Storrington Traffic Management Options Appraisal

Air Quality Assessment

Report for Horsham District Council

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Contact:

Andy Lewin
Ricardo-AEA Ltd
Gemini Building, Harwell, Didcot, OX11 0QR
t: 0870 190 6355
e: andrew.lewin@ricardo-aea.com

Ricardo-AEA is certificated to ISO9001 and ISO14001

Author:

Andy Lewin

Approved By:

Beth Conlan

Date:

02 April 2013

Signed:

Executive summary

In December 2010 Horsham District Council declared an Air Quality Management Area (AQMA) in part of Storrington village as annual mean nitrogen dioxide (NO_2) concentrations in excess of the national air quality objective were occurring at locations where local residents may be exposed. Subsequent air quality assessment work conducted by the Council has identified that road traffic emissions are the main source of NO_2 within Storrington.

A draft Action Plan setting out the measures Horsham District Council intends to take to achieve compliance with the air quality objectives within the area covered by the AQMA has been prepared. One element of the action plan is to consider a number of traffic management scenarios to help reduce vehicle emission and ambient NO_2 concentrations.

Eight traffic management scenarios have been modelled to predict their potential impact on air quality within the Storrington AQMA and surrounding area. The assessment has been conducted using atmospheric dispersion modelling of road traffic emissions. The study also includes an assessment of the potential impacts of the suggested traffic management measures on air quality in the neighbouring village of Pulborough.

A summary of the findings of each scenario assessed is as follows:

- Atmospheric dispersion modelling of road traffic emissions verified using NO_2 annual mean concentrations measured during 2011 indicates that the 40 $\mu g.m^{-3}$ air quality objective is currently being exceeded at many locations where relevant human exposure exists within Storrington. The worst case locations are where traffic is often slow moving and congestion is known to occur close to the main junctions in Storrrington and along the High Street.

- Modelling of projected road traffic NOx emissions with estimated future background NOx concentrations in 2015, indicates that for a business as usual scenario, annual mean NO_2 concentrations will decrease, however will still be in excess of the 40 $\mu g.m^{-3}$ objective at many locations of relevant exposure.

- The potential impact of a proposal to change Old Mill Drive to a shared surface, assessed for a future year of 2015, is that NO_2 annual mean concentrations may increase by up to 1 $\mu g.m^{-3}$ at some of the specified receptor locations on School Hill, but will remain below the 40 $\mu g.m^{-3}$ NO_2 annual mean objective. The impact of this proposal is not therefore considered significant.

- Assessment of a proposal to re-open Nightingale Way to Cars and light goods vehicles only predicted reductions of up to 0.7 $\mu g.m^{-3}$ in NO_2 annual mean concentrations at the junction of Manleys Hill and School Hill. This reduction is not sufficient to achieve compliance with the 40 $\mu g.m^{-3}$ annual mean objective at the residential properties close to the roadside on Manleys Hill.

- The impact of a 20mph speed restriction through the AQMA which could potentially improve air quality by smoothing flow and reducing congestion was considered. Based on the current understanding of the stop-start nature of the traffic flow along the High Street and West Street; and the estimation that the average speed of the traffic through the AQMA is currently around 20 mph during free flowing periods and much less than 20 mph during busy periods. It was concluded that no air quality benefit could be achieved by imposing a 20 mph restriction.

- The potential to reduce road traffic NOx emissions by enforcing a low emission zone within Storrrington was assessed. The proposed LEZ would restrict all HGV's of pre Euro V classification from entering the village. The model predictions indicate that an access restriction on Bus and HGV to Euro V or better could help achieve compliance with the NO_2 annual mean objective at all locations within Storrington. It is also noted however that Euro V HGV's NOx emit, on average

greater quantities of NOx than Euro IV HGV's at low speeds. The assumptions made with respect to vehicle speeds within the model may mean that there is uncertainity associated with these results.

- 'Gating', a technique which could be used to control the inflow of traffic into Storrington during busy periods, and hence reduce congestion, was assessed. The results indicated that a 50% reduction in queuing is required to achieve compliance with the 40 $\mu g.m^{-3}$ objective at all relevant locations. Additional assessment of how effective 'gating' can be at reducing congestion in Storrington based on the expertise of a traffic engineer is recommended.

- Discouraging or preventing heavy goods vehicles from accessing the village by means of access restrictions was assessed. The results indicate that a reduction of 75% of HGVs entering Storrington is required to reduce NOx emissions sufficiently to achieve compliance with the 40 $\mu g.m^{-3}$ NO_2 annual mean objective at all locations. How realistic it is to implement this option will require further consideration.

- The potential impact of using variable message signage (VMS) on strategic routes outside of Storrington to discourage through traffic was estimated and the potential air quality impacts modelled. The results indicate that a reduction in through traffic could potentially reduce annual mean NO_2 concentrations below the 40 $\mu g.m^{-3}$ objective at locations on West Street but will not be sufficient to comply with the objectives at all of the receptors at Manleys Hill.

- The potential impact of implementing a low emission zone, restricting HGVs and providing improved signage in Storrington on the neighbouring village of Pulborough was also assessed. This was based on assumptions of how the traffic flow in Pulborough could be affected by changes in Storrington. The results indicated that there would be no significant impact on air quality in Pulborough.

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Appendices

1 Introduction

Horsham District Council has a responsibility under the Environment Act 1995 to monitor and identify sources of air pollution within the district.

In December 2010 Horsham District Council declared an Air Quality Management Area (AQMA) in part of Storrington village as annual mean nitrogen dioxide (NO_2) concentrations in excess of the national air quality objective were occurring at locations where local residents may be exposed. Subsequent air quality assessment work conducted by the Council has identified that road traffic emissions are the main source of NO_2 within Storrington.

A draft Action Plan setting out the measures Horsham District Council intends to take to achieve compliance with the air quality objectives within the area covered by the AQMA has been prepared[1]. One element of the action plan is to consider a number of traffic management scenarios to help reduce vehicle emission and ambient NO_2 concentrations.

Policy background This report describes an assessment of eight different traffic management scenarios and their predicted impact on air quality within the Storrington AQMA and surrounding area. The assessment has been conducted using atmospheric dispersion modelling of road traffic emissions. The study also aims to quantify the potential impacts of some of the suggested traffic management measures on air quality in the neighbouring village of Pulborough.

1.1 Policy Background

The Environment Act 1995 placed a responsibility on UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA), carry out a Further Assessment of Air Quality, and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future.

Table 1 lists the air quality objectives relevant to this assessment that are included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

[1] Horsham District Council (2012) Storrington AQMA Draft Action Plan.

Table 1: NO_2 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective	
	Concentration	Measured as
Nitrogen dioxide	200 µg.m^{-3} not to be exceeded more than 18 times a year	1 hour mean
	40 µg.m^{-3}	annual mean

1.2 Locations where the objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely be exposed over the averaging period of the objective. Table 2 summarises examples of where air quality objectives for NO_2 should and should not apply.

Table 2: Examples of where the NO_2 Air Quality Objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
1-hour mean	NO_2	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks and railway stations etc. which are not fully enclosed. Any outdoor locations to which the public might reasonably be expected to have access.	Kerbside sites where the public would not be expected to have regular access.

1.3 Purpose of the assessment

Horsham District Council successfully secured Defra funding via the Air Quality Grant for 2011-2012 to fund a traffic management feasibility study in Storrington. The study is being undertaken to investigate various vehicle 'restriction' measures, designed to reduce traffic volume, and additional congestion reduction measures to improve vehicle flow through the village.

This initial phase of the study aims to provide evidence of the benefits of pursuing emission reductions through various traffic management strategies in Storrington. The study uses atmospheric dispersion modelling to determine the potential air quality benefits of eight traffic management scenarios in comparison to the existing and future predicted baseline NO_2 concentrations.

The Storrington AQMA Draft Action Plan acknowledges that it is important that the Council assesses the full costs, benefits and cost effectiveness of each of the scenarios. It goes on to state that the feasibility study will be extended to assess these aspects should any of the scenarios be identified as having a significantly beneficial impact on air quality and there being a realistic prospect of the scenario being adopted, based on technical feasibility and local acceptability. This will provide the Council with a robust impact assessment on each of the options to inform the final decision making process[2].

The study also aims to quantify the potential impacts of some of the suggested traffic management measures on air quality in the neighbouring village of Pulborough which is located approximately 5 miles north west of Storrington.

[2] Horsham District Council (2012) Storrington AQMA Draft Action Plan.

1.4 Overview of the assessment

The scenarios included in the air quality assessment are described in Table 3. The potential effect of the traffic management measures proposed in scenarios 6, 8 and 9 on air quality in Pulborough have also been included in the assessment.

Table 3: Storrington Traffic Management Feasibility Study Scenarios

Scenario		Description
1	Current baseline (2011)	Utilising latest traffic flow data and WSCC origin-destination ANPR camera survey data.
2	Business as usual for a future year (2015)	Modelled prediction of traffic volume for future year without imposition of any traffic management measures.
3	Assess impact of changing Old Mill Drive to a shared surface	The partial closure of Old Mill Drive in the centre of Storrington village is a long term aspiration of the Council as part of a regeneration scheme for an existing shopping precinct area. The restriction of traffic on this road will necessitate the redistribution of up to 1600 vehicles per day onto adjoining roads within the AQMA. It was agreed that the impact of this proposal should be tested as part of the feasibility study.
4	Assess impact of re-opening Nightingale Way	Nightingale Way is a residential road linking Manleys Hill and School Hill. The road was closed approximately 40 years ago on safety grounds. The feasibility study will assess whether re-opening the road to some vehicles may offer an opportunity to alleviate congestion at the School Hill/Manleys Hill junction.
5	Assess impact on air quality of imposing a 20mph speed restriction in the village.	Feasibility study will indicate whether imposition of a 20mph speed restriction through the AQMA would improve air quality by smoothing flow and reducing congestion.
6	Assess impact of Low Emission Zone (LEZ) in Storrington for a future year (2015).	The LEZ would limit access to the village for specific vehicle types not meeting specified emission standards (e.g. Euro V).
7	Assess impact of gating option in future year (2015)	Controlling traffic flow through the Storrington AQMA by means of traffic light 'gates' outside the village.
8	Assess impact of imposing a restriction on heavy goods vehicles in future year (2015)	Discouraging or preventing heavy goods vehicles accessing the village by means of access restrictions, either by way of height or weight, at strategic locations outside the village.
9	Assess impact of providing improved signage for a future year (2015)	Use of variable message signage (VMS) on strategic routes outside the village to discourage through traffic during periods of congestion within the AQMA.

1.5 Study area

1.5.1 Storrington

Storrington is a relatively large village with a population of approximately 4,500. Storrington has one main shopping area on West Street and High Street on the main A283 road which connects the village to Washington (A24) in the east and Pulborough to the west. The road is narrow in places with both commercial and residential properties positioned close to the kerbside. There are roundabout controlled junctions at both the western and eastern ends of the High Street and two traffic light controlled pedestrian crossings. The High Street suffers from congested traffic particularly at peak times but carries a consistently high traffic flow throughout the day. There are a relatively high number of heavy goods vehicles passing through the village.

The roundabout at the eastern end of the village is the junction of the continued A283 and School Hill which is the access road to the main shopping precinct car park. Both roads continue at an incline from the roundabout. At this junction the carriageway is narrow and the adjacent buildings are very close to the kerb.

The A283 running through Storrington forms a link between the A29 to the west and the A24 to the east, both of which are significant routes for accessing the main A27 coastal road. Locally the perception is that the A283 through Storrington is used as a cut-through to avoid congestion on the A27 at Arundel and Worthing.

A map showing the extent of the study area is presented in Figure 1 below.

1.5.1.1 Storrington Air Quality Management Area

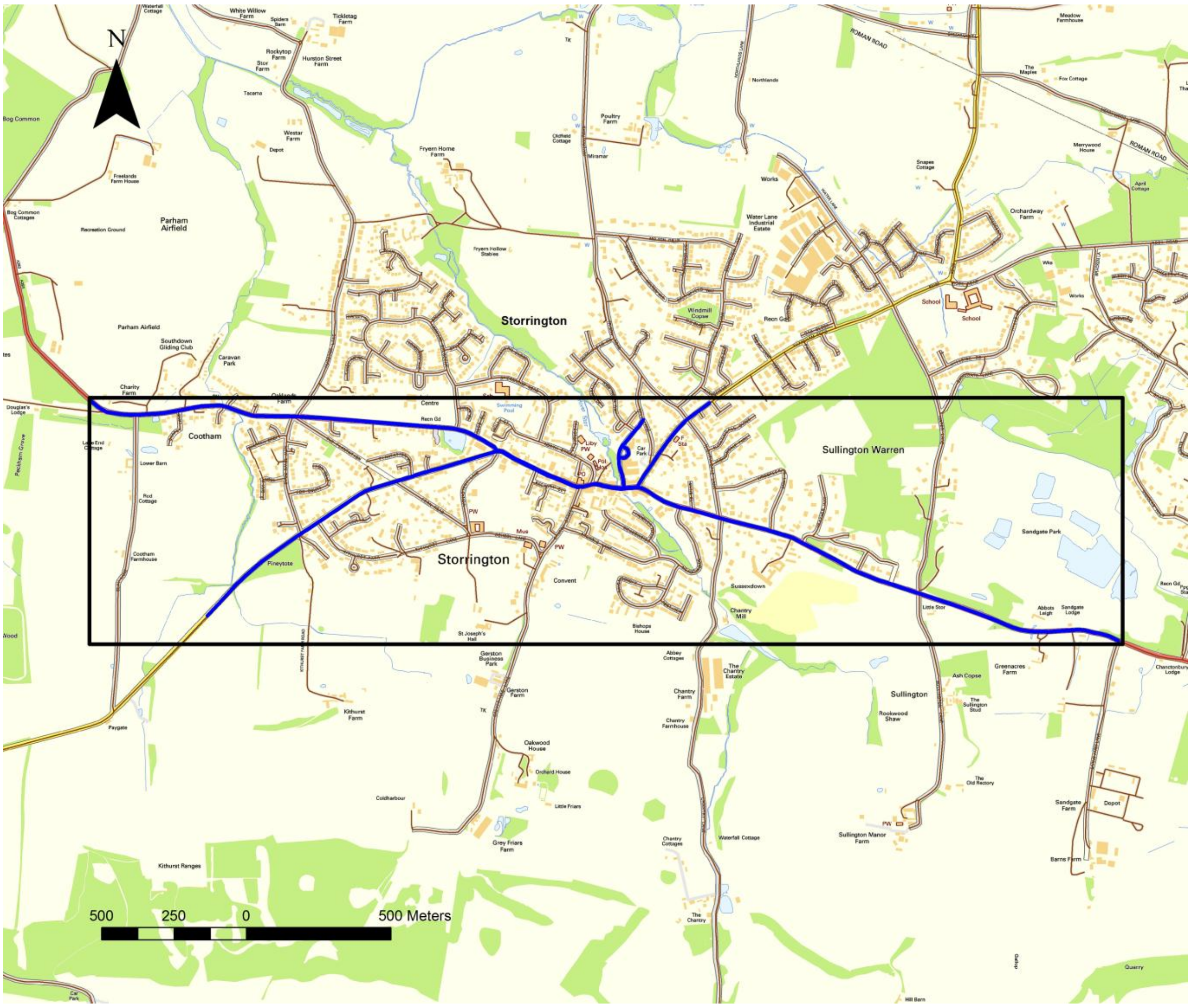
A Detailed Assessment of air quality in Storrington was conducted in June 2010. The report concluded that an AQMA should be declared for NO_2 along the High Street and Manleys Hill/School Hill junction. The AQMA was extended to incorporate the length of the High Street. There are 36 separate residential dwellings within the area of exceedence of the 40 $\mu g.m^{-3}$ annual mean objective for NO_2.

The Storrington Air Quality Management Area (AQMA) was formally declared by Council Order on 1st December 2010. The AQMA encompasses properties either side of the main road through the village, formed of the A283 West Street/ High Street, to the junction of the B2139 (School Hill) and A283 (High Street/Manleys Hill). A map showing the extent of the AQMA is presented in Figure 2.

