of all vehicles in central London is calculated to be 20.6 %[7];

- The proportion of taxis as percentage of all vehicles in inner London is 4.3 %;

- The proportion of taxis as percentage of all vehicles in outer London (defined by LTS) is 1 %;

- The hour-by-hour profile of taxi use in central London is given in Figure 3 and differs significantly from the profile of cars in central London. Taxi use begins later in the day (10 am), increases towards and evening peak at around 5 pm and shows consistency during the day, except for a lull in activity during lunchtime. In outer and inner London the profile is assumed to be the same as for cars;
- Weekend-weekday differences are significant and are summarised in Table 33. In central London taxis activity on Saturday and Sunday is 61 % and 34 % of a typical weekday, respectively;

- The majority of taxis conform to pre Euro 1 (34 %) and Euro 1 (50 %) emissions regulations. The number of taxis purchased is 2001 per annum with 976 being scrapped;

- 12 % of new purchases comply with Euro 3 regulations and 88 % with euro 2. From the end of 2001 all new purchases will comply with Euro 3.

Figure 24 Normalised taxi flow data for central London

[7] Note that this is an average of all roads assessed. There can be wide variation in numbers along different road links.

Table 33 Taxi vehicle km by area of London and day of the week

Vehicle km Factors	Central	Inner	Outer
Weekday	1.00	1.00	1.00
Saturday	0.61	0.82	0.84
Sunday	0.34	0.86	0.16

Appendix E

1 Model Uncertainty Assessment

1.1 Introduction

This appendix describes the application of Bayesian Monte Carlo (BMC) analysis to the ERG model developed to predict present and future concentrations of annual average NO_2 in London. Model uncertainties arise because of limited scientific knowledge, limited ability to assess the uncertainty of model inputs, for example, emissions from vehicles, poor understanding of the interaction between model and/or emissions inventory parameters, sampling and measurement error associated with NO_X and PM10 sites in London and whether the model itself completely describes all the necessary atmospheric processes. The application of the BMC technique here results in the reduction in uncertainties predicted through the additional information provided by the measurements themselves.

1.2 Uncertainty Assumption in Model Input Parameters

Selection of the uncertainty of input variables are obtained through access to published literature, the opinions of experts in the field, and through the assessment of relationships used within the model. A summary of the assumptions made for the model are given in the table below:

Table 34 Uncertainty Assumptions (1 σ) use for the Uncertainty Predictions

	(%)
Road Traffic Emissions	30
Other Emissions	50
London + Rural NO_X Contribution	10
Pollution Climate Mapping (NO_X)	11
NOx-NO2 Relationship	10
Roadside Dispersion	20

1.3 Bayesian Monte Carlo Analysis

In Monte Carlo analysis, the model is run with the input variables varied simultaneously and independently of each other and a resulting probability distribution of the output information, obtained. Bayes' theorem is then applied to derive a final uncertainty estimate, by assigning a high probability to those predictions that agree with the measurements and a low or zero probability to those, which do not. The application of probabilities to the model prediction uses the likelihood function (Equation 1) and results in the best estimate of overall model uncertainty.

(1)

A mathematical summary of BMC is given below. From Bayes' theorem the final probability of model output is defined by equation 2 as

$$p(Y_k \mid O) = \frac{L(Y_k \mid O)\, p(Y_k)}{\sum_{j=1}^{N} L(Y_j \mid O)\, p(Y_j)} \qquad (2)$$

1.4 Results at Background

A BMC uncertainty analysis was carried out for annual average NO_2 concentration throughout London.

The prior and posterior distributions for an average of the measurement sites in London are included in Table 35. The application of BMC analysis reduces the final uncertainty giving a standard deviations in this case are 2.0 ppb (8.5 %).

The BMC analysis was then applied for 5 sites individually and the results summarised in Table 36. Again BMC analysis results in a significant reduction in σ providing a reduction in uncertainty. The average σ for the 5 sites was 1.8 ppb.

