Air Quality
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Air Quality Assessment: Development Associated with the Local Plan, Warwick

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management & assessment

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1 Introduction

1.1 Warwick District Council (WDC) has identified locations with measured exceedences of the annual mean nitrogen dioxide objective. As a result, Air Quality Management Areas (AQMAs) have been declared in Warwick, Leamington Spa and Kenilworth.

1.2 The spatial planning system has an important role to play in improving air quality and reducing exposure to air pollution both within these AQMAs and elsewhere in the district. In particular, the local planning policies set the framework for the determination of individual planning applications.

1.3 WDC is currently preparing a new Local Plan for Warwick District, which will guide the area's future development for the next 18 years. The Preferred Options report has undergone public consultation for six weeks in June/ July 2013. WDC is currently preparing a submission draft of the Local Plan.

1.4 The Local Plan process will consider various sources of evidence, to inform the Council's emerging policies. Extensive analysis of the transport impacts of the proposals has already been undertaken using the S-Paramics model. This work included calculating the impacts of the proposals on peak-hour traffic flows within the Warwick and Leamington Spa AQMAs. Air quality has been identified as requiring further work to ascertain the impacts of development decisions on these AQMAs in more detail. This report uses the outputs of the S-Paramics traffic model, to assess air quality impacts (in terms of concentrations) on the AQMAs in Warwick and Leamington Spa. Two scenarios, the 'Revised Allocation' and the 'Revised Allocation Without Warwick Town Centre Improvements', have been compared with the 'Reference' scenario.

1.5 This report describes existing local air quality conditions (2011), which have also been used to verify the model, and the predicted air quality in the 2028 assuming that the 'revised approach'[1] to the allocation of growth, does, or does not proceed. Analysis has also been undertaken of a scenario within which the Warwick Town Centre Improvements (WTCI) have been removed. This is to provide a better understanding of the role that these works play in changes to traffic (and therefore air quality) within the Warwick AQMA.

[1] The revised approach is covered in detail in the Phase 3 Assessment Report of the Warwick Strategic Transport Assessment. Available at http://www.warwickdc.gov.uk/NR/rdonlyres/68108A0F-7A85-4410-A336-8819C3519B2A/0/21143919R0127__WDC_STA__Phase_3_Assessment_Report_Complete__ISSUEReportOnly.pdf

2 Policy Context and Assessment Criteria

Air Quality Strategy

2.1 The Air Quality Strategy published by the Department for Environment, Food, and Rural Affairs (Defra) provides the policy framework (Defra, 2007) for air quality management and assessment in the UK. It provides air quality standards and objectives for key air pollutants, which are designed to protect human health and the environment. It also sets out how the different sectors: industry, transport and local government, can contribute to achieving the air quality objectives. Local authorities are seen to play a particularly important role. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular reviews and assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date. If this is not the case, the authority must declare an Air Quality Management Area (AQMA), and prepare an action plan which identifies appropriate measures that will be introduced in pursuit of the objectives.

Planning Policy

National Policies

2.2 The National Planning Policy Framework (NPPF) (2012) introduced in March 2012 now sets out planning policy for the UK in one place. It replaces previous Planning Policy Statements, including PPS23 on Planning and Pollution Control. The NPPF contains advice on when air quality should be a material consideration in development control decisions. Existing, and likely future, air quality should be taken into account, as well as the EU limit values or national objectives for pollutants, the presence of any AQMAs and the appropriateness of both the development for the site, and the site for the development.

2.3 The NPPF places a general presumption in favour of sustainable development, stressing the importance of local development plans, and states that the planning system should perform an environmental role to minimise pollution. One of the twelve core planning principles notes that planning should *"contribute to…reducing pollution"*. To prevent unacceptable risks from air pollution, planning decisions should ensure that new development is appropriate for its location. The NPPF states that the effects of pollution on health and the sensitivity of the area and the development should be taken into account.

2.4 The need for compliance with any statutory air quality limit values and objectives is stressed, and the presence of AQMAs must be accounted for in terms of the cumulative impacts on air quality from individual sites in local areas. New developments in AQMAs should be consistent with local air quality action plans.

Local Policies

2.5 Warwick District Council's Local Plan (Warwick District Council, 2007) was published in September 2007. One of the Local Plan objectives is *"to protect and improve air quality"* (Objective 2F) and it contains the following policies relating to air quality:

Policy DP9 Pollution Control:

"Development will only be permitted which does not give rise to soil contamination or air, noise, radiation, light or water pollution where the level of discharge, emissions or contamination could cause harm to sensitive receptors.

Where there is evidence of existing land contamination, it will be necessary to ensure that that the land is made fit for its intended purpose and does not pose an unacceptable risk to sensitive receptors."

Policy DP7 Traffic Generation

"Development will not be permitted which generates significant road traffic movements unless practicable and effective measures are taken to avoid adverse impact from traffic generation.

In appropriate circumstances, development proposals will be required to demonstrate how they comply with this policy by way of a Transport Assessment and, where necessary, Travel Plan."

2.6 Changes to the planning legislation required the Council to replace the Local Plan with a Local Development Framework (LDF). This portfolio of planning documents will deliver the spatial development strategy for Warwick District Council and build upon existing local and regional strategies and initiatives. The Council are in the process of preparing a New Local Plan, which will form part of the LDF, and guide future development within the area for the next 18 years. The Preferred Options consultation document (Warwick District Council, 2012) identifies air quality as an issue and seeks to mitigate against negative transport impacts, such as the impact on air quality, by requiring developers to contribute to transport infrastructure improvements.

Assessment Criteria

Health Criteria

2.7 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air

Quality (England) Regulations, 2000, Statutory Instrument 928 (2000) and the Air Quality (England) (Amendment) Regulations 2002, Statutory Instrument 3043 (2002).

2.8 The objectives for nitrogen dioxide and PM_{10} were to have been achieved by 2005 and 2004 respectively, and continue to apply in all future years thereafter. The $PM_{2.5}$ objective is to be achieved by 2020. Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded where the annual mean concentration is below 60 $\mu g/m^3$ (Defra, 2009).

2.9 The objectives apply at locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Defra explains where these objectives will apply in its Local Air Quality Management Technical Guidance (Defra, 2009). The annual mean objectives for nitrogen dioxide and PM_{10} are considered to apply at the façades of residential properties, schools, hospitals etc.; they do not apply at hotels. The 24-hour objective for PM_{10} is considered to apply at the same locations as the annual mean objective, as well as in gardens of residential properties and at hotels. The 1-hour mean objective for nitrogen dioxide applies wherever members of the public might regularly spend 1-hour or more, including outdoor eating locations and pavements of busy shopping streets.

2.10 The European Union has also set limit values for nitrogen dioxide, PM_{10} and $PM_{2.5}$. Achievement of these values is a national obligation rather than a local one (Directive 2008/50/EC of the European Parliament and of the Council, 2008). The limit values for nitrogen dioxide are the same levels as the UK objectives, but applied from 2010 (The Air Quality Standards Regulations (No. 1001), 2010). The limit values for PM_{10} and $PM_{2.5}$ are also the same level as the UK statutory objectives, but applied from 2005 for PM_{10} and will apply from 2015 for $PM_{2.5}$.

2.11 The relevant air quality criteria for this assessment are provided in Table 1.

Table 1: Air Quality Criteria for Nitrogen Dioxide, PM_{10} and $PM_{2.5}$

Pollutant	Time Period	Objective
Nitrogen Dioxide	1-hour Mean	200 $\mu g/m^3$ not to be exceeded more than 18 times a year
	Annual Mean	40 $\mu g/m^3$
Fine Particles (PM_{10})	24-hour Mean	50 $\mu g/m^3$ not to be exceeded more than 35 times a year
	Annual Mean	40 $\mu g/m^3$
Fine Particles ($PM_{2.5}$) [a]	Annual Mean	25 $\mu g/m^3$

[a] The $PM_{2.5}$ objective, which is to be met by 2020, is not in Regulations and there is no requirement for local authorities to meet it. The EU limit value is the same, but is to be met by 2015.

3 Assessment Methodology

Existing Conditions

3.1 Monitoring for nitrogen dioxide within the study area has been carried out by Warwick District Council at a large number of diffusion tubes sites in Warwick and Leamington Spa over a number of years. The monitoring sites and study area for Warwick are shown in Figure 1 and for Leamington Spa in Figure 2. Warwick District Council deployed diffusion tubes prepared and analysed by Walsall MBC (50% TEA in acetone) from April 2008 to March 2011, however this lab closed without warning in March 2011 meaning that the tubes from that month were not analysed. From April onwards the diffusion tubes have been supplied and analysed by Bristol Scientific Services (20% TEA in water). Separate bias adjustment factors for 2011 for each laboratory were calculated and adjustments made, based on the local co-location study. This is described in detail in the 2012 Updating and Screening Assessment for Warwick District Council (Warwick District Council, 2012).

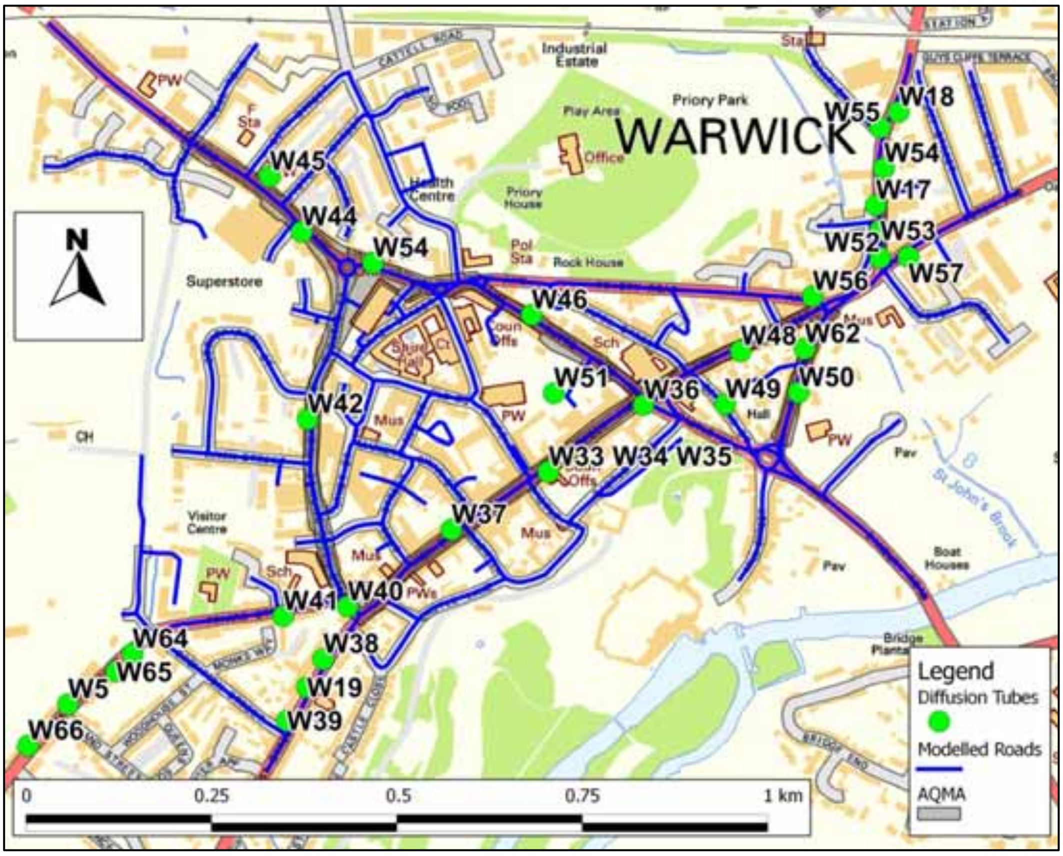

Figure 1: Warwick Detailed Assessment Study Area and Monitoring Locations. Roads explicitly included in the model shown in blue.

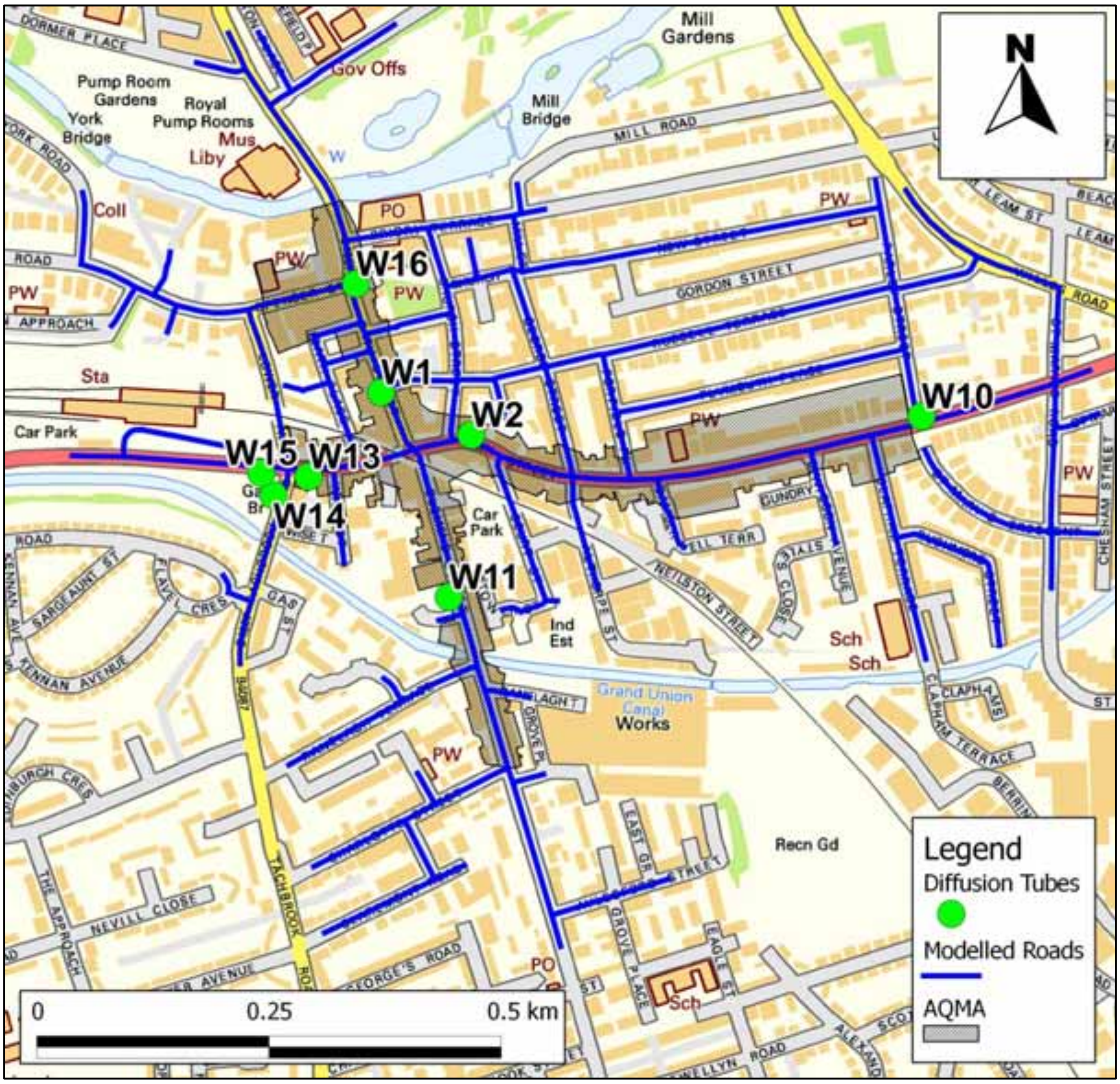

Figure 2: Leamington Spa Detailed Assessment Study Area and Monitoring Locations. Roads explicitly included in the model shown in blue.