1.5.2 Pulborough

Pulborough is a large village with a population of approximately 5,000 located approximately 5 miles northwest of Storrington on the A283. Measured annual mean NO_2 concentrations have been close to exceeding the annual mean NO_2 objective in previous years, Pulborough is therefore considered vulnerable to any significant redistribution of traffic arising from traffic management changes in Storrington.

Figure 1: Study area boundary



Key:

Study area boundary

Road to be modelled

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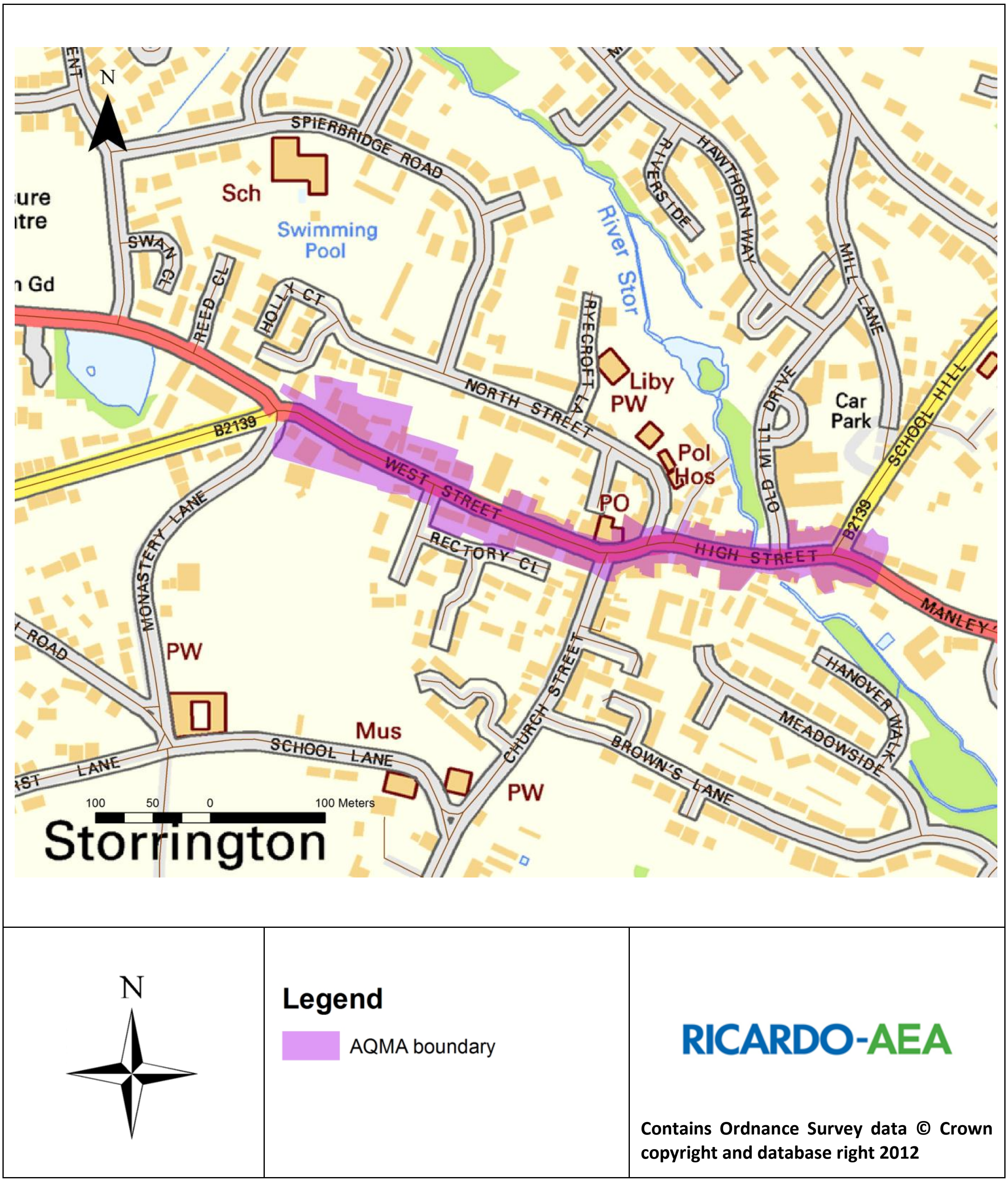
Figure 2: Storrington AQMA boundary



2 Supporting Information

2.1 Maps

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

2.2 Road traffic data

2.2.1 Average flow, speed and fleet split

Annual average daily traffic (AADT) flow and detailed vehicle fleet splits were collated from traffic count data provided by Horsham District Council. Some assumptions have been made when calculating traffic flows. A summary of all of the traffic flow data used, the road links modelled, the data sources and any assumptions made is presented in Appendix 1.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

2.2.2 Congestion

Local knowledge of traffic patterns within Storrington was provided by Horsham District Council. Traffic is known to become congested at certain locations close to the main junctions in Storrington during peak commuting hours in the morning and early evening. Congestion is also known to occur regularly in the High Street during the day time as parking, loading and turning vehicles restrict the flow of traffic along this narrow section.

A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC has been used to represent the periodic congestion. The method assumes that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 km/hr), with an average vehicle length of 4 m, and are positioned close to each other during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods.

A time–varying file is used in the model to turn the congested road sections on during the congested periods in the morning and afternoon/evening.

2.2.3 Emission factors

The most recent vehicle emissions factors from the NAEI (as derived from COPERT 4) released in June 2012 were used in this assessment. Parameters such as traffic volume, speed and fleet composition are used to calculate the emission rates, and an emissions factor in grams of NOx/second/kilometre is generated for input into the dispersion model.

AEA's proprietary LADSUrban 6.01 tool was used to calculate average emission factors for oxides of nitrogen for each road link. The LADSUrban tool uses the latest emission factors recommended by the National Atmospheric Emission Inventory derived from COPERT IV (released in June 2012). The tool uses national statistics to determine the default vehicle fleet with respect to:

- Emissions technology class (e.g. Euro 1, Euro 2…….)
- Fuel type
- Particle traps and filters
- Catalyst failures
- Car engine sizes
- Goods vehicle weights
- Bus and coach weights
- Motorcycle engine sizes and weights
- HGV Axle distributions

The default values can be overridden if better information is available. The default values (UK fleet characteristics from the NAEI) were used for the baseline assessments.

The COPERT IV emission factors are derived from test data for specified driving cycles that include stop-start driving conditions. The emission factor functions are valid formally down to 10 kph for cars and 5 kph for heavy goods vehicles.

Parameters such as traffic volume, speed and fleet composition are used to calculate the emission rates, and an emissions factor in grams of NOx/second/kilometre is generated for input into the ADMS-Roads atmospheric dispersion model.

2.3 Ambient Monitoring

Horsham District Council currently undertakes monitoring of NO_2 in Storrington at one automatic monitoring site and a network of diffusion tubes; and at Pulborough using two diffusion tubes. Further details of these monitoring locations and recent measured concentrations are provided in Section 3.

2.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) covering the Calendar year of 2011 from Boscombe Downe was obtained from a third party supplier and used in this assessment. The chosen site is located approximately 90km NWW of the study area and has good data quality for the period of interest. Data from the Shoreham meteorological measurement site which is closer to the study area was unsuitable for use in the study due to poor data capture during 2011. A wind rose for the meteorological dataset at Boscombe Downe is presented in Appendix 2.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

2.5 Background concentrations

The Defra LAQM background maps[3] provide estimates of background NOx and NO_2 concentrations from the outputs of a national scale dispersion at a 1km x 1km resolution covering the time period 2010 to 2030. A CSV file containing mapped background oxides of nitrogen (NOx) concentrations

[3] Defra (2012) http://laqm1.defra.gov.uk/review/tools/background.php (accessed July 2012)

across the Horsham District Council area was obtained and annual mean background concentrations for the appropriate grid square extracted for both the baseline year of 2011 and the future scenario year of 2015. In the future background concentrations are expected to be lower than currently as the result of reductions in emissions throughout the UK. It should be noted that as the Defra background maps are the outputs of a national scale model, they are subject to a degree of uncertainty.

The estimated annual mean NOx background concentrations in both years at Storrington and Pulborough are presented in Table 4.

Table 4: Background annual mean NOx concentrations 2011 and 2015

Village	Background annual mean NOx concentration (µg.m^{-3})	
	2011	2015
Storrington	12.7	10.9
Pulborough	10.4	9

3 Monitoring data

3.1 Storrington

Horsham District Council measure NO_2 concentrations in Storrington at one automatic monitoring station and fifteen diffusion tube sites. Ten of these monitoring locations were used in this study to verify the dispersion modelling results. A map showing the location of the monitoring sites used in the study is presented in Figure 3.

Full details of all NO_2 monitoring sites, recent measurements and QA/QC procedures are presented in the Horsham District Council 2012 Updating and Screening assessment[4].

A summary of the automatic and diffusion tube measurements during 2011 are presented in Table 5 and Table 6 respectively. Annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective were recorded at two of the monitoring locations during 2011; the Storrington 1&2 diffusion tube site on Manleys Hill, and the Storrrington 4 diffusion tube site on the High Street.

Table 5: Storrington – Automatic monitor - NO_2 annual mean 2011

Site	Type	OS Grid Ref.		Data Capture (annual) (%)	Data Capture (period) (%)	NO_2 annual mean ($\mu g.m^{-3}$)
		Easting	Northing			
Storrington Manleys Hill AURN	R	508991	114249	98%	98%	23.4
Exceedences of the annual mean objective are shown in bold * Annualised annual mean due to data capture <75%						
R - Roadside, 1 - 5m from the kerb						

Table 6: Storrington – NO_2 diffusion tube measurements 2011

Site	Type	OS Grid Ref.		Data Capture (%)	Bias corrected (0.82) annual mean ($\mu g.m^{-3}$)
		Easting	Northing		
Storrington 1 & 2 Duplicate	R	508960	114270	91.7	**45.4**
Storrington 3	R	508935	114297	100	33.4
Storrington 4	R	508832	114272	100	**42**
Storrington 5	R	508740	114285	91.7	25.8
Storrington 6	R	508396	114449	100	21
Storrington 7	R	508338	114374	91.7	24.6
Storrington 11	R	508511	114365	100	39.3
Storrington 12	R	508598	114323	100	32.8
Storrington 13	R	508821	114274	100	30.5
Storrington 15n	R	509103	114532	91.7	20.5
Storrington 18n	R	508215	114348	83.3	21.4
Exceedences of the annual mean objective are shown in bold					
R - Roadside, 1 - 5m from the kerb					

[4] Horsham District Council (2012) 2012 Updating and Screening assessment for Horsham District Council; April 2012.

Figure 3: Storrington NO_2 monitoring sites used in the assessment

Legend

NO2 monitoring site

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3.2 Pulborough

Horsham District Council measure NO_2 concentrations in Pulborough at two diffusion tube sites. Both of these sites were used to verify the dispersion modelling results. A map showing the location of the monitoring sites in Pulborough is presented in Figure 4.

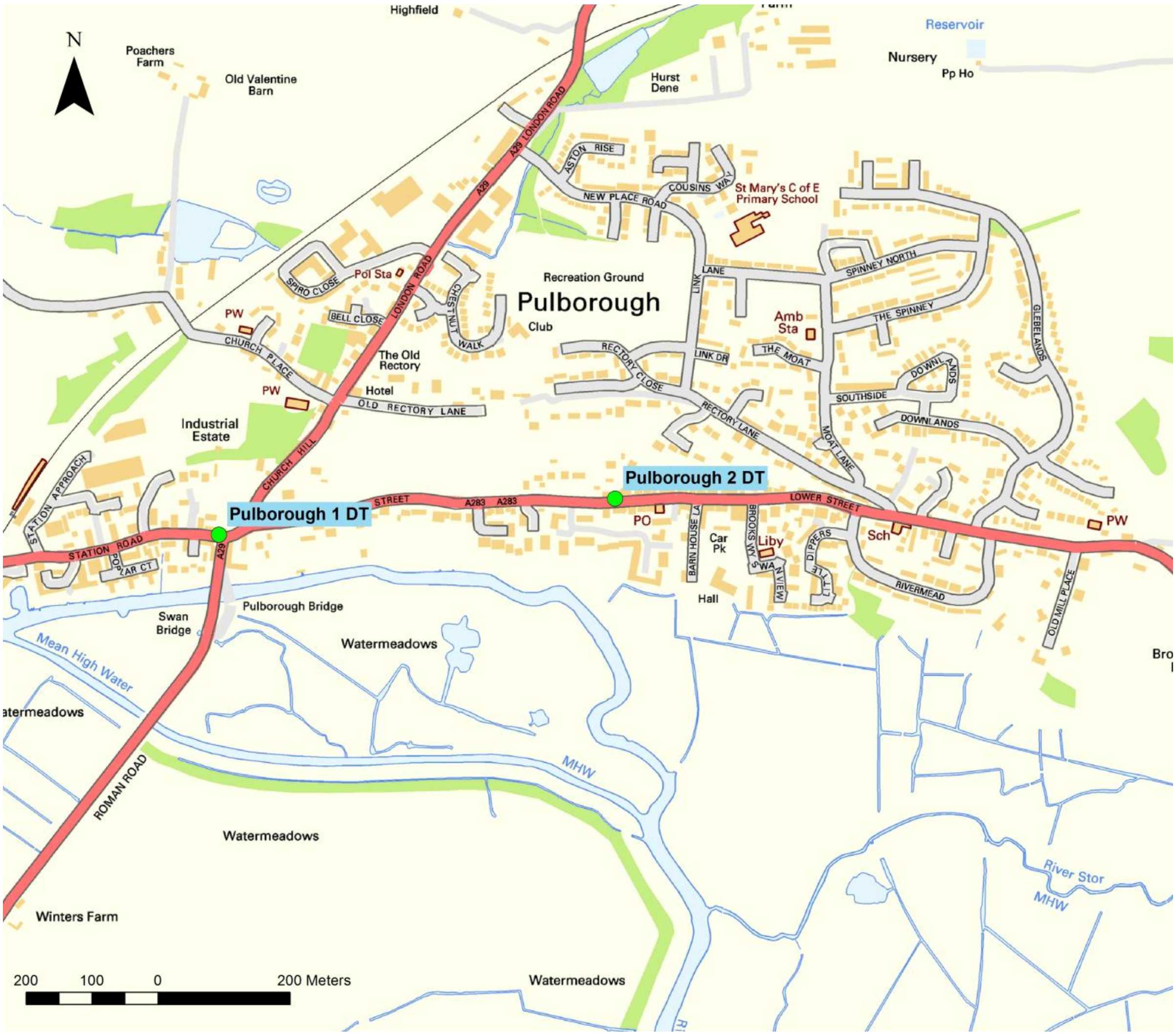
A summary of the diffusion tube measurements during 2011 are presented in Table 7. No annual mean NO_2 concentrations in excess of the 40 µg.m^{-3} objective were measured in Pulborough during 2011.

Table 7: Pulborough – NO_2 diffusion tube measurements 2011

Site	Type	OS Grid Ref.		Data Capture (%)	Bias corrected (0.82) annual mean (µg.m^{-3})
		Easting	Northing		
Pulborough 1	K	504584	118568	100	33.1
Pulborough 2	R	505185	118623	100	22.3

R - Roadside, 1 - 5m from the kerb
K – Kerbside, Up to 1m from the kerb

Figure 4: Pulborough NO_2 monitoring sites used in the assessment



Legend

● NO2 monitoring site

Contains Ordnance Survey data © Crown copyright and database right 2012

4 Modelling

4.1 Modelling methodology

Annual mean NO_2 concentrations for the 2011 baseline year and various future scenarios have been modelled using the atmospheric dispersion model ADMS Roads (version 3.1).

The 2011 baseline model was verified by comparing the modelled predictions of road NOx with local monitoring results. The available 2011 roadside diffusion tube and automatic analyser measurements (described in Section 3 above) were used to verify the annual mean road NOx model predictions. Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the monitoring results. Further information on model verification is provided in Section 5.1.3 and Appendix 1.