Table 35 Final uncertainty and measured annual mean NO_2 concentrations (ppb) at all sites in London for 1998

Average Model Prediction (ppb)	σ (ppb)	Uncertainty %	Measured Result (ppb)
23.6	2.0	8.5	23.2

Table 36 Final uncertainty and measured annual mean NO_2 Concentrations for separate Sites in London for 1998

Site Location	Final Model Prediction (ppb)	σ (ppb)	Uncertainty %	Measured Results (ppb)
Bridge Place	30.6	2.2	7.2	30.2
Bexley 2	19.1	1.5	7.8	18
Tower Hamlets 1	24.1	1.8	7.5	24.6
West London	26.8	2.0	7.5	26.8
Sutton 2	18.6	1.4	7.5	19.8

1.5 Results at Roadside

Predictions of the concentration of NO_2 at roadsides throughout London have shown a high sensitivity to the pass/fail standard of 21 ppb. These predictions are crucial to the development of air pollution control, through local authority action plans, and it is therefore essential to completely understand the uncertainty associated with them. Only then will the strengths and weaknesses of the predictive process be understood enough for decision-makers to make informed policy judgements. It is the uncertainties associated with these predictions, which are the subject of this appendix.

Monte Carlo modelling techniques have been used to calculate the uncertainties associated with roadside NO_2 predictions. It also includes a full sensitivity analysis to determine the most important input variables to the model. Specific tests include the uncertainties associated with flows and emissions from LGVs, HGVs and buses, vehicle speed, the dispersion model, and the pollution climate mapping technique, used for calculating background concentrations.

In *Monte Carlo* analysis, the input variables are varied simultaneously and independently of each other, and the effect on important outputs assessed. The model uncertainty, relating to the input parameters, is calculated by treating them as random variables. By studying the resulting probability distribution of the output (i.e. the concentration or emission estimate), information is obtained regarding the model uncertainty.

The original study has focused on Marylebone Road for a base year of 1997 for meteorology and atmospheric chemistry and uses the London Transportation Studies (LTS) traffic model. Further uncertainty assessments have also been undertaken for an "average road' in central and outer London, as well as a 'Motorway' in outer London.

The sensitivity analysis revealed that roadside NO_x predictions are mostly sensitive to the assumptions regarding HGV emissions and flows and the dispersion model used to predict roadside concentrations. For the prediction of NO_2, the NO_x-NO_2 relationship used is the most important factor. Table 37 below shows how each input data or modelling method affects the final concentration, for the Marylebone road example.

Table 37 The Relative Importance of Model Parameters in Predicting NO_2 at Marylebone Road

Model Parameter	Relative Importance 2005 (% of mean at 2σ)	Relative Importance 1997 (% of mean at 2σ)
NO_X-NO_2 relationship	13.9	11.9
HGV emissions	7.9	8.1
Dispersion model	7.3	6.8
HGV flow	5.5	5.5
LGV emissions	4.2	4.7
LGV flow	4.2	4.7
Vehicle speed	3.6	2.1
Background mapping	1.8	1.7
Bus emissions	1.2	0.9
Bus flow	0.6	0.4

For 1997, NO_x was predicted to be 258 +/- 83 ppb and NO_2 47 +/- 10 ppb, at two standard deviations – equivalent to the 95 % confidence interval. These statistics assume that the resultant distribution is normal.

The overall uncertainty of NO_2, which corresponds to 22 %, is less than that for NO_X (32 %). This feature is a result of the non-linear NO_2 relationship, which is quite insensitive to NO_x concentrations, implying that a stated NO_X uncertainty is a better indication of the quality of a prediction.

Measurements for the Marylebone Road site for NO_x and NO_2 are within the uncertainty limits calculated here. NO_x was between 213 and 229 ppb and NO_2 between 44 and 48 ppb for 1997. The range reflects the two different monitoring techniques used at the Marylebone site.

