HIGHWAYS AGENCY

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Halcrow Hyder Joint Venture

Highways Agency

M4 Bus Lane

Air Quality Study

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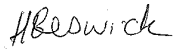
Author	Hannah Beswick	
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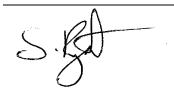
Approver	Stephen Pyatt	

Report No UA003263-001

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Halcrow Hyder Joint Venture

CONTENTS

Appendices

1 SUMMARY

2 Introduction

From the 7th June 1999 until the 24th December 2010, the M4 Bus Lane operated eastbound into London between Junctions 3 and 2, the lane was reserved for buses, taxis and motorcycles.

Hyder Consulting (Hyder) and Halcrow Joint Venture (HHJV) has been commissioned by the Highways Agency (HA) to assess the air quality impacts of the removal of the M4 Bus Lane on nitrogen dioxide (NO_2) concentrations at nearby sensitive receptors.

NO_2 concentrations at nearby sensitive receptors have therefore been predicted for two scenarios (i.e. with and without the Bus Lane) through detailed dispersion modelling, using ADMS-Roads.

3 Study Area

The study area, as depicted in Figure 1, Appendix A, has been chosen as it contains residential properties which border the M4 where the Bus lane operated. There are no other areas with properties in close proximity to the M4 Bus lane. The locations of the nearest sensitive receptors to the Bus Lane and the traffic count location are also presented in Figure 1. The northern section of the study area, around Norwood Green, is located within the London Borough of Ealing, although, the majority of the study area is within the London Borough of Hounslow (LBH). The section of the M4 within the study area boundary lies entirely within the LBH.

4 Legislation, Policy and Guidance

The UK Government and the Devolved Administrations (DAs) published the latest Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) in July 2007[1] defining both Standards and Objectives for a range of air pollutants.

The 'Standards' are set as concentrations below which health effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of a particular pollutant.

The 'Objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of the costs, benefits, feasibility and practicality of achieving the standards. The objectives are prescribed within The Air Quality (England) Regulations 2000[2] and The Air Quality (England) (Amendment) Regulations 2002[3] (together termed the 'Regulations'). Air Quality Objectives included in the Regulations and current legislation which are relevant to the study (Nitrogen Dioxide (NO_2)) are presented in Table 4-1.

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

[2] Stationery Office. Air Quality Regulations, 2000, Statutory Instrument 928

[3] Stationery Office. The Air Quality (England) (Amendment) Regulations 2002. Statutory Instrument 3043

Table 4-1 Air Quality Strategy Objectives for NO_2

Pollutant	AQS Objective	
	Concentration (µg/m^3)	Averaging Period
Nitrogen Dioxide (NO_2)	200	1-hour mean; not to be exceeded more than 18 times a year
	40	Annual mean

The AQS objectives take into account EU Directives that set Limit Values, which member states are legally required to achieve by their target dates. The UK's AQS objectives are equal to, or more stringent than, the EU Limit Values (no Member State may promulgate air quality standards that are weaker than the EU Limit Values).

The Environment Act (1995) also provides a legislative framework for a system of Local Air Quality Management (LAQM), which forms an important part of the overall Government strategy to improve air quality. Under Part IV of the Act, local authorities are required to carry out a process of Review and Assessment to identify any areas where the AQS objectives may not be achieved.

Where it is found that AQS objectives are unlikely to be met, responsible authorities must designate Air Quality Management Areas (AQMAs) and implement Air Quality Action Plans to help achieve the AQS objectives.

5 Methodology

LBH has declared an AQMA for NO_2 for the whole Borough, which therefore includes the M4 Bus Lane. LBH currently operates an extensive network of continuous and diffusion tube monitoring sites. However, there are few monitoring sites in close proximity to the M4 within the study area, therefore Hyder has undertaken NO_2 diffusion tube monitoring at locations close to the M4 to enable model verification.

The assessment has been undertaken using the atmospheric dispersion modelling package ADMS-Roads, developed by Cambridge Environmental Research Consultants Ltd (CERC), to predict NO_2 concentrations at sensitive receptor locations for the with and without M4 Bus Lane scenarios.

5.1 NO_2 Diffusion Tube Monitoring

An NO_2 diffusion tube survey was undertaken over a six month period, between the 17th of March 2011 and the 13th of September 2011, and consisted of monthly exposure periods. Monitoring locations were selected in accordance with the methodology provided in 'Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance' produced by AEA Technology on behalf of DEFRA[4].

Monitoring was undertaken at 12 locations in close proximity to the M4 within the study area and one background location, as depicted in Figure 1, Appendix A. A further three diffusion tubes

4 AEA Technology Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance, 2008

were located at the closest continuous NO_2 analyser located on Heston Road to allow a local bias adjustment factor to be calculated in accordance with Local Air Quality Management (LAQM) guidance LAQM.TG(09)[5]. The diffusion tubes were sent to Staffordshire Scientific Services, a UKAS accredited laboratory, for analysis.

Appendix B contains flash cards for the diffusion tube monitoring sites, containing the OS grid references of the diffusion tubes, site descriptions and photographs.

Monitoring was undertaken following the closure of the Bus Lane and therefore the concentrations recorded represent this operating regime along the M4 in this location.

5.2 Modelling Inputs

The following sections detail the data used in the detailed modelling. Reference should be made to Appendix C for further details regarding the modelling inputs.

5.2.1 Traffic Data

Traffic data utilised in the ADMS-Roads modelling has been provided by Hyder's Transportation Team.

Traffic data for 2010 (with the Bus Lane) and 2011 (without the Bus Lane) has been obtained from actual traffic counts available from Motorway Incident Detection and Automatic Signalling (MIDAS) loop detectors and contains traffic flows for each lane of the M4 carriageway.

The Traffic Team have interrogated the data for 2010 and 2011 and determined that no growth factor needs to be applied to the 2010 data, and any changes in the traffic data between the two scenarios is as a result of the Bus Lane only, rather than a growth in traffic or any other scheme/development, between 2010 and 2011.

