Second Further Review and Assessment of Air Quality in Brighton and Hove

Brighton and Hove City Council
In fulfillment of Part IV of the Environment Act 1995
Local Air Quality Management

2010


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Executive Summary

The Further Review and Assessment is the most specialised of the Local Air Quality Management reports delivered by Brighton and Hove City Council. The technical content complements the Air Quality Progress Report and Air Quality Action Plan also completed during 2010.

An ADMS dispersion modelling assessment has enabled detailed mapping of Nitrogen Dioxide concentrations throughout the Brighton and Hove Air Quality Management Area AQMA (1050 hectares or 2600 acres). Adjacent to the AQMA; Portslade old village, the main roads surrounding Preston Park and Ditchling Road to Five Ways are also included.

This Further Review includes model comparison with monitoring data throughout. Source apportionment predicts the percentages of Oxides of Nitrogen that are from various sources including; commercial and domestic properties, busses, heavy goods vehicles, cars & taxis, light goods vehicles (vans) and motorbikes. The proportion of pollution from these sources varies considerably between neighbourhoods and within the city.

At this time the council has no plans to revoke or amend the current AQMA. A detailed assessment is required for the junction of Preston Drove and Preston Road (A23) and a distinct local area remote from the existing AQMA in Rottingdean High Street.

The multiple Review and Assessments carried out in 2010 show that exceedence of the long-term air quality objective for Nitrogen Dioxide continues at specific locations always less than 10 to 15 metres from traffic that frequently stops and starts or moves slowly. The number of diesel and heavy vehicles is significant for local pollutant concentrations and strategies to tackle the problem and improve local air quality need to take this into account. Measures to reduce both individual and city-wide climate change footprints are not always of benefit to local air quality.

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1.2 AQMA Declarations

This report sets out the Further Assessment of air quality within the Brighton and Hove Air Quality Management Area (AQMA) declared in 2008. The 2008-AQMA includes the entirety of the former 2004-AQMA (<24 hectares) and extends the area to approximately 1050 hectares. This report forms part of the Local Air Quality Management Process prescribed by the Devolved Administrations. The 2008-AQMA was declared because of likely exceedences of the annual mean nitrogen dioxide objective. It has been acknowledged in previous review and assessment reports that there is also a risk of the hourly mean objective for nitrogen dioxide being exceeded. Therefore the Brighton and Hove 2008-AQMA is declared for both short and long term nitrogen dioxide objectives.

1.3 Air Quality Objectives

The Air Quality Objectives (AQS) applicable to LAQM **in England** are set out in the Air Quality (England) Regulations 2000 (SI 928). The Air Quality (England) (Amendment) Regulations 2002 (SI 3043), and are shown in Table 1.1. This table shows the objectives in units of microgrammes per cubic metre $\mu g/m^3$ (milligrammes per cubic metre, mg/m^3 for carbon monoxide) with the number of exceedences in each year that are permitted (where applicable). The objectives for key pollutants aim to protect human health and the environment.

The nitrogen dioxides objectives (1-hour and annual mean) are the only one of relevance to this Further Assessment, other pollutants are included in the table for completeness. The objective applies outdoors where members of the public (not employees or workers) are likely to be frequently present for the averaging period of the objective. In Brighton the majority of sensitive receptors are private residential, with care homes and hospitals also relevant. The façade of these properties represents a receptor at the interface of indoor and outdoor air. Although schools are occupied for much less than half of the year they are also deemed by TG(09) to be sensitive receptors for the annual mean. The council's monitors are located accordingly at residential façade and outside hospitals and schools. The 1-hour objective applies at the same places as the annual mean objective and also at any outdoor locations where a member of the public might reasonably reside for nineteen hours or more in a year[1]. For example a; hotel façade, shopping street, courtyard, garden, public footpath, sports ground, railway and bus stations if the space is not fully enclosed or deemed to be indoors.

Measurements have shown that the 1-hour percentile nitrogen dioxide objective is unlikely to exeed unless the annual mean nitrogen dioxide is greater than 60 $\mu g/m^3$ [2]. In 2007 and 2008 Brighton's highest recorded concentration were near to or equivalent of this concentration.

European and World Health Organisation (WHO) limits for nitrogen dioxide are the same as the AQS, to be achieved by 2010 with extension currently being negotiated by defra. The achievement of this target is a national obligation in addition to the local one.

[1] Equivalent to 99.78 percentile of all the hours in the year. The eighteen highest hourly periods are excluded from the 1-hour objective. This is because pollution over the year is not likely to be a Gaussian or bell curve distribution. A skewed profile with higher concentrations in the top 0.22 percentile is most likely.
[2] (Laxen and Marner, 2003)

Table 1-1 Air Quality Objectives included in Regulations for the purpose of Local Air Quality Management in England.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene			
	16.25 µg/m³	Running annual mean	31.12.2003
	5.00 µg/m³	Running annual mean	31.12.2010
1,3-Butadiene	2.25 µg/m³	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m³	Running 8-hour mean	31.12.2003
Lead	0.5 µg/m³	Annual mean	31.12.2004
	0.25 µg/m³	Annual mean	31.12.2008
Nitrogen dioxide	200 µg/m³ not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg/m³	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 µg/m³, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 µg/m³	Annual mean	31.12.2004
Sulphur dioxide	350 µg/m³, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 µg/m³, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 µg/m³, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

1.4 Introduction to the Review and Assessment Process

The Air Quality Strategy (AQS) for England sets out a framework for air quality management which include a number of air quality objectives. A combination of UK and European measures are expected to achieve these objectives in the majority of locations. That said at specific roadside sites poor air quality persists and this is where local air quality management has an especially important remit.

Part IV of the Environment Act (1995) and relevant Policy and Technical Guidance documents requires local authorities to periodically review and assess the air quality in their areas. This process has flagged up specific locations where it is unlikely that certain air quality objectives will be be achieved. The local authority has duty to include areas of exceedence within a statutory declared AQMA. An Air Quality Action Plan (AQAP) must be devised for the AQMA in order to mitigate pollution concentrations, with the aim of ambient concentrations complying with the objective.

Brighton and Hove City Council (BHCC) has commenced the fourth round of review and assessment for Local Air Quality Management (LAQM) with submission of an Updating Screening and Assessment in April 2009. The latest Technical Guidance (TG09) was written by defra and the devolved administrations and prescribes the order of review and assessments from 2009.

A comprehensive list of BHCC Review and Assessment submissions is presented in table 1.2. The previous LAQM (Local Air Quality Management) report submitted by the council was the Updating Screening and Assessment, USA-2009. This table lists the reports and actions in chronological order and AQAM declarations, under section 84, of IV of the Environment Act 1995 are marked as bold. This report also refers to the Further Review and Assessment and new Air Quality Action Plan 2010.

Table 1-2 Order of Brighton and Hove LAQM reports 1999 to 2008

Review and Assessments Report	Dated
Stage 1 Consultation Draft	January 1999
Stage 2 & 3 Final Report	June 2000
Second round Updating Screening and Assessment	May 2003
First Detailed Assessment leading to declaration of the 2004-AQMA	**April 2004**
Second round Progress Report	April 2005
Third round Updating Screening and Assessment	April 2006
First Air Quality Action Plan for the 2004-AQMA	March 2007
Second Detailed Assessment leading to declaration of the 2008-AQMA	September 2007
Further Assessment following 2008-AQMA deceleration	Final January 2008
Third round Progress Report	April 2008
Declaration of expanded AQMA	**February 2008**
AQMA declaration amendment to include the short-term NO_2 AQO	**October 2008**
Fourth round Updating Screening and Assessment	April 2009
Further Review and Assessment on expanded AQMA	May-June 2010
Second Air Quality Action Plan on expanded AQMA	
Fourth round Progress Report	

The Detailed Assessment submitted in 2007 determined if there was an exceedence of the nitrogen dioxide objectives and considered the geographical extent of that exceedence. The second more substantial AQMA was declared as a result in 2008.

1.5 Findings of previous reports

BHCC's round three and four review and assessment reports including the Updating Screening Assessment (USA) of April 2009. The latest USA found that the objectives for all local-AQS pollutants would be achieved (throughout the local authority area) at the relevant locations with the exception of nitrogen dioxide. Nitrogen Dioxide concentrations above the annual mean objective were outside the 2004-AQMA. Dispersion modelling evidence presented in the Detailed Assessment 2007 and the Further Assessment 2008 confirmed a number of exceedence outside of the original 2004-AQMA. Therefore decision was made to declare a more expansive AQMA for Nitrogen Dioxide and this was signed in February 2008.

1.6 Purpose of the Further Assessment

This Further Assessment (FA) is being carried out to confirm the most recent AQMA declaration. It therefore addresses Nitrogen Dioxide only. Subsequent reports will continue to consider other AQS pollutants as part of the continuing review and assessment process. Section 7.02 of TG(09) outlines the purpose of the FA as follows:

• confirm their original assessment, and thus ensure the correct decision was made to designate an AQMA in the first place

• calculate more accurately what improvements in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA

• refine their knowledge of sources of pollution, so that the air quality Action Plan may be appropriately targeted

• take account of any new guidance issued by Defra and the Devolved Administrations, or any new policy developments that may have come to light since declaration of the AQMA – dealt with in the 2010 Progress Report

• take account of any new local developments that were not fully considered within the earlier Review and Assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc, that were not committed or known of at the time of preparing the Detailed Assessment – dealt with in the 2010 Progress Report

• Carry out additional monitoring to support the conclusion to declare the AQMA; Corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way and

• Respond to any comments made by statutory consultees in respect of the Detailed Assessment.

1.7 Report Content

The section of the report from this point on are as follows:

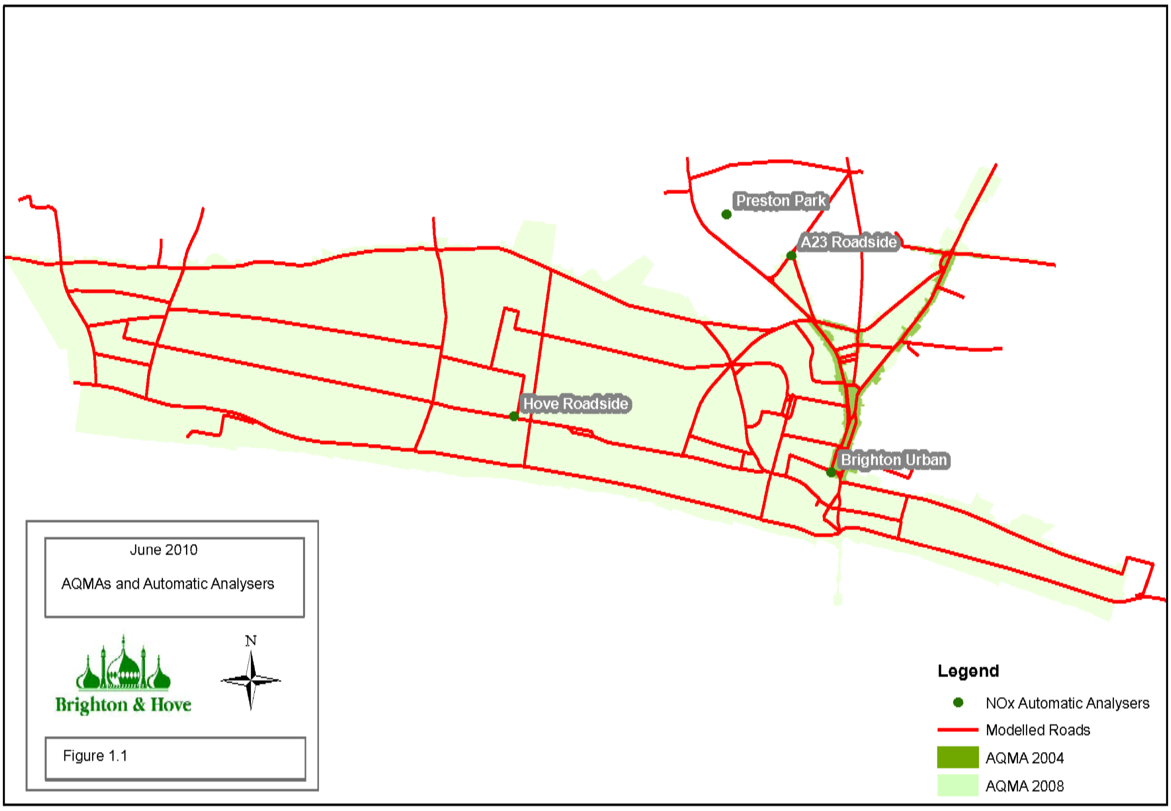
Section two of this report presents the Brighton and Hove 2008-AQMA equivalent to the study area for this report. Section three outlines developments since the AQMA declaration in February 2008.
Section four builds on the 2009 review and assessment, stage four Updating Screening and Assessment and analysis in further detail recent changes to Nitrogen Dioxide monitoring in the AQMA. Based on this evidence; priorities are suggested for the AQAP. Section five discusses a new pollution inventory for the city. Section six presents the dispersion model methodology. Section seven presents results for the new dispersion modelling used to confirm the area of exceedence within the expanded AQMA and uses the emissions inventory and model to establish source apportionment in order to estimate the proportion of pollution from different sources. Section eight comments on the air quality improvements required to meet the objectives with section nine suggesting recommendations as to how this can be theoretically achieved.

2 New AQMA Location

The 2008-AQMA extends from Arundel Road in the east to Adur District Council in the west, Preston Park & the Old Shoreham Road to the north and the Sea to the south. The AQMA boundary envelopes localised areas of nitrogen dioxide exceedence in; Brighton, Hove and Portslade. The AQMA and the location of continuous analysers are shown in Figure 2-1. The current AQMA includes the original one and is considerably larger in size. At approximately 10 km^2 the new AQMA block is equal to about 11% of the city's total area.

Brighton and Hove encompasses some of the highest and lowest population densities in the South East of England. The city area includes rural parts of the South Downs where only a few farm dwellings reside per km^2 and long-term Nitrogen Dioxide concentrations are typically 10-13 $\mu g/m^3$. By contrast in the city centre population density is more than 5,000 per km^2, with urban background nitrogen dioxide levels close to 30 $\mu g/m^3$; annual mean as a maximum over one km^2.