3.2 WDC monitors air quality using both real time analysers and passive diffusion tubes. Table 2 presents the results of nitrogen dioxide real-time monitoring between 2008 and 2012, while Table 4 presents results for PM_{10} monitoring at a background site in Leamington Spa.

Table 2: Results of Automatic Monitoring of Nitrogen Dioxide: Comparison with Annual Mean Objective (2008 – 2012)

Site ID	Site Type	Within AQMA?	Annual Mean Concentration µg/m^3 2008	2009	2010	2011	2012
Hamilton Terrace, Leamington Spa	Urban background	N	27.1	27.0	28.3	21.1	20.7
Pageant House, Warwick	Roadside	Y	**58.0**	**62.5**	**56.5**	**58.2**	**60.4** [a]
Objective			**40**	**40**	**40**	**40**	**40**

[a] This annual mean incorporates the data for 1 January to 4 April, which seems anomalously high. Without this period the 9-month (April to December) mean would be 43.0 µg/m^3.

Table 3: Results of Automatic Monitoring of PM_{10} Hamilton Terrace, Leamington Spa: Comparison with Annual Mean and 24 Hour Objective (2008 – 2012)

Hamilton Terrace, Leamington Spa	Objective	2008	2009	2010	2011	2012
Annual Mean (µg/m^3)	**40**	14.7 [a]	19.8	20.7	20.0	26.3
Number of Exceedences of 24-Hour Mean (50 µg/m^3)	**35 (50)**	3 [a] (25.3) [b]	9	2	13	4

[a] 2008 data measured by TEOM and corrected using the Volatile Correction Model (http://www.volatile-correctionmodel.info). Data from 2009 onwards were measured by FDMS.

[b] where data capture is less than 90%, 90th percentile of 24-hour means have been included in brackets

3.3 Table 4 includes diffusion tube monitoring data from both Warwick and Leamington Spa, which has been used for verification of the model and for background information. There have been a number of exceedences of the annual mean nitrogen dioxide objective in both Warwick and Leamington Spa over the last 4 years.

Table 4: Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) in Warwick and Leamington Spa (2009-2012)

Site ID	Site Type	Within AQMA?	Annual mean concentration (adjusted for bias) µg/m^3 2009 (Bias Adjustment Factor = 1.43)	2010 (Bias Adjustment Factor = 1.35)	2011 (Bias Adjustment Factor = 1.32 and 0.81)	2012 (Bias Adjustment Factor = 0.84)
Warwick						
W51	Urban Background	N	22.1	23.7	15.6	19.6

Site ID	Site Type	Within AQMA?	Annual mean concentration (adjusted for bias) μg/m^3			
			2009 (Bias Adjustment Factor = 1.43)	2010 (Bias Adjustment Factor = 1.35)	2011 (Bias Adjustment Factor = 1.32 and 0.81)	2012 (Bias Adjustment Factor = 0.84)
W54	Roadside	Y	**56.7**	**58.1**	**43.1**	32.5
W46	Roadside	Y	**47.2**	**48.6**	36.9	36.4
W40	Kerbside	Y	**52.2**	**45.7**	37.1	**42.2**
W42	Roadside	Y	36.5	35.2	31.7	34.7
W33 W34 W35	Roadside	Y	**66.5**	**61.5**	**57.8**	**46.1**
W37	Roadside	Y	**46.9**	**43.7**	37.5	36.6
W38	Kerbside	N	**47.1**	**43.6**	32.6	36.9
W19	Roadside	N	N/A	37.1	34.5	32.9
W39	Roadside	N	31.2	35.8	30.1	27.5
W41	Roadside	N	31.1	**45.3**	26.7	26.1
W44	Roadside	Y	36.8	36.9	30.9	31.6
W45	Roadside	Y	32.6	29.8	29.3	28.6
W48	Roadside	Y	**42.6**	34.2	37.5	36.0
W49	Roadside	N	32.4	28.7	24.6	24.7
W50	Roadside	N	35.8	31.2	31.7	30.0
W62	Roadside	Y	**54.5**	**46.5**	**47.5**	**45.6**
W56	Roadside	N	n/a	32.0	21.0	24.7
W52	Kerbside	Y	**51.8c**	**50.8**	**43.3**	**42.0**
W53	Roadside	Y	**53.2**	**47.8**	**43.0**	**41.0**
W54	Roadside	N	36.4	39.5	31.3	32.5
W55	Roadside	N	34.1	35.6	30.4	29.4
W17	Kerbside	N	33.7	34.1	27.7	27.8
W18	Roadside	N	39.1	34.0	26.6	27.9
W57	Roadside	N	37.6	**41.4**	31.3	31.9
W36	Roadside	Y	**48.0**	**49.8**	**49.1**	**44.6**
W5	Roadside	N	**41.7**	38.5	33.5	36.0
W64	Roadside	N	n/a	n/a	30.6	27.5
W65	Roadside	N	n/a	n/a	27.2	25.9
W66	Roadside	N	n/a	n/a	28.2	30.0
Leamington Spa						
W2	Roadside	Y	**42.3**	**48.6**	**42.8**	39.3

Site ID	Site Type	Within AQMA?	Annual mean concentration (adjusted for bias) μg/m³			
			2009 (Bias Adjustment Factor = 1.43)	**2010 (Bias Adjustment Factor = 1.35)**	**2011 (Bias Adjustment Factor = 1.32 and 0.81)**	**2012 (Bias Adjustment Factor = 0.84)**
W10	Roadside	N	30.0	27.2	29.0	25.4
W11	Roadside	Y	30.3	29.1	22.9	25.5
W13	Roadside	Y	**57.3**	**61.2**	**52.7**	**49.6**
W14	Roadside	N	**48.7**	**44.1**	**41.9**	**40.6**
W15	Roadside	N	**41.0**	**41.1**	**41.9**	**45.2**
W16	Roadside	N	37.8	32.4	31.0	31.6
W1	Kerbside	Y	**54.5**	**55.8**	**49.0**	**44.0**
Objective			**40**			

Modelling

3.4 Annual mean nitrogen dioxide concentrations have been predicted using detailed dispersion modelling (ADMS-Roads v3). The input data used are described in Appendix 2. The model outputs have been verified against the monitoring data presented above as described in paragraph A2.10. Further details of model verification are also supplied in Appendix 2. Concentrations have been predicted at a number of worst-case receptor locations (locations shown in Figure 3 and Figure 4), as well as a grid of receptor locations across the study areas.

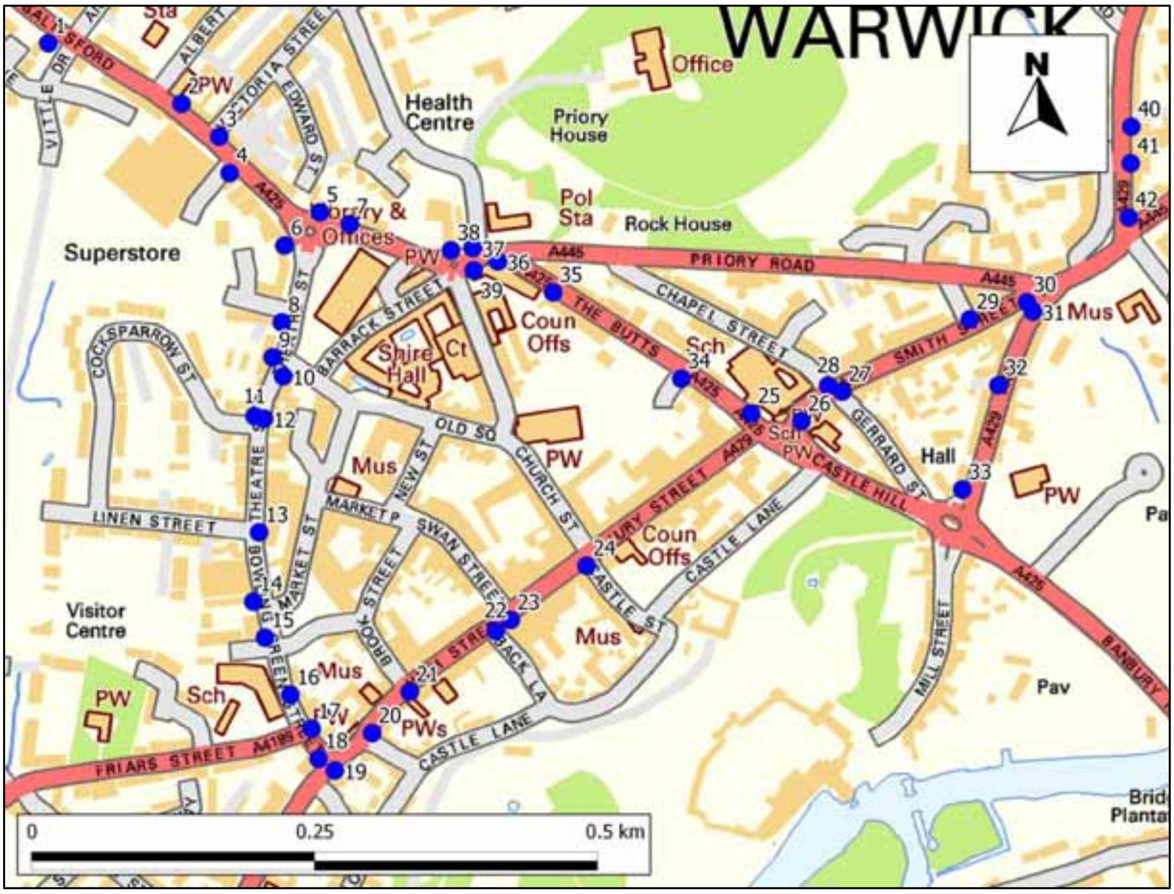

Figure 3: Specific Receptor Locations in Warwick

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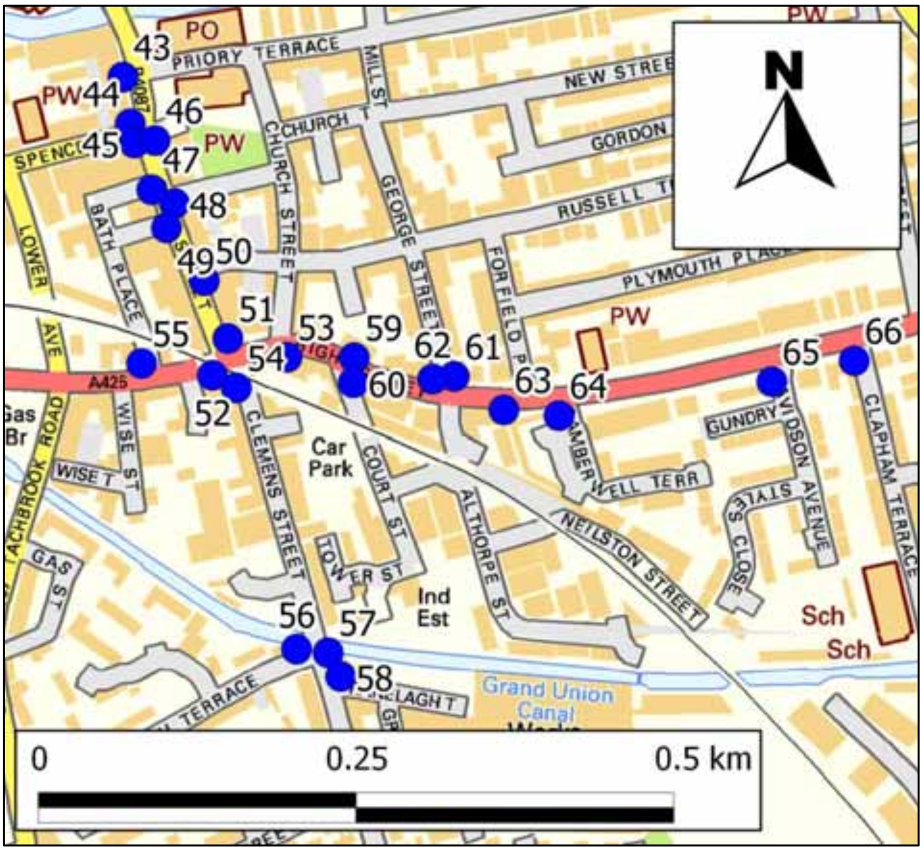

Figure 4: Specific Receptor Locations in Leamington Spa

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Road Traffic Impacts

Sensitive Locations

3.5 Concentrations of nitrogen dioxide, PM_{10} and $PM_{2.5}$ have been predicted at the receptor locations both within, and close to, the Warwick and Leamington Spa AQMAs. Receptors have been identified to represent worst-case exposure within the AQMAs. When selecting these receptors, particular attention has been paid to assessing impacts close to junctions, where traffic may become congested, and where there is a combined effect of several road links. The receptors have been located on the façades of the properties closest to the sources.

Assessment Scenarios

3.6 Predictions of nitrogen dioxide, PM_{10} and $PM_{2.5}$ concentrations have been carried out for a base year (2011), and for a future year (2028). For 2028, scenarios have been modelled assuming that the 'Revised Approach' to the allocation of growth, does, or does not proceed. Analysis has also been undertaken of the scenario within which the Warwick Town Centre Improvements have been removed from the 'Revised Approach'.

Modelling Methodology

3.7 Concentrations have been predicted for the baseline and future years using the ADMS-Roads dispersion model. Details of the model inputs and the model verification are provided in Appendix A2, together with the method used to derive current and future year background nitrogen dioxide concentrations.

3.8 Baseline concentrations for nitrogen dioxide in Warwick and Leamington Spa are illustrated in the Figure 5 and Figure 6.