Similarly, for 2005, NO_x is estimated to be 117 +/- 35 ppb and NO_2 33 +/- 7 ppb, at two standard deviations – equivalent to the 95 % confidence interval. It can therefore be concluded that with a probability of 95 % the true value lies within the ranges given above. This would indicate that, despite the calculation of uncertainty associated with the 2005 predictions, the NO_2 concentration always exceeds 21 ppb and therefore Marylebone Road will exceed the AQS objective. This may not always be the case however and with a prediction whose range straddles 21 ppb, a decision must be made concerning the approach to be taken. For example, a prediction of 20 +/- 2 ppb could be considered a pass or a fail.
It is further concluded that the prediction of NO_2 concentrations in London depend most on the NO_x-NO_2 relationship used and the traffic data for HGVs. It is flows of, and emissions from, HGVs and buses that become more important in the future, as emissions from these vehicles will make up a greater proportion of the total.

The results from the analysis of a further three roads is given in Table 38. These represent an average road at a central and outer location and an average motorway in outer London. The flow and percent HGV for the average road was derived from all 10,000 roads in the LTS 91 network.

Table 38 NO_2 Uncertainty Estimates for Typical Roads in London in 2005

Road Type/Location	**Total vehicle flow**	**Percent HGV**	**Uncertainty (% of mean at 2σ)**
Average road (central London)	17,000	9	16
Average road (outer London)	17,000	9	18
Motorway (outer London)	80,000	9	21

Our best estimate of the uncertainty in annual mean NO_2 predictions is therefore +/- 16-21 % at two standard deviations.

It has not been possible to quantify the uncertainty of PM10 predictions in the same way as NO_2. This is because the uncertainty of the measurement techniques themselves and the sources and sinks of particles has not been well established. *However, it is reasonable to expect that the uncertainty in PM10 predictions is larger than NO_2.*

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Appendix F

1 Air Pollution Measurements in London

1.1 Monitoring Update

Details of the continuous monitoring undertaken at comparable sites across the LAQN, as well as the Government's AURN sites in London were provided in the Stage 3 report. At the time of the preparation of that report, ratified data were only available up to 1997. These data can now be supplemented with more recent results.

The L.B of Newham also undertakes its own continuous monitoring at sites in its area at Cam Road and Tant Avenue, which are both roadside sites in Canning Town and Stratford respectively. Both sites opened in 1999 and the monitoring results for these sites are given in Table 39, Table 40, Table 41 and Table 42. AEA Technology provides the QA/QC for these sites.

The monitoring results for comparable LAQN sites are given separately in Figures 17 and 21 below.

1.2 Nitrogen dioxide

The NO_2 results for all years monitored confirm that the 40 $\mu g/m^3$ standard has been exceeded at both LB of Newham sites.

Table 39 Annual Mean NO_2 results for the LB of Newham sites

	NO_2 Annual mean ug/m3			
	1998	1999	2000	2001
Cam Road	(62.7)	(55.1)	51.3	53.2
Tant Ave	(49.4)	47.5	43.7	45.6

(Note: brackets indicate < 90% data capture)

Figure 25 and Figure 26 update the information in the Stage 3 report for the LAQN sites. These highlight that exceedences of the NO_2 annual mean objective have continued at all kerbside (K) and roadside sites (R) (apart from Croydon). Similarly the majority of background sites (B) also exceed the objective apart from some sites in outer London (e.g. the Brent, Enfield, Greenwich and Thurrock sites). The suburban sites (S) mostly do not exceed the objective, with the exception of Hillingdon.

Figure 25 Annual average NO_2 means for kerbside and roadside sites (1997-2000)

Figure 26 Annual average NO_2 means for background and suburban sites (1997-2000)

The figures suggest that the pollution for 1999 was marginally better than 1997, which was previously considered the worst-case year for NO_2. However it is not possible to fully conclude without further investigation, whether this was from either an emissions reduction (of NO_x) or as a result of the meteorology or a combination of these factors. It is also worth noting that during 1999 there was an absence of the major pollution incidents seen in previous years. For example, during 1994 and 1997 London experienced significant winter pollution incidents, a prolonged secondary particulate episode occurred during 1996 and the hot summer of 1995 produced substantial photochemistry. However, the summer of 1999 was characterised by a series of moderate photochemical episodes.