A surface roughness of 0.5 m was used in the modelling to represent the open suburbia land-use present across the modelled domain. A limit for the Monin-Obukhov length of 10 m was applied to represent a small town.

Annual mean NO_2 concentrations were predicted at both specified receptor points; and across a grid of points. The source-oriented grid option was used in ADMS-Roads; this option provides finer resolution of predicted pollutant concentrations along the roadside. The grid height was set to provide predictions at 1.5 m to represent human exposure. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping.

It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

Queuing traffic was treated in the model using the methodology described in Section 2.2.2 above as provided by the model developers. Queuing was assigned to specific road sections based on local knowledge following consultation with Horsham District Council. A time varying emissions file was used in the model to account for daily variations in queuing traffic. Further information on the queues modelled is presented in Appendix 1.

4.1.1 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and the proportion of NOx released as primary NO_2. For the purposes of this assessment we have assumed that 21.2% of NOx is released as primary NO_2 in the baseline year of 2011 and is projected to be 24% in 2015 for the future scenarios modelled. This primary NO_2 value is associated with the “All other UK urban traffic” option in the model.

4.1.2 Validation of ADMS-Roads

In simple terms, validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications. CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and DEFRA.

4.1.3 Verification of the model and model performance

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. Dispersion models of this nature carry a degree of uncertainty for the reasons explained in previous sections so it is important to check their performance against measurements and adjust their outputs accordingly. A full description of the model verification procedures for both the Storrington and Pulborough models is presented in Appendix 3.

To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3. Details of the RMSE are presented in Appendix 3.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE was calculated at 2 $\mu g.m^{-3}$ for the Storrington model, the model uncertainty is therefore considered acceptable and the model has performed sufficiently well for use within this assessment.

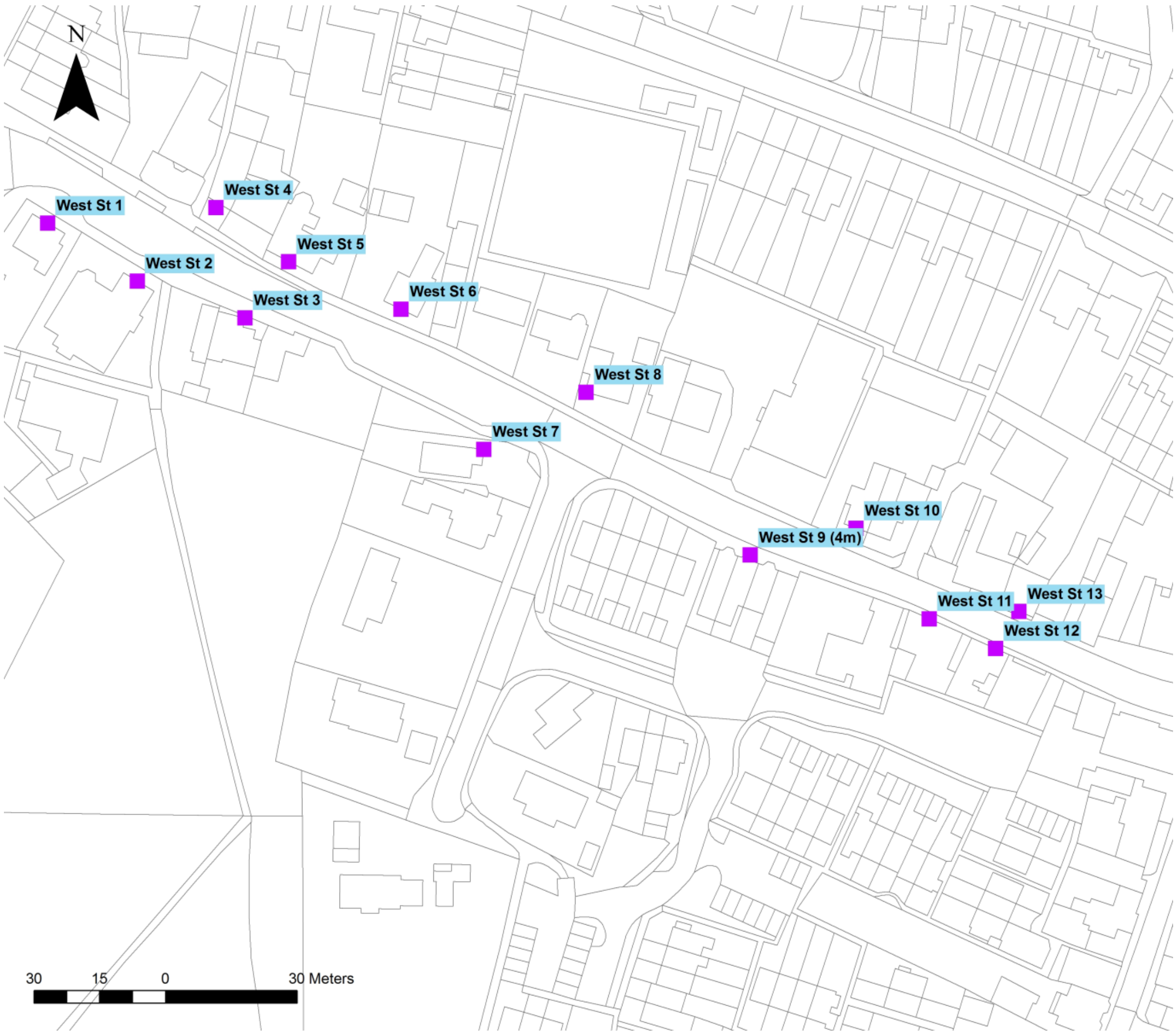
5 Model Results

For all of the scenarios, the adjusted model results have been used to predict annual mean NO_2 concentrations at a selection of specified receptors within the study area. The receptors are located at the facade of residential buildings in the model domain where relevant exposure exists and have been selected to be representative of worst case exposure to road traffic emissions. Some of the receptors have been modelled at a height of 4 m to represent human exposure at the first floor flats above commercial properties on West Street and High Street. Direct comparison of predicted annual mean NO_2 concentrations at the specified receptor for each scenario will provide a good indication of the likely air quality benefits of each traffic management option. The locations of the specified receptors are presented on Figure 5 and Figure 6.

A contour plot showing the spatial variation of predicted annual mean NO_2 concentrations across the study area has also been produced for the baseline scenario. This provides a good indication of the current locations where high annual mean NO_2 concentrations are occurring.

NO_2 annual mean contour plots are also included for some of the other scenarios where they are considered beneficial in interpreting the modelling results.

Figure 5: Specified receptor locations in West Street, Storrington



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Specified receptor location

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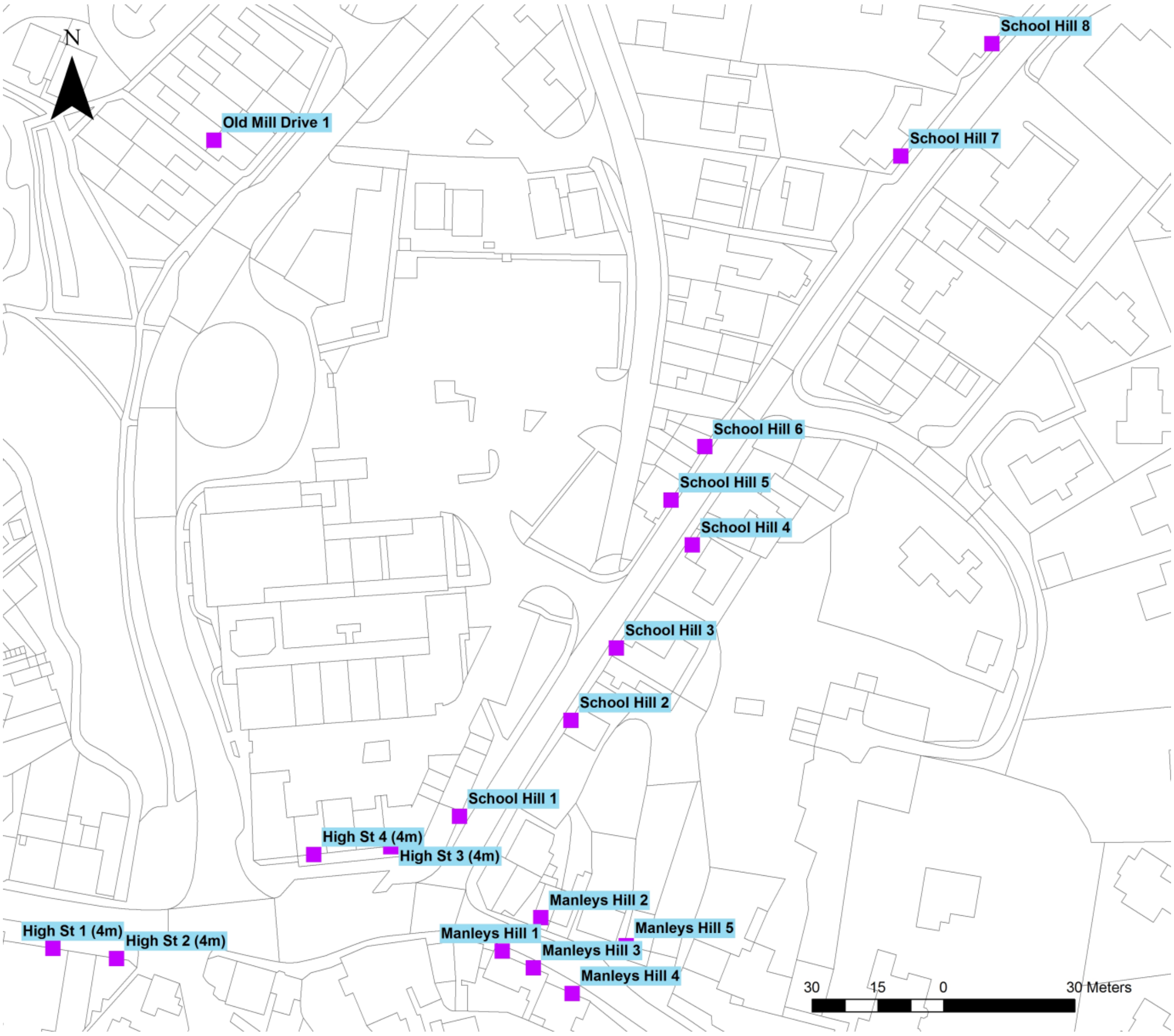
Figure 6: Specified receptor locations in High Street, School Hill and Manleys Hill, Storrington



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Specified receptor location

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5.1 2011 Current baseline (Scenario 1)

The predicted annual mean NO_2 concentrations at each of the specified receptors during 2011 are presented in Table 8. Predicted concentrations in excess of the objective are highlighted in bold in rose shaded cells. As described in Section 4.1.3 and Appendix 3, the RMSE was 2 $\mu g.m^{-3}$ therefore the model performed sufficiently well for use in this type of assessment.

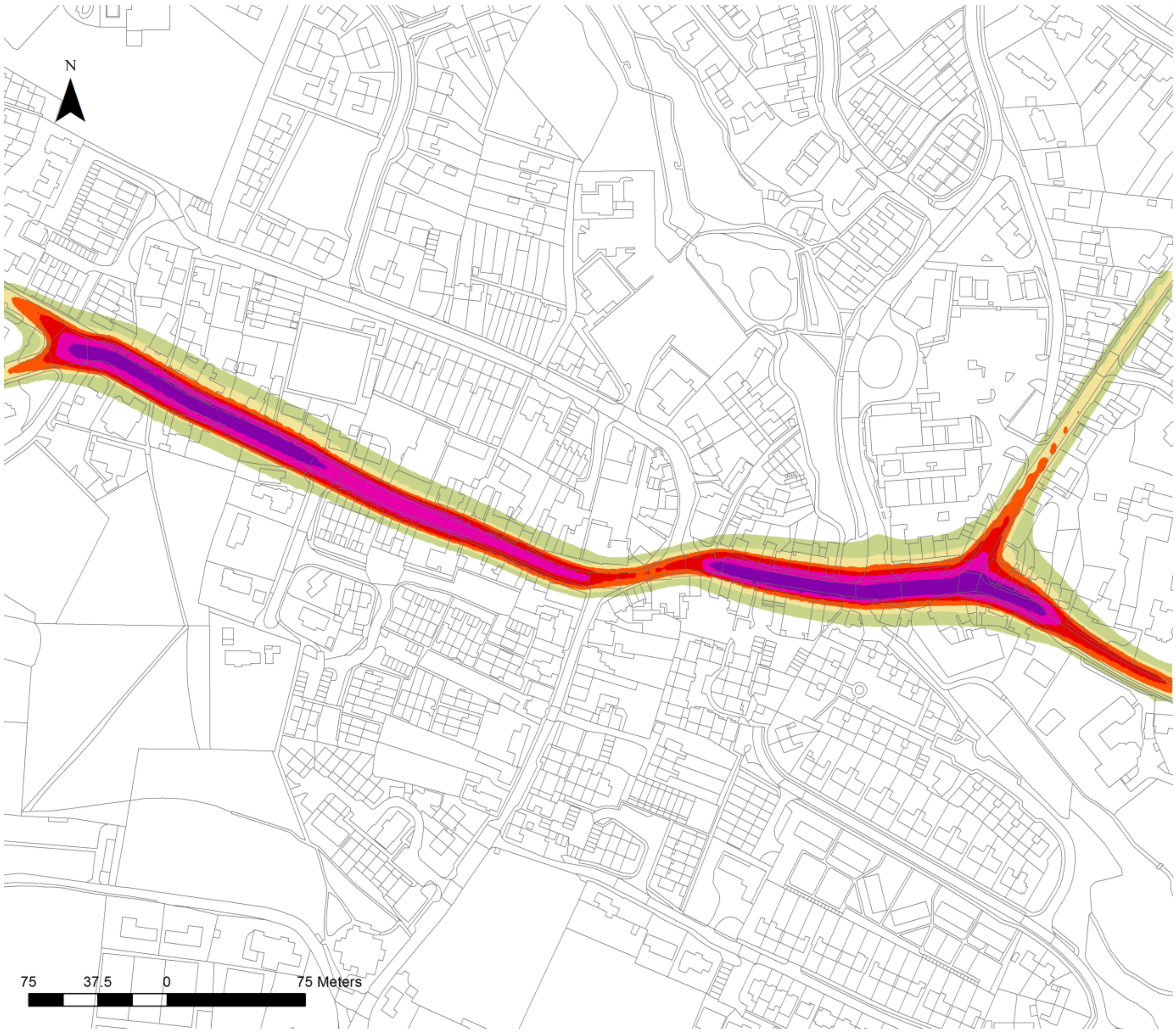
Annual mean concentrations in excess of the 40 $\mu g.m^{-3}$ objective were predicted at ground level receptors on West Street and at junction of Manleys Hill, School Hill and High Street. These are all locations where congestion is known to occur during busy periods. No annual mean concentrations in excess of the 40 $\mu g.m^{-3}$ objective were predicted at first floor height.

Table 8: Predicted annual mean NO_2 concentrations at specified receptors – 2011 Baseline scenario

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)
		X	Y	
West St 1	1.5	508458	114391	38.2
West St 2	1.5	508479	114377	34.4
West St 3	1.5	508503	114369	**42.3**
West St 4	1.5	508497	114394	**41.3**
West St 5	1.5	508513	114382	**45.9**
West St 6	1.5	508539	114371	**43.8**
West St 7	1.5	508558	114339	35.5
West St 8	1.5	508581	114352	38.9
West St 9 (4m)	4	508619	114315	24.6
West St 10	1.5	508643	114321	39.0
West St 11	1.5	508660	114300	**46.6**
West St 12	1.5	508675	114293	**44.3**
West St 13	1.5	508680	114302	**42.4**
High St 1 (4m)	4	508841	114270	26.5
High St 2 (4m)	4	508856	114267	26.8
Manleys Hill 1	1.5	508944	114269	**52.2**
Manleys Hill 2	1.5	508953	114277	**52.3**
Manleys Hill 3	1.5	508951	114265	**48.0**
Manleys Hill 4	1.5	508960	114259	**43.0**
Manleys Hill 5	1.5	508972	114270	**41.8**
High St 3 (4m)	4	508918	114293	28.5
High St 4 (4m)	4	508901	114291	28.2
Old Mill Drive 1	1.5	508878	114454	14.7
Old Mill Drive 2	1.5	508917	114498	14.0
School Hill 1	1.5	508934	114300	**40.0**
School Hill 2	1.5	508960	114322	36.5
School Hill 3	1.5	508970	114338	36.2
School Hill 4	1.5	508987	114362	32.8
School Hill 5	1.5	508982	114372	31.9
School Hill 6	1.5	508990	114384	30.9
School Hill 7	1.5	509035	114451	26.3
School Hill 8	1.5	509056	114476	26.2
School Hill 9	1.5	509119	114516	24.0

A contour plot showing the spatial variation in modelled annual mean NO_2 concentrations in the centre of Storrington during 2011 is presented in Figure 7.