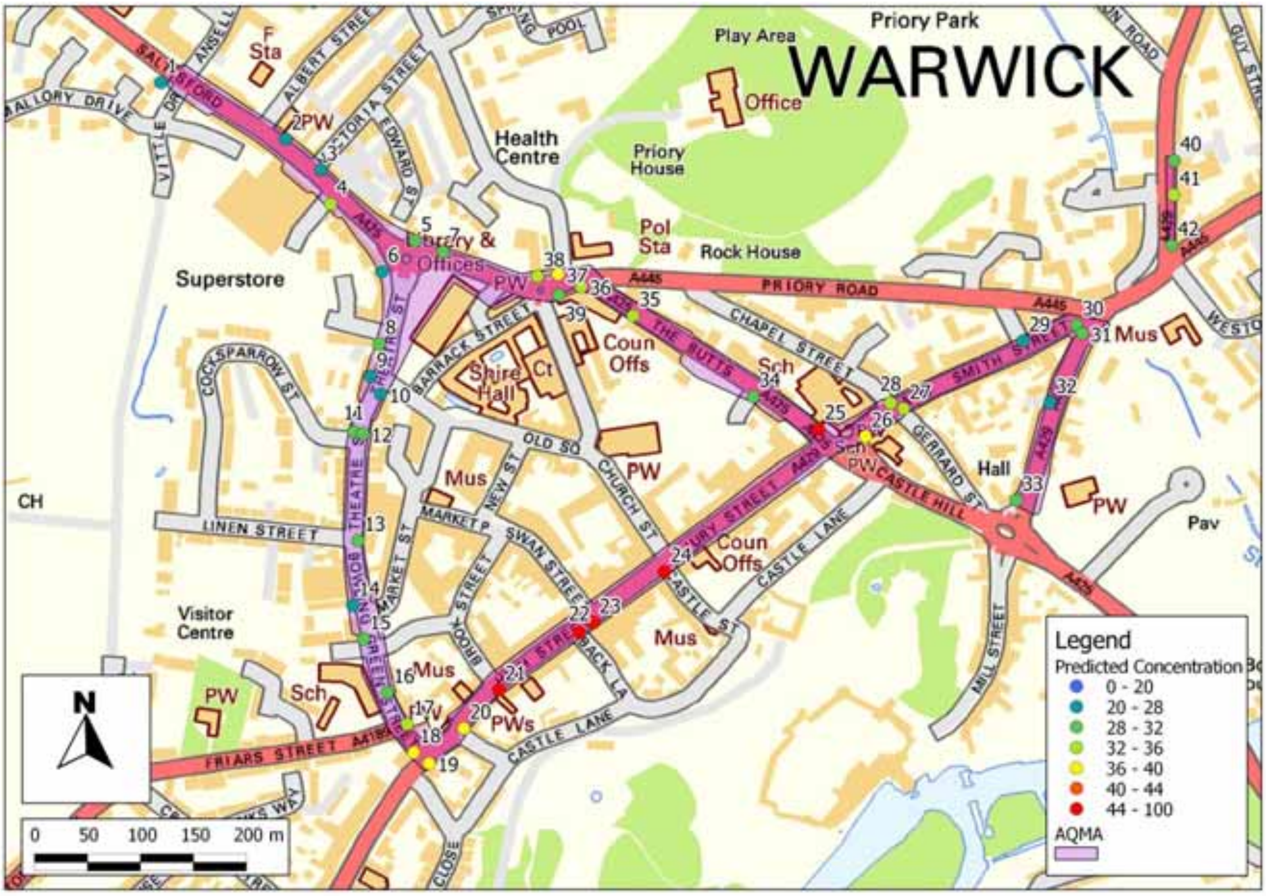

Figure 5: 2011 Nitrogen Dioxide Annual Mean Concentrations in Warwick

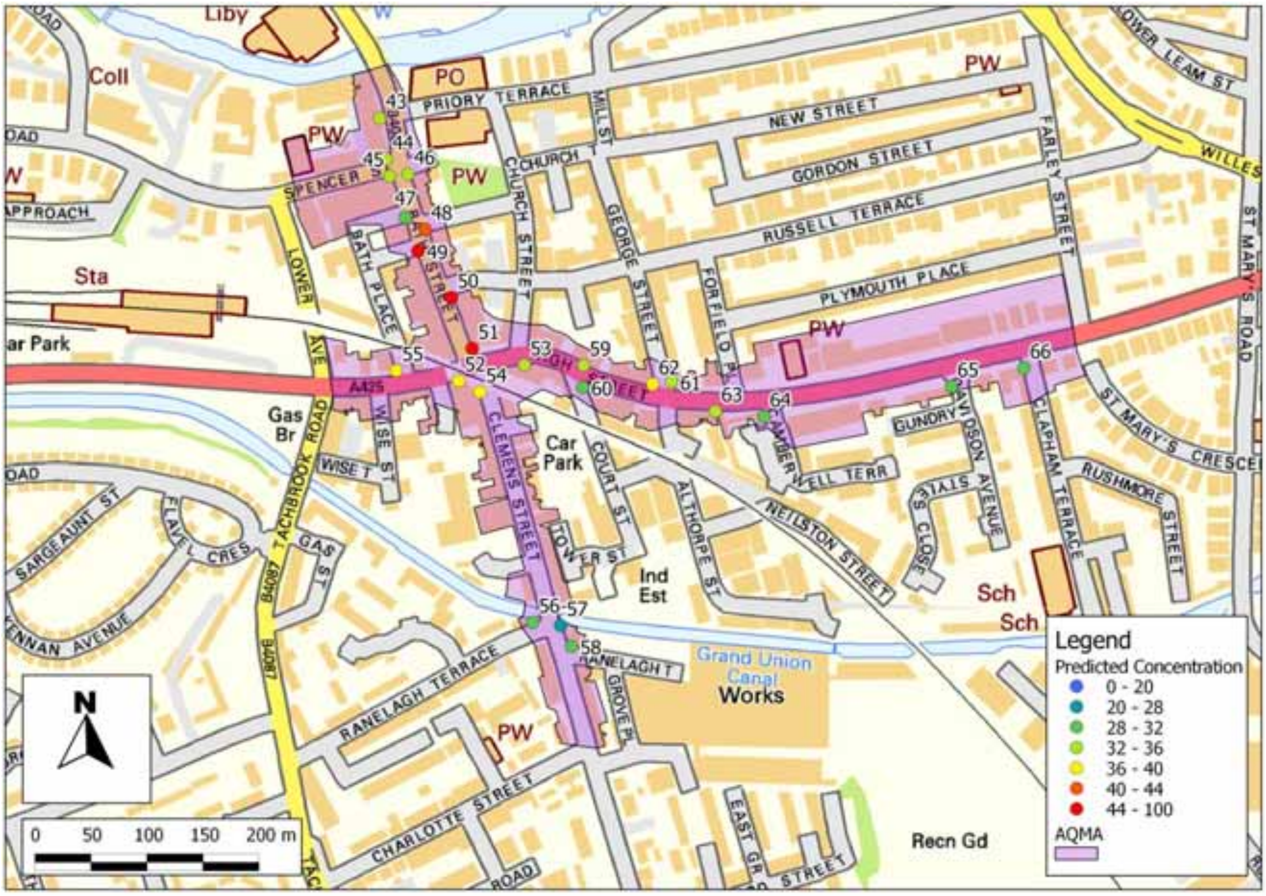

Figure 6: 2011 Nitrogen Dioxide Annual Mean Concentrations in Leamington Spa

4 Results

Road Traffic Impacts

4.1 Predicted annual mean concentrations of nitrogen dioxide, PM_{10} and $PM_{2.5}$, as well as days with PM_{10} >50 µg/m^3, are set out in Appendix A3 for the "Reference Case", "Revised Allocation" and "Revised Allocation without Warwick Town Centre Improvements" scenarios. Results are summarised below.

Nitrogen Dioxide

4.2 Concentrations of nitrogen dioxide are predicted to be much lower in 2028 than in 2011. This reduction is associated with the introduction of more stringent emissions controls on new vehicles via Euro standards; in 15 years' time these vehicles will make up the majority of the fleet on the roads in the UK. Background concentrations are also predicted to be substantially lower in 15 years' time, than current, due to reductions in various contributing sectors.

4.3 When comparing the 'Revised Allocation' with the reference case, there will be improvements in concentrations of nitrogen dioxide at some locations and dis-benefits at others. Figure 7 and Figure 8 show the difference between the two scenarios at each of the specific receptors (both positive and negative) in Warwick and Leamington Spa. The differences between the two scenarios are much more marked in Warwick than in Leamington Spa. The 'Revised Allocation' will have a much greater impact in Warwick, both positive and negative. At some locations there will be a change of over 4 µg/m^3 (both positive and negative), which would be classed as a large change using the criteria set out in the EPUK Guidance on Planning and Air Quality (EPUK, 2010). Beneficial impacts are mainly seen along High Street, Jury Street, Theatre Street and Bowling Green Street. Currently, the highest nitrogen dioxide concentrations within Warwick are experienced along High Street and Jury Street. There are negative impacts elsewhere on the network in Warwick. Impacts in Leamington are negative at all locations, with magnitudes of change mostly under 2 µg/m^3 (which would be classed by the EPUK Guidance as a 'small' change). There are though, receptors along Bath Street in Leamington Spa which show a negative impact of over 2 µg/m^3 with the Revised Allocation, which would be classed as a 'medium' change.

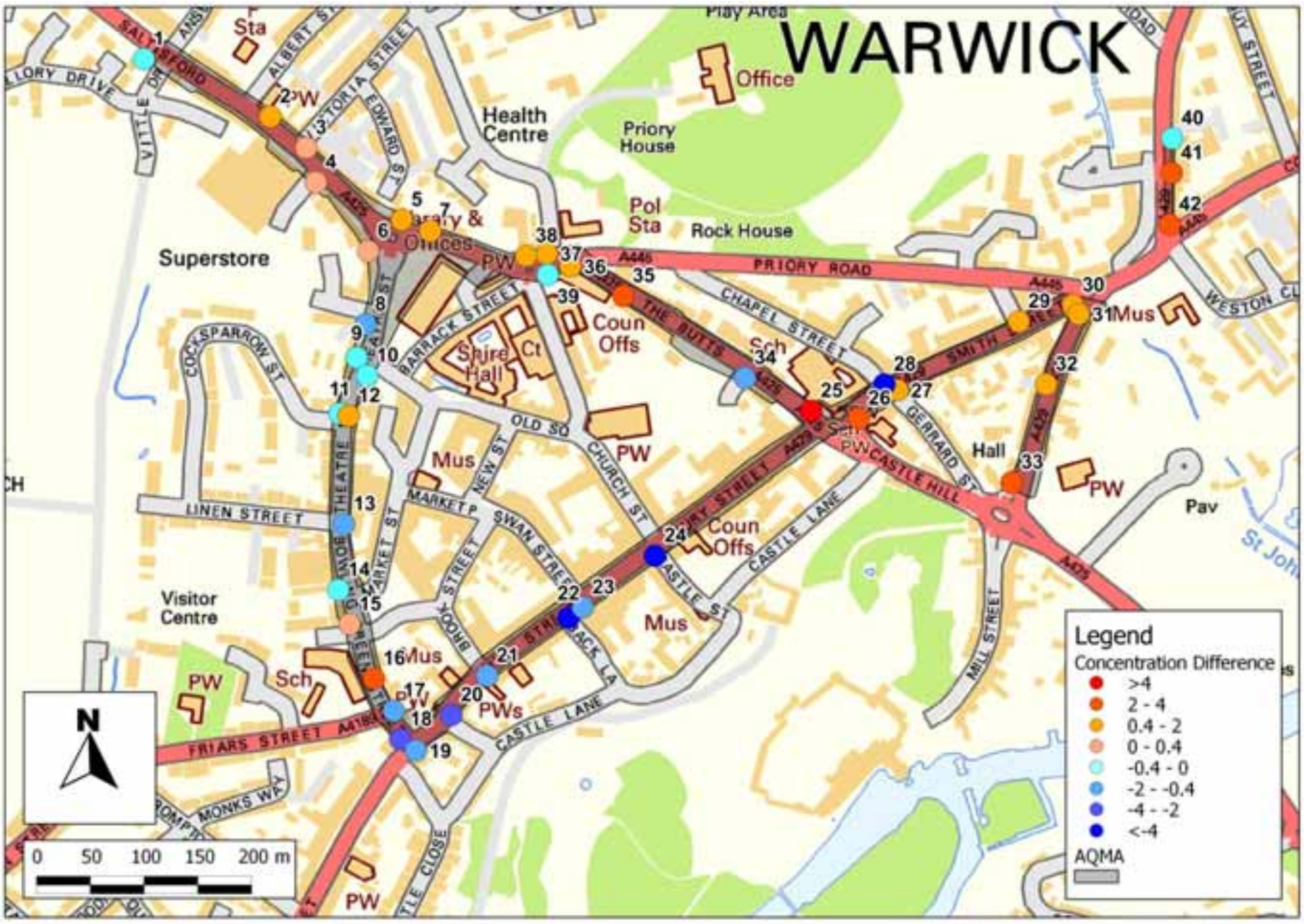

Figure 7: 2028 Difference in Nitrogen Dioxide Concentrations between the Reference Case and the Revised Allocation in Warwick