Figure 2-1 2008 AQMA and continuous monitors



3 Changes since declaration of the AQMA

3.1 New Developments

There have been no major new developments within the new AQMA or adjacent to it in the period since declaration. There have been no new roads built or industrial processes permitted[3] within the AQMA or the city. Further updated information on major development status is given in the Brighton and Hove, Progress Report 2010.

Construction of the Brighton Hove football stadium has commenced. The site is located >3km from the nearest AQMA boundary. A new wider access road to the site was built during 2009. It is not expected that the works traffic will directly impact on traffic within the AQMA. The additional construction traffic to the A27 (T) outside of the AQMA is expected to be insignificant and within the typical deviation expected for daily totals. Excavation and earth moving is to be restricted to the site and adjacent land. Air quality to the vicinity of the stadium is good and this design incorporates an advanced park and ride scheme for events.

3.2 Proposed Developments

The air quality officer has provided comments on a number of planning applications in accordance with the local plan and Local Development Framework (LDF)[4]. Due diligence has been applied to consider if the developments are likely to:

- Introduce new residences into the area where nitrogen dioxide concentrations are above the objectives
- Have an impact on local air quality
- Introduce new point source such a gas fired boiler chimney, combined heat and power plant or a biomass combustion facility
- Be in compliance with the clean air act (1993)

A number of smaller mixed retail development have been assessed for their potential air quality impact which were not deemed to be significant. Detailed assessments have been commissioned to establish if new developments will introduce residents to concentrations of Nitrogen Dioxide above the objective. In the case of the centrally situated Pelham Street collegiate development a new diffusion tube has been sited (February 2009) in close proximity to the proposed build in order to test the finding of the detailed assessment carried out by Cambridge Environmental Research Consultants (CERC).

3.3 National Changes in Air Quality

It is most likely that defra and the Devolved Administrations (DAs) will extend the EU set limit value compliance date for nitrogen dioxide to beyond 2010. It is acknowledged by defra that certain parts of London are unlikely to meet the annual mean target in 2020. Without significant action this situation may be repeated at a number of sites outside of Greater London. Defra and the DAs revised the AQS in July 2007 i.e. before BHHC's last AQMA declaration. The inclusion of other pollutants to the strategy made no difference to the objectives for Nitrogen Dioxide, i.e. the pollutant dealt with in this report.

[3] The Environmental Permitting Regulations (EPR) including Part A PPC (Pollution Prevention Control) processes regulated by the Environment Agency and Part B LAPPC (Local Authority PPC) processes.
[4] The Brighton and Hove LDF is currently being reviewed and will include a section on air quality requirements

The revised NO_x to NO_2 relationship and the NO_x to NO_2 distance calculator have been available since April 2007[5], also before BHHC last AQMA declaration and these tools and relationships were utilised in the previous FRA, finally delivered in January 2008.

Since the council's AQMA declaration policy guidance (PG09) and Technical Guidance (TG09) have been published in February 2009. This latest guidance is referenced throughout this Further Assessment and the previous Updating Screening Assessment.

[5] NOx to NO2 relationship and NOx to NO2 drop off with distance calculator can be found on the LAQM Air Quality Archive Website

4 Further Analysis of new monitoring data

4.1 Reporting of Nitrogen Dioxide

The 2008 nitrogen dioxide monitoring data was reported in detail in the 2009 Updating Screening and Assessment (USA). For completeness continuous analyser ten year graphs and bias correction diffusion tube results are also included in the appendix, 13.1& 13.2. Further analysis and comparison is provided in this section with recommendation made for the Air Quality Action Plan (AQAP). Continuous analyser audits are expected in February 2010 with ratification and diffusion tube bias correction confirmed shortly afterwards. Reporting of 2009 monitoring data is to be included in the next; Round Four Progress Report, also submitted in 2010.

4.2 Pattern of findings discovered to date

Typically concentrations of nitrogen dioxide that exceed the objective are in close proximity (< 15 m) to slow-moving, frequently congested road sections or junctions, surrounded by a high density of buildings, but not necessarily within an idealised or symmetrical street canyon.

4.3 Continuous analyser

BHCC has two roadside continuous analysers within the AQMA; one is located at Brighton Pavilion Gardens (BH1) near the A23 (T) at Pavilion Parade. This monitoring station is part of defra's Automatic Urban Rural Network (AURN). The other AQMA active analyser is located at Church Road Hove (BH2) and is part of the independent Sussex network. The AURN urban background monitor at Preston Park is outside of the AMQA and hence not so relevant to this report. During recent years (including 2008) both AQMA NO_x chemiluminescence analysers were manually calibrated by BHCC on a fortnightly basis. The analysers are serviced by AEA technology and the raw data is ratified by the Environmental Research Group (ERG), Kings College at the University of London. Supporting U also carry out a biannual service at both analysers. Further details are given in BHCC 2010 Air Quality Progress Report.

As stated in BHCC's 2009-USA during 2008 both continuous analysers recorded concentrations below the Nitrogen Dioxide annual mean concentration recent results are as follows:

Table 4-1 Recent results from NO_x Continuous Analysers in the AQMA

Site Code	Site Name and Type	Ordinance Survey Grid Reference	Sample Intake Height above pavement	Worst-case Location ?	Annual mean concentrations ratified (μg/m^3)		
					2006	2007	2008
BH1	Brighton Roadside	531,295 104,319	4.6	No	39	41	37
BH2	Hove Roadside	528,963 104,731	3.8		33	33	31

Both analyser intakes are located at height and is expected that ground and respiratory level concentrations will be higher than the measured concentrations. The LAQM tool; "roadside" NOx drop off with distance can be used to calculate concentrations back from the road. Trigonometry can be applied to obtain some idea of the extra distance entailed with elevated monitoring sites.

Previous review and assessments have acknowledged that the continuous analysers (located at selected secure sites a decade ago) are not at the worse-case locations for pollution within the city. In order to address this limitation a number of passive diffusion tubes monitor near to congested roads and busy junctions. Furthermore the new dispersion modelling presented in section 7 will investigate air quality at all worse-case zones within the AQMA.

A third NO_x roadside analyser is to be introduced to the AQMA, for 2010. The purpose of this analyser will be to monitor the influence of incoming traffic A23 (T) on ambient air quality near to the AQMA boundary. This new NO_x analyser will be collocated with a new particulate analyser funded by previous LAQM Defra grants.

4.4 Nitrogen Dioxide Diffusion tube assessment of change

Brighton and Hove City Council's (BHCC) Updating Screening and Assessment 2009 presented results for all passive diffusion tubes and reported that > 80% of Nitrogen Dioxide diffusion tubes show an improvement. This chapter provides greater transparency and explanation for recently recorded changes in Nitrogen Dioxide.

BHCC had sixty-five (65) passive diffusion tubes (located at background and façade sites) that are common to both 2007 and 2008. All sixty-five records are based on at least ten months annualised data for each year in accordance with latest government guidance TG (09). Several other monitoring locations with less than ten months of data (during either 2007 or 2008) are not included with the following inter-annual comparison.

Triplicate diffusion tubes were collocated with the BH2 analyser at Hove to derive the bias correction factor. The tubes were found to have a good precision and very close agreement with previous years bias correction factor.[6]

The magnitude of change from one year to the next can be characterised using Environmental Protection UK's guidance on significance as follows:

Table 4-2 Characterisation of the significance of change for Nitrogen Dioxide

Category	Change µg/m^3	Change percentage
large increase	> 4.1	> 10%
medium increase	2.1 to 4	5.1 to 10 %
small increase	0.4 to 2	1.1 to 5 %
imperceptible change	< 0.4 either way	< 1%
small improvement	- 0.4 to 2	- 1.1 to 5%
medium improvement	- 2.1 to 4	- 5.1 to 10 %
large improvement	> - 4.1	> - 10%

If these categories are applied to the Brighton and Hove tubes where the annual mean for 2008 is compared with the previous year the distribution is as follows:

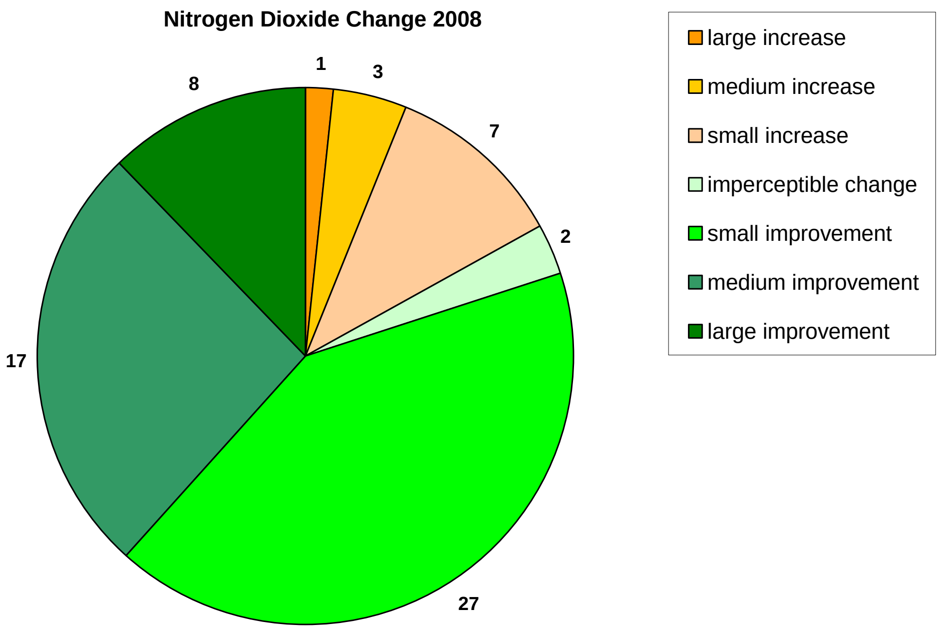
Table 4-3 Characterised Change in Nitrogen Dioxide levels 2007 to 2008

Category	Brighton and Hove Tube Tally
large increase	1
medium increase	3

[6] Details on 2008 bias correction, precision, laboratory QA and QC can be found in the 2009 Updating Screening and Assessment

small increase	7
imperceptible change	2
small improvement	27
medium improvement	17
large improvement	8

Figure 4-1 Level of Change in Recorded Nitrogen Dioxide 2008



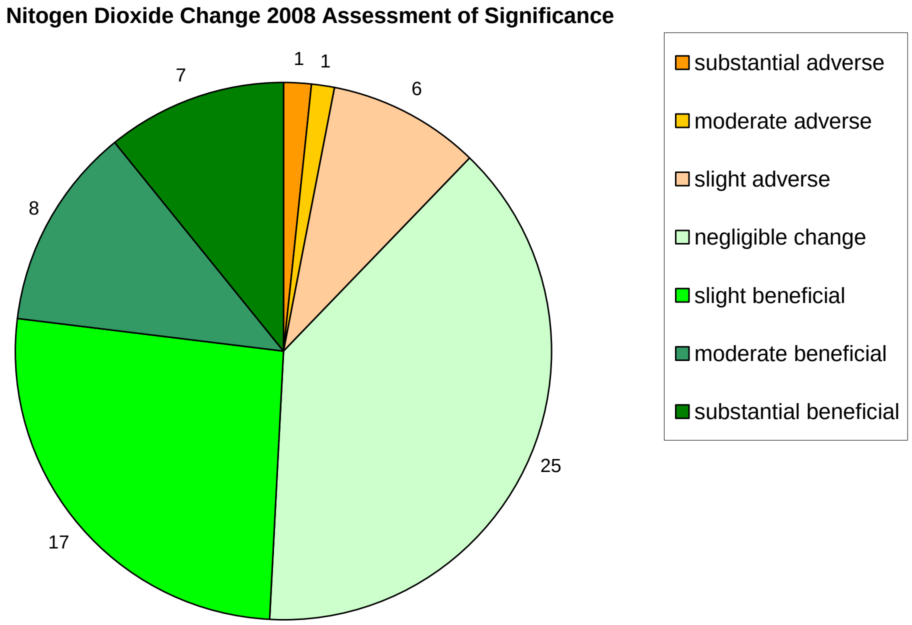
In 2008 ten tubes or 15% show an increase. This includes seven monitoring sites that indicate a perceptibly small rise of less than 5% or 2 μg/m³. However a number of tube localities that demonstrate change; up or down continue to record concentrations considerably below the AQS limit value. Our commonly quoted "> 80% show improvement" (or 15% show increase) does not take into account how high the recorded concentrations are relative to the limit value.

In 2008 Thirty-three diffusion tubes (51%) in Brighton and Hove record concentrations less than 36 μg/m³ (= 90% of the NO_2 objective). Small or moderate changes in concentrations <10% are deemed to be negligible where the monitor continues to record concentrations below 36μg/m³. Small changes < 5 % (up or down) are considered to be negligible where the monitor continues to record concentrations less than 40μg/m³. If this is taken into consideration the magnitude of change that happened during 2008 can be characterised as follows:

Table 4-4 Nitrogen Dioxide characterised change from 2007 to 2008

Category	Tally of changes assessed as true impact
substantial adverse	1
moderate adverse	1
slight adverse	6
negligible change	25
slight beneficial	17
moderate beneficial	8
substantial beneficial	7

Figure 4-2 Degree of significance in the change of Nitrogen Dioxide



The distribution shows that approximately half of the monitors show a significant improvement during 2008 compared to previous year. At the same time many sites continue to record NO_2 levels below 40µg/m³, below the target level small or moderate changes can be characterised as negligible.