Figure 7: Modelled NO_2 annual mean concentrations 2011 – Storrington



N

Legend:

Annual mean NO_2 concentration ($\mu g.m^{-3}$)

- < 30
- 30 - 36
- 36 - 40
- 40 - 44
- 44 - 50
- 50 - 60
- > 60

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5.2 Emission reduction scenarios

The following section of the report describes each of the traffic management scenarios modelled and any assumptions that have been made. All future scenarios have been modelled during the year 2015. All future modelled NO_2 concentrations account for the predicted reduction in background NOx/NO_2 concentrations, projected decreases in vehicle NOx emissions, and projected changes to the fraction of NOx emitted as primary NO_2 from road vehicles over time as the vehicle fleet changes.

The predicted change in annual mean NO_2 concentrations at each of the specified receptors in the study, in comparison with the future baseline i.e. business as usual in 2015 is presented for each scenario.

5.2.1 Scenario 2: Business as usual for a future year (2015)

The predicted annual mean concentrations at each of the specified receptor locations in 2015 assuming business as usual, i.e. no implementation of any traffic management measures, are presented in Table 9.

This scenario assumes:

- A local growth in traffic volume (AADT) by a factor of 1.0303 (TEMPRO derived growth factor) between 2011 and 2015
- A projected reduction in background NOx from 12.7 $\mu g.m^{-3}$ to 10.9 $\mu g.m^{-3}$ between 2011 and 2015
- Various reductions in vehicle NOx emissions attributable to changes in the typical composition of the vehicle fleet up to 2015.

It can be observed that at some of the locations where NO_2 annual mean concentrations were in excess of the 40 $\mu g.m^{-3}$ air quality objective during 2011, the predicted annual mean is predicted to be below the objective in 2015. The projected reductions in NOx emissions are not however sufficient to achieve compliance with the objective at all locations. The locations where concentrations in excess of the objective are predicted in 2015 are where congestion is currently known to occur. Based on the projected growth of AADT, it is likely that congestion will still occur at these locations in a 2015 for a business as usual scenario.

Table 9: Comparison of predicted NO_2 annual mean in 2015 with 2011 baseline – Scenario 2

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)	
		X	Y	2011 Baseline	2015 business as usual
West St 1	1.5	508458	114391	38.2	34.0
West St 2	1.5	508479	114377	34.4	30.4
West St 3	1.5	508503	114369	**42.3**	37.9
West St 4	1.5	508497	114394	**41.3**	36.9
West St 5	1.5	508513	114382	**45.9**	**41.4**
West St 6	1.5	508539	114371	**43.8**	39.3
West St 7	1.5	508558	114339	35.5	31.4
West St 8	1.5	508581	114352	38.9	34.6
West St 9 (4m)	4	508619	114315	24.6	21.5
West St 10	1.5	508643	114321	39.0	34.7
West St 11	1.5	508660	114300	**46.6**	**42.0**
West St 12	1.5	508675	114293	**44.3**	39.8
West St 13	1.5	508680	114302	**42.4**	38.0
High St 1 (4m)	4	508841	114270	26.5	23.1
High St 2 (4m)	4	508856	114267	26.8	23.4
Manleys Hill 1	1.5	508944	114269	**52.2**	**47.7**
Manleys Hill 2	1.5	508953	114277	**52.3**	**47.7**
Manleys Hill 3	1.5	508951	114265	**48.0**	**43.5**
Manleys Hill 4	1.5	508960	114259	**43.0**	38.7
Manleys Hill 5	1.5	508972	114270	**41.8**	37.4
High St 3 (4m)	4	508918	114293	28.5	24.8
High St 4 (4m)	4	508901	114291	28.2	24.6
Old Mill Drive 1	1.5	508878	114454	14.7	12.6
Old Mill Drive 2	1.5	508917	114498	14.0	12.0
School Hill 1	1.5	508934	114300	**40.0**	35.8
School Hill 2	1.5	508960	114322	36.5	32.7
School Hill 3	1.5	508970	114338	36.2	32.4
School Hill 4	1.5	508987	114362	32.8	29.2
School Hill 5	1.5	508982	114372	31.9	28.4
School Hill 6	1.5	508990	114384	30.9	27.4
School Hill 7	1.5	509035	114451	26.3	23.2
School Hill 8	1.5	509056	114476	26.2	23.1
School Hill 9	1.5	509119	114516	24.0	21.1

5.2.2 Scenario 3: Changing Old Mill Drive to a shared surface (2015)

The partial closure of Old Mill Drive in the centre of Storrington village is a long term aspiration of the Council as part of a regeneration scheme for the existing shopping precinct area. It has been proposed to create a shared surface whereby the street would become pedestrianized with access for slow moving vehicles only with no HGV or bus traffic permitted. The restriction of traffic on this road will necessitate the redistribution of up to 1600 vehicles per day onto adjoining roads within the AQMA.

Restricting buses from using Old Mill Drive may mean that an alternative bus stop will be required somewhere on the High Street. This may contribute to congestion and traffic queuing on the High Street as stopping buses will block westbound traffic; it may also however help reduce congestion as it will reduce the number of buses and HGVs stopping and waiting to turn right onto Old Mill Drive, and hence holding up westbound traffic when approaching from the east. The effects this may have on congestion on the High Street are difficult to quantify so have not been included in the scenario.

Based on local knowledge from discussions with Horsham District Council, it has been assumed that traffic would use School Hill to access the shopping precinct area instead of Old Mill Drive if it were to become a shared surface. The scenario aims to provide an indication of the potential impact of moving traffic from Old Mill Drive to School Hill, three sub-scenarios have been modelled as follows:

a. All Buses + HGV removed from Old Mill Drive - average speed reduced to 10 mph - 25% of traffic re-routed to School Hill.
b. All Buses + HGV removed from Old Mill Drive - average speed reduced to 10 mph - 50% of traffic re-routed to School Hill
c. All Buses + HGV removed - average speed reduced to 10 mph - 75% of traffic re-routed to School Hill

A comparison of the predicted annual mean NO_2 concentrations for the three Old Mill Drive sub-scenarios and the 2015 business as usual scenario is presented in Table 10. Results have been presented at the specified receptors on Old Mill Drive and School Hill only as there is no change in predicted concentrations at any of the other receptors.

The results indicate that annual mean NO_2 concentrations increase by up to 1 $\mu g.m^{-3}$ at some of the specified receptor locations on School Hill but are still below the 40 $\mu g.m^{-3}$ objective.

Table 10: Scenario 3 – Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)			
		X	Y	2015 business as usual	25% of traffic re-routed to School Hill.	50% of traffic re-routed to School Hill	75% of traffic re-routed to School Hill
Old Mill Drive 1	1.5	508878	114454	12.6	12.4	12.3	12.2
Old Mill Drive 2	1.5	508917	114498	12.0	11.8	11.7	11.6
School Hill 1	1.5	508934	114300	35.8	36.0	36.2	36.4
School Hill 2	1.5	508960	114322	32.7	33.0	33.2	33.5
School Hill 3	1.5	508970	114338	32.4	32.7	33.1	33.4
School Hill 4	1.5	508987	114362	29.2	29.5	29.8	30.1
School Hill 5	1.5	508982	114372	28.4	28.7	29.0	29.3
School Hill 6	1.5	508990	114384	27.4	27.7	27.9	28.2
School Hill 7	1.5	509035	114451	23.2	23.4	23.6	23.8
School Hill 8	1.5	509056	114476	23.1	23.3	23.5	23.7
School Hill 9	1.5	509119	114516	21.1	21.3	21.5	21.7

5.2.3 Scenario 4: Assess impact of re-opening Nightingale Way (2015)

Nightingale Way is a residential road linking Manleys Hill and School Hill. The road was closed approximately 40 years ago on safety grounds. Scenario 4 assesses re-opening the road to cars and light goods vehicles (LGV) which may help alleviate congestion at the School Hill/Manleys Hill junction.

Analysis of the origin-destination traffic survey conducted in May 2012[5] indicated that during the survey approximately 7% of the cars/LGV heading in to Storrington on School Road turned left onto Manleys Hill; and approximately 2% of the cars/LGV heading west on Manleys Hill turned right onto School Hill.

The effect of this percentage of traffic using Nightingale Way instead of travelling via the School Hill/Manleys Hill junction was modelled. A comparison of the predicted annual mean NO_2 concentrations at the specified receptors on School Hill and Manleys Hill is presented in Table 11.

It can be observed that reductions of up to 0.7 µg.m^{-3} in NO_2 annual mean concentrations are predicted for this scenario. This reduction is not sufficient to achieve compliance with the 40 µg.m^{-3} objective at the residential properties close to the roadside on Manleys Hill.

Table 11: Scenario 4: Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration (µg.m^{-3})	
		X	Y	2015 business as usual	Nightingale Way open to Cars/LGV
Manleys Hill 1	1.5	508944	114269	**47.7**	**47.0**
Manleys Hill 2	1.5	508953	114277	**47.7**	**47.0**
Manleys Hill 3	1.5	508951	114265	**43.5**	**42.9**
Manleys Hill 4	1.5	508960	114259	38.7	38.1
Manleys Hill 5	1.5	508972	114270	37.4	36.8
High St 3 (4m)	4	508918	114293	24.8	24.6
High St 4 (4m)	4	508901	114291	24.6	24.5
Old Mill Drive 1	1.5	508878	114454	12.6	12.5
Old Mill Drive 2	1.5	508917	114498	12.0	12.0
School Hill 1	1.5	508934	114300	35.8	35.1
School Hill 2	1.5	508960	114322	32.7	31.8
School Hill 3	1.5	508970	114338	32.4	31.5
School Hill 4	1.5	508987	114362	29.2	28.3
School Hill 5	1.5	508982	114372	28.4	27.5
School Hill 6	1.5	508990	114384	27.4	26.6
School Hill 7	1.5	509035	114451	23.2	22.5
School Hill 8	1.5	509056	114476	23.1	22.4
School Hill 9	1.5	509119	114516	21.1	20.7

[5] Sky High (2012) Storrington ANPR origin destination survey Friday 11th to Sunday 13th May; Sky High The Traffic Survey Company

5.2.4 Scenario 5: Impose a 20mph speed restriction in the village

Scenario 5 was to investigate the impact of a 20mph speed restriction through the AQMA which could potentially improve air quality by smoothing flow and reducing congestion.

Based on the stop-start nature of the traffic flow along the High Street and West Street as vehicles allow other vehicles to park and turn; the average speed of the traffic through the AQMA is currently understood to be around 20 mph during free flowing periods and less than 20 mph during busy periods, particularly at locations where congestion is known to occur. The baseline models in both 2011 (Scenario 1) and 2015 (Scenario 2) are based on an average speed of around 20 mph on the main sections of road in the AQMA.

It should also be considered that vehicle NOx emissions on average tend to increase at lower speeds. If all congestion could be removed and the traffic flowed freely within Storrington, traffic moving at an average speed of 25 to 30 mph would give rise to lower vehicle NOx emissions than at 20mph.

It is therefore considered unlikely that imposing a 20 mph speed limit on the AQMA will lead to an improvement in air quality. Numerical model predictions have not therefore been included for this scenario.

5.2.5 Scenario 6: Low Emission Zone (LEZ) in Storrington for a future year (2015).

The emissions of oxides of nitrogen from vehicles are regulated under various European Directives which specify emission standards for different vehicle types. The emission standards become increasingly stringent for newer vehicles over time. Vehicles meeting specific emissions regulations are classified according to a “Euro” class. A Low emission zone (LEZ) would limit access to the village for specific vehicle types not meeting specified emission standards (e.g. Euro V).

Scenario 6 considers the potential reduction in emissions if access to the AQMA were restricted so that the vehicle classes met the following standards in 2015:

- Rigid HGVs : Euro V or better
- Articulated HGVs: Euro V or better
- Buses: Euro V or better

A comparison of the predicted change in annual mean NO_2 concentrations at all of the specified receptors with an LEZ in place, compared to the 2015 business as usual scenario is presented in Table 12.

The predicted annual mean NO_2 concentrations have decreased at all of the specified receptors when the Euro V or better scenario is modelled for all HGV and Buses. The model predictions indicate that an access restriction on Bus and HGV to Euro V or better could help achieve compliance with the NO_2 annual mean objective at all locations within Storrington.

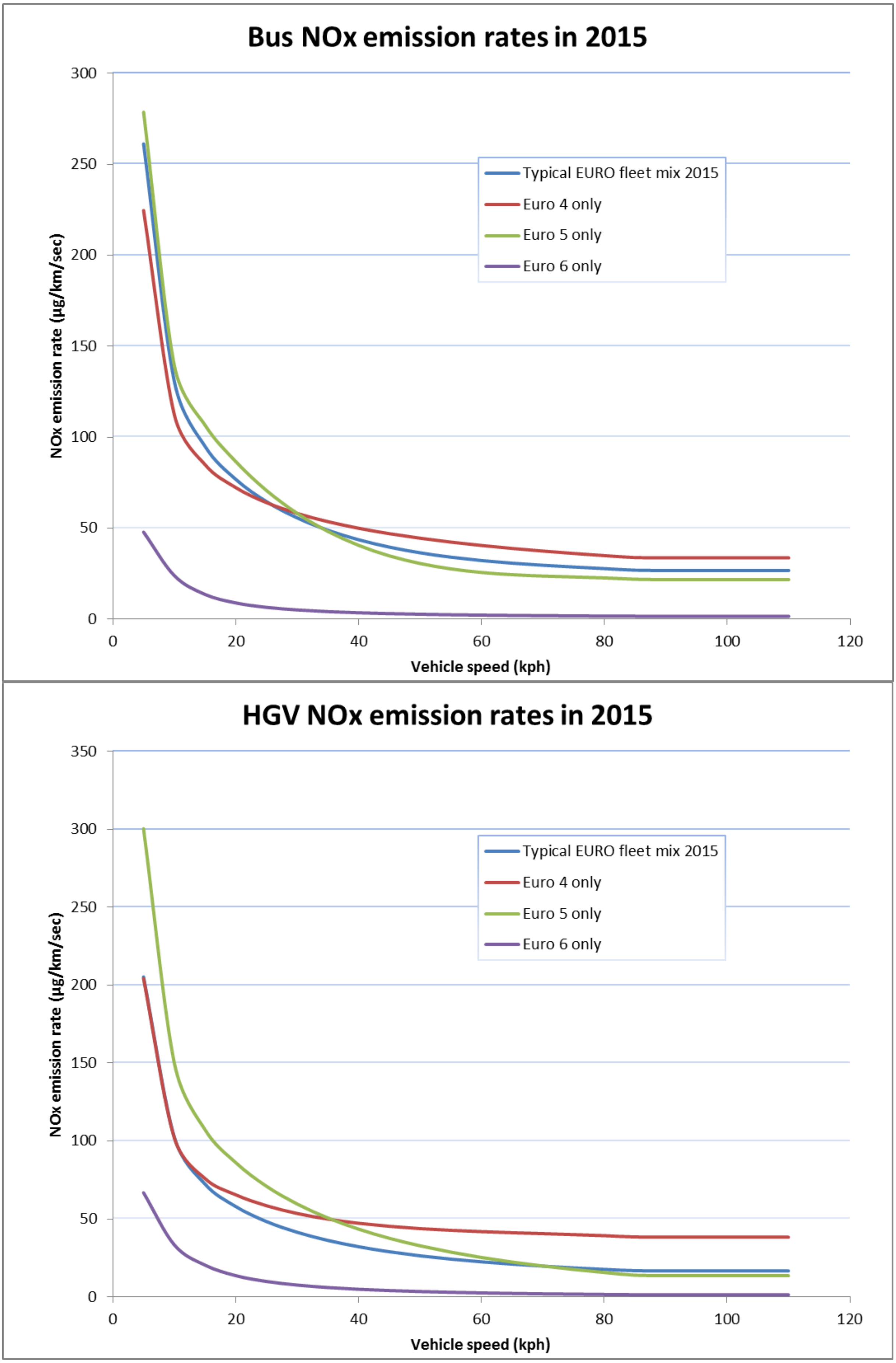
It should be noted that Bus and HGV Euro V NOx emission factors are higher at low speeds than for Euro IV. Graphs showing the difference in projected NOx emissions rates from buses and HGV in 2015 are presented in Figure 8. The graphs indicate that NOx emissions are greater for Euro V when compared to Euro IV at speeds up to approximately 30 kph (19 mph) for buses and 35 kph (22 mph) for HGV’s. The modelled predictions are based on a combination of average emissions based on assumed vehicle speeds for free flowing traffic, and time varying emissions for slow moving congested traffic. Although based on the best available local knowledge, these assumptions are a potential source of uncertainty within the model. It is therefore important to consider that Buses and HGVs at Euro V will emit more NOx during congested times than the typical projected split of Euro classes within the vehicle fleet.