The data comprises traffic flows and average speeds for each lane of the motorway, for different periods of the day and average percentage Heavy Duty Vehicles (%HDVs) for each direction. Whilst %HDVs are not available for each lane from the MIDAS data, a %HDV has been provided for the Bus Lane. The HDV proportions for the Bus Lane were based on Manual Classified Counts undertaken in 2010.

Data was provided for the following days:

1. Tuesday, Wednesday, Thursday;
2. Monday;
3. Friday;
4. Saturday; and
5. Sunday.

Analysis of the data indicated small differences between weekday traffic flows, therefore the weekday flows were amalgamated, and the following profiles were used:

5 DEFRA Local Air Quality Management (LAQM) Technical Guidance (TG) 2009

1. Weekday;
2. Saturday; and
3. Sunday.

Each of these profiles were separated into four periods:

1. AM peak (07:00 to 10:00);
2. Inter-Peak (IP) (10:00 to 16:00);
3. PM peak (16:00 to 19:00); and
4. Off Peak (OP) (19:00 to 07:00).

Traffic data has been provided for the section of the M4 within the study area. In addition, traffic data for the A3005 has been obtained from traffic counts from the Department for Transport (DfT) website[6] (in the format of an Annual Average Daily Traffic (AADT) flow and %HDV). No other roads were incorporated into the model. This however is sufficient to assess the impacts of the Bus Lane as the lane's operation is not expected to impact on traffic flows on the local road network within the study area.

5.2.2 Scenarios

Traffic data has been provided for 2010 (with the Bus Lane) and 2011 (without the Bus Lane). As discussed previously, it has been determined that traffic growth between the two years is negligible, therefore the two scenarios, with and without the Bus Lane, have been assessed for 2011. This ensures that any changes in NO_2 concentrations at receptor locations between the two scenarios are as a result of the removal of the Bus Lane only, rather than changes in background concentrations or vehicle emission factors which reduce between 2010 and 2011. The year 2011 has been selected rather than 2010, as the NO_2 diffusion tube monitoring and model verification was carried out in 2011.

5.2.3 Sensitive Receptors

Worst case sensitive receptors within 200m of the M4 and away from any other major roads were selected, and are presented in Figure 1, Appendix A and detailed in Table 5-1.

Table 5-1 Sensitive Receptor Locations

Sensitive Receptor	Receptor Location	Grid Coordinates	
		X	Y
R1	Residential property off Osterley Lane	514301	178465
R2	Residential property on Oxford Avenue	513036	177995
R3	Residential property on Winchester Avenue	512830	177879

[6] DfT website: http://dft.gov.uk/

R4	Residential property on The Alders	512634	177905
R5	Residential property on Grange Close	512583	177872
R6	Residential property on Heston Grange	512598	177817

5.2.4 Background Concentrations

A diffusion tube (HS7) was placed at a background location greater than 200m from the M4, and away from major roads. It was therefore decided that the bias adjusted concentration would be used within the modelling as it is representative of the background concentration within the study area.

5.3 Model Verification

As described in Section 5.1, monitoring of NO_2 has been undertaken at various locations in close proximity to the M4. As diffusion tubes only measure total NO_2, the road-traffic NO_x concentration measured by the diffusion tube was estimated following the methodology outlined in Box A3.6 of LAQM.TG(09). Using the background NO_2 concentration and the total NO_2 concentration measured, the road-traffic NO_2 component was converted to NO_x using the Version 2.1[7] of the NO_x to NO_2 calculator developed for LAQM.TG(09).

Full details of the verification process are included in Appendix C.

6 Results

6.1 Monitoring Results

Raw monthly NO_2 diffusion tube monitoring results are presented in Table 6-1 below.

Table 6-1 Nitrogen Dioxide Diffusion Tube Results

Monitoring Location	NO_2 Concentration ($\mu g/m^3$)							Data Capture (%)
	March	April	May	June	July	August	Period Mean	
HS1	63.8	54.0	48.8	50.4	46.5	40.0	50.6	100.0
HS2	64.2	57.0	50.6	51.5	52.1	39.0	52.4	100.0
HS3	64.9	55.7	52.2	44.4	53.0	39.6	51.6	100.0
HS4	59.1	48.7	41.4	43.8	48.2	43.6	47.5	100.0
HS5	-	48.8	47.2	47.5	50.8	43.0	47.5	83.3
HS6	55.6	37.8	31.9	36.9	38.0	33.6	39.0	100.0

[7] http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

HS7	44.7	32.7	28.9	29.0	28.4	31.7	32.6	100.0
HS8	55.1	47.6	45.7	45.1	43.8	49.2	47.8	100.0
HS9	58.0	44.9	36.3	42.2	41.7	38.4	43.6	100.0
HS10	81.6	79.1	75.0	77.4	80.7	67.8	76.9	100.0
HS11	55.4	43.4	38.3	39.7	37.0	39.3	42.2	100.0
HS12	60.2	47.4	41.9	42.8	42.0	41.5	46.0	100.0
HS13	64.8	-	-	-	47.1	37.4	49.8	50.0
HS14	55.4	45.6	49.6	-	53.0	38.9	48.5	83.3
HS15	45.5	43.0	42.2	41.4	-	40.2	42.5	83.3

- indicates tube missing for that month

6.1.1 Bias Correction

Due to bias associated with passive NO_2 diffusion tubes, it is necessary to utilise an adjustment factor which can be applied to the monitored concentration. The factor is derived from co-locating diffusion tubes with an automatic chemiluminescence analyser over the monitoring period. This was undertaken with the monitoring station on Heston Road. The automatic monitoring results were then compared to the triplicate diffusion tube results (HS1 to HS3) to derive a bias adjustment factor of 0.98 (Table 6-2), following the methodology in LAQM.TG(09).

Table 6-2 Bias Correction

NO_2 Average Concentration (µg/m³)		Bias Adjustment Factor
Diffusion Tube Triplicate Mean	Heston Road Monitoring Station Mean for Same Period	
51.5	50.5	0.98

6.1.2 Annual Mean Adjustment

In addition to bias adjustment, the NO_2 concentrations presented in Table 6-1 are the average concentration between March and August 2011. To verify the air quality model and to compare against the AQS Objectives, an annual mean concentration is required. Therefore the monitoring results have been adjusted based upon the methodology contained within LAQM.TG(09). This requires the period mean (i.e. the period the diffusion tubes were exposed) to be compared with the annual mean at automatic stations, to determine a ratio which is used to convert the short term diffusion tubes monitoring results into an equivalent 2011 annual average.