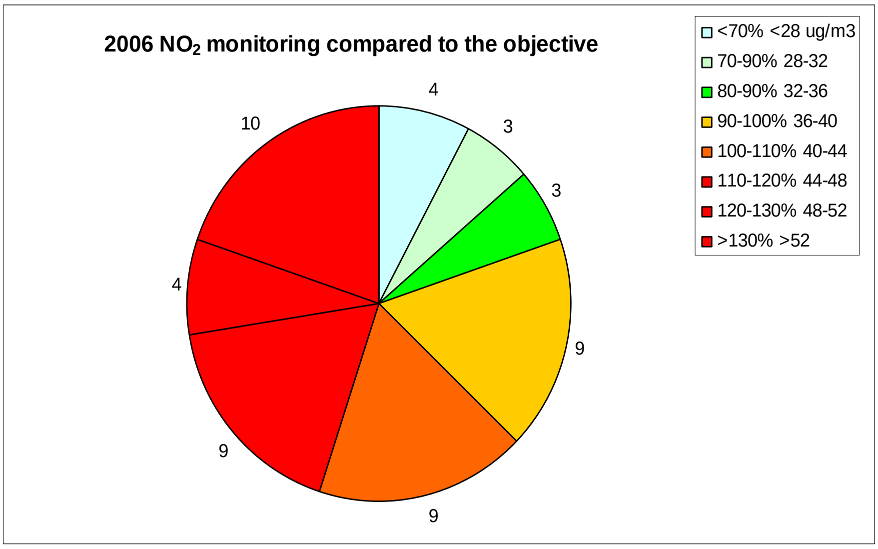
If we compare the 2008 concentrations with the objective at 10% increments the following pattern is observed:

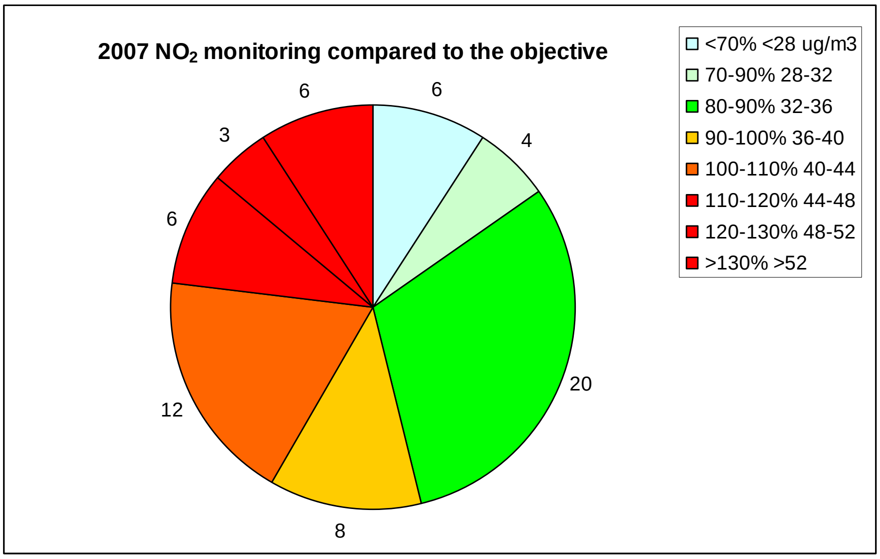
Table 4-5 Recorded concentrations of NO_2 characterised and compared to the objective

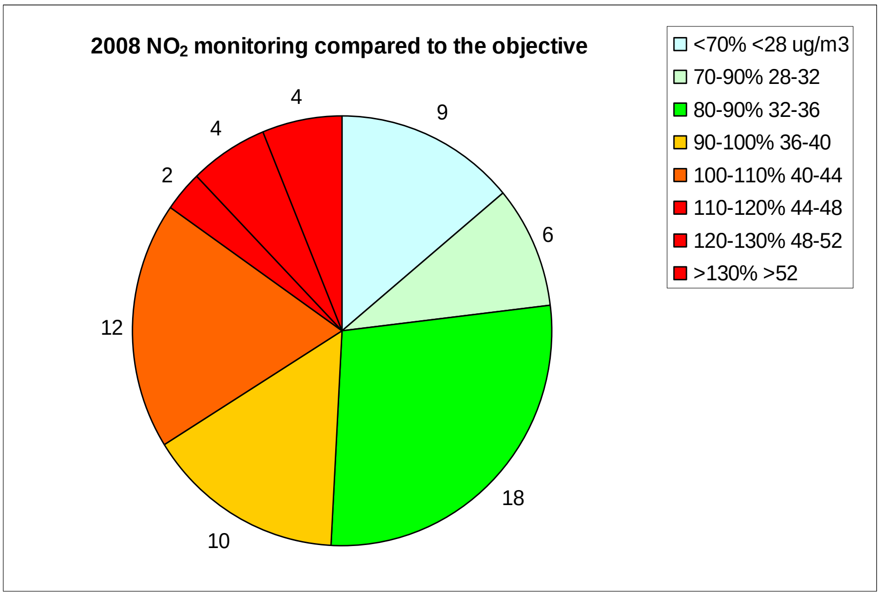
2008 µg/m³ (bias corrected)	Percentage (%) of AQS = 40 µg/m³	Count in Category
<28	<70	9
28-32	70-80	6
32-36	80-90	18
36-40	90-100	10
40-44	100-110	12
44-48	110-120	2
48-52	120-130	4
>52	>130	4

In 2008, 22 NO_2 diffusion tubes and one continuous analyser continued to exceed the objective. This compares favourably with previous two years as follows:

Figure 4-3 NO2 Diffusions Tube Monitoring compared to the AQO 2006-2008







The following sites show a substantial or moderate increase during 2008 and continue to record NO_2 concentration above the objective:

- North Street Facade
- Hill climb Old Shoreham Road, Prestonville Terrace Facade

Pollutant concentrations recorded on North Street in 2008 are considerably better than those recorded in 2006. Air Quality in the Old Shoreham Road (adjacent to New England Road) is likely to be influenced by light vehicles as they accelerate up the hill. At this site the carriageway is in close proximity to a row of terraced houses and the section of road is not frequented by busses.

Further more the following sites continue to record concentration above the objective and demonstrate a small increase during 2008:

- St James Street Façade near to Manchester Street
- Lewes Road Façade near to the Lectern PH
- Lewes Road Façade South of the Vogue Gyratory
- York Place Roadside (A23 Northbound)

These monitors occur with the AQMA within one area of exceedence. Counting the listed monitors as separate zones is highly misleading.

Hollingdean Road, Elm Grove, Ditchling Road, and all background sites demonstrate sustained improvements over a number of years.

It is recommended that roadside sites that record concentrations below 32 $\mu g/m^3$ during 2009, cease from January 2010 as resources will be better directed elsewhere.

The minority areas that do not show improvements will be priority for the advanced air quality action plan (AQAP). The AQAP will also focus on the remaining area or areas that persist with concentrations of NO_2 between 40 - 60 $\mu g/m^3$ (annual mean).

5 New pollution inventory

5.1 About the EMIT Emissions Inventory

Utilising defra grant funds from previous years the council has purchased licence for the emission inventory software EMIT created by Cambridge Environmental Research Consultants (CERC).

The EMIT inventory is a versatile tool designed to feed data into the ADMS-urban dispersion model (explained in section 6) and the council has authorisation to use both tools to October 2011. EMIT is a database tool (similar to Microsoft access) for organising emissions data from a variety of pollution sources. The Brighton EMIT inventory holds emissions for; road, commercial, domestic and industrial sources. The domestic and commercial sources of NOx are too small to be considered individually; therefore they are amalgamated over1km squares throughout the area of interest. Detailed traffic count data has been imported to the inventory and this is used to calculate emissions from all the modelled road links in the AQMA and adjacent to it. The calculated emissions are presented in 13.10 and 13.11.

5.2 FRA emissions Methodology

5.2.1 Rural Background

Hypothetically speaking if there were no pollution releases in the whole of the Brighton area, there would still be an outdoor concentration of Nitrogen Dioxide above zero. This ambient level is referred to as the Rural Background (RB) and comprises NOx (or any pollutant) from:

- Naturally occurring sources
- Other areas and regions

A good measure of the Sussex rural background level is the concentration of any pollutant that can be detected on the top of the South Downs and defra's rural monitoring network includes an automated analyser at Lullington Heath near Beachy Head. In 2008 the annual average NO_2 recorded at this site was: 10 $\mu g/m^3$ [7]. This is equivalent to the lowest concentration that we might expect anywhere within the bounds of BHCC, including the highest point at Ditchling Beacon. Lower ambient concentrations can be found further from human activity for example annual mean NO_2 in remote parts of the Highlands of Scotland[8] is typically 2-6 $\mu g/m^3$. All emissions of NOx in the Brighton area are added to the Sussex rural ambient concentration. The RB is approximately equivalent to 25% of the long-term AQO. As an attempt to estimate the real-world the dispersion model always includes the rural background concentration as a proportion of the total pollutant concentration at any given location.

5.2.2 Commercial Domestic and Industrial Sources

Referred to as CAND (Commercial & Domestic) these sources are imported to the inventory as a series of area sources in 1km^2 grid form, expressed as NO_x tonne/ km^2 yr. For the purposes of the FRA assessment this must cover a larger domain than the AQMA and the modelled roads. It is expected that emissions outside of the AQMA for example the Shoreham Power Station and other commerce in the port area will make a small contribution to ambient concentrations within the AQMA. In total 70 km^2 CAND either side of the

[7] Rounded to the nearest 1 ug.m3
[8] Remote monitoring archive Strathaen, Scotland http://www.airquality.co.uk/find_sites.php

boundary with Adur DC have been taken into consideration with the assessment. The commercial and domestic emissions are added to the rural background and together their combined ambient concentration can be described as the urban background level. Urban background excludes the emissions from roads described in the next section. In suburban parks and gardens and other areas more than 100-200 metres from main roads the pervading pollution concentration will be almost entirely urban background (due to RB+CAND). Whilst the rural background is constant over the area the urban background varies considerably. That said a typical value in the Brighton urban area, (remote from the influence of chimneys, kitchens and boiler flues) is 20 $\mu g/m^3$, equivalent to 50% of the relevant AQO or double the Sussex background.

5.2.3 Road Sources

All road emission used with the FRA have been derived from traffic survey counts as depicted in Figure 2-1. The most busy roads associated with the AQMA (either within the area or adjacent to it) have been drawn in detail using Arv View- GIS (Geographical Information System). For the 2010-FRA, 220 digitised road links are included. Each road link has at least two specific grid referenced locations known as nodes and curved sections tend to have a more complex road geometry, typically with several node points. The road links are imported from Arc View into EMIT. Each road link is unique. In addition to its geometry and length each linear road source has the following variables:

- Width
- Counts of Traffic expressed as AADT (Annual Average Daily Traffic) equivalent to the typical flow of vehicles for a representative 24-hour period in the year, this tally is made up of 11 category counts of various light and heavy vehicles
- Average speed of the flow

These parameters are used by EMIT to calculate the emission of NO_x per km of road per/ second. Slower speeds and higher counts of heavy vehicles increase the road's total release of NO_x. The rates of emission are derived from the Highways Agency's DMRB (Design Manual Road and Bridges) 2003 method and the LAEI (London Atmospheric Emission Inventory) 11 vehicle categories have been used. The LAEI-11, has the following eleven vehicle categories for road sources as follows:

- Motorcycles
- Cars
- Taxis
- Busses and Coaches or HPV (Heavy Passenger Vehicles)
- LGV (Light Goods Vehicles)
- Rigid HGV (Heavy Goods Vehicle) 2 axle
- Rigid HGV 3 axle
- Rigid HGV 4+ axle
- Articulated 3+4 axles
- Articulated 5 axles
- Articulated 6+ axles

5.3 Traffic Survey Methodology

Detailed collation of the traffic surveys is key to a sensible calculations of traffic emissions by EMIT. The process was started with a working trace presented in section 13.3. It establishes the location of all the traffic surveys. The LAEI Inventory (11) method was selected as it has the advantage of being able to analyse the various traffic flow constituents in more detail, compared with the alternative three way split i.e.; heavy, light and motorcycle. The LAEI-11 makes the valuable distinction between Heavy Passenger Vehicles (HPV) and HDV. This enables the FRA to achieve one if its key objectives which is source apportionment i.e. what percentage of pollution that is derived form emissions from certain source categories. In order to calculate emissions with the LAEI-11 method all traffic data must be imported to EMIT with a flow for each of the eleven vehicle categories at all the modelled road sections.

In Brighton there are two main types of traffic survey available for use with the FRA:

- Continuous automated counts at a point, measured by a weight sensitive strips across the carriageway
- Linear Manual 12-hour surveys for two-way and one-way streets
- Manual turning counts at junctions as 12-hour traffic survey

5.3.1 Automated Traffic Surveys

Automatic survey locations presented in section 13.4 and listed in 13.8. They are continuous throughout the year and only require minor adjustment for vehicle category in order to be used in conjunction with EMIT. Auto counts are available for the modelled year; 2008, however they are not available for all roads and junctions in the area of interest. Two relevant rings of auto counts are the inner-cordon and outer-cordon and where possible automated traffic data is fed into the FRA model in order to predict roadside air quality.

5.3.2 Manual 12-hour Traffic Counts

Manual count locations are presented in the map section 13.5 and 13.6 and listed in section 13.9. They are widely available, for one-off 12-hour periods; 7:00 AM to 19:00 on a specific date. The manual counts are normally taken on a weekday; Tuesday to Thursday and avoid major events and holiday periods such as August and Christmas which may provide an unrepresentative count of the normal traffic flow. If deemed representative and applicable to the FRA the 12-hour manual surveys require a number of adjustments so the data can be utilised with 11-category imports to EMIT. The adjustments are complex and as follows:

- Any surveyed counts for Pedal Cycles must be subtracted from the traffic totals, it is essential that bicycle counts are not mistaken for light vehicles (as a NO_X emissions is assigned to any light or heavy vehicle data imported to EMIT)
- 12-hour traffic surveys must be adjusted to 24-hour counts to provide an AADT equivalent as Table 5-1
- Archive surveys taken in previous years (2002-2007) must be adjusted so they are representative of the model year (2008)
- No traffic survey counts are available for taxis so for each road an assumption (based on local knowledge and observation) is made on the percentage of cars that are taxis
- The traffic survey counts often include ridged plated and rigid unplated trucks and articulated lorries, but not all six HGV axel categories demanded by the LAEI-11, therefore a national percentage as Table 5-2, is applied to the sum of articulated and rigid lorry counts for each traffic survey
- Survey counts for minibuses are added to the LDV (Light Duty Vehciles) total
- Turning junction counts like the ones presented in section 13.7 contain a lot of valuable information regarding traffic flows entering and leaving the junction, in order to utilise this information the turning carriageways from the junction are summed to establish multiple vehicle category flows for the road lines entering and leaving the junction

Table 5-1 shows the ratio of 24-hour traffic to 12-hour flows in various part of the city. These ratios are derived from the continuous traffic surveys and can be applied to the manual 12-hour counts in order to provide a full diurnal count (including nighttimes) at locations where there are continuous surveys.