This scenario also assumes that the total annual average daily number of HGVs travelling through Storrington would remain constant if an LEZ were in place. This may not however be the case as an LEZ may dissuade drivers from travelling via Storrington hence providing an additional reduction in NOx emissions.

Table 12: Scenario 6: Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)	
		X	Y	2015 business as usual	LEZ 2015
West St 1	1.5	508458	114391	34.0	31.1
West St 2	1.5	508479	114377	30.4	28.0
West St 3	1.5	508503	114369	37.9	34.9
West St 4	1.5	508497	114394	36.9	33.9
West St 5	1.5	508513	114382	**41.4**	38.1
West St 6	1.5	508539	114371	39.3	36.2
West St 7	1.5	508558	114339	31.4	29.0
West St 8	1.5	508581	114352	34.6	31.9
West St 9 (4m)	4	508619	114315	21.5	20.1
West St 10	1.5	508643	114321	34.7	32.1
West St 11	1.5	508660	114300	**42.0**	38.9
West St 12	1.5	508675	114293	39.8	36.9
West St 13	1.5	508680	114302	38.0	35.2
High St 1 (4m)	4	508841	114270	23.1	21.4
High St 2 (4m)	4	508856	114267	23.4	21.6
Manleys Hill 1	1.5	508944	114269	**47.7**	38.7
Manleys Hill 2	1.5	508953	114277	**47.7**	38.3
Manleys Hill 3	1.5	508951	114265	**43.5**	35.1
Manleys Hill 4	1.5	508960	114259	38.7	31.2
Manleys Hill 5	1.5	508972	114270	37.4	30.1
High St 3 (4m)	4	508918	114293	24.8	22.3
High St 4 (4m)	4	508901	114291	24.6	22.4
Old Mill Drive 1	1.5	508878	114454	12.6	12.1
Old Mill Drive 2	1.5	508917	114498	12.0	11.6
School Hill 1	1.5	508934	114300	35.8	31.4
School Hill 2	1.5	508960	114322	32.7	29.0
School Hill 3	1.5	508970	114338	32.4	28.9
School Hill 4	1.5	508987	114362	29.2	26.2
School Hill 5	1.5	508982	114372	28.4	25.5
School Hill 6	1.5	508990	114384	27.4	24.7
School Hill 7	1.5	509035	114451	23.2	21.1
School Hill 8	1.5	509056	114476	23.1	21.0
School Hill 9	1.5	509119	114516	21.1	19.3

Figure 8: Projected NOx emission rates for different Euro class Buses and HGV in 2015



5.2.6 Scenario 7: Gating option in future year (2015)

Another suggestion to help control the traffic flow through the Storrington AQMA is by means of traffic light 'gates' outside the village. Gating is a technique used to control the inflow of traffic into an area to help reduce and clear congestion. It is controlled by an automated traffic management system which can modify the signal settings at traffic lights away from the problem area based on real time information; hence re-locating queuing traffic and the associated NOx emissions away from areas where there is a relevant human exposure.

The suggested approximate locations of the gates in Storrington are presented on Figure 9. These are all at locations out-with the village where there are no residential properties close to the road.

The likely effect of the gating options on congestion in the town is not known; therefore four sub-scenarios have been modelled to represent varying percentage reductions in congestion times. The percentage reductions have been chosen arbitrarily but aim to provide an indication of how effective the 'gating' option could be in reducing annual mean NO_2 concentrations within the AQMA if these reductions in congestion times can be achieved.

If appraisal of this traffic management option is pursued further based on the potential air quality benefits, additional assessment of how effective 'gating' can be at reducing congestion in Storrington based on the expertise of a traffic engineer is recommended. It may be appropriate to model the traffic for this scenario using a traffic micro-simulation model such as PARAMICS, the outputs of which could inform a further more detailed assessment of the air quality impacts.

The four sub-scenarios modelled were:

a) 25% reduction in queuing during each hour when congestion is known to occur
b) 50% reduction in queuing during each hour when congestion is known to occur
c) 75% reduction in queuing during each hour when congestion is known to occur
d) 100% reduction in queuing during each hour when congestion is known to occur

A comparison of the predicted annual mean NO_2 concentrations for the four gating scenarios and the 2015 business as usual scenario is presented in Table 13. The results indicate that a 50% reduction in queuing is required for NO_2 concentrations to comply with the 40 $\mu g.m^{-3}$ objective at all of the specified receptor locations.

Figure 9: Proposed gating locations out-with Storrington

Legend

Approx. proposed gate locations

Table 13: Scenario 7: Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)				
		X	Y	2015 business as usual	25% less congestion	50% less congestion	75% less congestion	100% less congestion
West St 1	1.5	508458	114391	34.0	31.2	28.4	25.7	22.2
West St 2	1.5	508479	114377	30.4	28.0	25.5	23.1	20.1
West St 3	1.5	508503	114369	37.9	34.5	31.1	27.8	23.3
West St 4	1.5	508497	114394	36.9	33.8	30.8	27.7	24.1
West St 5	1.5	508513	114382	**41.4**	37.9	34.5	31.0	26.8
West St 6	1.5	508539	114371	39.3	36.0	32.8	29.5	25.5
West St 7	1.5	508558	114339	31.4	28.8	26.2	23.6	20.3
West St 8	1.5	508581	114352	34.6	31.8	29.0	26.2	22.9
West St 9 (4m)	4	508619	114315	21.5	20.1	18.7	17.3	15.5
West St 10	1.5	508643	114321	34.7	32.1	29.5	26.8	23.7
West St 11	1.5	508660	114300	**42.0**	38.7	35.1	31.5	26.8
West St 12	1.5	508675	114293	39.8	36.8	33.6	30.4	26.2
West St 13	1.5	508680	114302	38.0	35.7	33.4	31.0	28.2
High St 1 (4m)	4	508841	114270	23.1	21.5	19.8	18.2	16.2
High St 2 (4m)	4	508856	114267	23.4	21.6	19.9	18.2	16.2
Manleys Hill 1	1.5	508944	114269	**47.7**	**43.7**	39.4	35.2	29.6
Manleys Hill 2	1.5	508953	114277	**47.7**	**43.6**	39.2	34.6	29.1
Manleys Hill 3	1.5	508951	114265	**43.5**	39.9	36.0	32.3	27.2
Manleys Hill 4	1.5	508960	114259	38.7	35.5	32.1	28.9	24.5
Manleys Hill 5	1.5	508972	114270	37.4	34.1	30.8	27.4	23.3
High St 3 (4m)	4	508918	114293	24.8	22.9	20.9	19.0	16.7
High St 4 (4m)	4	508901	114291	24.6	22.7	20.8	19.0	16.8
Old Mill Drive 1	1.5	508878	114454	12.6	12.2	11.9	11.6	11.3
Old Mill Drive 2	1.5	508917	114498	12.0	11.7	11.5	11.2	11.0
School Hill 1	1.5	508934	114300	35.8	32.6	29.3	26.0	22.1
School Hill 2	1.5	508960	114322	32.7	29.8	26.7	23.7	20.1
School Hill 3	1.5	508970	114338	32.4	29.5	26.5	23.5	19.8
School Hill 4	1.5	508987	114362	29.2	26.6	24.0	21.4	18.2
School Hill 5	1.5	508982	114372	28.4	26.0	23.4	20.9	17.9
School Hill 6	1.5	508990	114384	27.4	25.1	22.7	20.2	17.3
School Hill 7	1.5	509035	114451	23.2	21.2	19.3	17.3	14.9
School Hill 8	1.5	509056	114476	23.1	21.2	19.2	17.2	14.8
School Hill 9	1.5	509119	114516	21.1	19.4	17.7	16.1	14.1

5.2.7 Scenario 8: Restriction on heavy goods vehicles in future year (2015)

Discouraging or preventing heavy goods vehicles accessing the village by means of access restrictions, either by way of height or weight, at strategic locations outside the village is another option for reducing NO_2 concentrations within the Storrington AQMA. The source apportionment study conducted for the Further Assessment of air quality at Storrington[6] indicated that emissions from HGV's accounted for approximately 30% of vehicle NOx emissions in Storrington (though this was based on now outdated emission factors so this figure should now be interpreted with care).

Four sub-scenarios have been modelled to represent varying percentage reductions in HGV traffic passing through Storrington in 2015 as follows:

- 25% reduction in HGV
- 50% reduction in HGV
- 75% reduction in HGV
- 100% reduction in HGV

A comparison of the predicted change in annual mean NO_2 concentrations at all of the specified receptors with the HGV restriction in place, compared to the 2015 business as usual scenario is presented in Table 14. The results indicate that a reduction of 75% of HGVs entering Storrington is required to reduce NOx emissions sufficiently to achieve compliance with the 40 $\mu g.m^{-3}$ NO_2 annual mean objective at all locations.

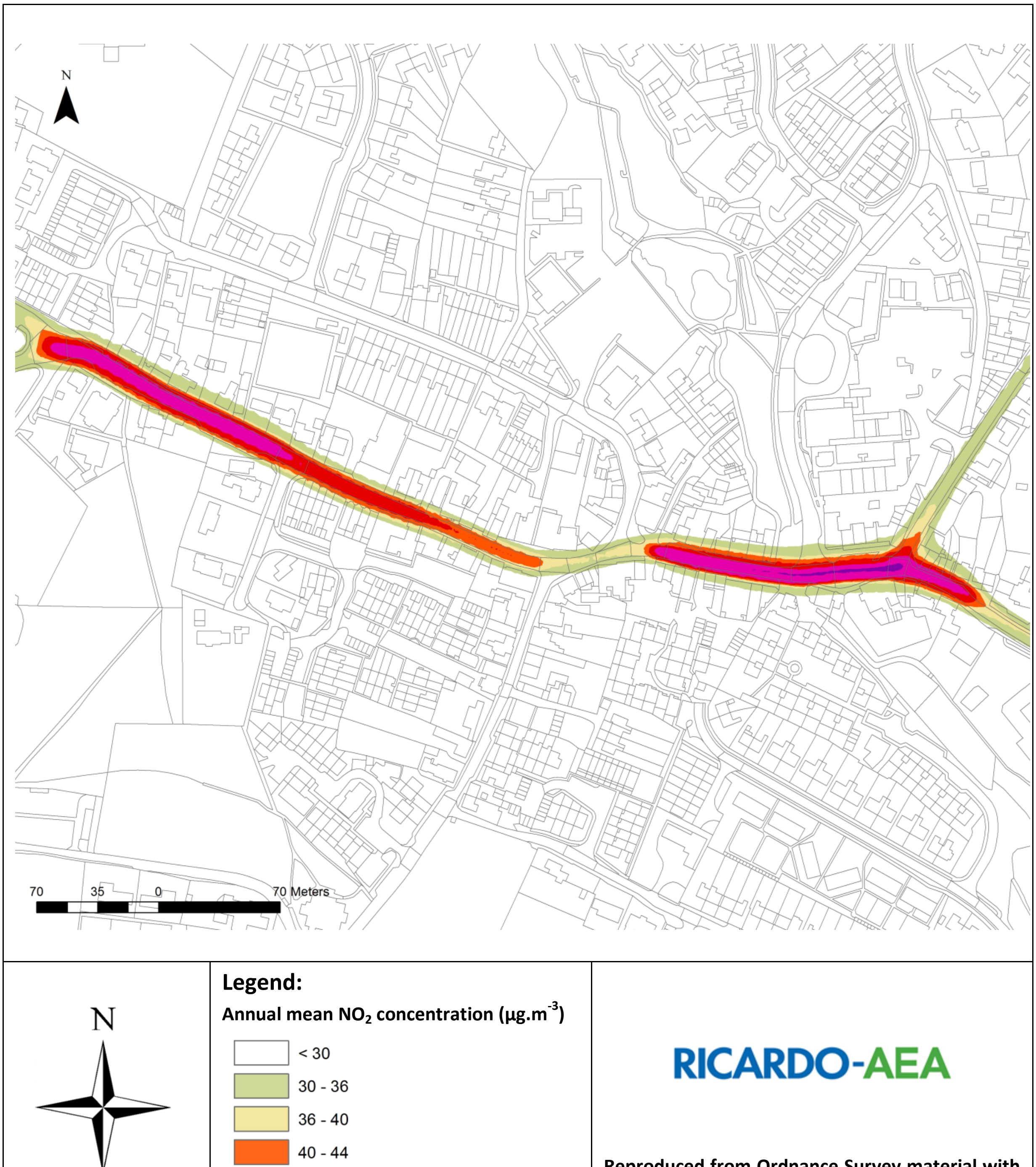
A contour plot showing the spatial variation in predicted NO_2 concentrations for the 50% reduction in HGV traffic in 2015 is presented in Figure 10.

[6] Horsham District Council (2012) Further Assessment Report Storrington Air Quality; Prepared March 2012

Table 14: Scenario 8: Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)				
		X	Y	2015 business as usual	25% reduction in HGV	50% reduction in HGV	75% reduction in HGV	100% reduction in HGV
West St 1	1.5	508458	114391	34.0	32.4	30.8	29.0	27.7
West St 2	1.5	508479	114377	30.4	29.1	27.7	26.2	25.0
West St 3	1.5	508503	114369	37.9	36.2	34.4	32.5	30.9
West St 4	1.5	508497	114394	36.9	35.2	33.4	31.6	30.0
West St 5	1.5	508513	114382	**41.4**	39.4	37.5	35.4	33.6
West St 6	1.5	508539	114371	39.3	37.5	35.7	33.7	32.0
West St 7	1.5	508558	114339	31.4	30.0	28.6	27.2	25.9
West St 8	1.5	508581	114352	34.6	33.0	31.5	29.9	28.4
West St 9 (4m)	4	508619	114315	21.5	20.7	20.0	19.1	18.4
West St 10	1.5	508643	114321	34.7	33.1	31.7	30.1	28.7
West St 11	1.5	508660	114300	**42.0**	**40.2**	38.4	36.5	34.7
West St 12	1.5	508675	114293	39.8	38.1	36.4	34.6	33.0
West St 13	1.5	508680	114302	38.0	36.3	34.8	33.1	31.5
High St 1 (4m)	4	508841	114270	23.1	22.2	21.3	20.4	19.5
High St 2 (4m)	4	508856	114267	23.4	22.4	21.5	20.5	19.7
Manleys Hill 1	1.5	508944	114269	**47.7**	**45.0**	**42.3**	39.2	37.4
Manleys Hill 2	1.5	508953	114277	**47.7**	**44.9**	**42.2**	39.0	37.2
Manleys Hill 3	1.5	508951	114265	**43.5**	**41.0**	38.6	35.7	34.2
Manleys Hill 4	1.5	508960	114259	38.7	36.5	34.4	31.8	30.5
Manleys Hill 5	1.5	508972	114270	37.4	35.2	33.1	30.7	29.4
High St 3 (4m)	4	508918	114293	24.8	23.7	22.7	21.6	20.7
High St 4 (4m)	4	508901	114291	24.6	23.5	22.5	21.4	20.5
Old Mill Drive 1	1.5	508878	114454	12.6	12.4	12.2	12.0	11.8
Old Mill Drive 2	1.5	508917	114498	12.0	11.9	11.7	11.5	11.4
School Hill 1	1.5	508934	114300	35.8	34.1	32.6	30.7	29.3
School Hill 2	1.5	508960	114322	32.7	31.2	30.0	28.5	27.2
School Hill 3	1.5	508970	114338	32.4	31.1	29.9	28.4	27.1
School Hill 4	1.5	508987	114362	29.2	28.0	27.0	25.7	24.6
School Hill 5	1.5	508982	114372	28.4	27.3	26.3	25.1	24.0
School Hill 6	1.5	508990	114384	27.4	26.3	25.4	24.2	23.2
School Hill 7	1.5	509035	114451	23.2	22.3	21.6	20.8	20.0
School Hill 8	1.5	509056	114476	23.1	22.3	21.6	20.7	20.0
School Hill 9	1.5	509119	114516	21.1	20.4	19.8	19.1	18.4

Figure 10: Modelled NO_2 annual mean concentrations 2015 - 50% reduction in HGV in Storrington



5.2.8 Scenario 9: Providing improved signage for a future year (2015)

Scenario 9 assesses the potential impact of using variable message signage (VMS) on strategic routes outside of Storrington to discourage through traffic during periods of congestion within the AQMA.