LAQM.TG(09) stipulates that background sites should be used to avoid any local effects that may occur at roadside sites, and should, wherever possible lie within a radius of about 50 miles. Table 6-3 presents background monitoring locations, which are within 50 miles of the site, and the relationship between period and annual mean NO_2 concentrations.

Urban background monitoring sites are characterised as urban locations distanced from sources and broadly representative of city-wide background concentrations.

Table 6-3 Period to Annual Mean Factors

Monitoring Site*	NO_2 Concentration (µg/m^3)		
	2011 Annual Mean	Period Mean (i.e. the period that the diffusion tubes were exposed)	Ratio Annual Mean: Period Mean
Ealing- Southall (urban background monitoring location, 1.13km north-west of the study area)	27.7	23.0	1.2
Ealing Town Hall (urban background monitoring location 3.45km north-east of the study area)	41.8	37.8	1.1
Hounslow Hatton Cross (urban background monitoring location 3.25km south-west of the study area)	33.7	28.2	1.2
Mean Value (adjustment factor)			**1.17**

*Data capture exceeds 90% at all monitoring stations

Applying the calculated annual adjustment factor of 1.17 to the bias adjusted monitoring results provides an estimation of the 2011 annual mean NO_2 concentration, as shown in Table 6-4.

Table 6-4 Adjusted Monitoring Results

Monitoring Location	NO_2 Concentration (µg/m^3)		
	Period Mean	Bias Adjusted Period Mean	Estimate of 2011 Annual Mean
HS1	50.6	49.6	58.0
HS2	52.4	51.4	60.0
HS3	51.6	50.6	59.2
HS4	47.5	46.5	54.4
HS5	47.5	46.5	54.4
HS6	39.0	38.2	44.7
HS7	32.6	31.9	37.3
HS8	47.8	46.8	54.7
HS9	43.6	42.7	49.9
HS10	76.9	75.4	88.2
HS11	42.2	41.4	48.3
HS12	46.0	45.1	52.7
HS13*	49.8	48.8	57.0
HS14	48.5	47.6	55.6
HS15	42.5	41.6	48.7

*Data capture is in excess of 80% at all locations, with the exception of HS13, which has a data capture of 50%.

As indicated in Table 6-4, the annual mean NO_2 concentrations at all diffusion tube monitoring locations except HS7 exceed the annual mean NO_2 AQS objective of 40µg/m^3. The highest recorded NO_2 concentration is at HS10, which is located on the A4 Heston Road and adjacent to the M4. The lowest recorded NO_2 concentration is at HS7, which was selected as a background monitoring location.

6.2 Modelled Results

Table 6-5 presents the modelled results for annual mean NO_2, at each of the six receptors, for the with and without M4 Bus Lane scenarios, and the difference between the two scenarios, for 2011.

Table 6-5 2011 Modelled Annual Mean NO_2 Concentrations at Receptor Locations (µg/m^3)

Receptor	Annual Mean NO_2 (µg/m^3)		
	With Bus Lane	Without Bus Lane	Difference
R1	44.1	44.4	0.3
R2	50.7	51.4	0.8
R3	49.5	49.8	0.4
R4	48.0	48.6	0.6
R5	54.8	55.9	1.1
R6	50.0	50.3	0.4

As indicated in Table 6-5, the annual mean NO_2 concentrations at all receptor locations exceed the annual mean NO_2 AQS objective of 40µg/m^3, for both with and without the Bus Lane scenarios.

LAQM.TG(09) stipulates that "exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60µg/m^3 or above". Whilst all predicted concentrations are below 60µg/m³, NO_2 concentrations at R5 are just below 60µg/m³. The 1-hour mean NO_2 objective may be exceeded at this location, as concentrations were predicted at the facade of the property, therefore the hourly NO_2 concentrations within the gardens of the property, which are closer to the M4 than the property itself, may exceed the 1-hour mean NO_2 objective of 200µg/m³.

The differences between the two scenarios, as presented in Table 6-5, indicate that the without Bus Lane scenario results in an increase in NO_2 concentrations at receptor locations in close proximity to the M4, based on the traffic data provided when compared to the scenario with the Bus Lane. The largest change in NO_2 is at R5, due to its closest proximity to the M4. R1 is the furthest away from the motorway (out of the selected receptors), therefore changes in NO_2 concentrations as a result of the Bus Lane removal are smaller than at other receptor locations. This is as a result of the diminishing impact of the road with distance and therefore the background concentrations begin to dominate resulting in smaller overall change in total NO_2 concentration.

The increases in NO_2 concentrations are due to a number of factors. Firstly, the removal of the Bus Lane may have encouraged more traffic to use the motorway, due to the increase in capacity along this section of the M4 (i.e. by increasing the number of lanes from two to three which cars and vans can use). This is reflected in the overall AADTs for the eastbound

carriageway, as presented in Table 6-6, which shows an increase in traffic in 2011, when the Bus Lane was no longer operational.

Secondly, as indicated in Table 6-6, the Bus Lane displaced a proportion of the total HDVs (i.e. buses and coaches) away from the inside lanes (link 1), to the outside lane (i.e. the Bus Lane - link 2). However, without the Bus Lane, all HDVs are restricted to the two innermost lanes (link 1), which are closer to sensitive receptors adjacent to the M4.

Table 6-6 Traffic Data – With and Without Bus Lane

	Total Flow		HDV		Speed (kph)	
Road Link	Flow Without Bus Lane	Flow With Bus Lane	Flow Without Bus Lane	Flow With Bus Lane	Without Bus Lane	With Bus Lane
Link 1	36920	43236	3328	2286	90.0	79.9
Link 2	12322	4711	0	647	104.0	93.0

Note: Link 1 represents the first two lanes of the eastbound carriageway and link 2 represents the Bus Lane.