Table 5-1 Applied factors used to convert 12-hour traffic survey to a 24-hour equivalent count

Auto No	Road or Street	Traffic Survey Category							
		MC	CAR	LGV	RUP	RP	ART	BUS	MB
05	OSR	1.3481	1.2102	1.1750	1.1404	1.1404	1.2299	1.2667	1.0541
22	Wellington	1.2426	1.2386	1.4048	1.1064	1.1064	1.1186	1.1625	1.0435
800	Kings	1.4551	1.3162	1.1943	1.1827	1.1827	1.1818	1.1636	1.0400
802	Western	1.3	1.5701	1.1091	1.1131	1.1131	1.1273	1.3105	1.0000
807	Buckingham	1.1633	1.3618	1.3448	1.3130	1.3130	1.3030	1.4659	1.3953
811	Ditchling	1.2830	1.2469	1.0909	1.0988	1.0988	1.3333	1.1256	1.2381
813	Lewes	1.2772	1.2890	1.3455	1.1628	1.1628	1.1379	1.4295	1.3040
823	Edward	1.1921	1.2942	1.1354	1.1993	1.1993	1.0556	1.2944	1.3214
824	St James	1.2143	1.4303	1.0000	1.0000	1.0000	1.2500	1.2453	1.4000

Key: OSR Old Shoreham Road, MC Motor Cycles, LGV Light Duty Vehicles, RUP Rigid unplated lorry, RP Rigid plated lorry, ART Articulated lorry, MB Minibus

It is apparent that in the centre of Brighton on Western Road for example night time counts of cars (including taxis) are a significant addition to the 12-hour day time tally (*1.6). This is what we might expect given Brighton's active night time economy and the high density of licensed premises operating between 19:00 and 7:00. A standard 12-hour traffic survey without an applied 24-hour ratio would miss the night time traffic flow. Night traffic is likely to be a significant addition to the total pollutant budget given that air flow, atmospheric stability and photochemistry behave differently at night. A judgement has been made regarding which 12 to 24-hour ratios to apply where only manual counts are available. For example Wellington Road factor is most appropriate for the A259 and adjoining roads in Portslade, whilst the Western Road ratio is more representative of the commercial area in the city centre. Night busses travel along Lewes Road to the universities and this accounted for in both automated and adjusted-manual traffic counts.

5.3.3 Adjustment of Archive Traffic Surveys

In order to use past traffic surveys a factor of 1% increase has been applied year on year to all the vehicle categories. This is consistent with BHCC last Detailed Assessment in 2007 and the do-nothing assumptions cited in LTP2. It is likely to be a fair approximation for the period 2002-2007 i.e. the period that the archive surveys are adjusted for use with the 2008 model. Any traffic surveys taken during 2009 were note adjusted backwards to 2008 in accordance with the LAQM guidance, TG 09. The manual archive surveys compliment the recent manual and automated counts from 2008 and 2009 and provide a much improved geographical coverage.

5.3.4 Heavy Vehicle Proportions

Emissions calculations for road sources are based on the type of vehicles including six sub classes for HDV. As the Brighton and East Sussex CC traffic surveys do not include all the axle categories for HDV the following proportions supplied by CERC were applied to the tallies of rigid and Articulated Lorries. The subtotals of rigid and articulated HGV add up to 100%.

Table 5-2 Proportional breakdowns of Rigid and Articulated HGV

Heavy Duty Vehicle Percentages	Axle Category % of Rigid and Artic
Rigid HGV (Heavy Goods Vehicle) 2 axle	76%
Rigid HGV 3 axle	11.5%
Rigid HGV 4+ axle	12.6%

Articulated 3+4 axles	18.7%
Articulated 5 axles	39.7%
Articulated 6+ axles	41.7%

5.3.5 Other Factors Influencing Road Sources

Furthermore some of the road links include information relating to:

- Slopes – either flat (85.5% of road links) or with a gradient for roads on hills (14.5 % of modelled road links)
- Street Canyon – roads in the model are included either with no street canyon (82% of road links) or with street canyons parameters (18% of road links; discussed further in the next section)

Mini street canyons flanked by building on both sides will influence pollutant dispersion, but not the calculated emission. Slopes will have some influence on the emissions from vehicles, that is to say engines in load on hill climbs will produce higher emissions rates compared with vehicles travelling on flat roads.

Table 5-3 Road Links with gradients and traffic hill climbs

Link ID	Street	Traffic Survey Count ID	Road Width (m)	Gradient Slope %	Modal Speed (kph)
77	Vernon Denmark and Montpelier Road	M4359	9	7	35
78	Dyke Road north of Seven Dials slow	M4355	11	7	15
83	Chatham Place Intermediate	M4356	8	8	35
84	Chatham Pl nr to junction with OSR-NER	M4356	8	7	10
85	NER under bridge uphill to Chatham Pl	A74/2	10	6	15
87	OSR under bridge to join NER	A74/2	7	7	10
91	Dyke Rd Buckingham Rd to Landsdown	A_806+2 bus	9	6	30
92	UNS and Regent Hill	2 bus plus	14	9	15
93	UNS to North Street	4 bus plus	11	7	10
95	Terminus Road Bath St to Railway St	M4573	8	7	30
96	Termimus Road Railway St to Guildford St	M4573	11	6	20
100	Upper Gloucester Road	M4543_4	10	10	20
102	Queens Road Station to Quadrant	M4543_1	0	6	10
105	Queens Road Air Street to Clock Tower	M4544_3	10	7	15
118	Stamford Av Beaconsfield to 5 ways	M4847_4	12	7	35
119	Stamford Av northbound by traffic island	M4847_4 / 2	6	7	35
121	Stamford Av Preston Rd to island	A_810	12	5	30
127	Viaduct Road to Ditchling Road slow	M4577	8	4	10
138	Fleet Street Cheapside	Pelaham DA	20	6	20
141	Trafalger Street	A_711+bus	10	9	20
143	Queens Road Quadrant	A_711+bus	7	6	10
144	North Road east end	M4548_4	12	6	15
145	North Road west end	M4544_2	13	6	25
152	Church Street New St to Portland St	M4897_1	8	6	10
154	North Street from Clock Tower	M4406_3	20	7	15
155	North Street Windsor to Ship St	M4406_3	22	7	20
156	North Street Ship Street to East St	M4406_1	18	5	25
202	Bear Road nr VG to past Bevendean Rd	A_814	9	10	40
201	Bear Road near to Vogue Gyratory	A_814	7	7	20
206	Elm Grove MIton Rd to Queens Park Rd	A_817	10	8	40
205	Elm Grove Lewes Rd to Milton Road	A_817	12	8	25
209	Edward Street & Eastern Road	A_823	14	8	30

NB: the gradients are calculated from the road heights on the Ordinance Survey. The digitised road links are viewed in conjunction with base maps in Arv View GIS. OSR, Old Shoreham Road; NER, New England Road; VG, Vogue Gyratory.

5.4 EMIT calculated emissions

Using the methods discussed in this section an emission rate has been derived for commercial and domestic sources over 70 km^2 expressed as tonne NO_X / per 1km^2 per year. Road source emissions of NO_X and NO_2 have been calculated for 220 distinct road links and emissions are expressed as grams / per km of road length / per second. Table 5-4 shows the road links with the highest emissions in the model area (top 15 percentile).

Table 5-4 FRA Model Road Links Top 15% by NO_x Emission

Link ID	Street Name	Cars + Taxis	Bus	Total HGV	Total LDV	Emission NO_X g/km/sec
71	Churchill Squ to Lower Dyke Rd	5712	3265	242	828	0.49
72	Lower Dyke Road to Clock Tower	5712	3265	242	828	0.49
157	Castle Square East Street to Old Stiene	6228	3265	269	946	0.40
154	North Street from Clock Tower	5712	3265	242	828	0.39
98	Queens Road North Taxis into Station	9346	721	182	811	0.38
165	Old Stiene Grand Jct to Castle Squ	24189	2500	961	3583	0.38
155	North Street Windsor to Ship St	5712	3265	242	828	0.34
160	Pavillon Parade Old Stiene to Edward St	24189	2500	961	3583	0.32
51	OSR east of Sackville jctn slow	21085	258	849	3498	0.31
156	North Street Ship Street to East St	6228	3265	269	946	0.31
50	Sackville to OSR nr junction slow	31323	230	970	4188	0.29
44	Kingsway west of Hove st	24094	204	1184	3829	0.28
6	OSR_East of Lock Hill Slow	23475	239	1080	3889	0.28
40	Kingsway west of junction with Wharf Rd	18776	259	1505	3443	0.26
161	Pavilion Parade Edward St to Grand Pde	19882	1443	756	2569	0.25
102	Queens Road Station to Quadrant	9346	721	182	811	0.25
48	Sackville Rd Blachington to Firth	31323	230	970	4188	0.25
187	Lewes Rd Edinburgh to Vogue Gyratory	15871	1136	720	3719	0.25
185	Lewes Rd north of Elm Grove Jnct slow	17697	1035	775	3181	0.25
20	Wellington Road btn Church and Boundary	18647	402	1469	3479	0.24
146	Gloucester Place North Road to York Place	18908	2054	751	2420	0.23
60	Kingsway east of Hove St slow	25392	187	1083	3828	0.23
42	Kingsway east of Wharf Rd slow	18218	204	1502	3923	0.23
75	Kingsway from Metropole to West Street	31468	64	698	1591	0.23
8	OSR Slow West of Hangleton Link	27275	342	858	1601	0.22
186	Lewes Rd Gladstone to Edinburgh	15871	1136	720	3719	0.22
136	London Rd Oxford St to St Peters	20481	1160	622	1299	0.22
163	Grand Parade Church Rd link	14536	871	622	3455	0.21
74	Kingsway from Montpelier to Metropole	31468	64	698	1591	0.21
151	Church Street Marlborough to New Rd	14073	1013	603	1729	0.21
19	Wellington Road Portslade W of Church Rd	18647	259	1469	3479	0.21
55	Church Rd nr junction with Hove St	15197	1269	292	2012	0.21
62	Kingsway at jctn with Grand Av	25392	187	1083	3828	0.21

6 Dispersion Model Methodology

6.1 Aims of the Model

Also using defra's LAQM grant funds from previous years the council has purchased a three year licence for the ADMS-Urban dispersion model created by Cambridge Environmental Research Consultants (CERC).

This Further Assessment is the first opportunity to apply; EMIT, ADMS-Urban and Arc-View to predict air quality throughout the larger Brighton and Hove AQMA. This chapter outlines the approach used with the dispersion model in order to establish the validity of the 2008-AQMA. The model has multiple aims and objectives in support of the advanced FRA as follows:

- to map the area of exceedence. This entails establishing in detail the extent of the 40 $\mu g/m^3$ contour throughout the new AQMA.
- Estimate Nitrogen Dioxide throughout the expanded AQMA including predictions at a number of locations that do not have monitoring
- Provide detailed source apportionment at a number of worse-case locations within the AQMA

6.2 About ADMS-Urban

6.2.1 Introduction to ADMS Urban and Dispersion

ADMS-Urban is a comprehensive version of the Atmospheric Dispersion Modelling System (ADMS) it is a computer-based model that estimates dispersion in the low altitude atmosphere. The concentration of pollutants (mass per volume of air i.e. xg/m^3) released to air from; exhaust-pipes, chimneys and flues substantially drops away from the point of discharge. Therefore it is essential to understand that an emission is very different to an ambient concentration in the surrounding environment i.e. the air that people inhale. The dispersion model predicts what will happen to the emission in the environment before it reaches sensitive receptors such as residential dwellings. Dispersion assessment is relevant to local air quality and is applied to pollutants harmful to human health when inhaled. It is not applicable to the emission of green house gasses which add to the atmospheric carbon budget of the northern hemisphere.

ADMS-urban can asses the dispersion of an emission from a linear, area, point, volume or grid source. The model can process the most complex scenarios where multiple industrial, domestic, commercial and traffic emissions occur over a large area.

6.2.2 Model Validation

ADMS predictions have been validated by comparison with field, laboratory and numerical data sets. The model has been compared with other dispersion systems such as US Caltrans, CAKINE4 and DMRB[9]. A study by HMIP (Her Majesty's Inspectorate of Pollution; now process industry regulation at the Environment Agency) compared ADMS with LIDAR (Light Detection and Ranging; laser used for scanning airborne pollutants). Furthermore model predictions have been compared with automated monitoring data in a number of UK cities. The street canyon model used within ADMS-urban and this FRA is based on the Danish traffic model OSPM which has been independently verified.

[9] ADMS-Urban User Guide

6.3 Model year and future estimations

The model assesses dispersion over every sequential hour of the calendar year. 2008 is the year of choice for the FRA for the following reasons:

Since Nitrogen Dioxide monitoring commenced in the mid-1990s, BHCC recognises that locally 2008 had the lowest NO_2 concentrations. Therefore it deemed likely that the 2008 baselines will be a fair estimation of how air quality will be for the period 2011-2014 either as a typical year or as a worse-case scenario. In recent years it has been found that dispersion models have a tendency to under estimate future pollution concentrations. For example ADMS prediction of how air quality could be in London for 2009/2010 made in 2004 actually turns out to be less than the level now being monitored. Therefore at this time future model predictions have not been carried out. Updates to the national emissions inventory are due shortly and it is hoped this will enable more realistic predictions of air quality for 2015 and beyond.

The emissions inventory (used in conjunction with ADMS) assumes an anticipated uptake of cleaner vehicles in future years for example some percentage replacement of pre-Euro, Euro-I and Euro-II emissions categories with cleaner Euro-V and VI type. In reality there is a fair probability this will not happen at the previously anticipated rate because:

- The economic downturn will influence private and public cost cutting and reduce capitol investment in new vehicle technology
- A greater proportion of diesel in urban fleets increases NO_x and primary NO_2 emissions, and in air quality terms this could counter balance the benefits of improved efficiency and this is difficult to predict for future years

6.4 Model Methodology

This section outlines the FRA-model choices that together went onto estimate Nitrogen Dioxide for 2008 throughout the AQMA and its surroundings. The model predictions will be influenced to varying degrees by the variables discussed in this section. Emissions have been calculated by EMIT and are derived from the density of commercial and domestic sources in combination with the flows of traffic.

6.4.1 Latitude

The decimal latitude has been selected at 50.8 to represent Brighton. The model calculates the height of the sun for each hour and day and the degree of solar radiation has some influence (in combination with other variables) on atmospheric stability and vertical convective turbulence and hence dispersion of pollution.