Data from the origin-destination traffic survey conducted in May 2012[7] was used to approximate how much of the traffic entering Storrington is through traffic. This is based on analysis of automatic number plate recognition (ANPR) vehicle counts which provided information on the number of vehicles that enter the village, the number that leave the village within an hour of entering, and also the number leaving within 15 minutes for comparison. It should be noted that the percentage of vehicles leaving within 1-hr was calculated from the available data on one week day only (Friday 11th May 2012) of the traffic survey only and the percentage leaving within 15 minutes was an average over five weekdays.

All other vehicles are assumed to be visiting the village for e.g. shopping or other reasons. A summary of the count analysis is presented in Table 15. The percentage of vehicles leaving within 15 minutes is slightly lower than the percentage leaving within 15 minutes on all the roads assessed. This indicates that some through traffic may be taking more than fifteen minutes to get through Storrington, this could be occurring during busy periods when congestion occurs.

Table 15: Proportion of vehicles passing through Storrington from ANPR traffic counts

Road name (entering Storrington)	% leaving within 15 minutes	% leaving within 1-hour
Pulborough Road (A283)	35%	36%
Amberley Road (B2139) 1	51%	63%
School Hill (B2139)	19%	24%
Washington Road (A283)	51%	58%

It is difficult to quantify how much of an effect improved signage would have on the number of vehicles passing through Storrington. The effect of 'improved signage' has been modelled for three indicative sub-scenarios each representing a potential reduction in the number of vehicles that enter the village but do not stop. The sub-scenarios modelled were:

a) 10% reduction in through traffic
b) 25% reduction in through traffic
c) 50% reduction in through traffic

The sub scenarios have been modelled using the calculated percentages of through traffic leaving within 15 minutes as this represents the minimum potential benefit that could be potentially be achieved by improved signage.

The percentage reduction in through traffic for each scenario was also applied to the congestion modelled to represent the effect of reduced overall AADT on vehicle queuing. A comparison of the predicted annual mean NO_2 concentrations for the three 'improved signage' scenarios and the 2015 business as usual scenario is presented in Table 16.

The results are quite uncertain but indicate that a reduction in through traffic could potentially reduce annual mean NO_2 concentrations below the 40 $\mu g.m^{-3}$ objective at the specified receptors on West Street but will not be sufficient to comply with the objectives at all of the receptors at Manleys Hill.

[7] Sky High (2012) Storrington ANPR origin destination survey Friday 11th to Thursday 17th May 2012; Sky High The Traffic Survey Company

Table 16: Scenario 9: Predicted annual mean NO_2 concentrations 2015

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)			
		X	Y	2015 business as usual	10% reduction in through traffic	25% reduction in through traffic	50% reduction in through traffic
West St 1	1.5	508458	114391	34.0	33.1	31.8	29.5
West St 2	1.5	508479	114377	30.4	29.7	28.5	26.5
West St 3	1.5	508503	114369	37.9	36.9	35.4	32.9
West St 4	1.5	508497	114394	36.9	35.9	34.5	31.9
West St 5	1.5	508513	114382	**41.4**	**40.3**	38.6	35.7
West St 6	1.5	508539	114371	39.3	38.3	36.7	34.0
West St 7	1.5	508558	114339	31.4	30.6	29.4	27.4
West St 8	1.5	508581	114352	34.6	33.7	32.3	30.0
West St 9 (4m)	4	508619	114315	21.5	21.1	20.4	19.2
West St 10	1.5	508643	114321	34.7	33.8	32.4	30.1
West St 11	1.5	508660	114300	**42.0**	**41.0**	39.3	36.5
West St 12	1.5	508675	114293	39.8	38.8	37.3	34.6
West St 13	1.5	508680	114302	38.0	37.0	35.5	32.9
High St 1 (4m)	4	508841	114270	23.1	22.6	21.9	20.5
High St 2 (4m)	4	508856	114267	23.4	22.8	22.1	20.7
Manleys Hill 1	1.5	508944	114269	**47.7**	**46.4**	**44.3**	**40.6**
Manleys Hill 2	1.5	508953	114277	**47.7**	**46.3**	**44.2**	**40.5**
Manleys Hill 3	1.5	508951	114265	**43.5**	**42.3**	**40.4**	37.0
Manleys Hill 4	1.5	508960	114259	38.7	37.6	35.9	32.9
Manleys Hill 5	1.5	508972	114270	37.4	36.3	34.6	31.7
High St 3 (4m)	4	508918	114293	24.8	24.3	23.4	22.0
High St 4 (4m)	4	508901	114291	24.6	24.0	23.2	21.7
Old Mill Drive 1	1.5	508878	114454	12.6	12.5	12.3	12.0
Old Mill Drive 2	1.5	508917	114498	12.0	11.9	11.8	11.6
School Hill 1	1.5	508934	114300	35.8	35.1	33.9	32.0
School Hill 2	1.5	508960	114322	32.7	32.1	31.3	29.9
School Hill 3	1.5	508970	114338	32.4	31.9	31.2	30.0
School Hill 4	1.5	508987	114362	29.2	28.8	28.1	27.1
School Hill 5	1.5	508982	114372	28.4	28.0	27.4	26.4
School Hill 6	1.5	508990	114384	27.4	27.0	26.5	25.5
School Hill 7	1.5	509035	114451	23.2	22.9	22.5	21.8
School Hill 8	1.5	509056	114476	23.1	22.8	22.4	21.7
School Hill 9	1.5	509119	114516	21.1	20.9	20.5	19.9

5.3 Predicted impact of relevant measures in Pulborough

Implementing traffic management measures in Storrington may lead to the redistribution of traffic within the road network in the neighbouring village of Pulborough and could potentially impact on local air quality. The potential impacts of scenarios 6, 8 and 9 have been included in the assessment. For reference, a summary of these scenarios are presented in Table 17.

Table 17: Scenarios considered likely to impact on traffic in Pulborough

Scenario		Description
6	Assess impact of Low Emission Zone (LEZ) in Storrington for a future year (2015).	The LEZ would limit access to the village for specific vehicle types not meeting specified emission standards (e.g. Euro V).
8	Assess impact of imposing a restriction on heavy goods vehicles in future year (2015)	Discouraging or preventing heavy goods vehicles accessing the village by means of access restrictions, either by way of height or weight, at strategic locations outside the village.
9	Assess impact of providing improved signage for a future year (2015)	Use of variable message signage (VMS) on strategic routes outside the village to discourage through traffic during periods of congestion within the AQMA.

These scenarios may affect the traffic in Pulborough in the following ways:

- Traffic which currently travels via Pulborough to and from Storrington uses Lower Street in Pulborough. Implementation of either an LEZ, restriction of HGVs, or use of improved signage could potentially lead to similar changes in traffic fleet and AADT on Lower Street as expected in Storrington.
- Implementation of these measures may lead to traffic diverted from Lower Street and Storrington using the section of London Road south of Pulborough as an alternate route.

The assumptions made with respect to changes from the 2015 baseline road traffic emissions for each scenario are summarised in Table 18. These assumptions are based on a best guess of what the knock-on effects of implementing traffic management measures in Storrington may have in Pulborough. More detailed appraisal of this using the expertise of a traffic engineer is recommended.

Table 18: Assumed changes to traffic flows in Pulborough

Scenario		Assumed changes to traffic flow in Pulborough
6	Assess impact of Low Emission Zone (LEZ) in Storrington for a future year (2015).	Percentage of vehicle fleet older than Euro V removed from Lower Street and added to London Road (South of Pulborough crossroads)
8	Assess impact of imposing a restriction on heavy goods vehicles in future year (2015)	All HGV from Lower St are displaced to London Rd + all HGV from Amberley Road in Storrington are displaced to London Road + Church Hill (assumed worst case i.e. all HGV traffic from Amberley Road travels north/south via Pulborough).
9	Assess impact of providing improved signage for a future year (2015)	Three sub-scenarios modelled with 10%, 25% and 50% reduction in known perentage of traffic travelling through Storrington (36%)

A 2011 baseline dispersion model of road traffic emissions in Pulborough was run and verified using the 2011 diffusion tube results. Full details of the traffic data used in the model and the model verification procedure are presented in Appendix 1 and Appendix 3 respectively.

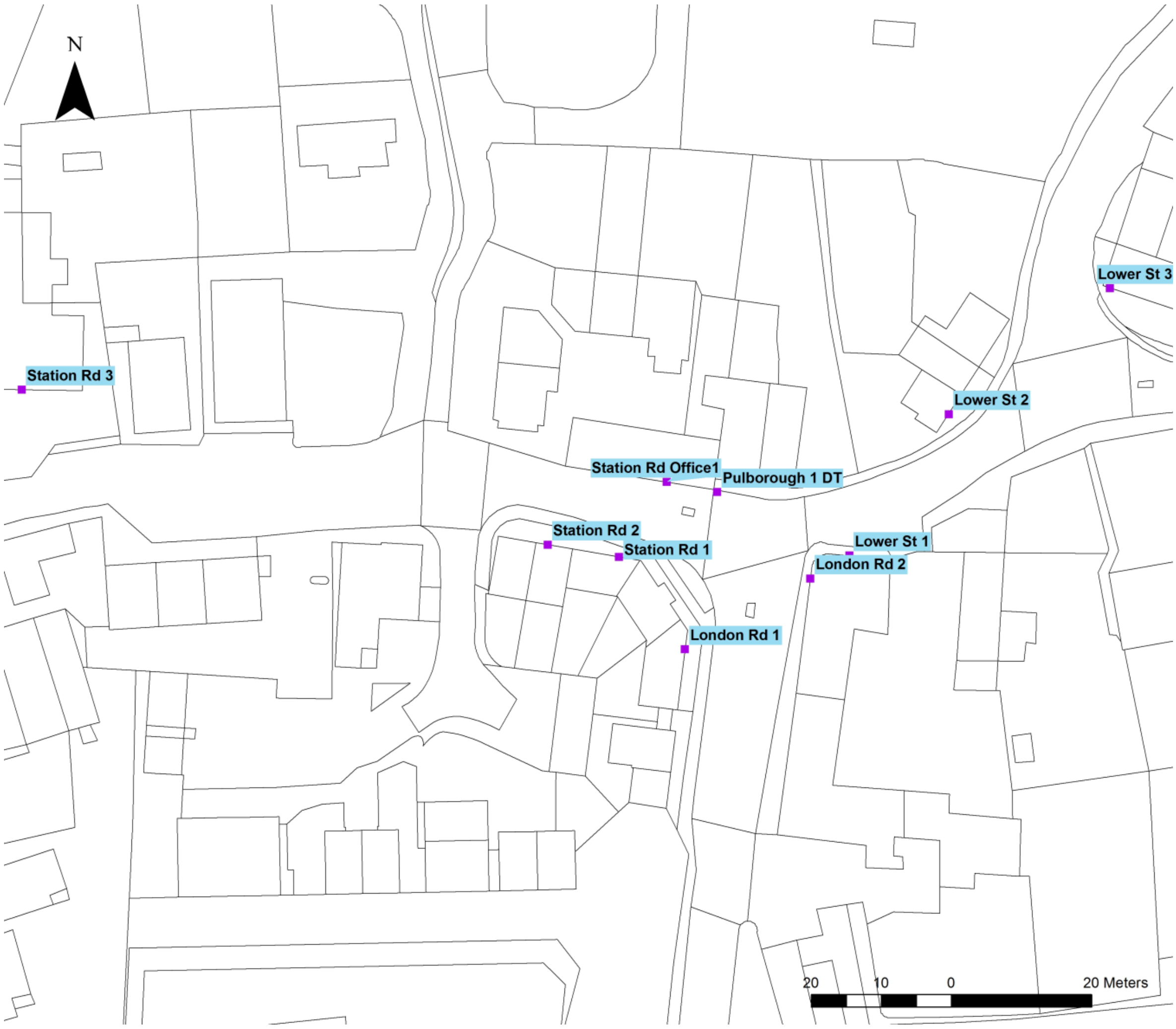
The effect of scenarios 6, 8 and 9 has been modelled in Pulborough and compared with a 2015 business as usual scenario. For all of the scenarios, the adjusted model results have been used to predict annual mean NO_2 concentrations at a selection of specified receptors within the study area. The receptors are located at the facade of residential buildings in the model domain where relevant exposure exists and have been selected to be representative of worst case exposure to road traffic emissions. Maps showing the locations of the specified receptors in Pulborough are presented in Figure 11 and Figure 12. A comparison of the predicted annual mean NO_2 concentrations for each scenario with the 2015 business as usual scenario is presented in Table 19.

The results indicate:

- During 2011 the 40 $\mu g.m^{-3}$ NO_2 annual mean objective was exceeded at only one of the specified receptors, Station Road Office 1. This receptor is however a commercial property where the annual mean objective does not apply.
- The 2015 business as usual scenario indicates that the 40 $\mu g.m^{-3}$ objective will not be exceeded at any of the specified receptor location.
- Displaced traffic from Lower Street onto London Road attributable to the proposed traffic management measures in Storrington, will not lead to annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective at any of the specified receptors.

Therefore no significant impact on air quality in Pulborough is predicted based on these assumptions.