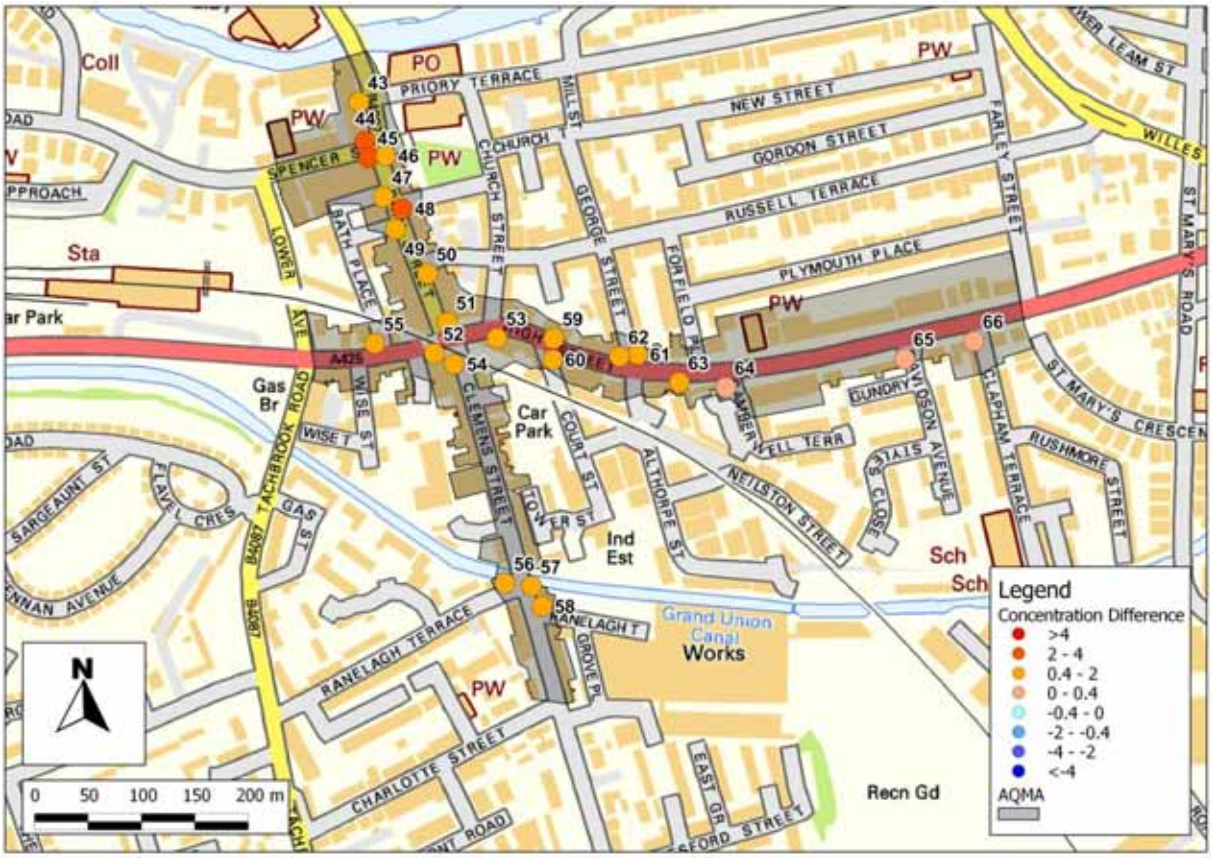

Figure 8: 2028 Difference in Nitrogen Dioxide Concentrations between the Reference Case and the Revised Allocation in Leamington Spa

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4.4 Similarly, the 'Revised Allocation without WTCI' has been compared with the reference case. In all cases the impacts are in the same direction as for the 'Revised Allocation', i.e. the positive and negative impacts are in the same places (Figure 9 and Figure 10). However, the improvements are all greater and the deteriorations smaller than the 'Revised Allocation' scenario with WTCI.

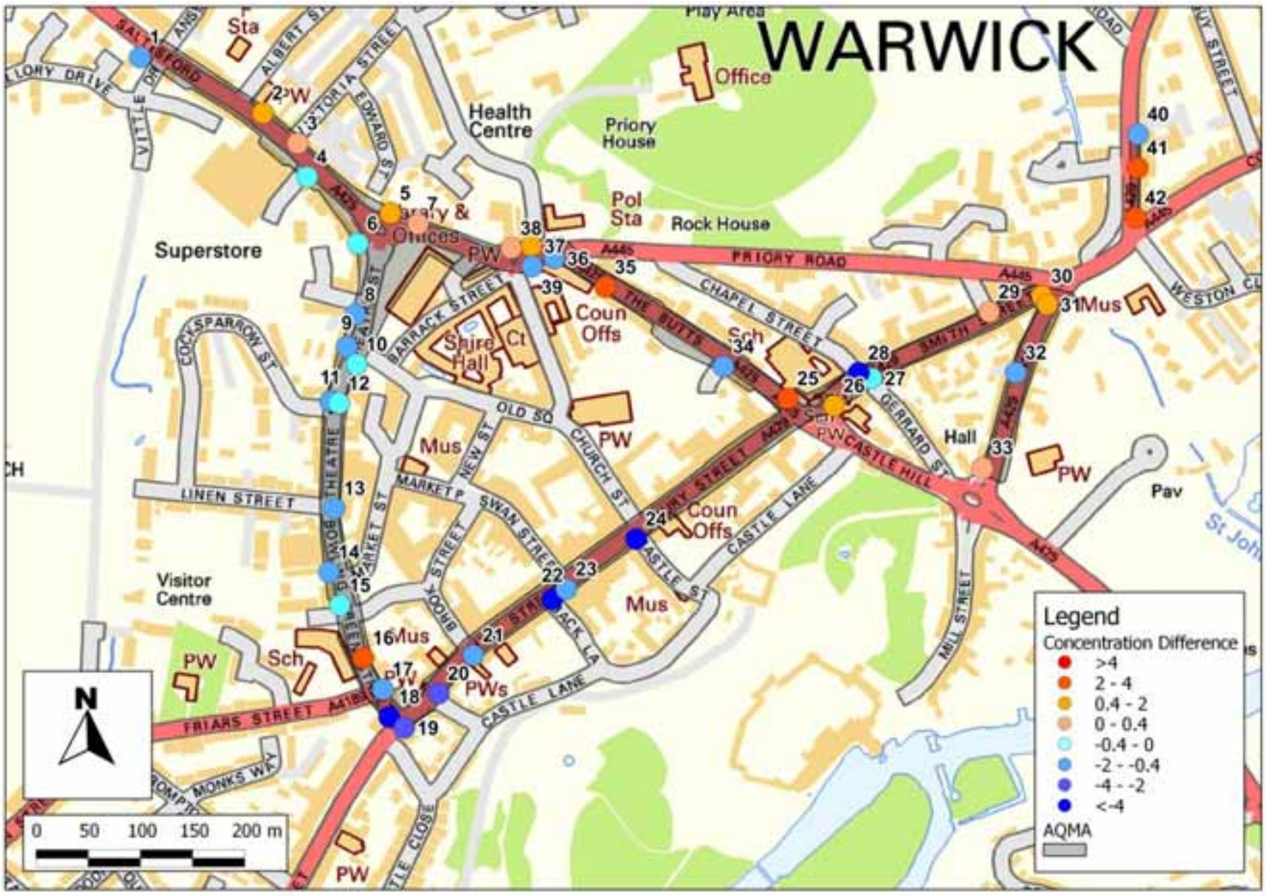

Figure 9: 2028 Difference in Nitrogen Dioxide Concentrations between the Reference Case and the Revised Allocation minus WTCI in Warwick

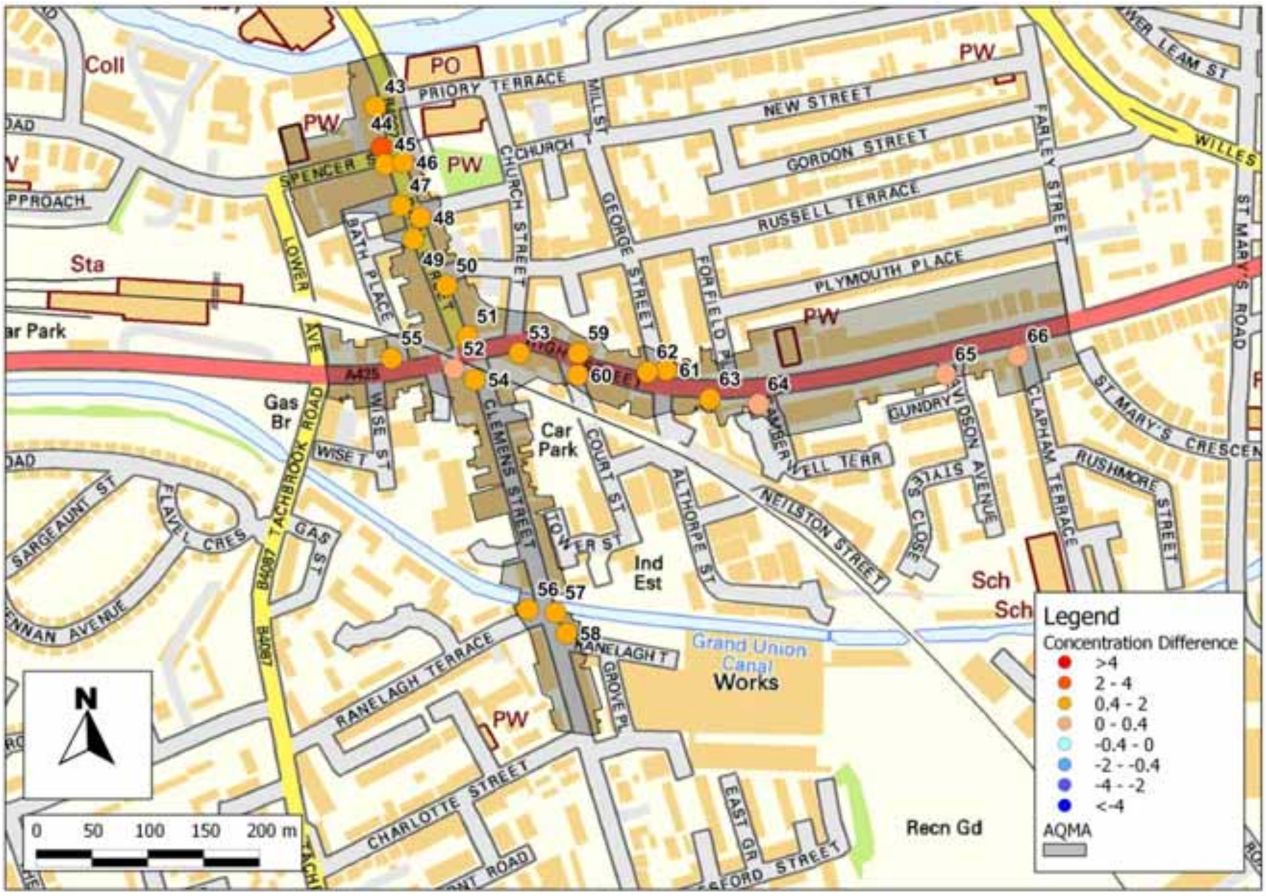

Figure 10: 2028 Difference in Nitrogen Dioxide Concentrations between the Reference Case and the Revised Allocation minus WTCI in Leamington Spa

PM_{10} and $PM_{2.5}$

4.5 The annual mean PM_{10} and $PM_{2.5}$ concentrations are all well below the objectives at all receptors, in both 2011 and in 2028 for all scenarios, as are the numbers of days with PM_{10} concentrations above 50 µg/m^3. The patterns of impact of the scheme are the same for PM_{10} as they are for nitrogen dioxide (i.e. in terms of positive and negative impacts). For this reason, they have not been illustrated.

4.6 Maps showing the concentrations contours of all scenarios modelled are included in Appendix A4.

Uncertainty in Road Traffic Modelling Predictions

4.7 There are many components that contribute to the uncertainty of modelling predictions. The model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as the model is required to simplify real-world conditions into a series of algorithms. An important stage in the process is model verification, which involves comparing the model output with measured concentrations (see Appendix A2). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of current year (2011) concentrations.

4.8 Predicting pollutant concentrations in a future year will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future, and it is necessary to rely on a series of projections provided by DfT and Defra as to what will happen to traffic volumes, background pollutant concentrations, and vehicle emissions. A disparity between the road transport emission projections and measured annual mean concentrations of nitrogen oxides and nitrogen dioxide has been identified by Defra (Carslaw, Beevers, Westmoreland, & Williams, 2011). This is evident across the UK, although the effect appears to be greatest in inner London; there is also considerable inter-site variation. Whilst the emission projections suggested that both annual mean nitrogen oxides and nitrogen dioxide concentrations should have fallen by around 15-25% over the past 6 to 8 years, at many monitoring sites levels have remained relatively stable, or have even shown a slight increase.

4.9 This disparity led to a detailed review of the emission factors and fleet mix for UK conditions, and in July 2012, Defra issued a revised Emissions Factors Toolkit (ETFv5.1.3). This has since been updated to version EFTv5.2c, which has undergone some further, more minor, revisions. The new EFT utilises revised nitrogen oxides emissions factors and also incorporates revised vehicle fleet composition data (Defra, 2012). The new EFT goes some way to addressing the disparity between air quality measurements and emissions, but does not fully address it, and it is recognised that the forecast reductions may still be optimistic in the near-term (i.e. the next five years or so).

4.10 The reason for the disparity is thought to relate to the on-road performance of modern diesel vehicles. New vehicles registered in the UK have to meet progressively tighter European type approval emissions categories, referred to as "Euro" standards. While the nitrogen oxides emissions from newer vehicles should be lower than those from equivalent older vehicles, the on-road performance of some modern diesel vehicles is often no better than that of earlier models (Carslaw, Beevers, Westmoreland, & Williams, 2011). The best current evidence is that, where previous standards have had limited on-road success, the ‘Euro VI’ and ‘Euro 6’ standards that new vehicles will have to comply with from 2013/15[2] will achieve the expected on-road improvements, as, for the first time, they will require compliance with the World Harmonized Test Cycle, which better represents real-world driving conditions and includes a separate slow-speed cycle for heavy duty vehicles.

4.11 As noted above, the new forecast reductions in nitrogen oxides emissions may still be optimistic in the near-term. However, as 2028 is so far into the future, it is expected that the penetration into the fleet of Euro VI HDVs and Euro 6 LDVs will be almost complete. For example, by 2022 it is

2 Euro VI refers to heavy duty vehicles, while Euro 6 refers to light duty vehicles. The timings for meeting the standards vary with vehicle type and whether the vehicle is a new model or existing model.

forecast that there will be a roughly over 95% penetration of Euro VI HDVs and a roughly 70% penetration of Euro 6 LDVs. This will be even higher in 2028. These new vehicles are expected to deliver real on-road reductions in nitrogen oxides emissions. For this reason, future forecasts are based on the current 'official' emissions factors, which assume the new standards will deliver the expected reduction.

5 Summary and Conclusions

5.1 In 2011 there are exceedences of the annual mean nitrogen dioxide objective predicted in both Warwick and Leamington Spa, which reflects the outcomes of the Review and Assessment process. For PM_{10}, there are no exceedences of either objective either in 2011, or in any of the 2028 scenarios.

5.2 For both pollutants, there are much lower concentrations in 2028 than in 2011. This reduction is associated with the introduction of more stringent emissions controls on new vehicles via Euro standards; in 15 years' time these vehicles will make up the majority of the fleet on the roads in the UK.

5.3 The impacts of both the 'Revised Allocation' and the 'Revised Allocation without WTCI' are mixed. Beneficial impacts are mainly seen along High Street, Jury Street, Theatre Street and Bowling Green Street. Currently, the highest nitrogen dioxide concentrations within Warwick are experienced along High Street and Jury Street. There are negative impacts elsewhere on the network in Warwick. Impacts in Leamington are negative at all locations, with magnitudes of change mostly under 2 $\mu g/m^3$ (which would be classed by the EPUK Guidance as a 'small' change). There are though, receptors along Bath Street in Leamington Spa which show a negative impact of over 2 $\mu g/m^3$ with the 'Revised Allocation', which would be classed as a 'medium' change. The scenario without the Warwick Town Centre Improvements has smaller adverse impacts and greater improvements than the scenario with Warwick Town Centre Improvements. The same patterns are apparent for PM_{10}, although the magnitudes of change are smaller.