6.4.2 Surface Roughness

Surface roughness is a measure of the height and density of obstacles on the earth's surface that may disrupt the flow of air, near the ground by creating mechanical turbulence. Laminar air flow (in the absence of convective turbulence) is more likely over a plain surface such as; ice, sand or short grass and these surfaces have a low surface roughness index (m). A surface roughness of 1 m is has been assigned to Brighton in the FRA model and 0.2 m to represent the meteorological station at Shoreham Airfield.

6.4.3 Monin-Obukov Length

The Monin-Obukov length provides a measure of stability in the atmosphere. It is possible that Brighton may have a small urban heat island effect which could prevent the atmosphere over the city becoming truly stable or stratified. For many hours of the year convective turbulence will be more influential than mechanical friction. The Monin-Obukov length used to representative Brighton in the FRA-model is: 50. This value represents the entire coastal conurbation; an area of half a million people.

6.4.4 Primary NO_2 emission

In accordance with the LAQM tool[10] primary NO_2 emissions have been calculated as 17% of total NO_X emissions for all traffic category sources in the Brighton FRA-model. Emissions calculations based on the traffic data in EMIT were exported to GIS and the primary NO_2 manually amended and then imported back to EMIT. In recent years changes to vehicle technology and penetration of diesel into the fleet have seen an increase in the ratio of NO_2 to NO emitted from vehicles in recent years. This could have repercussions for kerbside and near roadside concentrations of NO_2 as it takes some time and distance for NO emissions to convert to post-combustion NO_2 in the atmosphere. That said the majority of NO converts to NO_2 after the emission and not on board the vehicle during combustion or exhaust.

6.4.5 Modelling Chemistry

This is a facility within ADMS that calculates chemical reactions in the atmosphere between NO, NO_2, O_3, and VOC (Volatile Organic Compounds) in the presence of ultra violet radiation form the sun. All model predictions used in support of the FRA use the chemical reaction scheme. The method uses a generic sequence of photochemical reactions. The background data, cloud cover and latitude entered into the model are used as variables during these calculations.

6.4.6 Street Canyons

The street canyon module in ADMS has been selected for streets within the AQMA that have multiple storey buildings on both sides in close proximity to the road carriageway. It takes account of additional turbulent flow patterns and air circulation in the near field i.e. within the enclosed street environment. Only predictions at locations within the street canyon are influenced by this model option. For road links characterised as street canyons are assigned a width of 1 to 2m more than the building edge to opposite façade is used in order to include receptors and monitoring sites that reside on buildings at the margins of the street canyon. In all 40 road links have been selected as street canyons in the FRA model and this is 18% of the total. Table 6-1 lists the model road links selected as “street canyons”. The model idealises the canyon’s form (not all the selected streets have equally tall walls on both sides) and this can increase the level of model uncertainty in street canyon environments.

Table 6-1 Road Links selected as Street Canyons

Link ID	Street	Traffic Survey Count_ID	Road Width (m)	Canyon Height (m)	Modal Speed (kph)
12	Trafalger Rd to Shelldale Rd	M5171_3	15	10	25
16	Vale Rd East westbound only	A_603 /2	20	10	30
17	Denmark-Franklin Road Eastbound	A_603	20	10	10
18	St Andrews Road Portslade	A_602	23	10	20
21	Boundary Rd north of Kingsway	22B_1	23	14	20
22	Boundary Rd / St Andrews to NCRH	22B_1+bus	25	14	20

[10] Local Authority primary NO_2 emission calculator; http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

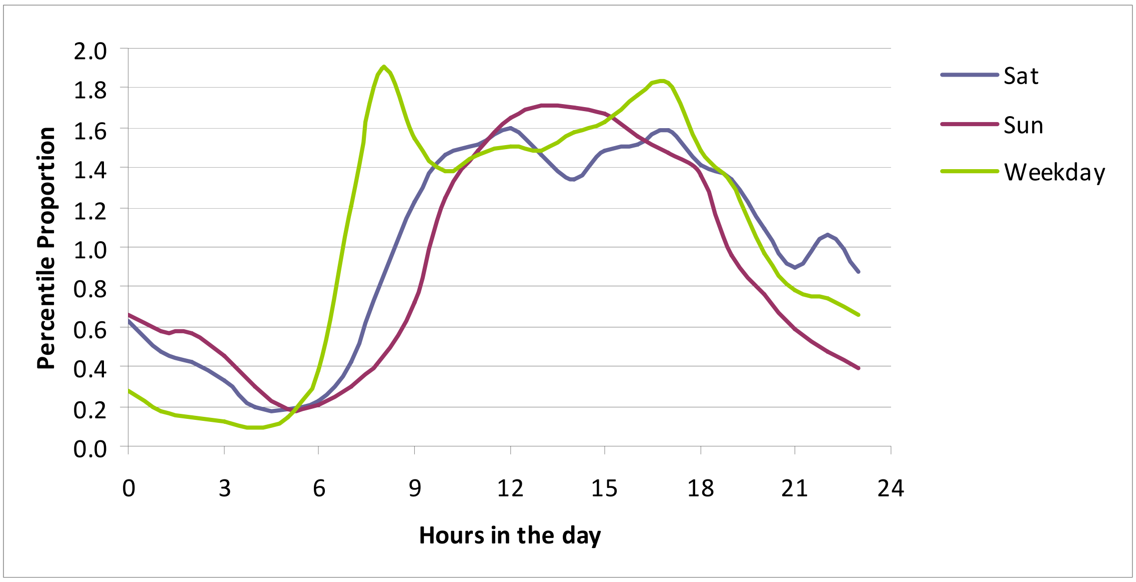
23	Station Rd between NCRH & Portland Rd	22B_1+bus	25	14	20
53	OSR Prestonville to NE Rd	77B_1	15	10	15
55	Church Rd nr junction with Hove St	M4795_4-bus	22	20	15
69	Western Road Holland to Montpelier	M4158	19	25	25
70	Western Road Montpelier to Churchill Sq	M4572	20	25	20
92	UNS and Regent Hill	2 bus plus	14	12	15
94	Montpelier Terrace & UNS to Regent Hill	A_803	15	15	25
96	Termimus Rd Railway St to Guildford St	M4573	11	7	20
100	Upper Gloucester Road	M4543_4	10	12	20
101	Buckingham Road from UGR to Dyke Rd	M4543_4	19	16	25
103	Queens Road Quadrant to North Road	M4543_3	21	15	20
104	Queens Road North Road to Air Street	M4544_3	14	15	25
107	Preston Road north of Preton Circus slow	A_809	18	12	15
108	Preston Road northbound to Stanford Av	A_809	21	12	40
123	Beaconsfield Rd island to Preston Circus	A_810	20	10	20
126	Viaduct Road Intermediate	M4577	15	10	40
135	London Rd Preston Circus to Oxford St	A_50	22	15	25
136	London Rd Oxford St to St Peters	A_50+A5119	21	15	20
138	Fleet Street Cheapside	Pelaham DA	20	20	20
141	Trafalger Street	A_711+bus	10	10	20
142	Frederick Street	A_711+bus	14	15	20
144	North Road east end	M4548_4	12	14	15
145	North Road west end	M4544_2	13	12	25
152	Church Street New St to Portland St	M4897_1	8	16	10
153	Church St Portland Street to North St	M4897_1 / 3	5	11	15
154	North Street from Clock Tower	M4406_3	20	20	15
155	North Street Windsor to Ship St	M4406_3	22	18	20
156	North Street Ship Street to East St	M4406_1	18	18	25
158	East Street taxi area	taxi estimation	20	18	15
170	Oxford St Ditchling to London Rds	A5219	14	12	15
185	Lewes Rd north of Elm Grove Jnct slow	M3973_1	20	20	15
186	Lewes Rd Gladstone to Edninburgh	M4575	23	23	20
187	Lewes Rd Edinburgh to Vogue Gyratory	M4575	23	23	15
215	St James Street	A_824 (6 bus)	15	18	20
216	Rock Gardens bus link	A_824 - (5bus)	25	18	25

NB: UNS, Upper North Street; NCRH, New Church Road Hove; NE, New England

6.4.7 Time Varying Emissions and Diurnal Profile

Emissions from sources (exhaust pipes and chimneys) can vary with the time of the day, week, month or season. In the FRA model a weekday and weekend diurnal profile is included for all road sources. The traffic emission is factored for each hour of the day with three distinct categories; Weekday, Saturday and Sunday. Figure 6-1 shows the 24-hour traffic pattern for the three day categories.

Figure 6-1 Brighton Traffic Representative Diurnal Profile



NB: Pattern taken from continuous traffic survey N° 800 on Kings Road

The diurnal profile takes account of the relative proportions of traffic at different times of the day and week. Pollutants emitted in the night will behave differently than those emitted during the day, partly because of chemical reactions in the presence of strong sunlight and also the influence of convective turbulence on dispersion. The pattern is derived from the 2008 continuous traffic survey on Kings Parade Brighton; the most heavily trafficked road section in the model area.

6.4.8 Meteorology

Hourly sequential data has been purchased from the meteorological office for the full 2008 calendar year from Shoreham airfield. The meteorological station is 5 km from the western boundary of the AQMA. The pattern of wind velocity (speed and direction) is presented in the windroses as thirty-six, 10° sectors. The FRA model uses 2008, however windrose patterns for six years from Shoreham-by-Sea are included for completeness.

Figure 6-2 Wind Velocity Patterns from Shoreham-by-Sea 2003 t0 2006

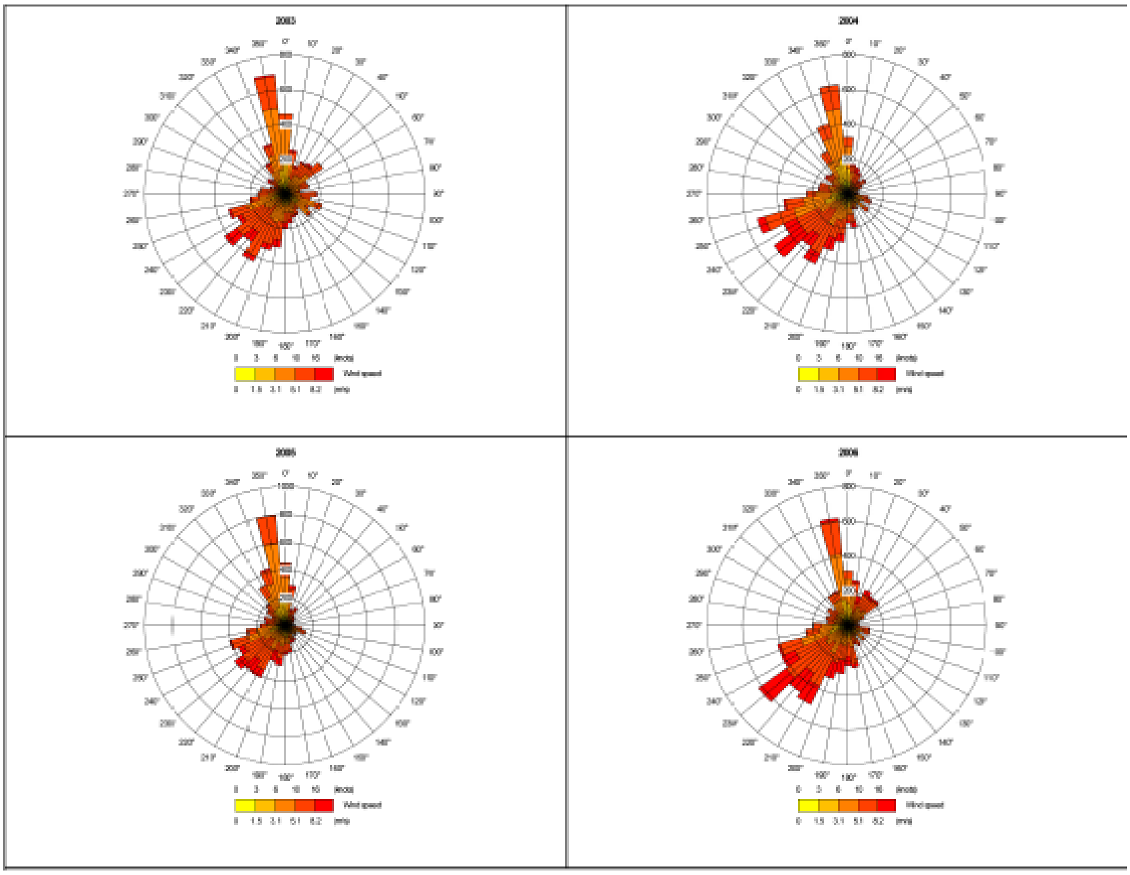
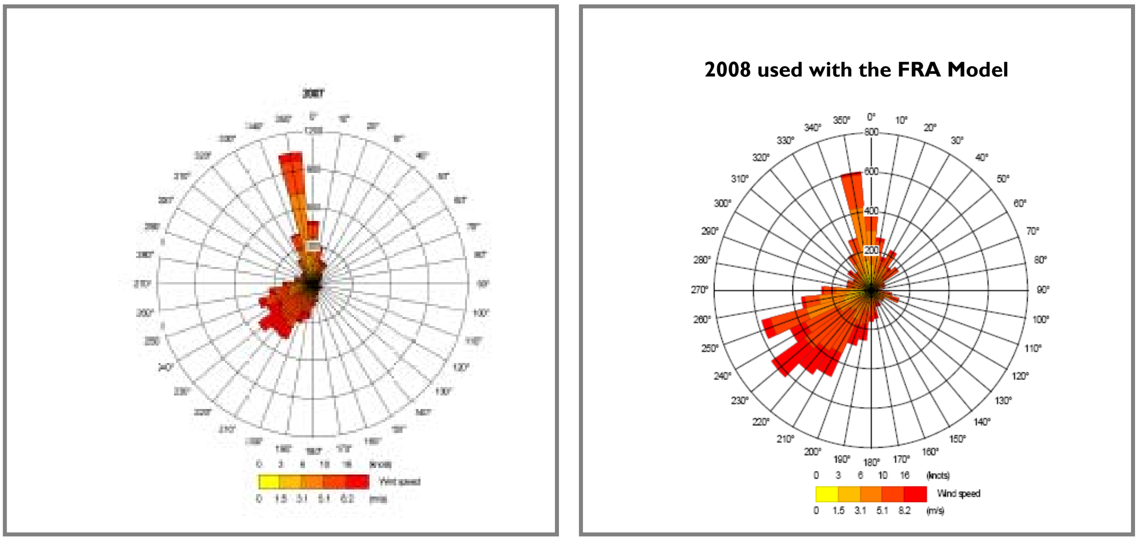


Figure 6-3 Wind Velocity Patterns Shoreham-by-Sea for 2007 and 2008



In ADMS the unrepresentative meteorological option has been selected. The land type surrounding the meteorological station is predominately short grass and estuary with a gap in the line of the Downs to the north. This contrasts with the Central AQMA which has a higher density of taller buildings and the Downland escarpment to the north. In order represent the different environments a Surface Roughness's (SR) of 0.2 has been selected for the meteorological site and SR value of I for the city.