In addition, the data in Table 6-6 indicates that the average speed is higher without the Bus Lane in operation (although the speed limit has remained at 60m.p.h.). This would also have contributed to an increase in NO_2 concentrations at receptor locations in close proximity to the M4.

7 Conclusions

An NO_2 diffusion tube survey was undertaken over a six month period at various locations in close proximity to the M4. Monitoring was undertaken following the closure of the Bus Lane and therefore the concentrations recorded represent the current operation of the M4 in this location. The diffusion tube results were bias and annually adjusted and then used to verify the model.

Worst case sensitive receptors within 200m of the M4 and away from any other major roads were selected and NO_2 concentrations at nearby sensitive receptors have been predicted for two scenarios (i.e. with and without the Bus Lane) through detailed dispersion modelling, using ADMS-Roads.

NO_2 concentrations at receptors in close proximity to the M4 are predicted to be higher as a result of the M4 Bus Lane removal. It is considered that this is as a result of several factors.

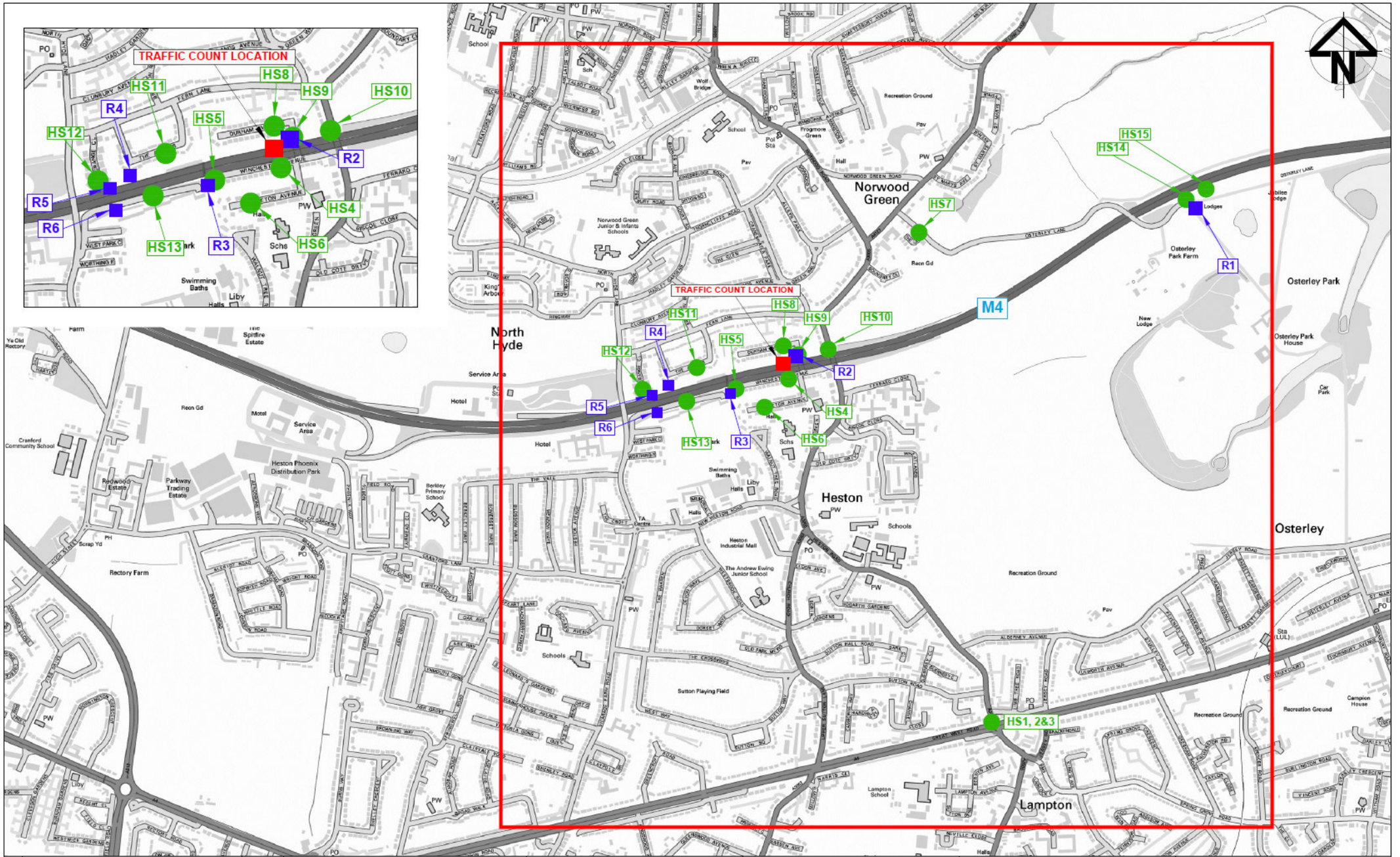
Firstly, the removal of the Bus Lane may have encouraged more traffic to use the motorway, due to the increase in capacity along this section of the M4 (i.e. by increasing the number of lanes from two to three which cars and vans can use).

Secondly, the Bus Lane displaced a proportion of the total HDVs (i.e. buses and coaches) away from the inside lanes (link 1), to the outside lane (i.e. the Bus Lane - link 2). However, without the Bus Lane, all HDVs are restricted to the two innermost lanes (link 1), which are closer to sensitive receptors adjacent to the M4.

Additionally, the traffic data indicates that the average speed is higher without the Bus Lane in operation (although the speed limit has remained at 60m.p.h.). This would also have contributed to an increase in NO_2 concentrations at receptor locations in close proximity to the M4.