The hourly standard of 200 $\mu g/m^3$ however was only exceeded during 1999 at the L.B of Newham sites and this was for a maximum of two hours, which means that the sites easily meet the hourly objective of less than 18 occasions.

Table 40 Number of Hourly NO_2 results > 200$\mu g/m^3$ for LB of Newham sites

NO_2 Hours > 200 ug/m3				
	1998	1999	2000	2001
Cam Road	(0)	(1)	0	0
Tant Ave	(0)	2	0	0

(Note: brackets indicate < 90% data capture)

Figure 27highlights that only one roadside site in London exceeded the hourly objective level for NO_2. This was the Marylebone Road site that is in a street canyon in central London. Results from the roadside sites at Tower Hamlets 2 and the urban background site at Hackney show possible exceedences, within the boundaries of uncertainty.

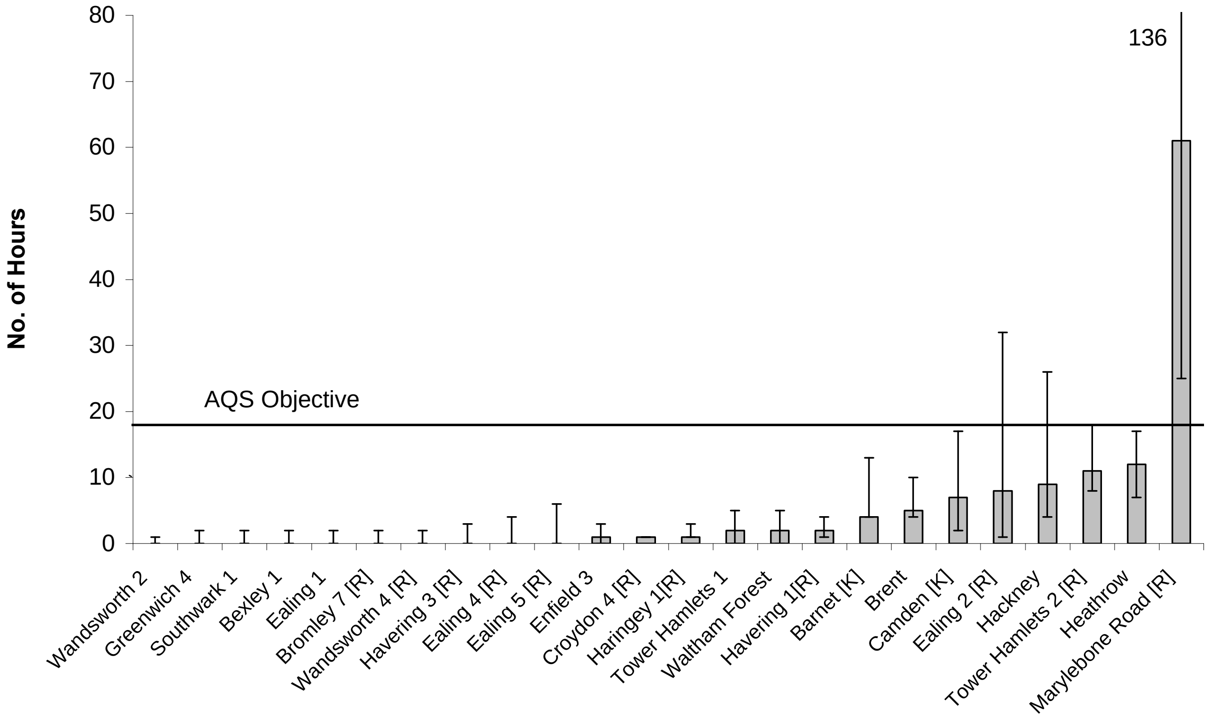

Figure 27 Number of hourly averages > 104.6 ppb nitrogen dioxide for LAQN sites (1999)

It is also worth noting that during 1999 there was an absence of the major pollution incidents seen in previous years. For example, during 1994 and 1997 London experienced significant winter pollution incidents, a prolonged secondary particulate episode occurred during 1996 and the hot summer of 1995 produced substantial photochemistry. However, the summer of 1999 was characterised by a series of moderate photochemical episodes.