5.4 Finally, it should be recognised that the 2028 concentrations, especially those for nitrogen dioxide, may be higher than presented in this assessment, as they rely on new vehicles meeting the emission control standards currently coming into force. Recent experience with previous standards suggests that this may be optimistic. In addition, the changes set out within the policy scenarios will affect traffic flows well before 2028, and thus have effects on air quality at a time when emissions, and hence concentrations, are still high. The picture presented by this analysis in terms of absolute concentrations may thus be overly optimistic. The changes brought about by the two scenarios in relation to the 'Reference' scenario will though be reasonably well represented.

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7 Glossary

AADT	Annual Average Daily Traffic
ADMS-Roads	Atmospheric Dispersion Modelling System
AQMA	Air Quality Management Area
AURN	Automatic Urban and Rural Network
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
EFT	Emissions Factor Toolkit
Exceedence	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
HDV	Heavy Duty Vehicles (> 3.5 tonnes)
HGV	Heavy Goods Vehicle
LAQM	Local Air Quality Management
LDF	Local Development Framework
LDV	Light Duty Vehicles (<3.5 tonnes)
$\mu g/m^3$	Microgrammes per cubic metre
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
NPPF	National Planning Policy Framework
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
PM_{10}	Small airborne particles, more specifically particulate matter less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal
TEA	Triethanolamine – used to absorb nitrogen dioxide

8 Appendices

A1 Professional Experience

Prof. Duncan Laxen, BSc (Hons) MSc PhD MIEnvSc FIAQM

Prof Laxen is the Managing Director of Air Quality Consultants, a company which he founded in 1993. He has over forty years' experience in environmental sciences and has been a member of Defra's Air Quality Expert Group and the Department of Health's Committee on the Medical Effects of Air Pollution. He has been involved in major studies of air quality, including nitrogen dioxide, lead, dust, acid rain, PM_{10}, $PM_{2.5}$ and ozone and was responsible for setting up the UK's urban air quality monitoring network. Prof Laxen has been responsible for appraisals of all local authorities' air quality Review & Assessment reports and for providing guidance and support to local authorities carrying out their local air quality management duties. He has carried out air quality assessments for power stations; road schemes; ports; airports; railways; mineral and landfill sites; and residential/commercial developments. He has also been involved in numerous investigations into industrial emissions; ambient air quality; indoor air quality; nuisance dust and transport emissions. Prof Laxen has prepared specialist reviews on air quality topics and contributed to the development of air quality management in the UK. He has been an expert witness at numerous Public Inquiries, published over 70 scientific papers and given numerous presentations at conferences. He is a Fellow of the Institute of Air Quality Management.

Dr Clare Beattie, BSc (Hons) MSc PhD CSci MIEnvSc MIAQM

Dr Beattie is a Principal Consultant with AQC, with more than fourteen years' relevant experience. She has been involved in air quality management and assessment, and policy formulation in both an academic and consultancy environment. She has prepared air quality review and assessment reports, strategies and action plans for local authorities. Dr Beattie has developed guidance documents on air quality management on behalf of central government, local government and NGOs. She has appraised local authority air quality assessments on behalf of the UK governments, and provided support to the Review and Assessment helpdesk. She has also provided support to the integration of air quality considerations into Local Transport Plans and planning policy processes. She has also carried out numerous assessments for new residential and commercial developments, including the negotiation of mitigation measures where relevant. Clare also works closely with Defra and is currently managing the Defra Air Quality Grant Appraisal contract. She is a Member of the Institute of Air Quality Management.

Dr Austin Cogan, MPhys (Hons) PhD

Dr Cogan is an Assistant Consultant with AQC and now has over one years' experience in the field of air quality modelling, monitoring and assessment. Prior to this he studied at the University of Leicester, gaining 2 years' experience of scientific instrument design and spent 4 years' pioneering research in satellite observations of carbon dioxide, including data validation, model comparisons, bias correction, and software development. He now works in the field of air quality assessment and has been involved in air quality and greenhouse gas assessments of road schemes, railways, airports, waste incinerators, commercial developments and residential developments in the UK. Dr Cogan has also been involved in the analysis and interpretation of air quality data and the preparation of review and assessment reports for local authorities.

Full CVs are available at www.aqconsultants.co.uk.

A2 Modelling Methodology

Background Concentrations

A2.1 The background concentrations across the study area have been defined using the national pollution maps published by Defra (2013a). These cover the whole country on a 1x1 km grid and are published for each year from 2010 until 2030. The maps include the influence of emissions from a range of different sources; one of which is road traffic. As noted in Paragraph 3.6, there are some concerns that Defra may have over-predicted the rate at which road traffic emissions of nitrogen oxides will fall in the future. The maps currently in use were verified against measurements made during 2010 at a large number of automatic monitoring stations and so there can be reasonable confidence that the maps are representative of conditions during 2010. Similarly, there is reasonable confidence that the reductions which Defra predicts from other sectors (e.g. rail) will be achieved.

A2.2 In order to calculate background nitrogen dioxide and nitrogen oxides concentrations in 2011, it is assumed that there was no reduction in the road traffic component of backgrounds between 2010[3] and 2011. This has been done using the source-specific background nitrogen oxides maps provided by Defra (2013a). For each grid square, the road traffic component has been held constant at 2010 levels, while 2011 values have been taken for the other components. Nitrogen dioxide concentrations have then been calculated using the background nitrogen dioxide calculator which Defra (2013a) publishes to accompany the maps. The result is a set of 'adjusted 2011 background' concentrations.

A2.3 As an additional step, the background maps have been calibrated against national measurements made as part of the AURN during 2011. The published background maps were calibrated against 2010 monitoring data. 2010 was identified as a 'high pollution' year, as a result the background maps may over predict the local background concentrations. Therefore a comparison between the 2011 annual mean nitrogen dioxide concentration at all background monitoring sites within the AURN and the background mapped concentrations has been carried out (see Figure A2.1). Based on the 68 sites with more than 75% data capture for 2011 the maps over-predict the background concentrations by 5%, on average. This has been allowed for in production of the calibrated 'adjusted' 2011 background concentrations.

3 This approach assumes that has been no reduction in emissions per vehicle but also that traffic volumes have remained constant. This is not the same as the assumption made for dispersion modelling, in which emissions per vehicle are held constant while traffic volumes are assumed to change year on year. Overall, this discrepancy is unlikely to influence the overall conclusions of the assessment.

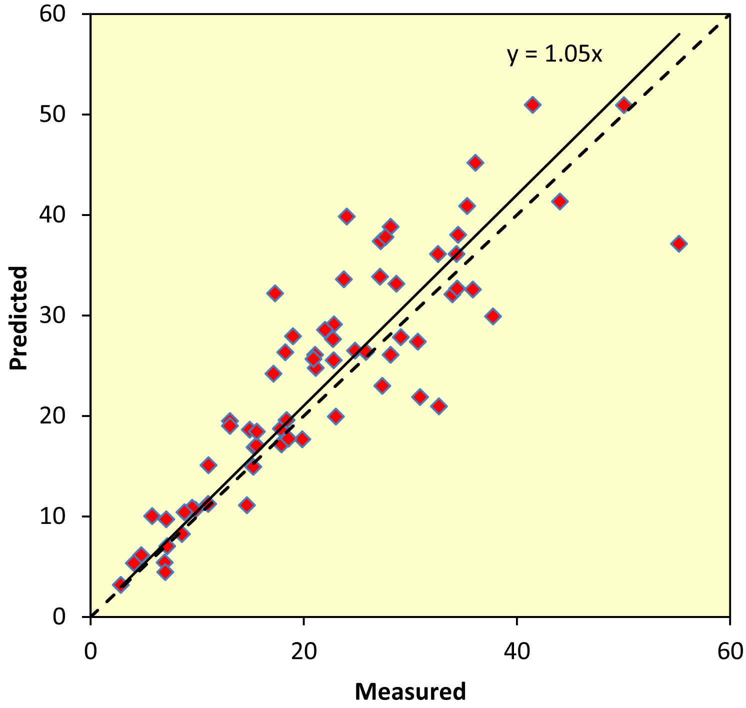

Figure A2.1: Predicted Mapped versus Measured Concentrations at AURN Background Sites in 2011

A2.4 Background nitrogen dioxide and nitrogen oxides concentrations in 2028 have been used for the future-year assessment. The 2028 background assumes that Defra's revised predicted reductions occur from 2011 onward. This dataset has been derived first by calculating the ratio of the unadjusted mapped value for 2028 to the unadjusted mapped value for 2011. This ratio has then been applied to the adjusted 2011 value (as derived in Paragraph A2.2). This has been further adjusted by the national factor of 0.952 for the background calibration, as described above.

A2.5 For PM_{10} and $PM_{2.5}$, there is no strong evidence that Defra's predictions are unrealistic and so the year-specific mapped concentrations have been used in this assessment.

Model Inputs

A2.6 Predictions have been carried out using the ADMS-Roads dispersion model (v3.1). The model requires the user to provide various input data, including emissions from each section of road, and the road characteristic (including road width and street canyon height, where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed using the Emission Factor Toolkit (Version 5.2c) published by Defra (2013a). For nitrogen dioxide future-year concentrations have been predicted once using year-specific emission factors from the EFT and once using emission factors for 2011[4] which is the year for which the model has been verified.

4 i.e. combining current-year emission factors with future-year traffic data.

A2.7 The model has been run using the full year of meteorological data that corresponds to a recent set of nitrogen dioxide monitoring data (2011). The meteorological data has been taken from the monitoring station located at Coventry, which is considered suitable for this area.

A2.8 For the purposes of modelling, it has been assumed that the front façades of existing properties along a number of road links are within street canyons formed by the buildings along those road links. These road links include parts of Bath Street, Clemens Street, Charlotte Street, Church Street, George Street, Clapham Terrace, Rushmore Street, Castle Lane, Leycester Place, Castle Street, High Street, Jury Street, Swan Street, Brook Street, New Street, Market Street, Barrack Street, The Butts, Chapel Street, Smith Street, Mill Street, Gerrard Street, Guy Street, Cherry Street and St Nicholas Church Street. These roads have a number of canyon-like features which reduce dispersion of traffic emissions and can therefore lead to concentrations of pollutants being higher here than they would be in areas with greater dispersion. As a precautionary measure, these roads have been assumed to be canyons and ADMS-roads may therefore have over predicted concentrations at the façades of existing properties along these roads.

A2.9 Peak hours flows, proportions of HGVs and speeds have been provided by Warwick District Council. These were derived from the S-Paramics Micro-simulation traffic model. Diurnal flow profiles for the traffic have been derived from the national diurnal profiles published by DfT (DfT, 2011), and used to factor the peak hour flows to AADT flows.

Model Verification

A2.10 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements. The verification methodology is described below.

A2.11 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The model has been run to predict the annual mean NOx concentrations during 2011 at all Warwick and Leamington Spa roadside diffusion tube monitoring sites within the modelled road network.

A2.12 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2013a).

A2.13 A primary adjustment factor was determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A2.2). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx from NO_2 calculator. A secondary adjustment factor was finally calculated as the slope of the best-fit line applied to the adjusted data and forced through zero (Figure A2.3).

A2.14 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Warwick Primary adjustment factor : 0.905
- Warwick Secondary adjustment factor: 1.091
- Leamington Spa Primary adjustment factor : 1.566
- Leamington Spa Secondary adjustment factor: 0.989

A2.15 Figure A2.4 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship for both Warwick and Leamington Spa.