Appendix A

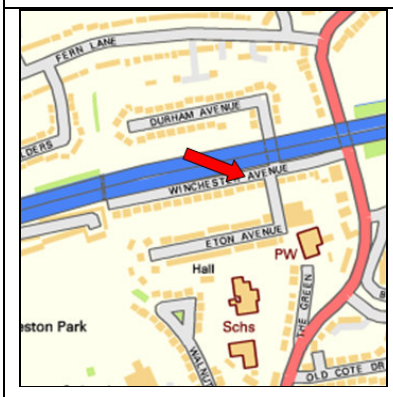
Figure


TRAFFIC COUNT LOCATION
HS1
HS2
HS3
HS4
HS5
HS6
HS7
HS8
HS9
HS10
HS11
HS12
HS13
HS14
HS15
R1
R2
R3
R4
R5
R6
M4
North Hyde
Heston
Osterley
Lampton
Norwood Green
Osterley Park
Osterley Park Farm
Osterley Park House
Hyder Consulting (UK) Limited
3301 Firecrest Court
Centre Park
Warrington
WA1 1RG
Tel: +44 (0)1925 800700
Fax: +44 (0)1925 572462
Notes
STUDY AREA
DIFFUSION TUBE LOCATIONS
RECEPTOR LOCATIONS
TRAFFIC COUNT LOCATION
Client
HIGHWAYS AGENCY
Status
Scales N.T.S
Original Size A3
Datum DATUM
Grid GRID
Current Issue Signatures
Author J.NORMAN
Checker H.BESWICK
Approver S.PYATT
© Copyright reserved
Filename: K:\PROJECTS\UA003263-M4-BUS-LANE\E-OUR-DRAWINGS\001-UA003263-UE31D-01-STUDY-DIFF-REC-LOC.DWG
Project
M4 BUS LANE
AIR QUALITY STUDY
Title
FIGURE 1 - STUDY AREA, DIFFUSION TUBE LOCATIONS AND RECEPTOR LOCATIONS
Drawing No. 001
Project No. UA003263
Issue 01
01 JAN 12
Issue Description Date
50mm on Original
Plot Date: 17/Jan/2012 10:38:13 AM File Location: K:\PROJECTS\UA003263-M4-BUS-LANE\E-OUR-DRAWINGS\001-UA003263-UE31D-01-STUDY-DIFF-REC-LOC.DWG VER

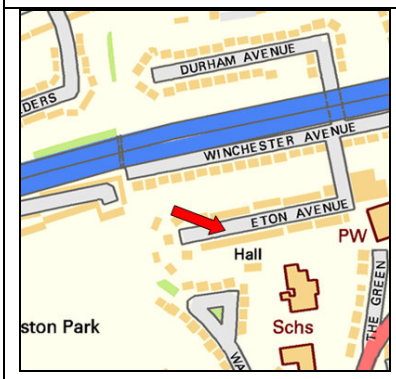
Appendix B

Monitoring Locations

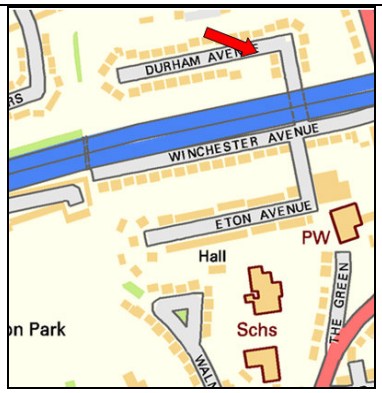
Site Details	Diffusion Tube ID	HS1, HS2 and HS3
	**Site Name**	Heston Road Triplicate
	Grid Reference	513655,176837
	Site Description	Co- located with the CMS at Heston Rd/ A4 junction.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	HS1 = 50.6 HS2 = 52.4 HS3 = 51.6

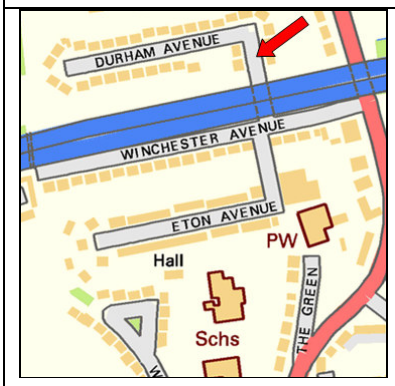
Site Details	Diffusion Tube ID	HS4
	**Site Name**	Winchester Avenue (1)
	Grid Reference	513014,177923
	Site Description	Lamp post on Winchester Avenue (East)
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	47.5

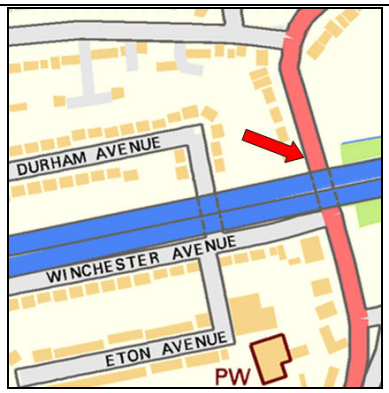
Site Details	Diffusion Tube ID	HS5
	**Site Name**	Winchester Avenue (2)
	Grid Reference	512850,177890
	Site Description	Lamp post on Winchester Avenue (West)
	**Data Capture**	83%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	47.5

Site Details	Diffusion Tube ID	HS6
	**Site Name**	Eton Avenue
	Grid Reference	512938,177833
	Site Description	Lamp post on south facing side of the street.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	39.0

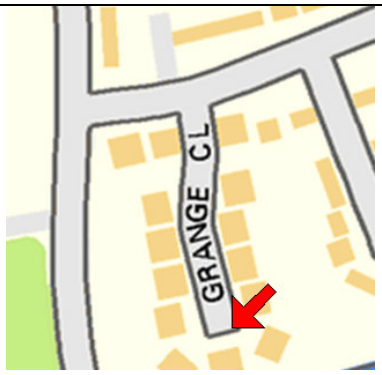
Site Details	Diffusion Tube ID	HS7
	**Site Name**	Osterley Lane (background)
	Grid Reference	513425,178387
	Site Description	Lamp post at junction of Osterley Lane/ The Lawn outside residential property.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	32.6

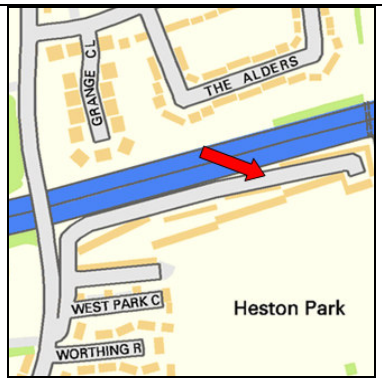
Site Details	Diffusion Tube ID	HS8
	**Site Name**	Durham Avenue (1)
	Grid Reference	512997,178029
	Site Description	Lamp post on north facing side of the street.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	47.8