Figure 11: Specified receptor locations in Station Rd, London Rd & Church Hill - Pulborough

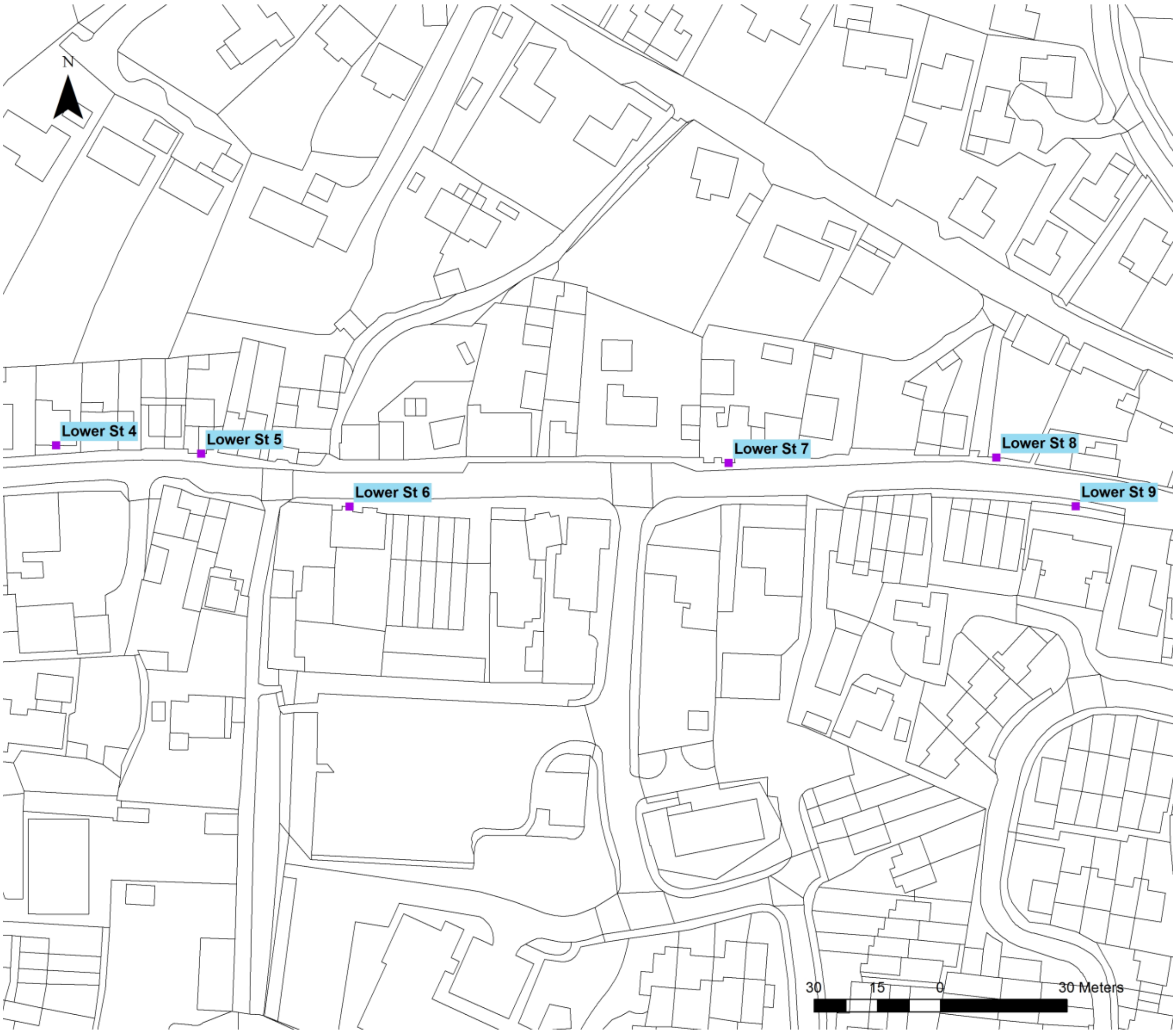


Legend:

Specified receptor location

RICARDO-AEA

Figure 12: Specified receptor locations in Lower Street - Pulborough



Legend:

Specified receptor location

RICARDO-AEA

Table 19: Predicted annual mean NO_2 concentrations in Pulborough

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)						
		X	Y	2011 Baseline	2015 business as usual	2015 LEZ in Storrington	2015 all HGV banned in Storrington	2015 10% reduction in through traffic	2015 25% reduction in through traffic	2015 50% reduction in through traffic
Station Rd Office1	1.5	504577	118569	**41.0**	36.2	37.0	36.8	36.3	36.3	36.4
Station Rd 1	1.5	504570	118559	25.9	22.3	23.0	23.0	22.4	22.4	22.5
Station Rd 2	1.5	504560	118561	21.7	18.7	19.1	19.1	18.7	18.7	18.8
Station Rd 3	1.5	504485	118583	13.2	11.3	11.4	11.3	11.3	11.3	11.3
London Rd 1	1.5	504579	118546	27.6	23.7	25.3	25.4	23.8	24.0	24.3
London Rd 2	1.5	504597	118556	39.4	34.6	37.3	37.0	34.7	35.0	35.5
Lower St 1	1.5	504603	118559	35.3	30.8	33.4	32.5	31.0	31.2	31.6
Lower St 2	1.5	504617	118579	32.9	28.6	31.0	29.4	28.7	28.9	29.2
Lower St 3	1.5	504640	118597	39.2	34.4	34.8	34.4	34.4	34.4	34.4
Lower St 4	1.5	505258	118631	15.6	13.4	12.4	12.1	13.2	12.9	12.4
Lower St 5	1.5	505292	118629	17.6	15.0	13.7	13.4	14.7	14.4	13.7
Lower St 6	1.5	505328	118616	15.4	13.2	12.2	12.0	13.0	12.7	12.3
Lower St 7	1.5	505418	118627	17.9	15.3	13.9	13.6	15.0	14.6	14.0
Lower St 8	1.5	505481	118628	17.4	14.9	13.6	13.3	14.6	14.3	13.6
Lower St 9	1.5	505500	118616	16.4	14.0	12.9	12.7	13.8	13.5	13.0

6 Conclusions

Eight traffic management scenarios have been modelled to predict their potential impact on air quality within the Storrington AQMA and surrounding area. The assessment has been conducted using atmospheric dispersion modelling of road traffic emissions. The study also includes an assessment of the potential impacts of the suggested traffic management measures on air quality in the neighbouring village of Pulborough.

A summary of the findings of each scenario assessed is as follows:

- Atmospheric dispersion modelling of road traffic emissions verified using NO_2 annual mean concentrations measured during 2011 indicates that the 40 $\mu g.m^{-3}$ air quality objective is currently being exceeded at many locations where relevant human exposure exists within Storrington. The worst case locations are where traffic is often slow moving and congestion is known to occur close to the main junctions in Storrrington and along the High Street.

- Modelling of projected road traffic NOx emissions with estimated future background NOx concentrations in 2015, indicates that for a business as usual scenario, annual mean NO_2 concentrations will decrease, however will still be in excess of the 40 $\mu g.m^{-3}$ objective at many locations of relevant exposure.

- The potential impact of a proposal to change Old Mill Drive to a shared surface, assessed for a future year of 2015, is that NO_2 annual mean concentrations may increase by up to 1 $\mu g.m^{-3}$ at some of the specified receptor locations on School Hill, but will remain below the 40 $\mu g.m^{-3}$ NO_2 annual mean objective. The impact of this proposal is not therefore considered significant.

- Assessment of a proposal to re-open Nightingale Way to Cars and light goods vehicles only predicted reductions of up to 0.7 $\mu g.m^{-3}$ in NO_2 annual mean concentrations at the junction of Manleys Hill and School Hill. This reduction is not sufficient to achieve compliance with the 40 $\mu g.m^{-3}$ annual mean objective at the residential properties close to the roadside on Manleys Hill.

- The impact of a 20mph speed restriction through the AQMA which could potentially improve air quality by smoothing flow and reducing congestion was considered. Based on the current understanding of the stop-start nature of the traffic flow along the High Street and West Street; and the estimation that the average speed of the traffic through the AQMA is currently around 20 mph during free flowing periods and much less than 20 mph during busy periods. It was concluded that no air quality benefit could be achieved by imposing a 20 mph restriction.

- The potential to reduce road traffic NOx emissions by enforcing a low emission zone within Storrrington was assessed. The proposed LEZ would restrict all HGV's of pre Euro V classification from entering the village. The model predictions indicate that an access restriction on Bus and HGV to Euro V or better could help achieve compliance with the NO_2 annual mean objective at all locations within Storrington. It is also noted however that Euro V HGV's NOx emit, on average greater quantities of NOx than Euro IV HGV's at low speeds. The assumptions made with respect to vehicle speeds within the model may mean that there is uncertainity associated with these results.

- 'Gating', a technique which could be used to control the inflow of traffic into Storrington during busy periods, and hence reduce congestion, was assessed. The results indicated that a 50%

reduction in queuing is required to achieve compliance with the 40 µg.m^{-3} objective at all relevant locations. Additional assessment of how effective ‘gating’ can be at reducing congestion in Storrington based on the expertise of a traffic engineer is recommended.

- Discouraging or preventing heavy goods vehicles from accessing the village by means of access restrictions was assessed. The results indicate that a reduction of 75% of HGVs entering Storrington is required to reduce NOx emissions sufficiently to achieve compliance with the 40 µg.m^{-3} NO_2 annual mean objective at all locations. How realistic it is to implement this option will require further consideration.

- The potential impact of using variable message signage (VMS) on strategic routes outside of Storrington to discourage through traffic was estimated and the potential air quality impacts modelled. The results indicate that a reduction in through traffic could potentially reduce annual mean NO_2 concentrations below the 40 µg.m^{-3} objective at locations on West Street but will not be sufficient to comply with the objectives at all of the receptors at Manleys Hill.

- The potential impact of implementing a low emission zone, restricting HGVs and providing improved signage in Storrington on the neighbouring village of Pulborough was also assessed. This was based on assumptions of how the traffic flow in Pulborough could be affected by changes in Storrington. The results indicated that there would be no significant impact on air quality in Pulborough.

7 Acknowledgements

Ricardo-AEA gratefully acknowledges the support received from Lisa Hawtin at Horsham District Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Meteorological dataset wind rose

Appendix 3: Model verification

Appendix 1 – Traffic Data

Various sources of traffic data have been used for the assessment:

- West Sussex County Council automatic traffic counts conducted during 2011
- An origin-destination ANPR camera survey conducted from May 11th to May 13th 2012
- AADT and HGV split data from a traffic assessment for the proposed Waitrose store in Storrington
- 2010 Traffic count data from the Department of Transport dataset were used to derive 2011 and 2015 flows in Pulborough

The AADT flows for each road were factored forward to 2011 and 2015 using local traffic growth factors derived using TEMPRO 6.2. The growth factors are presented in Table A1.1

Table A1.1 Derived local traffic growth factors

Applicable location and time period	Growth factor
Storrington 2011 – 2015	1.0303
Pulborough 2010 – 2011	1.0069
Pulborough 2011 – 2015	1.0394

A summary of the AADT flows and vehicle fleet splits used for the assessment in Storrington are presented in Table A1.2.

Table A1.2: AADT flows used in the assessment – Storrington

Road	AADT 2011	AADT 2015	%Cars	%LGV	%HGV	%Bus	%2WM
Pulborough Road (A283)	7294	7515	88.0	8.4	2.4	0.2	1.0
Amberley Road (B2139) 1	8884	9153	86.5	9.8	2.7	0.1	0.8
High Street/West Street	18133	18682	87.0	9.6	2.2	0.2	1.0
School Hill (B2139)	6711	6914	92.6	3.9	1.6	0.3	1.6
Manleys Hill (A283)	14029	14454	84.9	3.8	3.3	0.0	8.1
Washington Road (A283)	18571	19134	86.4	9.8	2.5	0.3	1.0
Old Mill Drive	1492	1537	93.6	-	6.4	-	-

A summary of the AADT flows and vehicle fleet splits used for the assessment in Pulborough are presented in Table A1.3

Table A1.3: AADT flows used in the assessment – Pulborough

Road	AADT 2011	AADT 2015	%Cars	%LGV	%HGV	%Bus	%2WM
Lower Street	5805	6033	81.8	13.5	3.3	0.7	0.7
Station Road	5452	5667	80.5	14.9	3.0	0.6	1.0
Roman Road	9038	9394	80.8	13.7	3.8	0.6	1.1
London Road	11434	11885	79.6	13.7	3.8	0.9	2.0

Congestion

A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC (Guidance note[8] 60) has been used to represent the periodic congestion at the junction.

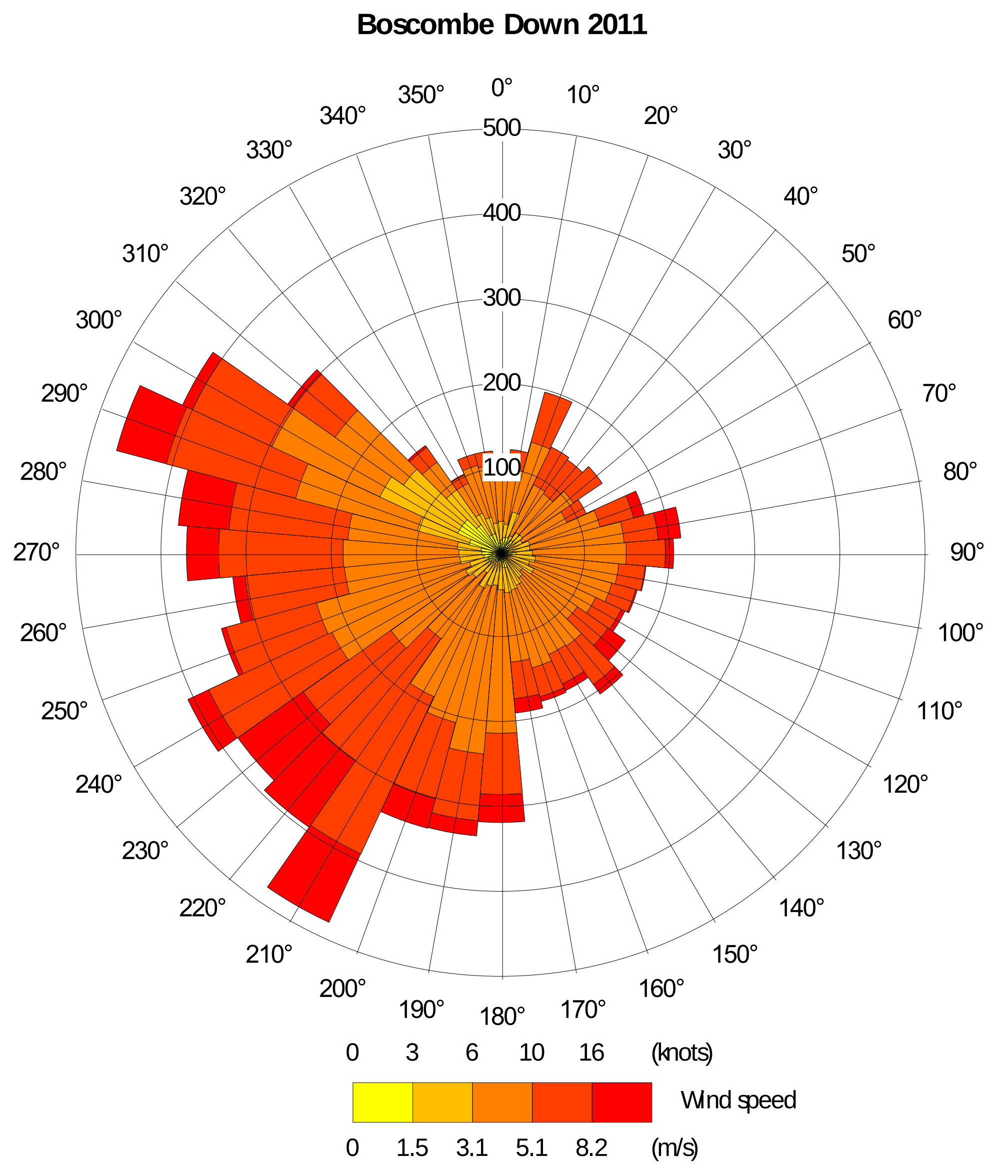
The method assumes that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 $km.hr^{-1}$), with an average vehicle length of 4m, and are positioned close to each other during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods. The emissions from this AADF figure with the traffic composition of the corresponding road were then input into the Emission Factor Toolkit to calculate an emission rate. The emission rates were then used within the dispersion model as a separate line emissions of pre-defined length representing each queue. Figure A1.1 shows the locations where queuing traffic was modelled.

Traffic Speeds

As stated in Technical Guidance LAQM.TG(09), the speed of traffic on a road will change approximately 50m from a junction. As such the speed of traffic was changed linearly between the maximum “open road” speed to the “close to a junction” speed approximately 50m from the junctions. Judgement of traffic speeds throughout the study area were based on local knowledge gained form discussions with Horsham District Council

[8] Cambridge Environmental Research Consultants Ltd, Modelling Queuing Traffic – note 60, 20th August 2004

Appendix 2 - Meteorological dataset wind rose



Appendix 3 – Model verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. This can be followed by adjustment of the modelled results if required. LAQM.TG(09) recommends making the adjustment to the road contribution only and not the background concentration these are combined with.

Storrington Model Verification

The approach outlined in Example 2 of LAQM.TG(09) has been used in this case.

It is appropriate to verify the performance of the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). To verify the model the predicted annual mean Road NOx concentrations were compared with concentrations measured at the monitoring sites in Storrington during 2011.