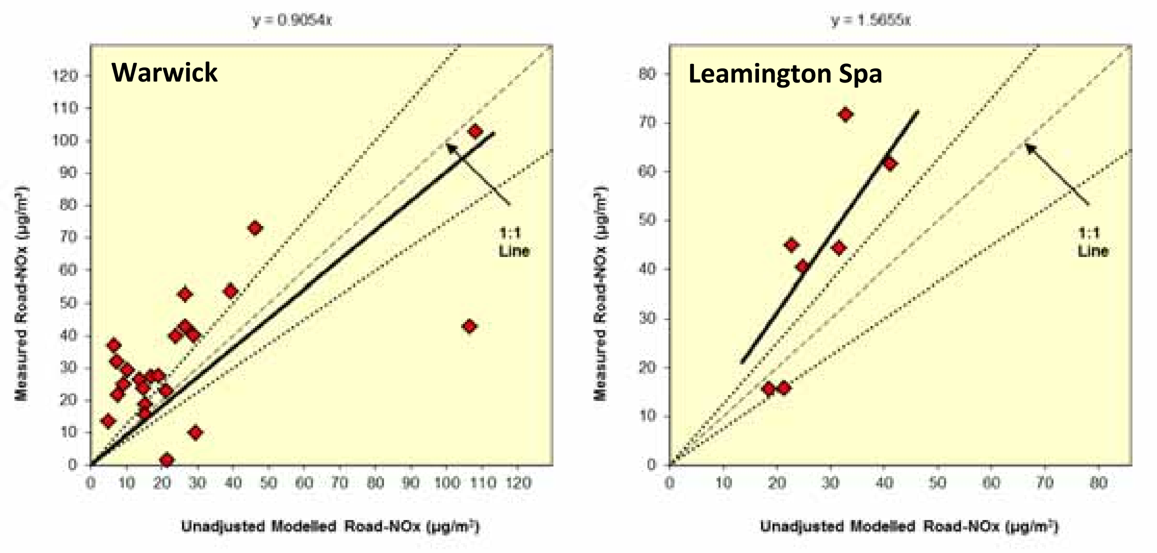

Figure A2.2: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

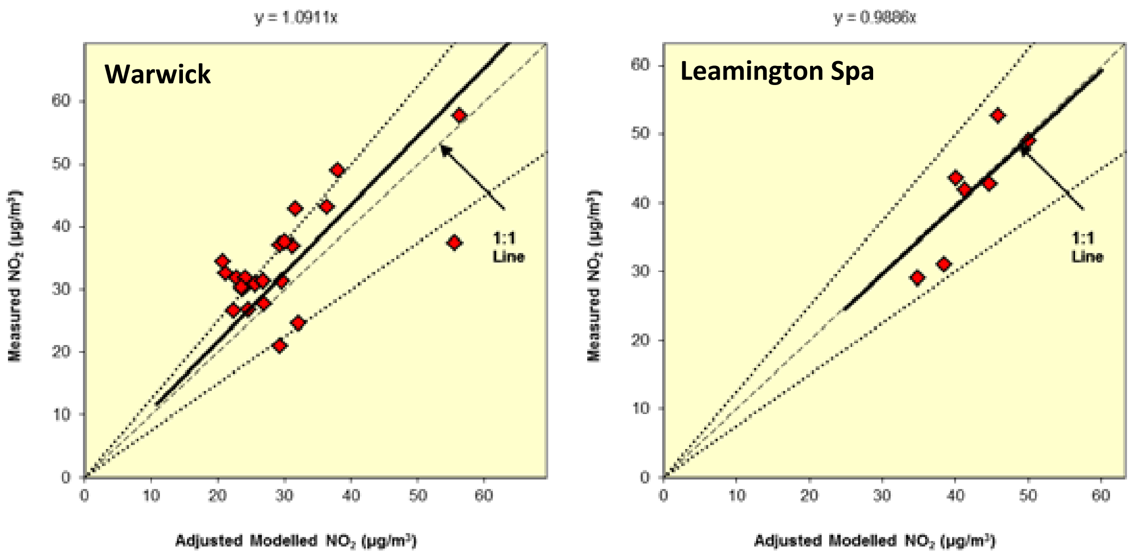

Figure A2.3: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

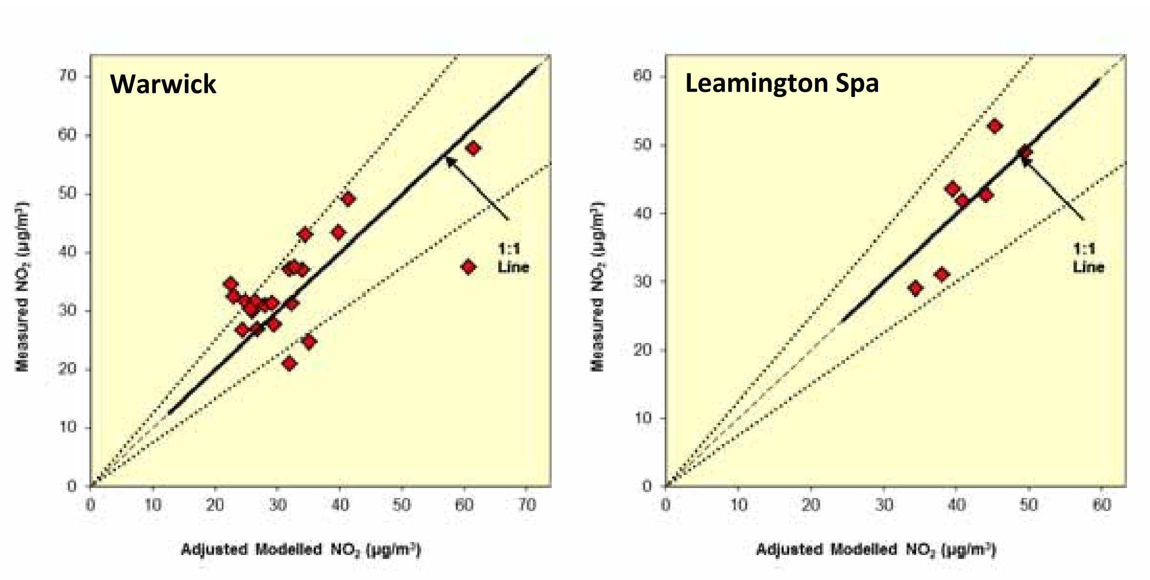

Figure A2.4: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

PM_{10} and $PM_{2.5}$

A2.16 There are no nearby PM_{10} or $PM_{2.5}$ monitors. It has therefore not been possible to verify the model for PM_{10} or $PM_{2.5}$. The model outputs of road-PM_{10} and road-$PM_{2.5}$ have therefore been adjusted by applying the primary adjustment factor calculated for road NO_x.

Model Post-processing

Nitrogen oxides and nitrogen dioxide

A2.17 The model predicts road-NOx concentrations at each receptor location. These concentrations have then been adjusted using the primary adjustment factor, which, along with the background NO_2, is processed through the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2013c). The traffic mix within the calculator was set to “All other urban UK traffic”, which is considered suitable for the study area. The calculator predicts the component of NO_2 based on the adjusted road-NOx and the background NO_2. This is then adjusted by the secondary adjustment factor to provide the final predicted concentrations.

PM_{10} and $PM_{2.5}$

A2.18 The number of exceedences of 50 μg/m^3 as a 24-hour mean PM_{10} concentration has been calculated from the adjusted-modelled total annual mean concentration following the relationship advised by (Defra, 2009):

$$A = -18.5 + 0.00145\, B^3 + 206/B$$

where A is the number of exceedences of 50 μg/m^3 as a 24-hour mean PM_{10} concentration and B is the annual mean PM_{10} concentration. The relationship is only applied to annual mean concentrations greater than 16.5 μg/m^3, below this concentration, the number of 24-hour exceedences is assumed to be zero.

A3 Results for Specific Receptors

Table A3.1: Predicted Annual Mean Nitrogen Dioxide Concentrations (μg/m^3) at Specific Receptors Warwick

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	23.4	15.1	14.8	14.6
2	25.9	15.9	17.7	17.2
3	25.2	15.1	15.5	15.2
4	32.3	15.8	15.9	15.7
5	28.3	17.0	18.8	18.0
6	25.9	15.7	15.9	15.6
7	30.4	18.0	18.6	18.1
8	28.9	16.9	16.0	15.7
9	27.8	16.3	16.1	15.7
10	25.8	15.4	15.3	15.1
11	28.8	17.3	17.0	16.5
12	29.1	17.5	18.0	17.4
13	30.5	17.8	17.2	16.8
14	25.2	15.8	15.3	15.1
15	28.1	16.1	16.1	15.8
16	31.4	17.3	20.1	19.5
17	33.6	19.7	18.6	17.9
18	38.0	21.8	17.8	17.2
19	37.7	18.5	16.8	16.4
20	37.8	21.2	18.2	17.7
21	57.6	19.4	18.7	18.3
22	91.0	24.4	19.1	18.5
23	63.5	18.7	17.5	17.0
24	49.3	24.5	18.9	18.0
25	44.3	16.8	22.1	20.7
26	37.1	19.4	22.3	20.5
27	34.3	19.6	20.3	19.2

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
28	32.4	24.6	20.3	19.2
29	27.9	17.0	18.0	17.4
30	29.4	17.6	19.1	18.4
31	29.5	17.8	19.4	18.6
32	27.8	23.2	24.6	22.7
33	29.2	18.0	20.0	18.2
34	30.7	18.5	17.4	16.8
35	35.2	18.2	21.2	20.2
36	33.1	18.5	18.9	17.8
37	36.5	18.6	20.3	19.0
38	34.9	18.2	19.2	18.2
39	31.5	18.0	17.9	17.1
40	31.2	19.5	19.3	18.8
41	34.2	17.9	21.0	20.3
42	31.1	17.2	20.2	19.4
Objective	**40**		**40**	

Table A3.2: Predicted Annual Mean PM_{10} Concentrations (µg/m^3) at Specific Receptors Warwick

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	16.1	14.6	14.4	14.3
2	16.4	14.8	15.1	15.0
3	16.4	14.4	14.5	14.4
4	17.0	14.7	14.6	14.5
5	16.8	14.8	15.1	15.0
6	16.4	14.5	14.5	14.5
7	16.9	15.1	15.2	15.0
8	16.7	14.9	14.6	14.5
9	16.6	14.7	14.6	14.5
10	16.3	14.5	14.4	14.3

11	16.9	15.2	14.9	14.8
12	16.9	15.2	15.2	15.0
13	16.9	15.2	15.2	15.0
14	16.2	14.7	14.5	14.4
15	16.7	14.7	14.7	14.6
16	17.1	14.9	15.7	15.4
17	17.1	15.0	15.1	14.9
18	17.4	15.3	14.9	14.8
19	17.4	15.1	14.8	14.7
20	17.9	16.4	15.0	14.8
21	19.4	15.7	15.3	15.0
22	24.1	16.8	15.4	15.1
23	19.9	15.4	14.9	14.7
24	20.4	16.9	15.0	14.8
25	18.5	14.7	15.8	15.5
26	18.0	15.2	15.8	15.5
27	17.9	15.2	15.3	15.1
28	17.4	16.5	15.4	15.2
29	16.9	14.6	14.8	14.6
30	17.1	14.7	15.0	14.8
31	17.1	14.8	15.0	14.9
32	16.8	16.7	16.0	15.7
33	17.0	14.9	15.1	14.8
34	16.9	15.2	14.8	14.6
35	17.8	15.0	15.8	15.5
36	17.4	15.0	15.0	14.8
37	18.1	15.1	15.4	15.1
38	17.9	15.0	15.2	15.0
39	17.3	14.9	14.9	14.7
40	17.2	15.2	15.2	15.1
41	17.4	14.8	15.4	15.2
42	17.1	14.6	15.1	15.0

Objective	40	40

Table A3.3: Predicted PM_{10} (Days > 50 µg/m^3) [a] (µg/m^3) at Specific Receptors Warwick

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	1	0	0	0
5	1	0	0	0
6	0	0	0	0
7	1	0	0	0
8	1	0	0	0
9	1	0	0	0
10	0	0	0	0
11	1	0	0	0
12	1	0	0	0
13	1	0	0	0
14	0	0	0	0
15	1	0	0	0
16	1	0	0	0
17	1	0	0	0
18	1	0	0	0
19	1	0	0	0
20	1	0	0	0
21	3	0	0	0
22	10	1	0	0
23	3	0	0	0
24	4	1	0	0
25	2	0	0	0
26	1	0	0	0
27	1	0	0	0

28	1	0	0	0
29	1	0	0	0
30	1	0	0	0
31	1	0	0	0
32	1	1	0	0
33	1	0	0	0
34	1	0	0	0
35	1	0	0	0
36	1	0	0	0
37	1	0	0	0
38	1	0	0	0
39	1	0	0	0
40	1	0	0	0
41	1	0	0	0
42	1	0	0	0
Objective	**35**		**35**	

[a] The numbers of days with PM_{10} concentrations greater than 50 $\mu g/m^3$ have been estimated from the relationship with the annual mean concentration described in LAQM.TG(09) (Defra, 2009).

Table A3.4: Predicted Annual Mean $PM_{2.5}$ concentrations ($\mu g/m^3$) at Specific Receptors Warwick

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	11.4	9.7	9.6	9.6
2	11.6	9.8	10.0	9.9
3	11.6	9.6	9.7	9.6
4	12.0	9.8	9.7	9.7
5	11.9	9.9	10.0	10.0
6	11.6	9.7	9.7	9.6
7	12.0	10.0	10.1	10.0
8	11.8	9.9	9.7	9.7
9	11.7	9.8	9.7	9.7
10	11.5	9.7	9.6	9.6

11	11.9	10.0	9.9	9.8
12	11.9	10.0	10.0	9.9
13	11.9	10.1	10.0	9.9
14	11.4	9.8	9.6	9.6
15	11.8	9.7	9.7	9.7
16	12.1	9.9	10.3	10.2
17	12.1	9.9	10.0	9.9
18	12.3	10.1	9.9	9.8
19	12.2	10.0	9.8	9.7
20	12.5	10.7	9.9	9.8
21	13.6	10.3	10.1	10.0
22	17.2	11.0	10.2	10.0
23	14.1	10.2	9.9	9.8
24	14.6	11.0	10.0	9.9
25	13.1	9.8	10.4	10.3
26	12.8	10.2	10.4	10.3
27	12.8	10.2	10.2	10.1
28	12.4	10.9	10.3	10.1
29	12.0	9.8	9.9	9.9
30	12.2	9.9	10.0	10.0
31	12.3	9.9	10.1	10.0
32	12.0	11.0	10.7	10.5
33	12.1	10.0	10.1	10.0
34	12.0	10.1	9.9	9.8
35	12.5	10.0	10.4	10.2
36	12.3	10.0	10.0	9.9
37	12.9	10.0	10.2	10.1
38	12.8	10.0	10.1	10.0
39	12.3	9.9	9.9	9.8
40	12.2	10.2	10.2	10.1
41	12.4	10.0	10.3	10.2
42	12.2	9.9	10.1	10.1

Objective	15	15

Table A3.5: Predicted Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) at Specific Receptors Leamington Spa

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	32.3	19.5	21.1	20.9
2	34.3	20.4	22.9	22.5
3	33.4	20.1	22.2	21.8
4	34.6	20.5	22.3	22.0
5	31.7	19.3	20.6	20.3
6	42.4	24.1	26.2	25.5
7	45.2	24.3	26.1	25.4
8	44.6	24.7	26.4	25.9
9	49.1	26.7	28.1	27.6
10	36.7	21.2	21.6	21.3
11	35.1	20.3	21.0	20.8
12	37.4	21.7	23.0	22.8
13	37.1	21.1	22.4	22.1
14	29.2	19.0	20.0	19.8
15	27.8	18.4	19.0	18.9
16	28.8	19.0	19.6	19.6
17	33.6	19.3	20.1	20.0
18	30.6	18.5	19.1	19.0
19	35.5	19.7	20.9	21.0
20	37.0	19.9	21.1	21.0
21	32.4	18.4	18.9	18.9
22	28.8	17.4	17.7	17.7
23	28.4	16.7	16.8	16.8
24	29.1	16.8	16.9	16.9
Objective	40		40	

Table A3.6: Predicted Annual Mean PM_{10} Concentrations ($\mu g/m^3$) at Specific Receptors Leamington Spa

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	19.1	17.2	17.3	17.2
2	19.4	17.4	17.6	17.6
3	19.3	17.3	17.5	17.4
4	19.5	17.4	17.5	17.5
5	19.2	17.1	17.2	17.2
6	21.4	18.2	18.4	18.3
7	21.7	18.2	18.3	18.2
8	21.6	18.3	18.4	18.3
9	22.2	18.8	18.8	18.7
10	19.5	17.5	17.4	17.4
11	19.3	17.3	17.4	17.3
12	19.9	17.8	18.0	18.0
13	19.7	17.7	17.6	17.6
14	19.1	17.2	17.4	17.3
15	18.9	17.0	17.1	17.1
16	19.1	17.2	17.4	17.3
17	19.1	17.2	17.2	17.2
18	18.8	16.9	17.0	17.0
19	19.5	17.5	17.7	17.7
20	19.8	17.7	17.9	17.9
21	19.1	17.1	17.1	17.1
22	18.6	16.6	16.7	16.7
23	18.3	16.3	16.3	16.3
24	18.3	16.3	16.3	16.3
Objective	40		40	

Table A3.7: Predicted PM_{10} (Days > 50 µg/m^3) [a] (µg/m^3) at Specific Receptors Leamington Spa

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	2	1	1	1
2	3	1	1	1
3	3	1	1	1
4	3	1	1	1
5	2	1	1	1
6	5	2	2	2
7	6	2	2	2
8	6	2	2	2
9	7	2	2	2
10	3	1	1	1
11	3	1	1	1
12	3	1	1	1
13	3	1	1	1
14	2	1	1	1
15	2	1	1	1
16	2	1	1	1
17	2	1	1	1
18	2	1	1	1
19	3	1	1	1
20	3	1	1	1
21	2	1	1	1
22	2	1	1	1
23	2	0	0	0
24	2	0	0	0
Objective	**35**		**35**	

[a] The numbers of days with PM_{10} concentrations greater than 50 µg/m^3 have been estimated from the relationship with the annual mean concentration described in LAQM.TG(09) (Defra, 2009).