Site Details	Diffusion Tube ID	HS9
	**Site Name**	Oxford Avenue
	Grid Reference	513044,178000
	Site Description	Lamp post on west facing side of the street.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	43.6

Site Details	Diffusion Tube ID	HS10
	**Site Name**	Heston Road
	Grid Reference	513139,178017
	Site Description	Lamp post on west facing side of street approximately 20m from the M4 flyover.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	76.9

Site Details	Diffusion Tube ID	HS11
	**Site Name**	The Alders
	Grid Reference	512723,177960
	Site Description	Lamp post on south facing side of street.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) ($\mu g/m^3$)	42.2

Site Details	Diffusion Tube ID	HS12
	**Site Name**	Grange Close
	Grid Reference	512553,177891
	Site Description	Lamp post at end of street nearest to M4.
	**Data Capture**	100%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) ($\mu g/m^3$)	46.0

Site Details	Diffusion Tube ID	HS13
	**Site Name**	Heston Grange Lane
	Grid Reference	512691,177853
	Site Description	Lamp post adjacent to M4 boundary fence.
	**Data Capture**	50%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	49.8

Site Details	Diffusion Tube ID	HS14
	**Site Name**	Osterley Lane M4 (1)
	Grid Reference	514269,178492
	Site Description	Mounted on fence of footpath/ track approximately 50m from M4.
	**Data Capture**	83%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) (µg/m^3)	48.5

Site Details	Diffusion Tube ID	HS15
	**Site Name**	Osterley Lane M4 (2)
	Grid Reference	514333,178525
	Site Description	Mounted on fence of footpath/ track approximately 10m from M4.
	**Data Capture**	83%
	Sampler	NO_2 Diffusion Tube
	Commissioned	17/03/2011
	Decommissioned	13/09/2011
	Average NO_2 Concentration (raw data) ($\mu g/m^3$)	42.5

Appendix C

Modelling Inputs

Traffic Flow Data

The traffic data used in the assessment is presented in Tables A1 and A2. Figure A1 depicts the link locations (note that links extend across whole study area, not just the area shown in the figure).

Table A1 2010 Traffic Data – With Bus Lane

Road Link	Day(s) Data Applies to	Time Period Data Applies to	Traffic Flow	HDV Proportion of Fleet (%)	Speed (km/hr)
Link1	Weekday	AM	7314	6.9	55.2
Link1	Weekday	IP	14339	6.0	88.1
Link1	Weekday	PM	8677	1.7	71.6
Link1	Weekday	OP	13399	9.0	90.7
Link1	Saturday	AM	6913	4.8	91.0
Link1	Saturday	IP	15887	2.0	77.6
Link1	Saturday	PM	7956	1.6	70.5
Link1	Saturday	OP	11542	6.6	92.6
Link1	Sunday	AM	5706	3.3	93.5
Link1	Sunday	IP	14860	1.1	70.8
Link1	Sunday	PM	7828	0.5	48.2
Link1	Sunday	OP	13323	3.8	90.2
Link2	Weekday	AM	1279	14.0	84.9
Link2	Weekday	IP	1458	14.0	96.7
Link2	Weekday	PM	832	14.0	90.7
Link2	Weekday	OP	1273	14.0	97.4
Link2	Saturday	AM	740	13.0	98.2
Link2	Saturday	IP	1586	13.0	93.7
Link2	Saturday	PM	750	13.0	90.9
Link2	Saturday	OP	788	13.0	99.6
Link2	Sunday	AM	697	13.0	99.9
Link2	Sunday	IP	1744	13.0	92.4
Link2	Sunday	PM	1151	13.0	82.8
Link2	Sunday	OP	1308	13.0	98.0
Link3	Weekday	AM	10359	5.1	102.1
Link3	Weekday	IP	18064	8.8	105.5
Link3	Weekday	PM	10337	4.5	102.6
Link3	Weekday	OP	15963	8.0	108.3

Link3	Saturday	AM	8034	4.7	106.4
Link3	Saturday	IP	19441	3.4	106.9
Link3	Saturday	PM	9285	2.7	103.5
Link3	Saturday	OP	14951	5.5	106.1
Link3	Sunday	AM	6446	3.3	108.4
Link3	Sunday	IP	18293	2.4	106.2
Link3	Sunday	PM	9799	2.4	101.3
Link3	Sunday	OP	16405	3.7	107.1
Link 4	All days	All periods	21426	2.1	48

Note: Link 1 represents the first two lanes of the eastbound carriageway, link 2 represents the Bus Lane, link 3 represents the three lanes going westbound and link 4 represents the A3005.

Table A2 2011 Traffic Data – Without Bus Lane

Road Link	Day(s) Data Applies to	Time Period Data Applies to	Traffic Flow	HDV Proportion of Fleet (%)	Speed (km/hr)
Link1	Weekday	AM	6008	13.6	71.7
Link1	Weekday	IP	12618	9.6	93.0
Link1	Weekday	PM	6633	4.3	89.6
Link1	Weekday	OP	11567	13.2	94.2
Link1	Saturday	AM	5897	8.8	94.0
Link1	Saturday	IP	13603	4.4	93.6
Link1	Saturday	PM	6600	3.6	90.3
Link1	Saturday	OP	10625	9.0	95.0
Link1	Sunday	AM	5076	6.2	94.7
Link1	Sunday	IP	14294	3.4	93.3
Link1	Sunday	PM	6700	3.6	76.8
Link1	Sunday	OP	11515	6.3	91.5
Link2	Weekday	AM	2642	0.0	82.5
Link2	Weekday	IP	3236	0.0	110.6
Link2	Weekday	PM	3144	0.0	103.7
Link2	Weekday	OP	3719	0.0	110.7
Link2	Saturday	AM	1835	0.0	110.5
Link2	Saturday	IP	3687	0.0	110.9
Link2	Saturday	PM	2340	0.0	106.1
Link2	Saturday	OP	2256	0.0	112.5
Link2	Sunday	AM	1309	0.0	111.9