To further understand the effect of changing pollution climates over time it is possible to start to consider the relative results from 1995 to 1999. Data from November 1995 to September 2000 have been analysed to place the results from 1999 in context. Rolling annual means from November 1996 have been calculated in an attempt to eliminate seasonal effects. Note that the mean value for a particular date represents that for the preceding year e.g. the value calculated for November 1996 represents the mean between November 1995 and November 1996. To provide a perspective across the network as a whole, the rolling means from each of the long term sites have been averaged to produce a LAQN rolling mean, normalised to 100 % for each pollutant as at November 1996 to illustrate relative change. Measurements from roadside and background sites have been used. However, due to data availability, a different set of sites has been used for each pollutant. Twelve sites have been used for the rolling NO_X and NO_2 calculation. (NOx is the sum of NO and NO_2). It should be noted that data from summer 2000 are still subject to ratification.

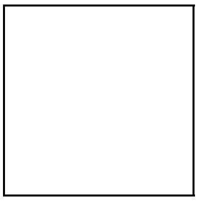

Figure 28 Relative Rolling Annual LAQN Means for O_3, NO_X and NO_2

Figure 28 shows a fall of around 23 % in the NO_X concentration over the period November 1996 to September 2000. This is very likely the result of reduced NO_X emissions due to technological changes in the vehicle fleet. The effects of pollution incidents during autumn 1997 can also be clearly seen in the NO_X concentration, causing a rise in concentration at this time and a consequential fall during autumn 1998 as this incident drops from the rolling annual mean. The overall fall in NO_X concentrations has not been matched by those of NO_2, which show little change over the period, although data that are yet to be ratified suggested a decline during the summer of 2000. This decrease might be linked to the relatively poor summer weather rather than being part of a long-term trend. The overall stability of NO_2 concentrations, in the face of NO_X reductions, is of profound importance to air quality management strategies.

The behaviour of NO_2 over the period begs the question whether the rate of decline is sufficient to achieve the objective by 2005. Clearly the required reduction in NO_2 concentrations is different at each site, dependent on its annual mean at the start of the period of analysis. To illustrate this, target rates of reduction have been derived for four sites in London. For illustrative purposes these are assumed to be constant. The rolling annual LAQN mean NO_2 is shown compared to these target reduction rates in Figure 29.