Table A3.8: Predicted Annual Mean $PM_{2.5}$ concentrations ($\mu g/m^3$) at Specific Receptors Leamington Spa

Receptor	2011	2028 Reference Case	2028 Revised Allocation	2028 RA without WTCI
1	13.3	11.2	11.2	11.2
2	13.6	11.3	11.5	11.4
3	13.5	11.3	11.4	11.3
4	13.7	11.3	11.4	11.4
5	13.4	11.2	11.2	11.2
6	15.2	11.8	11.9	11.8
7	15.5	11.8	11.9	11.8
8	15.4	11.9	11.9	11.9
9	15.7	12.1	12.1	12.1
10	13.7	11.4	11.4	11.3
11	13.5	11.3	11.3	11.3
12	13.9	11.5	11.7	11.6
13	13.7	11.5	11.5	11.4
14	13.3	11.2	11.3	11.3
15	13.1	11.1	11.2	11.2
16	13.3	11.2	11.3	11.3
17	13.4	11.2	11.2	11.2
18	13.2	11.1	11.1	11.1
19	13.6	11.4	11.5	11.5
20	13.8	11.5	11.6	11.6
21	13.3	11.2	11.2	11.2
22	13.0	10.9	10.9	10.9
23	12.8	10.8	10.8	10.8
24	12.8	10.7	10.7	10.7
Objective	15		15	

A4 Contour Maps for Scenarios

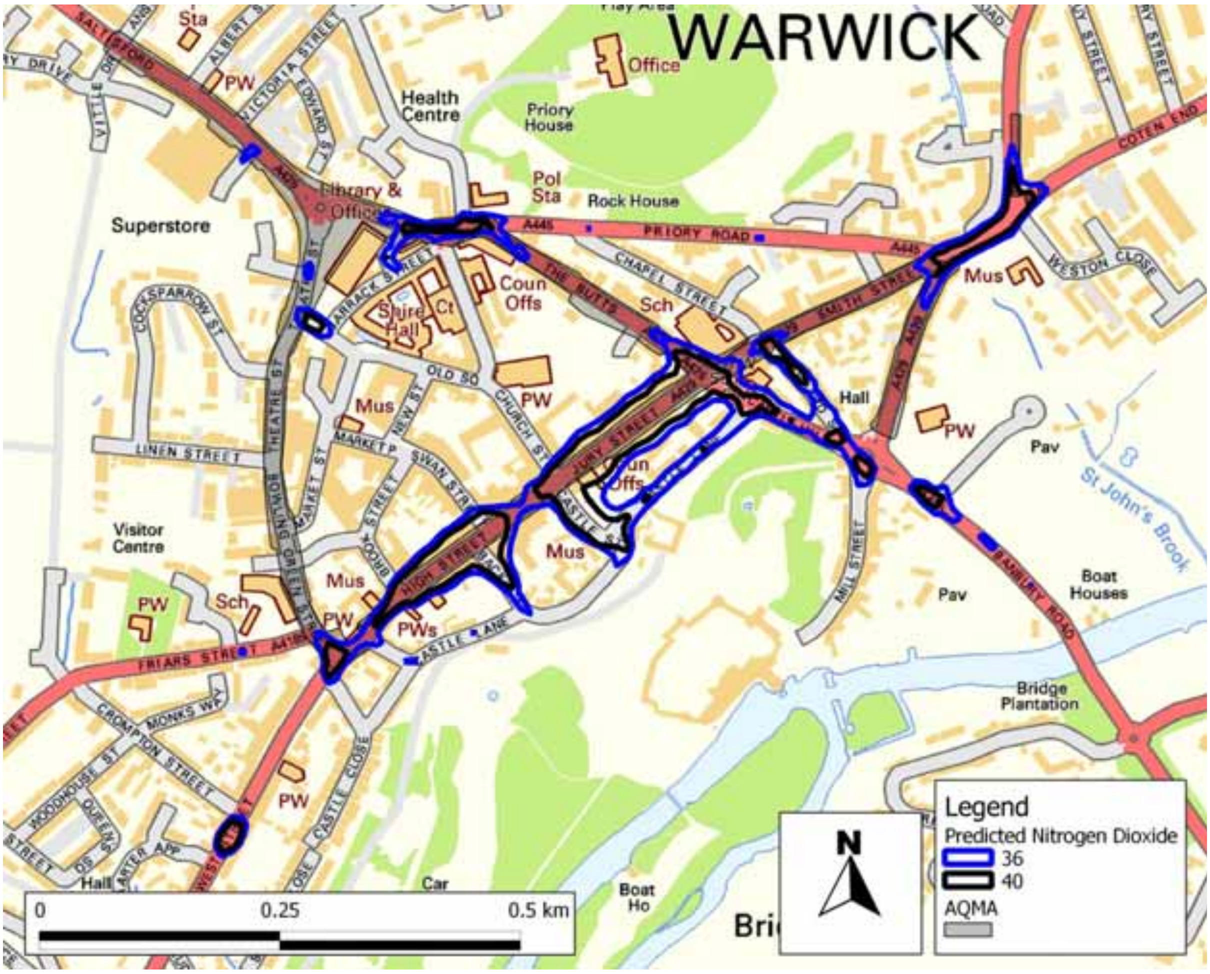

Figure A4.1: 2011 Baseline Annual Mean Nitrogen Dioxide Concentrations Warwick

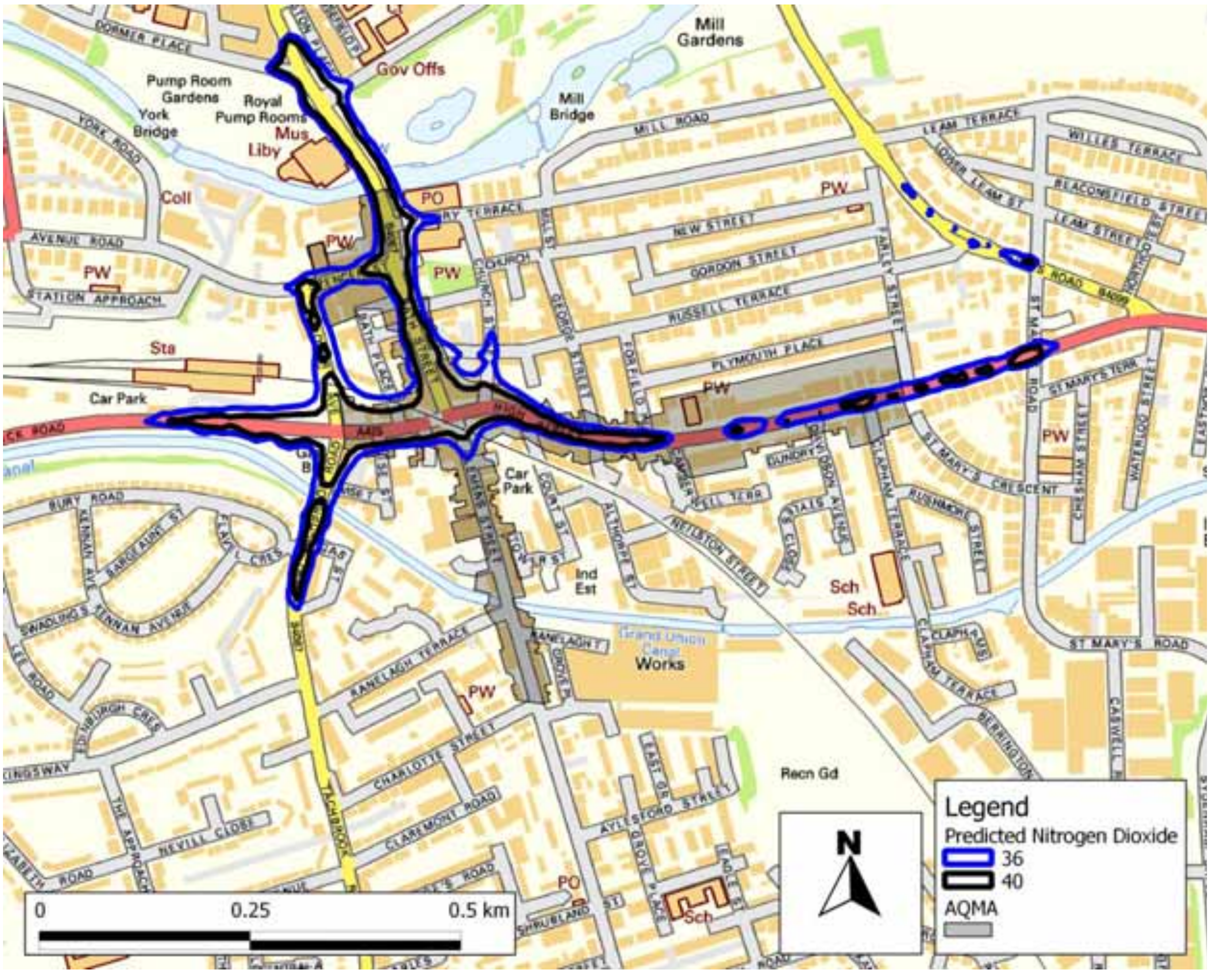

Figure A4.2: 2011 Baseline Annual Mean Nitrogen Dioxide Concentrations Leamington Spa

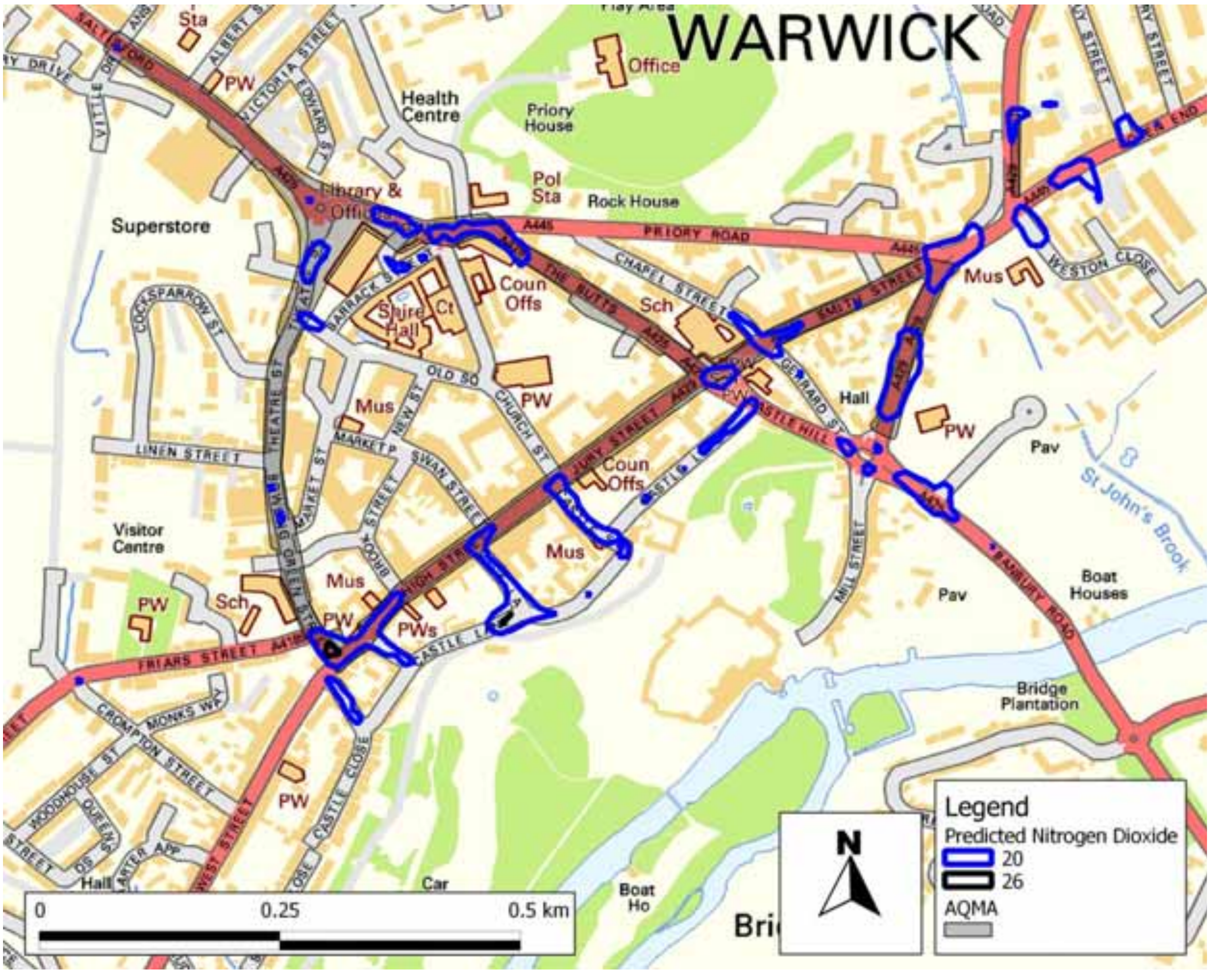

Figure A4.3: 2028 Reference Case Annual Mean Nitrogen Dioxide Concentrations Warwick