Link2	Sunday	IP	4528	0.0	109.6
Link2	Sunday	PM	3027	0.0	88.6
Link2	Sunday	OP	3569	0.0	106.6
Link3	Weekday	AM	10539	4.5	106.4
Link3	Weekday	IP	18726	7.9	106.8
Link3	Weekday	PM	11010	3.8	103.8
Link3	Weekday	OP	16339	6.7	107.9
Link3	Saturday	AM	8100	4.1	108.4
Link3	Saturday	IP	19624	3.2	108.2
Link3	Saturday	PM	9656	3.1	103.0
Link3	Saturday	OP	14733	4.8	108.1
Link3	Sunday	AM	6847	3.2	109.0
Link3	Sunday	IP	19108	2.4	107.8
Link3	Sunday	PM	10248	2.3	101.7
Link3	Sunday	OP	16434	3.4	107.8
Link 4	All days	All periods	21426	2.1	48

Note: Link 1 represents the first two lanes of the eastbound carriageway, link 2 represents the Bus Lane, link 3 represents the three lanes going westbound and link 4 represents the A3005.

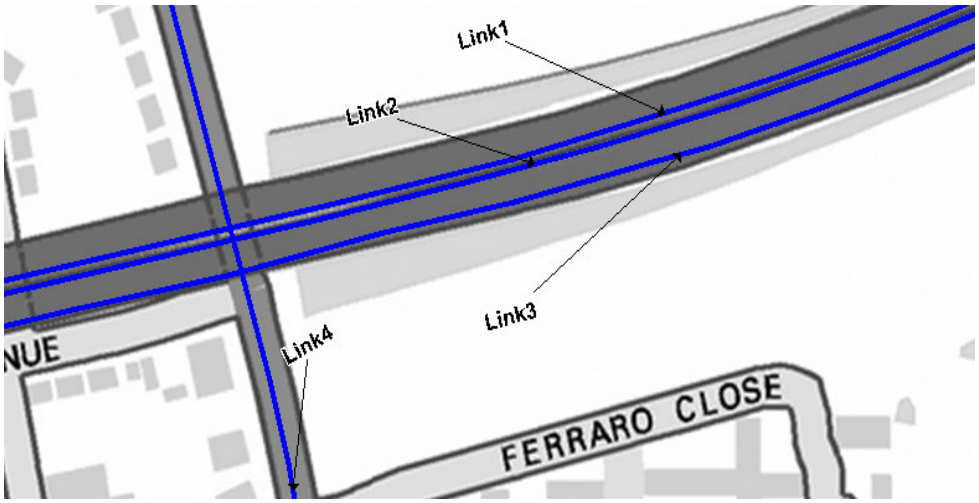


Figure A1 Link Diagram

Emission Factors

The variation in emissions was taken into account in the model by using a fac-file for links 1, 2 and 3, which contains factors for each period of the day. The emission factor toolkit v 4.2.2 was used to calculate emission rates for each profile (i.e. weekday, Saturday and Sunday for the AM, IP, PM and OP periods) for the with and without Bus Lane scenarios. These were incorporated into a fac-file to ensure that the variation in emission rates was accounted for in the model.

Meteorological Data

Meteorological data used in this assessment was taken from Heathrow meteorological station over the period 1st January 2011 to 31st December 2011 (inclusive). Heathrow observation station is located at National Grid Reference (NGR): 507800, 176700 which is approximately 4.25km west of the study area. LAQM.TG(09) recommends meteorological stations within 30km of an assessment area as being suitable for use in detailed modelling.

Figure A2 presents the wind rose for the Heathrow station for 2011.

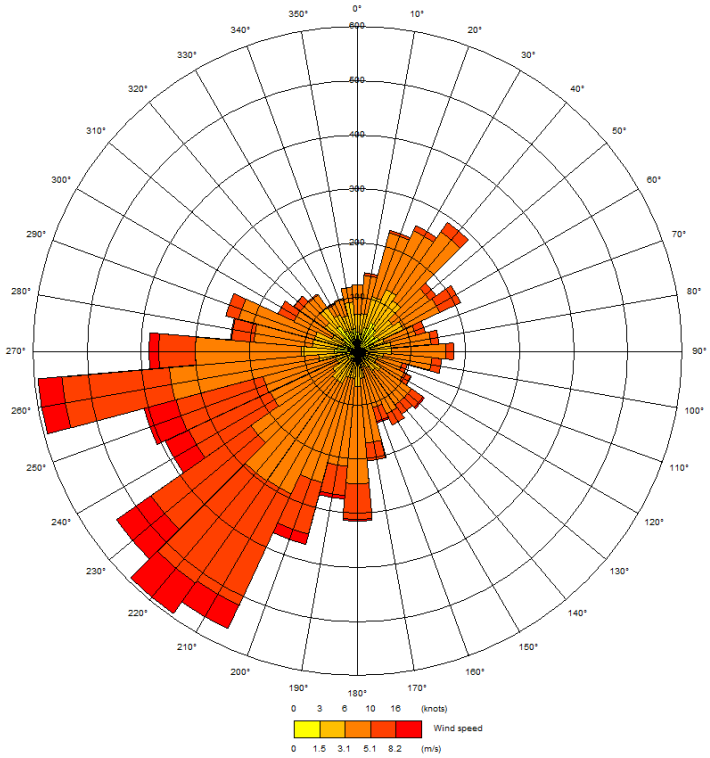


Figure A2 2011 Wind Rose for Heathrow

Roughness Length

A roughness length (z_0) of 0.5m was used, which was considered appropriate for the morphology of the dispersion modelling assessment area and is suggested within ADMS-Roads as being suitable for 'open suburbia'.

Monin-Obukhov Length

The Monin-Obukhov length provides a measure of the stability of the atmosphere. A Monin-Obukhov length of 100m was used in this dispersion modelling study for all study areas. This value is considered appropriate for nature of the assessment area and is suggested within ADMS-Roads as being suitable for 'large conurbations with a population of greater than a million'.