The model output of Road NOx (the total NOx originating from road traffic) has been compared with the measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each diffusion tube was calculated from the measured NO_2 concentration using the 2010 version of the Defra NOx/NO_2 calculator.

The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Various refinements were subsequently made to the model input to improve the overall model performance.

The gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as the adjustment factor. This factor was then applied to the modelled Road NOx concentration for each modelled point to provide adjusted modelled Road NOx concentrations. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A3.1.

The background NOx concentration was then added to determine the adjusted total modelled NOx concentrations. The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator.

A primary adjustment factor (PAdj) of **1.9035** based on model verification using 2011 monitoring results was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. A plot comparing modelled and monitored NO_2 concentrations before and after adjustment during 2011 is presented in Figure A3.2.

For each of the future modelled scenarios in 2015 the predicted Road NOx contributions were adjusted using the 1.9035 factor as derived from the 2011 NO_2 monitoring data. The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator using the background NOx concentrations and settings within the calculator for 2015.

Figure A3.1 Comparison of modelled Road NO_x Vs Measured Road NO_x before and after adjustment

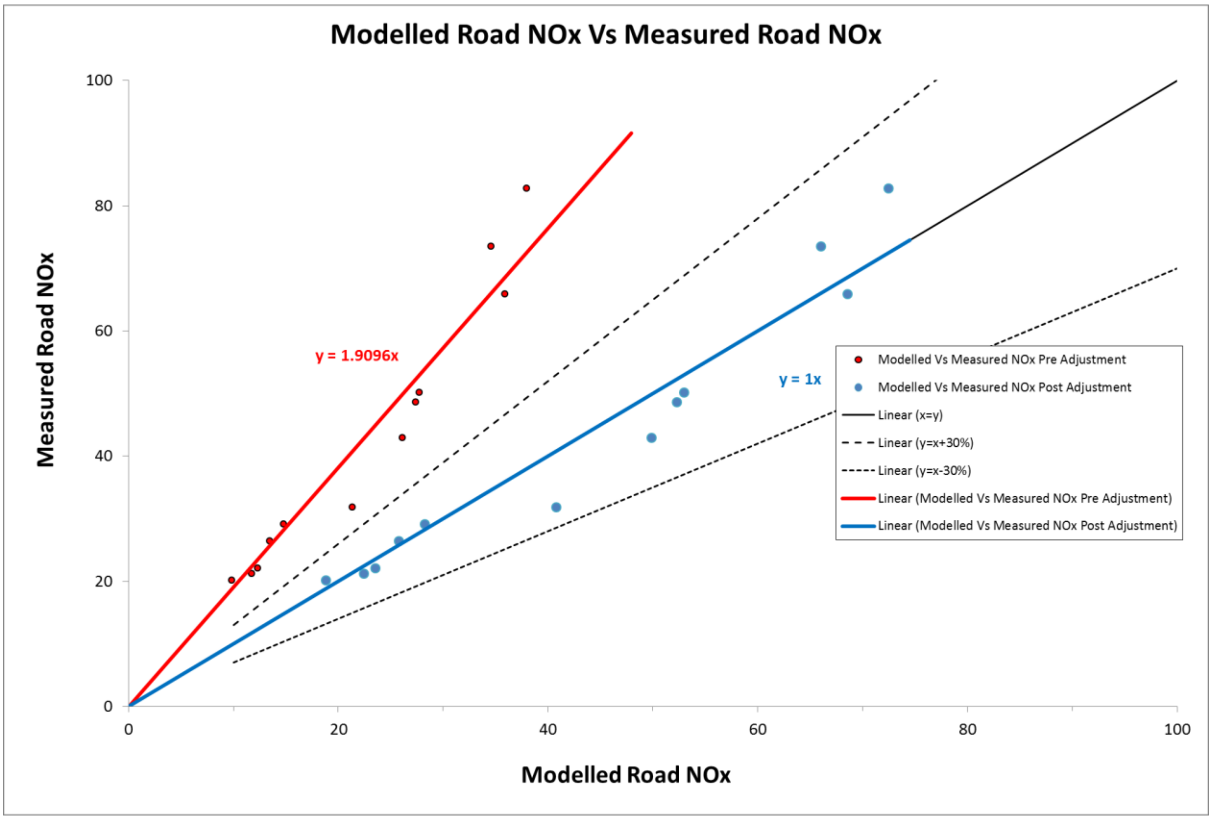
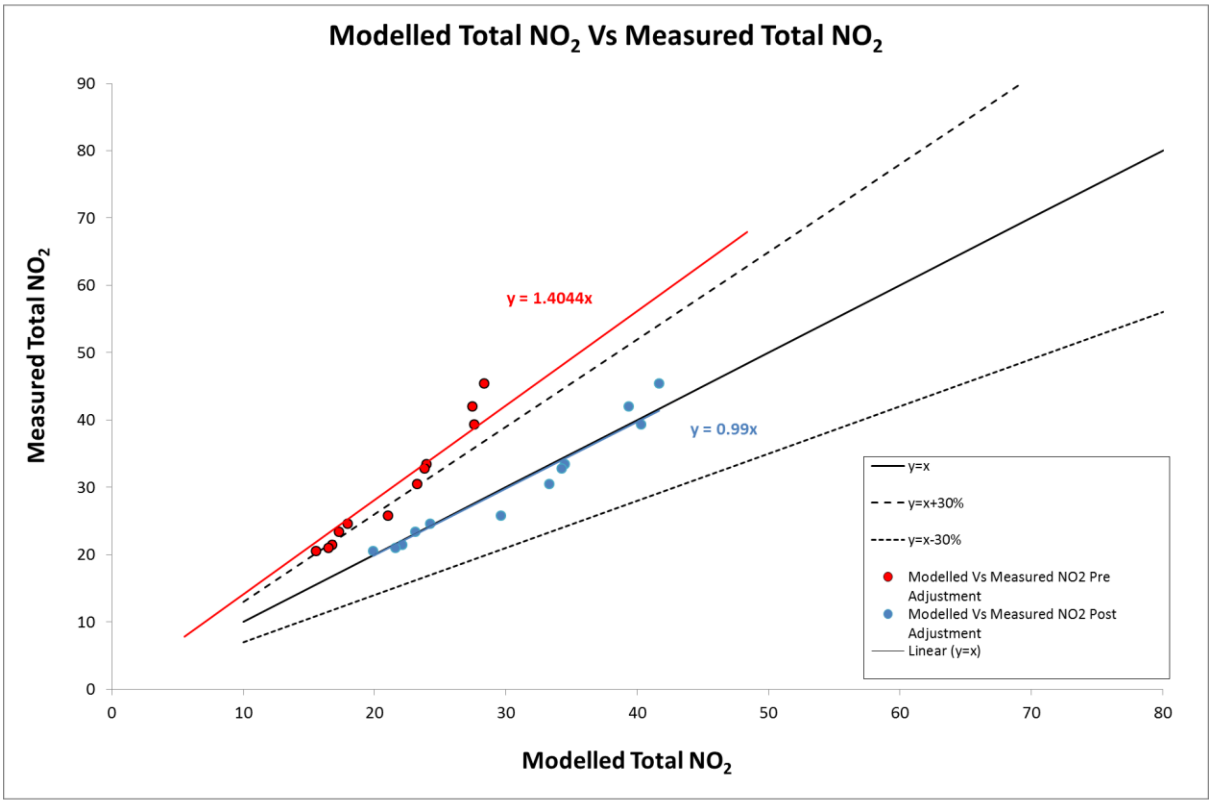


Figure A3.2: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2011



To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3. The calculated RMSE is presented in Table A3.1.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE is calculated at 2.03 $\mu g.m^{-3}$, the model uncertainty is therefore considered acceptable and the model has performed sufficiently well for use within this assessment.

Table A3.1: Storrington model - Root mean square error

NO_2 Monitoring Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
Storrington 1&2 DT	41.6	45.4
Storrington 3 DT	34.5	33.4
Storrington 15 DT	19.9	20.5
Storrington 4 DT	39.4	42
Storrington 18 DT	22.1	21.4
Storrington 13 DT	33.3	30.5
Storrington 5 DT	29.6	25.8
Storrington 12 DT	34.2	32.8
Storrington 11 DT	40.3	39.3
Storrington 6 DT	21.6	21
Storrington 7 DT	24.2	24.6
Automatic AURN site	23.1	23.4
	RMSE =	**2.03**

Pulborough Model Verification

The approach outlined in Example 2 of LAQM.TG(09) has also been used in this case.

The predicted annual mean Road NOx concentrations were compared with concentrations measured at the monitoring sites in Pulborough during 2011. The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Various refinements were subsequently made to the model input to improve the overall model performance. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A3.3.

A primary adjustment factor (PAdj) of 1.9465 based on model verification using 2011 monitoring results was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. A plot comparing modelled and monitored NO_2 concentrations before and after adjustment during 2011 is presented in Figure A3.4.

For each of the future modelled scenarios in 2015 the predicted Road NOx contributions were adjusted using the 1.9465 factor as derived from the 2011 NO_2 monitoring data. The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator using the background NOx concentrations and settings within the calculator for 2015.

Figure A3.3 Comparison of modelled Road NO_x Vs Measured Road NO_x before and after adjustment

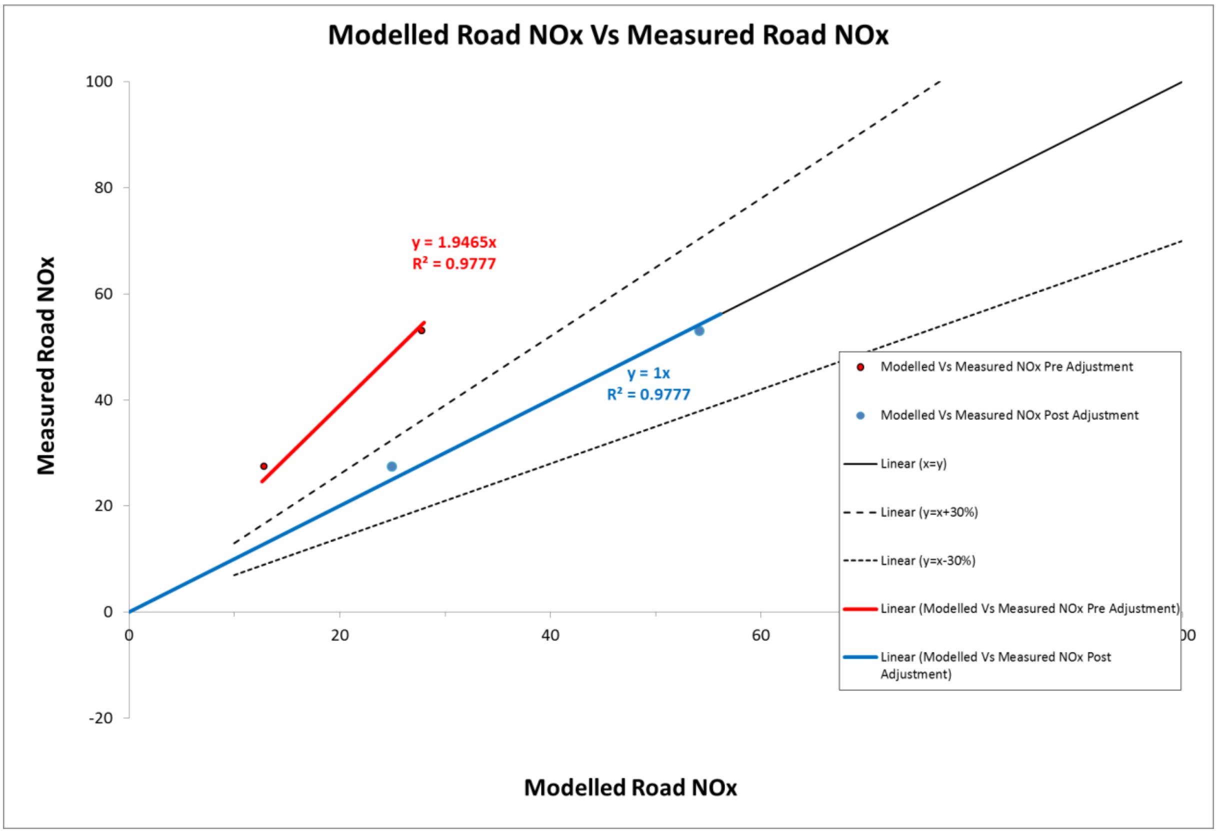
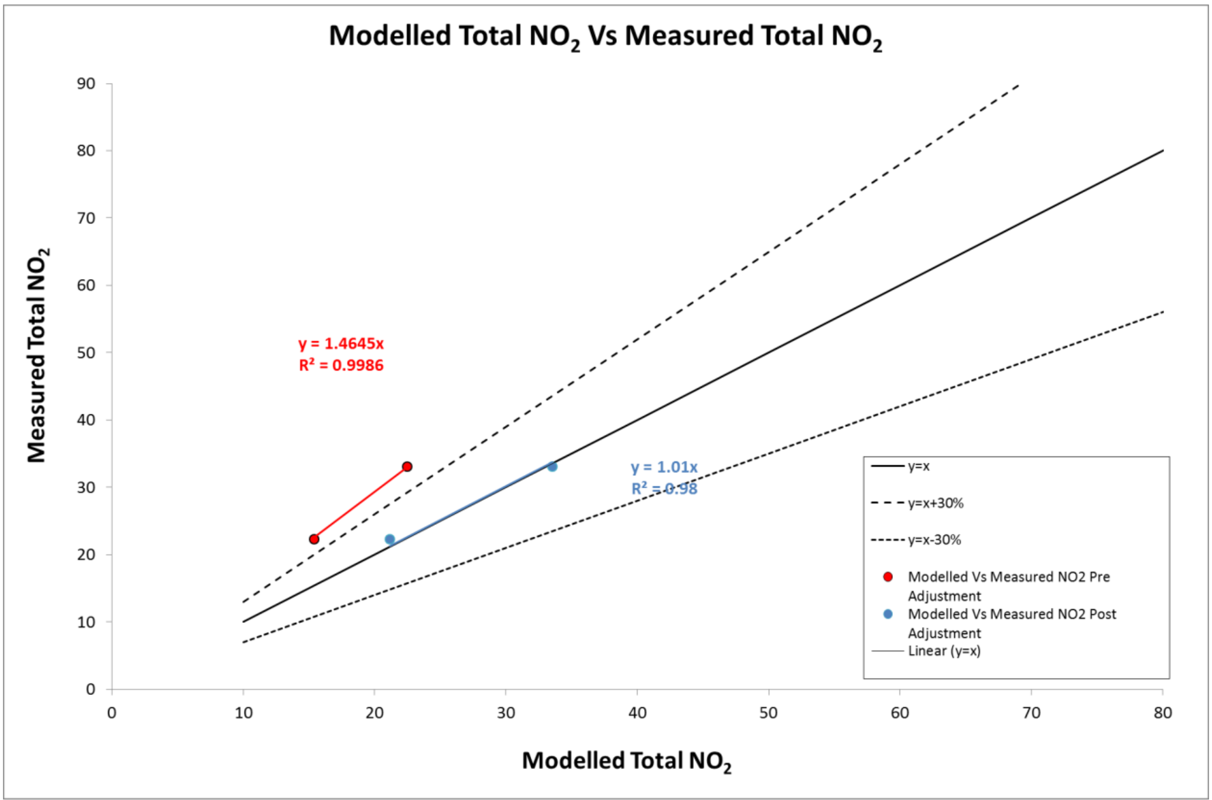


Figure A3.2: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2011



It was not appropriate to calculate the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations in this case as there were only two monitoring locations used to verify the dispersion model in Pulborough. A comparison of the modelled versus measured NO_2 concentrations at the diffusion tube sites following model adjustment is presented in Table A3.2.

Table A3.2: Measured vs modelled NO_2 concentrations in Pulborough after model adjustment

NO_2 Monitoring Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
Pulborough Diffusion tube 1	33.5	33.1
Pulborough Diffusion tube 2	21.2	22.3

RICARDO-AEA

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 0870 190 1900
Fax: 0870 190 6318

www.ricardo-aea.com