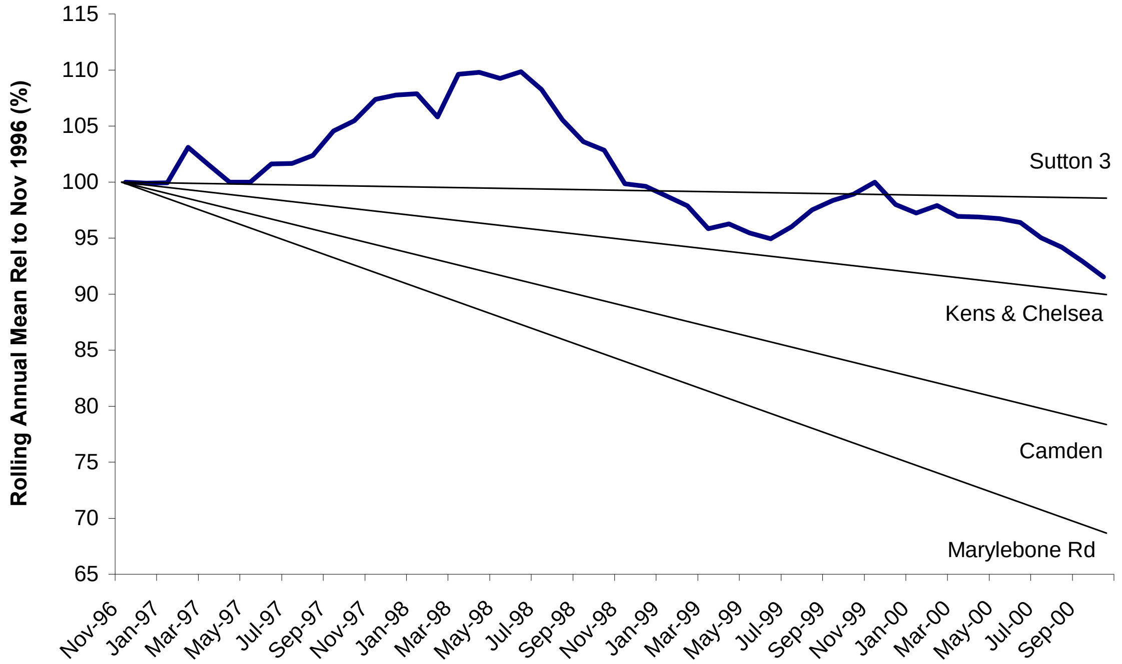

Figure 29 Relative Rolling Annual LAQN Means for NO_2 and target reduction rates for 4 sites.

Figure 29 suggests that the rate of change in NO_2 concentration seen over the previous 4 years may be sufficient to achieve the AQS objective at outer London suburban sites such as Sutton 3. The rate of change is approaching the rate at which inner London background sites will achieve the objective. The background site at Kensington & Chelsea illustrates this. It is evident that a greater rate of reduction will be required if inner and central kerbside sites, such as Camden and Marylebone Road, are to meet the objective by 2005.

1.3 Particles (PM10)

The monitoring for PM10 confirms that the daily mean standard of 50 µg/m^3 has been exceeded each year, with only 1999 having more than 35 days monitored for the period 1997 to 2000 inclusive. It should however be noted that these results are TEOM only; hence they may under read gravimetric results. Furthermore it is not possible to calculate the number of days, which exceed from the summary of results shown.

Table 41 Daily mean PM10 objective results for the L.B of Newham

PM10 Days>50 µg m^{-3}				
Cam Road	(19)	40	13	21
Tant Ave	(10)	25	20	21

(Note: these PM10 statistics based on TEOM data and therefore may under-read gravimetric results by 30%)

Table 42 below indicates the gravimetric equivalent annual mean for PM10 for the L.B of Newham sites and these confirm that the current annual mean objective of 40 µg/m^3 has not been exceeded at either of the sites for any monitored.

Table 42 Annual mean PM10 objective results for the L.B of Newham

PM10 Annual mean µg m^{-3}				
Cam Road	36.4	33.8	27.3	29.9
Tant Ave	28.6	28.6	29.9	28.6

(Note: these PM10 statistics based on TEOM x 1.3 to represent gravimetric results)

The following figure updates the PM10 concentrations monitored at London sites for the period 1997 to 2000. These measurements indicate that the objective levels of PM10 are reducing at most sites. The only site, which exceeded the objective in 1999 and 2000, was the Marylebone Road site. The Marylebone Road site also exceeded in 1998 as did the A3 roadside site. Background sites exceeded the objective in 1997 only (apart from Kensington and Chelsea and Brent), as did the roadside and kerbside sites.

Figure 30 Days exceeding 50µg/m^3 for sites (1997-2000)

The reduction in PM10 can also be seen to fall in the following diagram, which shows approximately a 30% in the rolling annual mean for PM10 since 1996. Four sites have been used for the rolling PM10 calculation.

Figure 31 Relative Rolling Annual LAQN Means for PM10

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Figure 1 (Available on Request) London Borough of Newham - Annual Mean Nitrogen Dioxide (microgrammes per
cubic metre, µg/m3) for 2005 based on 1999 meteorology

Figure 2 (Available on Request) London Borough of Newham - Number of days with daily mean PM10 exceeding 50 microgrammes per cubic metre (ug/m3) for 2004 based on 1996 meteorology

Figure 4 (Available on Request) London Borough of Newham - LEZ scenario - Annual Mean Nitrogen Dioxide (microgrammes per cubic metre, µg/m3) for 2005 based on 1999 meteorology

Figure 5 (Available on Request)

Figure 6 (Available on Request)

Figure 7 (Available on Request)

Figure 8 (Available on Request)