Background Concentrations

As stated previously, the bias and annually adjusted HS7 diffusion tube concentration was used within the modelling as a background concentration.

NO_x to NO_2 Conversion

Predicted annual mean NO_x concentrations from the dispersion modelling were converted to NO_2 concentrations using the NO_x to NO_2 spreadsheet provided by DEFRA.

Model Verification

The systematic and random error in the raw outputs from the ADMS-Roads dispersion modelling study was assessed through verification with local monitoring results. The without Bus Lane scenario was run for 2011 (i.e. the situation that existed during the diffusion tube monitoring) using the input data previously detailed and compared with the monitoring results shown in Table A3. The NO_2 concentrations measured by the diffusion tubes were compared to the modelled NO_2 concentrations presented in Table A3. HS10 was removed from the comparison as Heston Road, which is a busy road (>20,000 AADT), was not included in the modelling.

Table A3 Monitoring and Adjusted Modelled Results – NO_2

Monitoring Location	Grid Reference		2011 Concentration* (µg/m^3)		
	x	y	Monitored NO_2	Modelled NO_2	Percentage Difference between Modelled and Monitored NO_2
HS4	513014	177924	54.4	50.5	7.2
HS5	512851	177891	54.4	52.1	4.3
HS6	512938	177833	44.7	41.9	6.2
HS7	513426	178388	37.3	39.0	-4.5
HS8	512997	178029	54.7	44.1	19.5
HS9	513044	178001	49.9	50.1	-0.3
HS11	512724	177960	48.3	44.2	8.6
HS12	512553	177891	52.7	46.6	11.5
HS13	512692	177853	57.0	54.2	5.0
HS14	514270	178492	55.6	52.6	5.4
HS15	514333	178525	48.7	56.2	-15.5

*Factored to an annual mean using method stated in LAQM.TG(09)

The relationship between measured and predicted NO_2 concentrations at the monitoring locations was graphed following the procedure outlined in LAQM.TG(09).

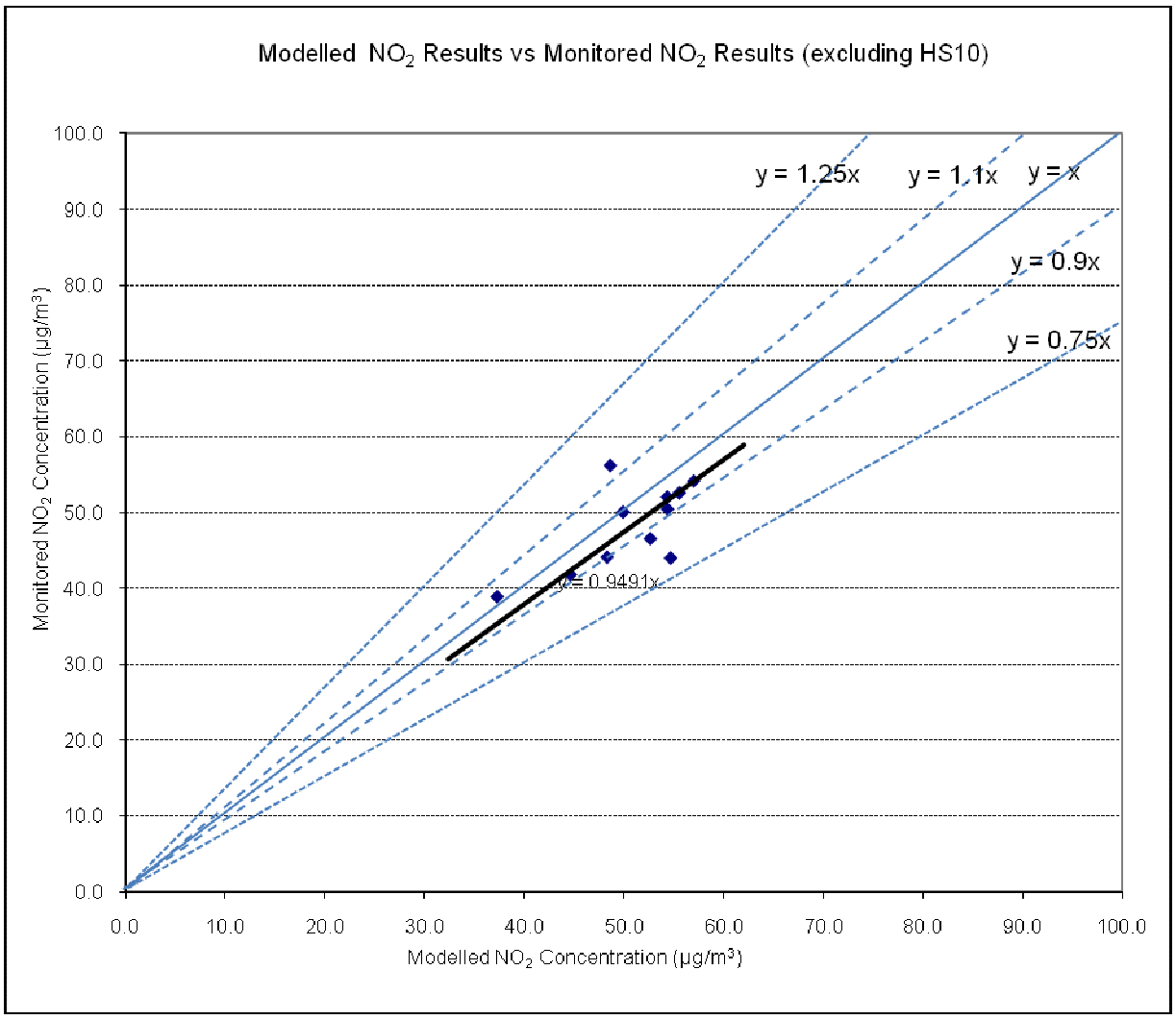


Figure A3 Modelled versus Monitored Results – NO_2

Table A4 and Figure A3 indicate that the model is performing well, with the difference between modelled and monitored NO_2 being within 20%, therefore the results require no further adjustment.