6.4.9 Rural Background

Hourly sequential data has been downloaded from the AURN monitoring location at Lullington Heath in rural East Sussex on the South Downs. The annual mean background values are as follows:

Pollutant		**2008 annual mean µg/m^3**
Nitrogen Dioxide	NO_2	9.7
Nitrogen Oxide	NO	12.6
Ozone	O_3	59

The rural background for the region represents the lowest possible concentration of NO_2 in the onshore Brighton area. This NO_2 component is included in all FRA model predictions at kerbside, roadside-façade and urban-background (suburban and park locations). The hourly rural background data including ozone is essential as the model requires this data in order to simulate photochemical reactions and estimate the rate that NO_x emissions form NO_2 in ambient air.

6.4.10 Discrete Receptor Points

Fifty specified points have been selected at worse-case facade locations in close proximity (<10 metres) to modelled roads where there is no history of monitoring. The selected points are at:

- Residential houses and flats' roadside-façades
- Commercial façade locations where the general public are likely to be for more than an hour if concentrations risk exceeding 60 µg/m^3 NO_2 annual mean equivalent to concentration above the short-term NO_2 objective

The model estimates concentrations of the AQO at these locations. In addition the model predicts the AQO at all past and present monitoring locations. The model predictions at specified points are given in section 7.

6.4.11 Intelligent Gridding and Isopleth Output

The FRA uses the intelligent gridding option in ADMS to predict NO_2 concentrations in close proximity to the modelled roads. This option tells ADMS to add receptor points close to the road sources where pollution gradients are greatest. This enables a better resolution of contouring output where it is needed most i.e. adjacent to the road traffic sources. Contour plots are included for the whole area, Central Brighton and Portslade.

6.4.12 Air Quality Objective Output

The model predicts AQS AGO for Nitrogen Dioxide. Model predictions have been produced for:

- The annual mean,
- The hourly percentile equal to the hourly 99.78%ile in year or 19^{th} highest hourly concentration in the year as stated in the AQO
- The number of hours in the year that exceed 200 $\mu g/m^3$ a tally of 19 in the year is equivalent to an exceedence of the hourly AQO

The prediction is repeated at all past and present monitoring locations (continuous analyser and diffusion tube) and at all the specified receptors and intelligent grid locations. However this report concentrates on the annual mean objective which is key for defining compliance and exceedence with both the short and long-term.

7 Results of Dispersion Modelling

7.1 Model Choice

7.1.1 Prediction Locations

The Atmospheric Dispersion Model System, ADMS-Urban has been used to estimate Nitrogen Dioxide throughout Brighton at the following locations:

- Sensitive receptor points that do not have a monitoring history
- All continuous and passive monitoring locations; past and present
- Gridding points surrounding road sources over the entire modelling domain –utilised for creating resolved contour maps presented in appendix section 13.15 to 13.17

7.1.2 Model Year Justification

The model includes meteorology, traffic data and and monitoring from 2008. When the FRA was started 2008 was the most recent full calendar year with validated data. It is also the year of model choice for the following reasons:

Since Nitrogen Dioxide monitoring commenced in the mid-1990s, BHCC recognises that locally 2008 and 2009 are the best-case years for concentrations of NO_2. In all likelihood it is probable that roadside concentrations of NO_2 are lower now than at any time since the inter and post war years (1940 to 1948), when there was comparatively little traffic on the roads. In 1968 the problem of road traffic pollution is discussed by Dr Parker in the Medical Officer Report[11]. Assuming a do nothing scenario it is anticipated that 2008 concentrations will be a "typical or worse-case year", during the period 2011-2014.

7.2 Model Verification

7.2.1 Model Results Comparison with Monitoring Data

Table 7-1 compares modelled results with all available 2008 monitoring for both continuous analysers and passive diffusion tubes. In accordance with the technical guidance an adjustment has been made to the roadside NO_X component to achieve a closer agreement between the modelled and monitored concentrations. Without adjustment the model shows an excellent agreement with background monitoring throughout the AQMA.

Table 7-1 Comparison of Monitored and Modelled Nitrogen Dioxide

Site ID	Urban Background (Rural Level 9.7 µg/m^3 + Commercial Domestic)	Monitor total NO_2 2008	Modelled total NO_2	% Difference (modelled – monitored)/ monitored *100	Modelled NO_2 Roadside NO_x adjustment *1.94	Difference After Roadside NO_x adjustment
CA PP	**18.8**	**19.7**	**20.0**	**1.5**		
CA BH1	21.7	38.2	29.6	-22.4	43.0	12%
CA BH2	19.1	30.2	24.1	-20.2	31.7	5%
DT 02	18.9	42.3	25.9	-38.7	37.1	-12%

[11] Annual Report of the Director of Public Health, 2009 and Dr Parker's Medical Officer Report 1968

DT 03	19.1	30.2	24.6	-18.5	33.0	9%
DT 04	22.3	42.2	28.2	-33.3	36.7	-13%
DT 05	22.0	49.0	29.6	-39.6	41.1	-16%
DT 06	21.7	49.6	26.9	-45.8	35.3	**-29%**
DT 07	22.6	32.4	31.0	-4.2	43.6	**35%**
DT 08	22.0	40.3	30.0	-25.6	41.2	2%
DT 09	22.2	46.6	31.3	-32.9	44.5	-5%
DT 10	22.7	41.5	28.8	-30.5	37.4	-10%
DT 11	22.4	53.6	30.2	-43.7	42.0	-22%
DT 12	22.2	36.8	30.3	-17.8	42.1	14%
DT 13	22.1	41.7	34.9	-16.3	53.3	**28%**
DT 14	21.6	33.6	27.4	-18.5	36.7	9%
DT 15	21.8	27.4	24.7	-9.8	28.1	2%
DT 16	21.1	41.8	29.4	-29.6	43.1	3%
DT 17	21.3	48.0	27.4	-43.0	36.9	-23%
DT 18	21.2	38.9	29.6	-23.9	42.9	10%
DT 19	20.7	36.1	26.2	-27.5	35.0	-3%
DT 20	**19.6**	**18.9**	**20.8**	**10.3**		
DT 22	20.7	36.5	27.9	-23.5	39.8	9%
DT 23	21.4	38.9	29.0	-25.3	41.2	6%
DT 24	21.7	50.9	28.7	-43.6	40.1	-21%
DT 25	21.8	42.1	30.4	-27.7	44.0	4%
DT 26	**21.8**	**24.4**	**25.6**	**4.8**		
DT 27	22.0	40.0	30.0	-25.1	42.4	6%
DT 28	22.2	33.5	28.4	-15.2	37.2	11%
DT 29	20.8	39.2	29.9	-23.8	44.3	13%
DT 30	20.1	53.9	39.9	-26.0	66.0	23%
DT 31	19.8	43.1	24.7	-42.6	33.1	-23%
DT 32	18.7	40.9	24.5	-40.0	34.3	-16%
DT 33	19.5	36.0	23.4	-34.9	29.2	-19%
DT 34	20.3	32.1	25.9	-19.5	34.8	8%
DT 35	20.1	30.2	23.6	-21.8	29.8	-1%
DT 36	21.3	33.1	27.6	-16.7	37.1	12%
DT 37	22.6	33.4	31.0	-7.3	43.5	**30%**
DT 38	22.8	41.3	30.3	-26.7	41.1	0%
DT 39	19.8	35.2	28.0	-20.4	39.7	13%
DT 40	20.2	43.3	28.1	-35.0	39.2	-9%
DT 41	20.4	35.9	25.1	-29.9	32.8	-9%
DT 42	17.9	33.7	22.7	-32.5	31.0	-8%
DT 43	17.4	40.0	22.5	-43.8	31.6	-21%
DT 44	16.4	36.0	21.2	-41.2	29.4	-18%
DT 46	19.1	32.1	24.9	-22.5	34.3	7%
DT 47	19.1	30.3	24.9	-17.9	34.3	13%
DT 48	19.1	32.6	24.9	-23.7	34.3	5%
DT 49	20.6	34.9	26.2	-24.8	35.3	1%
DT 50	21.0	33.7	27.2	-19.2	37.5	11%
DT 52	19.7	31.9	26.8	-15.9	38.4	21%
DT 53	19.3	32.1	24.5	-23.5	33.2	3%
DT 54	19.1	25.8	23.3	-9.8	30.3	17%
DT 55	19.4	26.1	24.5	-6.1	32.5	24%
DT 56	**17.1**	**18.4**	**17.4**	**-5.2**		
DT 58	18.9	36.2	25.2	-30.4	36.6	1%
DT 59	19.9	38.2	29.8	-21.9	45.9	20%
DT 60	22.0	34.2	28.3	-17.3	38.7	13%
DT 61	19.1	36.7	23.1	-37.0	30.5	-17%
DT 62	**18.9**	**20.4**	**20.2**	**-0.9**		
DT 63	20.3	31.8	25.1	-21.0	34.0	7%
DT 65	21.0	33.6	28.5	-15.1	40.9	22%

DT 66	21.9	36.4	24.6	-32.3	28.2	-22%
DT 67	20.8	32.8	27.6	-16.0	38.5	17%
DT 68	20.4	28.2	25.6	-9.1	34.5	22%
DT 69	21.0	40.9	27.7	-32.4	38.4	-6%
DT 70	20.8	31.8	25.5	-19.8	32.7	3%
DT 71	21.0	25.8	26.6	3.1	35.7	**38%**
DT 72	21.0	26.6	24.1	-9.6	28.7	8%
DT 73	20.8	45.7	26.8	-41.4	36.4	-20%
DT 74	20.7	49.5	32.7	-33.9	50.9	3%
DT 75	20.7	40.0	35.0	-12.6	53.7	**34%**
DT 76	20.9	53.1	35.6	-33.0	55.0	4%
DT 77	21.1	60.2	42.5	-29.4	70.5	17%

CA, Continuous Analyser; DT, Diffusion Tube **Blue= Background Sites where roadside NO_x adjustment is not essential**
Bold = agreement between adjusted model and monitoring is not within +/- 25%

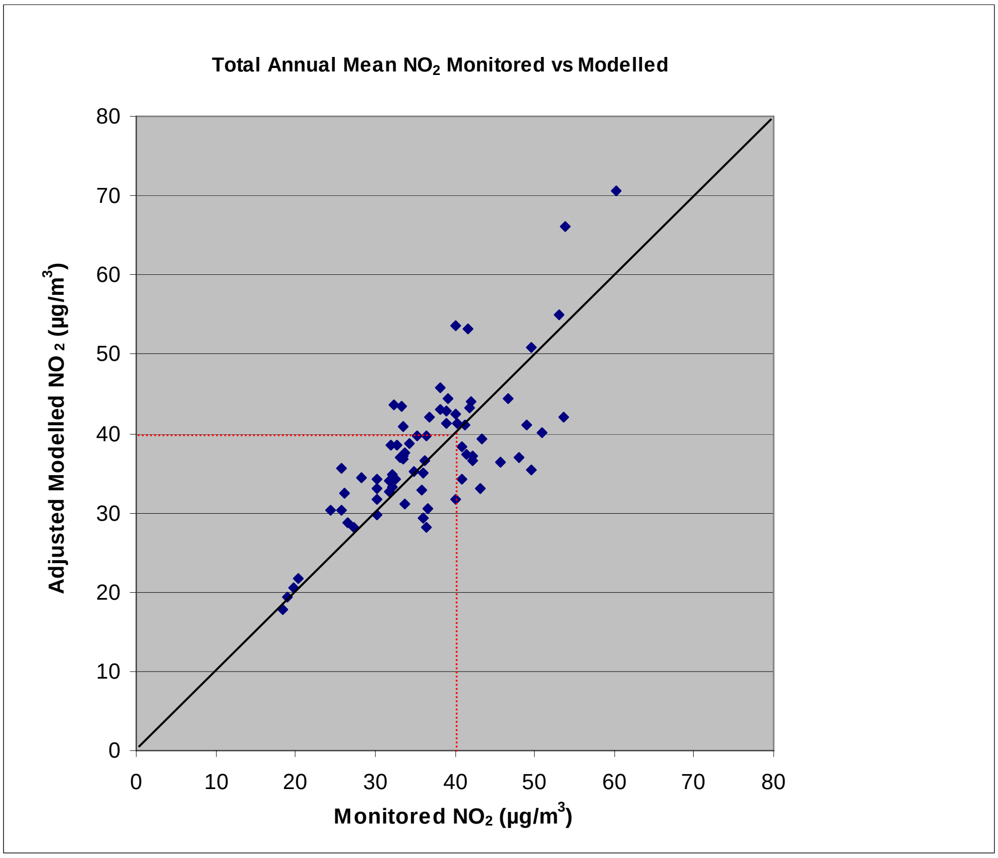
When roadside NO_x is adjusted and added to the urban background the level of agreement achieved with ambient NO_2 monitoring is given in Table 7-2 and characterised depending on the closeness.

Figure 7-1 presents the scatter of all monitoring points compared to the modelling predictions at the same locations, with the 40 µg/m³ AQO added as guideline.

Table 7-2 Summary of Monitoring and Modelling Agreement

Modelled Results compared to monitoring	Tally	Percentage
Within +10%	23	31.1%
Within -10%	10	13.5%
Subtotal Within +/-10%	33	44.6%
Within +25%	44	59.5%
Within -25%	24	32.4%
Subtotal Within +/-25%	68	91.9%
More than +25%	5	6.8%
More than -25%	1	1.4%
Subtotal More than +/- 25%	6	8.1%
TOTAL	**74**	**100.0%**

Figure 7-1 Comparison of Monitored and Modelled NO_2 following Modelled roadside NOx Adjustment



7.2.2 Model Adjustment

The full model Adjustment process is laid out in appendix section 13.14 and dispersion model contour plots follow at the end of this document. After adjustment 68 out of 74 or 92% of model predictions show a good agreement; within 25% compared to 2008 monitoring. The six sites that doe not show a fair agreement are discussed below.

7.2.3 Terminus Road and DT06

Model predictions on Terminus road under predict by 29%. This could be because the model does not sufficiently account for:

- Accelerating vehicles up the hill away from the station area
- Vehicles queuing at the lights on the downhill carriageway
- Close proximity of terrace houses to the kerb

7.2.4 North Road and DT07

The model over predicts by 35% compared to diffusion tube results at North Road in the North Lanes. In theory this is because:

- Lower North Road is a one way street and hence there are no emissions from vehicles travelling uphill. Uphill emissions are likely to be considerably more compared with the one-way lane rolling down-slope
- The street canyon influence on the dispersion of a lower emission rate is overestimated

This area of Central Brighton shows strong evidence of complying with the AQO over the last four years (2006-2009). Therefore monitoring has ceased at the site.

7.2.5 Oxford Place London Road and DT13

The model over predicts by 28% compared to the diffusion tube at the site. It is thought that on this part of London Road the model overestimates the influence of slow moving traffic in a street canyon. It is also possible that the traffic count extrapolated from a near by survey location over estimates the flow of vehicles passing Oxford Place.

7.2.6 Richmond Place and DT37

The model over predicts by 30% at this location. It is possible that the modelled speeds along this road section are over estimated and hence the simulated emissions are unrepresentatively high. The model demonstrates the influence of westerly winds with higher NO_2 predicted to the west of the Richmond Place and this could be overestimated.

7.2.7 Vernon Terrace and DT71

Vernon Terrace has recorded exceptionally low concentrations of NO_2 and the model predicts a concentration 38% higher. This may be because concentrations drop off within a very short distance from the Seven Dials roundabout and the model does not have sufficient resolution to account for the rapid spatial difference. Monitoring in the area over a number of years has shown that air quality is good in the surrounding neighbourhoods.

7.2.8 Western Road and DT 75

The model over predicts at this site by 34%. It is believed that the street canyon option is overestimated in this local area, but is thought this is Western Road to the east and west. The clear space around Brunswick Square is likely to have a positive influence on air quality along this section of Western Road.

7.3 Adjusted Model Predictions at specified Points

In addition to predictions at 2008 monitoring locations, Table 7-3 shows the model estimations of NO_2 at new monitoring sites that commenced in 2010.

Table 7-3 Adjusted Model Predictions at new monitoring sites

Receptor ID	X	Y	Street	Adjusted Model Prediction
W02	530963	104837	Surrey Street west facing façade	**38.6**
W06	530576	105400	Lower OSR, south facing façade	**35.5**
W11	529576	104563	Western Road near Holland Rd	**54.1**
W18	525970	105230	Vale Park nr St Andrews Rd	**23.8**
W20	525406	106329	Portslade Old Village, South Street	**25.0**
C01	531171	103962	East Street	**28.4**
C02	531231	103919	Pool Coach Station North facing wall	**31.5**
C04	531228	104088	Lower North Street nr East Street	**47.7**
C14	530833	104276	West Street east-face south of Clock Tower	**37.7**
C18	531373	105136	Oxford Street south face nr London Road	**50.0**
C25	530985	105419	New England Road nr Argyle Road	**36.7**

C26	531164	105203	Fleet Street lamppost near new flats	**38.1**
C27	531151	104850	Trafalger Street Upper, north face façade	**34.1**
C28	531033	104842	Frederick Place	**41.0**
E09	532105	105735	Lewes road façade east face opposite existing	**63.8**
E10	532126	105838	Vogue gyratory east facing façade	**45.1**
E11	532146	105832	Vogue gyratory west facing façade	**48.5**

NB: Does not include Rottingdean which is not within or close to the existing AQMA and hence the within the scope of this report. There are no modelled roads next to C 1; East Street and C 2; Pool Coach station so it is anticipated that concentration will be a few µg/m^3 at these locations.

There are a number of relevant receptors at locations that have no monitoring; past or present. In these cases model receptors have been placed at specified receptor points in; Porslade, West Hove, the Central Area and East Brighton as follows:

Table 7-4 Model Prediction at Receptor Locations in Portslade

Receptor ID	X	Y	Street	Distance (m)	Adjusted Model Prediction
R01	525368	106345	High Street Portslade Village	3.5	**23.4**
R02	525416	106344	South Street Portslade Village	3.5	**23.8**
R03	525644	105925	West of Locks Hill Portslade	3	**28.2**
R04	525646	105885	East of Locks Hill Portslade	6	**33.1**
R05	525662	105833	Trafalger Rd / OSR junction	7	**35.5**
R06	525499	105835	Abinger Road	9	**26.8**
R07	525651	105799	Trafalger Road	5	**40.0**
R08	526415	105516	Pub on Boundary Road nr Station	3.5	**39.6**
R09	526515	105801	Victoria Court Carlton Terrace	5	**34.5**
R10	526552	105801	West of Boundary Rd/ 392 OSR	4	**34.9**
R11	526213	105834	Benfield Court OSR, Portslade	3.5	**34.9**
R12	527198	105425	Portland Road nr Mansfield Road	4.5	**29.9**

Table 7-5 Model Prediction at Receptor Locations in the West Hove Area

Receptor ID	X	Y	Street	Distance (m)	Adjusted Model Prediction
R13	527528	105396	Portland Road West Hove Junior	3.5	**23.4**
R14	527590	104325	Portland Road Gala Bingo site	3.5	**23.8**
R15	528216	104502	Vicerroy Lodge, Hove Street	3	**28.2**
R16	528378	104842	Church Road Hove/ Hove Street	6	**33.1**
R17	528372	104842	Church Road Hove/ Hove Street	7	**35.5**
R18	528443	105541	Sackville Road near Colerdige Rd	9	**26.8**
R19	528832	105317	Goldstone Villas nr Hove station	5	**40.0**
R20	528440	105182	Clarendon/Portland/Sackville Rd	3.5	**39.6**

Table 7-6 Model Prediction at Receptor Locations in Central Brighton and Hove

Receptor ID	X	Y	Street	Distance (m)	Adjusted Model Prediction
R21	530599	105039	Buckingham Close on Bath Street	1.9	**35.7**
R22	530574	105383	Stamford Road Lower OSR	1.5	**48.5**
R23	531048	105370	New England Street / Argyle Rd	3.2	**30.8**
R24	530885	105114	Buckingham/ Howard Place	2	**35.2**
R25	530922	105084	Terminus Road west of station	2.5	**34.2**
R26	529191	105360	The Drive/Cromwell/Davigdor Rd	6	**30.7**
R27	529100	104687	Church Rd-Hove/Grand Avenue	3	**36.0**

R28	529561	104570	Western Road/Holland Road PH	3.5	**56.0**
R29	529485	104589	Western Road Palmeira Court	3	**31.0**
R30	528774	104419	St Catherines Terrace, Kingsway	7.3	**28.0**
R31	528593	104418	Victoria Terrace Kingsway	2.4	**29.8**
R32	530139	104289	Montpelier Road/Sillwood Street	1.6	**38.2**
R33	530334	104287	Preston Street	2.4	**40.9**
R34	530644	104449	Regent Hill north of Western Rd	1.7	**34.4**
R35	530832	104316	75 North Street nr Clock Tower	4.5	**57.1**
R36	530869	104305	67 North Street nr Clock Tower	5	**87.6**
R37	530893	104316	130 North Street nr Clock Tower	4	**80.1**
R38	530878	104369	Queens Road Central	2.8	**49.2**
R39	531008	104735	Frederick Place	5	**36.3**
R40	531305	104984	Cheapside nearest façade	2	**38.2**
R41	530964	104601	North Road/ Queens Road Faacde	2.5	**40.0**
R42	531333	104522	Marlborough Place/North Road	1.5	**52.0**
R43	531288	104351	Marlborough Place/Church Street	7.5	**42.3**
R44	530970	104364	Portland Street	2.3	**34.2**
R45	531197	103867	Brills Lane Hotel/Grand Avenue	3	**39.5**
R46	531409	103927	Albermale Flats, Marind Parade	3.5	**37.6**
R47	531510	103921	Marine Parade	5	**36.3**

Table 7-7 Model Prediction at Receptor Locations in East Brighton

Receptor ID	X	Y	Street	Distance (m)	Adjusted Model Prediction
R48	531798	105298	Elm Grove/Lewes Rd	2.7	**40.6**
R49	532154	105904	Vogue Gyratory PH - East Side	5.5	**44.6**
R50	532146	105915	Vogue Gyratory PH - West Side	5	**46.4**
R51	532174	105903	Vogue Gyratory west	3.5	**50.5**
R52	533447	103915	Arundel Road	4.5	**37.2**

NB: The distances in metres are measured from the receptor-façade to the nearest kerbside, this is an indication of the room that traffic emission have to disperse.

The receptor locations are mapped and presented in APP. Model predictions at receptor points can be used in order prioritise future monitoring.

8 Source Apportionment

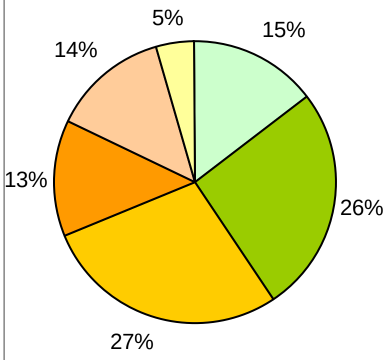
Detailed source apportionment has been carried out at all the 2008 monitoring sites and selected receptor locations. This is more than 170 locations in the modelled area. This report presents source break-downs at priority sites i.e. the monitors that have shown exceedence of the AQO over a number of years and at the Brighton and Hove continuous analysers.

8.1.1 Motorcycle contribution to ambient pollution

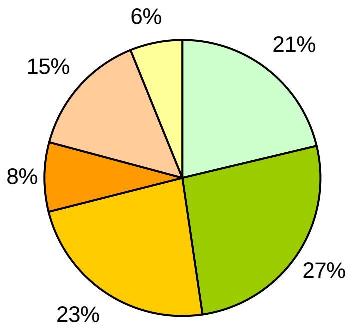
Motorbikes were modelled as a separate category; with their own distinct traffic counts and emissions. In some cities in Southern Europe motor scooter can be a significant contributor to ambient pollution. However the Brighton modelling evidence suggests that motorbikes and scooters do not contribute more than 1% to total ambient NO_2 concentrations. A more typical contribution from motor cycles is 0.3 to 0.5 % of the ambient total (including urban background). Alternatively this could be expressed as <2% of total traffic contribution throughout the city. Therefore motorcycles are not included as category on the presented pie-charts, discussed in the next section.

Source Apportionment Modelled NO_x Contribution to air quality at Representative Monitoring Locations 2008 (unless stated)

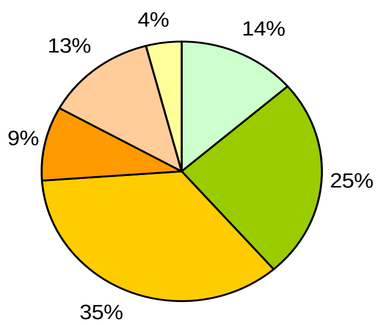
BH1 Pavilion Parade
Monitored NO_2 38 µg/m^3



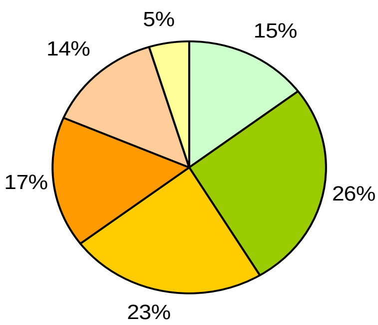
BH2 Hove Church Rd
Monitored NO_2 30 µg/m^3



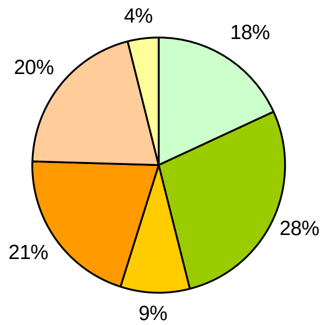
DT 09 Marlbrough Place
Monitored NO_2 47 µg/m^3



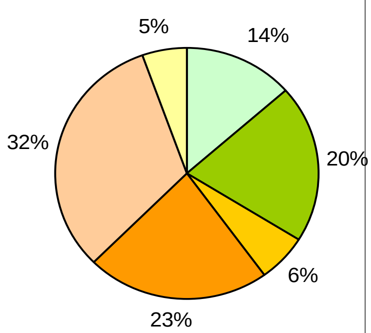
DT11 York Place
Monitored NO_2 54 µg/m^3



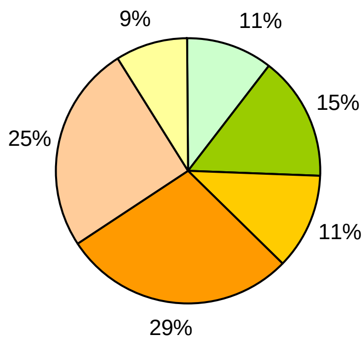
DT17 London Rd North
Monitored NO_2 48 µg/m^3



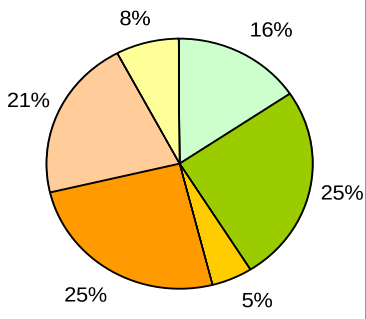
DT16 New England Rd
Monitored NO_2 42 µg/m^3



DT74 Old Shoreham Road near Chatam Place
Monitored NO_2 50 µg/m^3

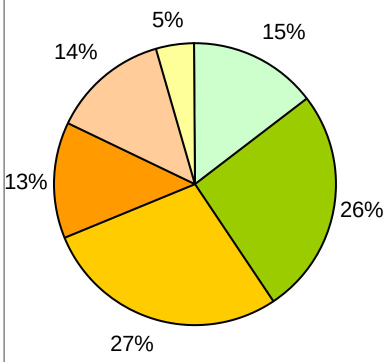


DT24 Viaduct Rd Monitored
NO_2 51 µg/m^3

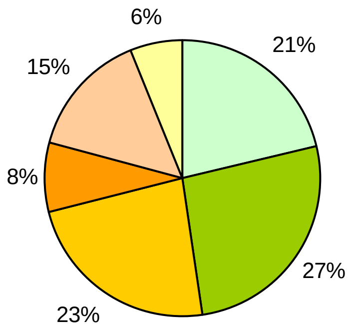


Source Apportionment Modelled NO_x Contribution to air quality at Representative Monitoring Locations 2008 (unless stated)

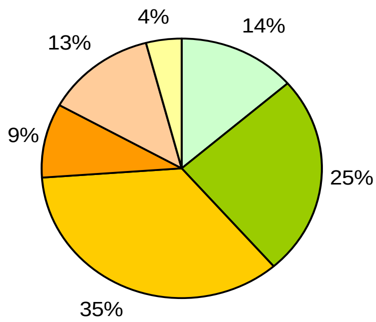
BH1 Pavilion Parade
Monitored NO_2 38 µg/m^3



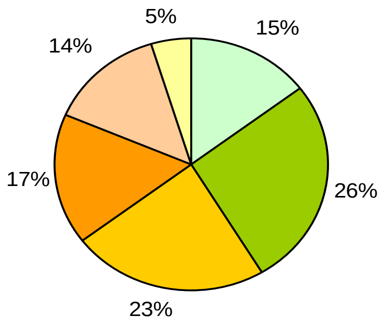
BH2 Hove Church Rd
Monitored NO_2 30 µg/m^3



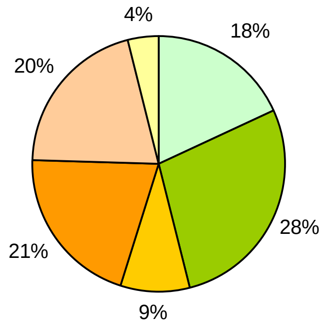
DT 09 Marlbrough Place
Monitored NO_2 47 µg/m^3



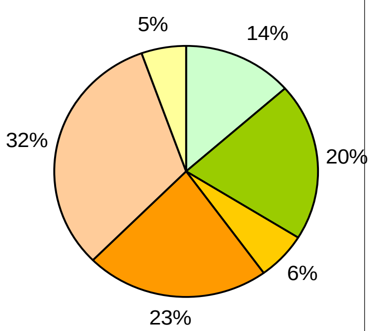
DT11 York Place
Monitored NO_2 54 µg/m^3



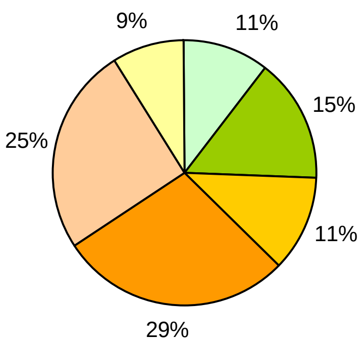
DT17 London Rd North
Monitored NO_2 48 µg/m^3



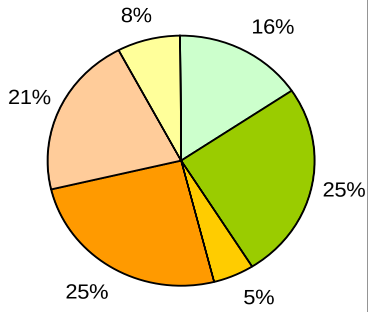
DT16 New England Rd
Monitored NO_2 42 µg/m^3



DT74 Old Shoreham Road near Chatam Place
Monitored NO_2 50 µg/m^3



DT24 Viaduct Rd Monitored NO_2 51 µg/m^3



9 Improvements required for compliance

Table show the level of improvement required to achieve compliance in 2008 and the proportion of ambient Nitrogen Dioxide that is derived from local traffic sources.

Table 9-1 Improvement required to attain Compliance with the Objective

Diffusion Tube (DT) Number	Location	DT Type	Annual mean concentrations ($\mu g/m^3$)		
			2008 NO_2 monitored	Improvement Needed	NO_X Traffic Contribution to total
DT 77	North Street	F	**60.2**	20.2	82%
DT 30	Lewes Road Central	F	**53.9**	13.9	82%
DT 76	Western Road East	F	**53.1**	13.1	73%
DT 24	Viaduct Terrace	F	**50.9**	10.9	59%
DT 11*	York Place	R	**49.7**	9.7	59%
DT 06	Terminus Rd	F	**49.6**	9.6	51%
DT 74	Lower Old Shoreham Rd	F	**49.5**	9.5	74%
DT 05	Queens Road North	F	**49.0**	9	58%
DT 17	London Road West	F	**48.0**	8	54%
DT 09	Marlborough Place	F	**46.6**	6.6	62%
DT 73	Chatham Place	F	**45.7**	5.7	53%
DT 40	St James Street	F	**43.3**	3.3	59%
DT 31	Hollingdean Road	F	**43.1**	3.1	53%
DT 25	Ditchling Road North	F	**42.1**	2.1	64%
DT 16	New England Road	F	**41.8**	1.8	66%
DT 13	Oxford Place	F	**41.7**	1.7	72%
DT 10	Gloucester Place	F	**41.5**	1.5	48%
DT 38	Grand Parade North	F	**41.3**	1.3	55%
DT 32	Lewes Road North	F	**40.9**	0.9	60%
DT 69	Buckingham Place	F	**40.9**	0.9	57%
DT 08	Grand Parade South	F	**40.3**	0.3	57%
DT 27	Ditchling Road Central	F	**40.0**	0	61%
DT 43	Eastern Rd Hospital	F	**40.0**	0	60%
DT 75	Western Road Brunswick	F	**40.0**	0	73%

DT11 in 2008 was located at kerbside, the concentration has been adjusted to represent a façade concentration. All tube values are bias correction (raw annual mean *0.72)

9.1 Discussion on model results

The contribution from traffic sources varies within the zone of AQO exceedence. The sum of commercial and domestic sources does not cause a breach of the AQO. That said these sources do contribute to the overall total. It is possible the introduction of a new combustion process or an increase in coal and wood burning for domestic use could locally increase the contribution of pollution from sources other than traffic. The model predictions suggest that road traffic accounts for between 48% and 82% of total NO_x; in the area of NO_2 AQO exceedence.

At suburban locations more than 100-m away from main roads sources other than road traffic will be most influential on air quality. However these neighbourhoods throughout Brighton and Hove are in compliance with all the air quality objectives.

The pollution contribution form busses, cars, taxis, vans and lorries varies considerably from one street to another. Therefore a more intelligent strategy than simply reducing the total traffic is required in order to address the localised issues.

10 Compliance Recommendations

Actions to attain improvement are presented in detail in the 2010 Air Quality Action Plan (AQAP) as a multifaceted approach including elements of the Local Transport Plan (LTP) and Local Development Framework (LDF). Recently published planning guidance is also discussed.

Government initiatives such as the ten year boiler and car replacement schemes should be applauded as a step in the right direction and could have a beneficial influence on local NO_x emissions and ambient NO_2.

The higher taxation of more polluting vehicles is also a policy that sends a fiscal message enforcing the polluter pays principal. Ambient air quality is influenced by the choices people make and this is everyone's responsibility for example:

- Behavioural change on travel arrangements
- Consumer choice on the mode of travel
- Consumer choice re vehicle type, maintenance, road worthiness ect
- Vehicle manufactures responsibility to meet the innovation challenge, introduce further improvements in engine technology and develop cost effective and sustainable alternatives
- Developer's responsibility not to add pollution or introduce residence to areas of existing poor air quality
- Planning responsibility to avoid the creation of closed streetscapes that envelope busy urban roads
- Planning responsibility to create clear space, public green amenity and room for gaseous emissions to disperse before they are inhaled

Additional reductions in NO_X emissions (including primary NO_2 from the exhaust pipes) will be required in order to attain compliance at the worse-case locations in the AQMA. Older diesels cars and goods vehicles are priority for improvement. A business as usual scenario is likely to see some localised NO_2AQO breaches in the years to 2015.

Car club and electrical charring points are ideal options for the AQMA. Further increases in cycling and walking are required as a means of replacing short vehicle journeys in the especially in the city centre.

Whilst some strategies can be win-win for the whole city, local air quality is best dealt with on a case by case basis or as part of a master plan or urban realm improvement. Achieving compliance between 2010 and 2015 will be especially challenging during the current economic climate.

11 Footnote References

[1] Footnote explanation re short term percentile AQO
[2] (Laxen and Marner, 2003) regarding relationship of annual mean and hourly percentile Nitrogen Dioxide
[3] The Environmental Permitting Regulations (EPR) including Part A PPC (Pollution Prevention Control) processes regulated by the Environment Agency and Part B LAPPC (Local Authority PPC) processes.
[4] The Brighton and Hove LDF and core strategy linked to the Air Quality Progress Report
[5] NOx to NO2 relationship and NOx to NO2 drop off with distance calculator can be found on the LAQM Air Quality Archive Website at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php
[6] Details on 2008 bias correction, precision, laboratory QA and QC can be found in the 2009 Updating Screening and Assessment
[7] Footnote explanation on $\mu g/m^3$ expressed to a whole unit
[8] Remote monitoring archive Strathaen, Scotland http://www.airquality.co.uk/find_sites.php
[9] ADMS-Urban User Guide http://www.cerc.co.uk/environmental-software/ADMS-Urban-model.html
[10] Local Authority primary NO_2 emission calculator; http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php
[11] Annual Report of the Director of Public Health, 2009 and citation of Dr Parker's Medical Officer Report 1968

12 Glossary

Table 12-1 Glossary of Air Quality Terms (not all used with the FRA)

Glossary of terms

ANPR	**Automatic Number Plate Recognition**
APR	**Annual Progress Report**
AQ	**Air Quality**
AQAP	**Air Quality Action Plan**
AQMA	**Air Quality Management Area**
AQEG	**Air Quality Expert Group**
AQMS	**Air Quality Monitoring Station**
AQO	**Air Quality Objectives**
AURN	**Automatic Urban and Rural Network**
BHCC	**Brighton and Hove City Council**
BHEP	**Brighton and Hove Economic Partnership**
BRE	**Building Research Establishment**
BV	**Bureau Veritas**
CDT	**Cycle Demonstration Town**
CHP	**Combined Heat and Power**
CO_2	**Carbon Dioxide**
CEMP	**Construction Environmental Management Plan**
CFC	**Chlorofluorocarbons**
CO	**Carbon monoxide**
COMEAP	**Committee on the Medical Effects of Air Pollutants**
DA	**Detailed Assessment**
defra	**Department for Environment Food and Rural Affairs**
DMRB	**Design Manuel for Roads and Bridges**
DPD	**Development Plan Document**
DPF	**Diesel Particulate Filters**
DPE	**Decimalised Parking Enforcement**
DfT	**Department for Transport**
EC	**European Community**
EMIT	**Emissions Inventory**
ESCC	**East Sussex County Council**
EST	**Energy Saving Trust**
ERG-KCL	**Environmental Research Group -Kings College London**
EU	**European Union**
FR&A	**Further Review and Assessment**
HA	**Highways Agency**
HGV	**Heavy Goods Vehicles**
IPPC	**Integrated Pollution Prevention and Control**
ITS	**Intelligent Transport Systems**
IZS	**Internal Zero Span**
LA	**Local Authority**
LR2	**Lewes Rd/London Rd Urban Development**
LDF	**Local Development Framework**
LAQM	**Local Air Quality Management**
LAPPC	**Local Air Pollution Prevention and Control**
LEZ	**Low Emission Zone**
LCP	**Large Combustion Plants Directive**
LPA	**Local Planning Authority**
LPG	**Liquid Petroleum Gas**
LTP (2)	**Local Transport Plan (second)**
MRF	**Materials Recovery Facility**
mg/m^3	**Milligrams of the pollutant per cubic metre of air**
NAQS	**National Air Quality Strategy**
NECD	**National Emissions Ceiling Directives**

O_3	**Ozone**
QA/QC	**Quality Assurance/Quality Control**
$\mu g/m^3$	**Micrograms of the pollutant per cubic metre of air**
ppb	**Parts per billion**
PAN	**Planning Advice Note**
PATC	**Permanent Automatic Traffic Count**
PPC	**Pollution Prevention and Control**
ppm	**Parts per million**
PPS 23	**Planning Policy Statement 23**
NAQS	**National Air Quality Strategy**
NETCEN	**National Environmental Technology Centre**
NSCA	**National Society for Clean Air**
NO	**Nitric Oxide**
NO_x	**Oxides of Nitrogen**
NO_2	**Nitrogen dioxide**
P2W	**Powered Two Wheelers**
PAH	**Polycyclic Aromatic Hydrocarbons**
PCT	**Primary Care Trust**
PM_{10}	**Particles with diameter less than 10µm**
$PM_{2.5}$	**Particles with diameter less than 2.5µm**
QA/QC	**Quality Assurance / Quality Control**
R & A	**Review and Assessment**
RBMP	**Regular Base Monitoring Program**
RET	**Roadside Emissions Testing**
RIBA	**Royal Institute of British Architects**
RSEP	**Road Safety Engineering Plan**
RPS	**Residents Parking Schemes**
RTPI	**Real Time Passenger Information**
RTS	**Rapid Transport System**
SAQSG	**Sussex Air Quality Steering Group**
SCA	**Smoke Control Area**
SCOOT	**Split Cycle Offset Optimisation Technique**
SO_2	**Sulphur dioxide**
STC	**Sustainable Transport Corridor**
SPD	**Supplementary Planning Document**
SNCI	**Site of Nature Conservation Impotence**
STC	**Sustainable Transport Corridor**
STP	**School Travel Plan**
STS	**School Travel Strategy**
TATC	**Temporary Automatic Traffic Counters**
TOC	**Train Operating Companies**
UDP	**Unitary Development Plan**
USA	**Updating & Screening Assessment**
UTMC	**Urban Traffic Management and Control**
UWE	**University of the West of England**
VMS	**Variable Message Signs**
VOSA	**Vehicle and Operator Services Agency**
VOC	**Volatile Organic Compounds**
WASP	**Workplace Analysis Scheme for Proficiency**
ESCC	**East Sussex County Council**
WHO	**World Health Organisation**
WTS	**Waste Transfer Station**