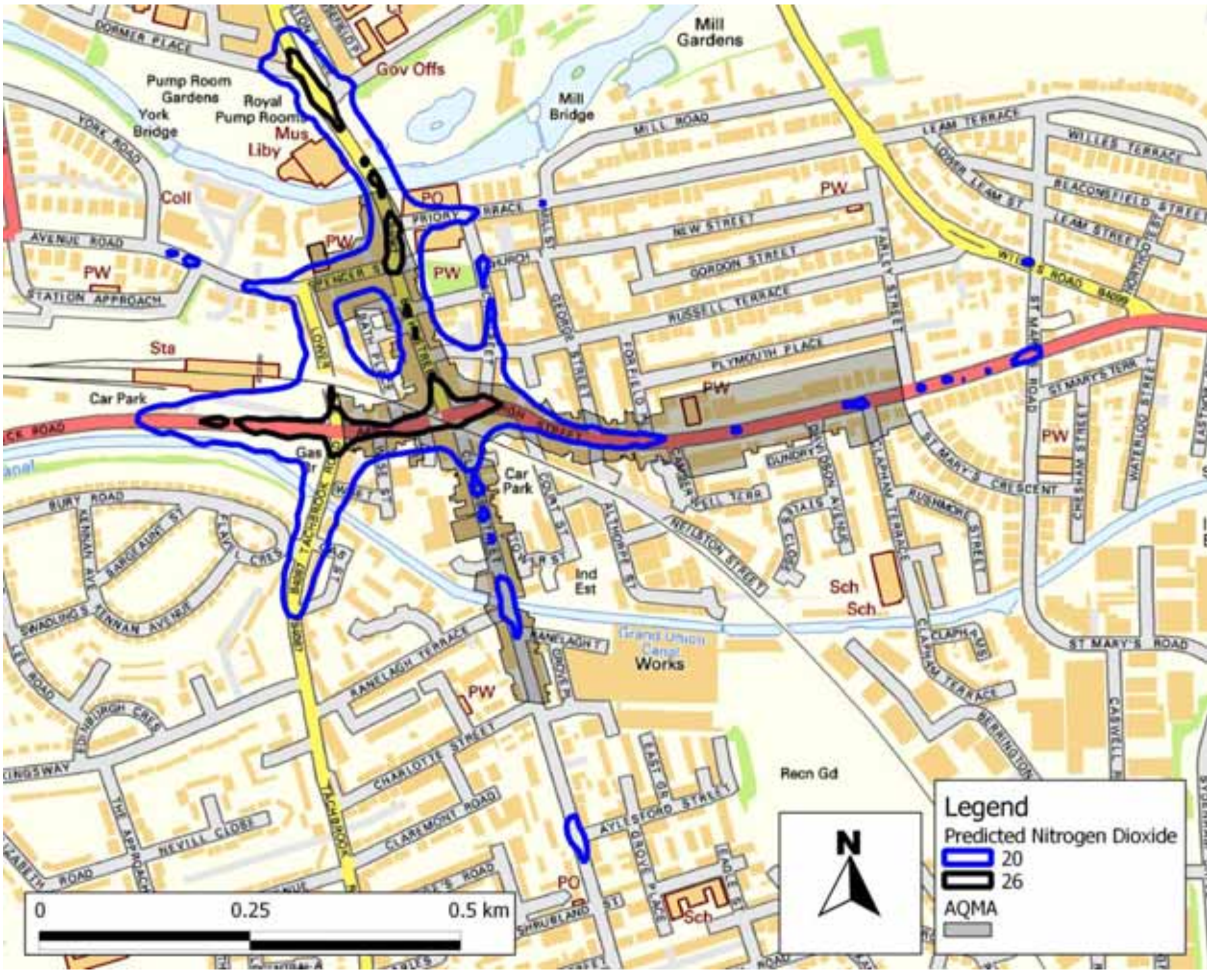

Figure A4.4: 2028 Reference Case Annual Mean Nitrogen Dioxide Concentrations Leamington Spa

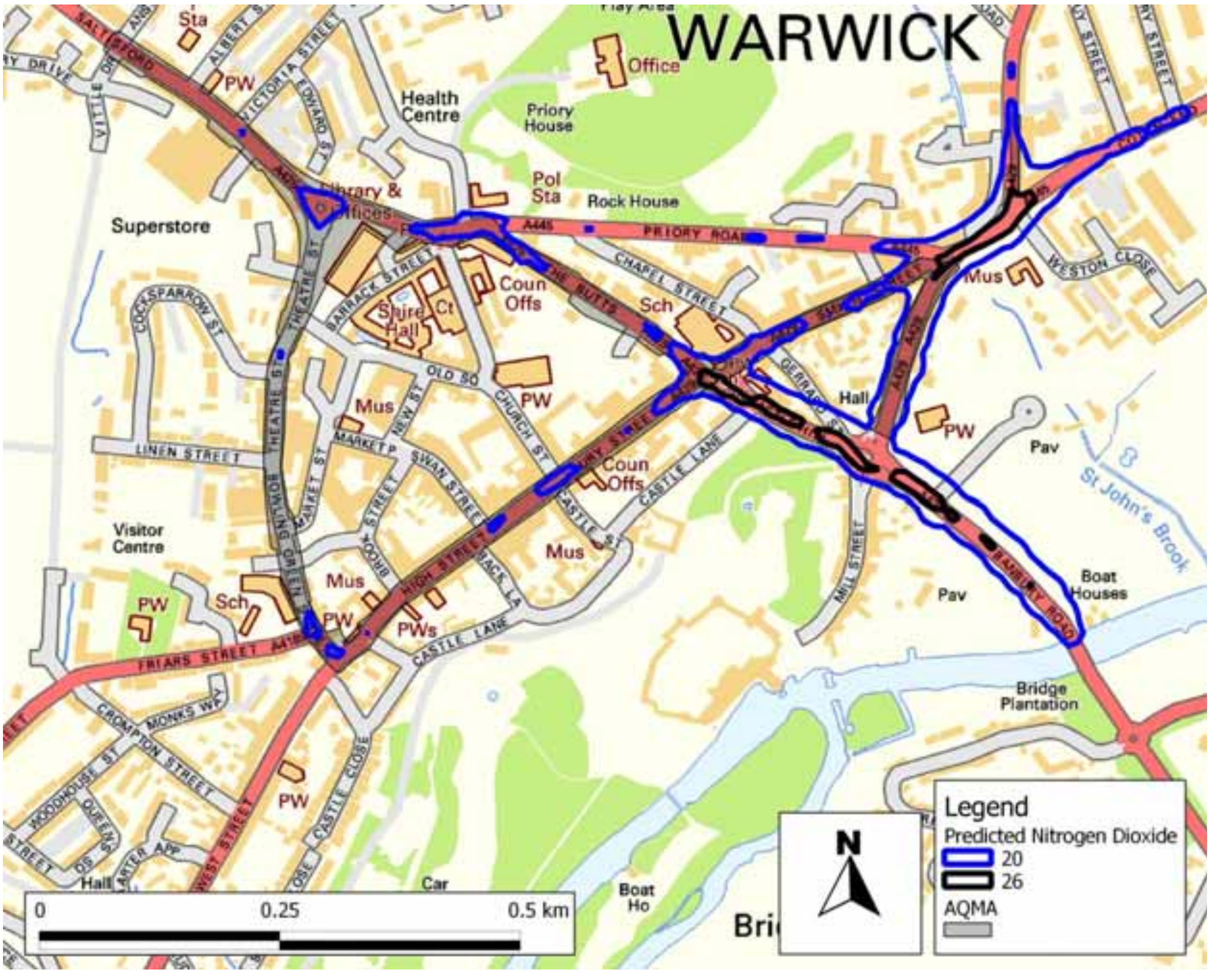

Figure A4.5: 2028 Revised Allocation Annual Mean Nitrogen Dioxide Concentrations Warwick

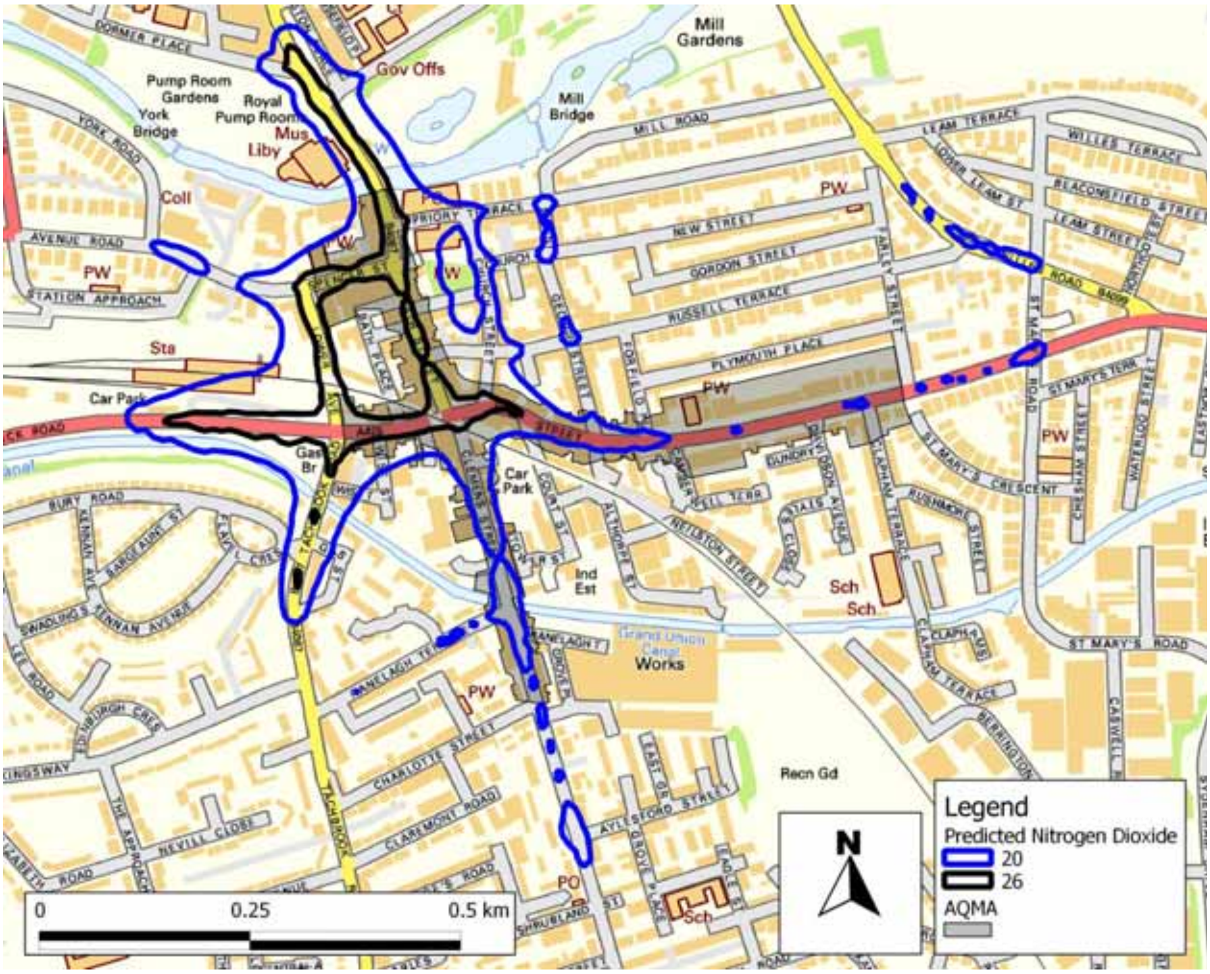

Figure A4.6: 2028 Revised Allocation Annual Mean Nitrogen Dioxide Concentrations Leamington Spa

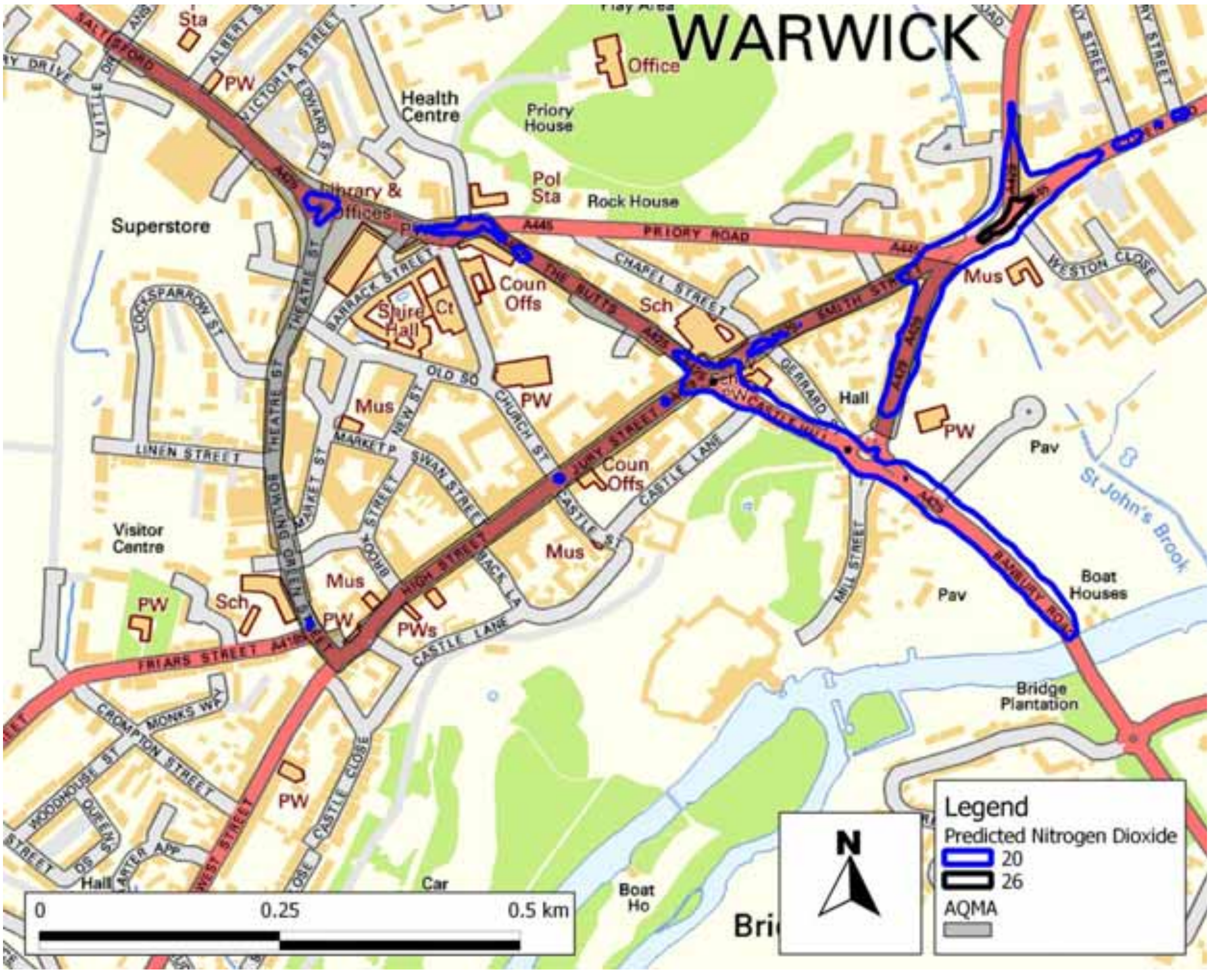

Figure A4.7: 2028 Revised Allocation minus Warwick Town Centre Improvements Annual Mean Nitrogen Dioxide Concentrations Warwick

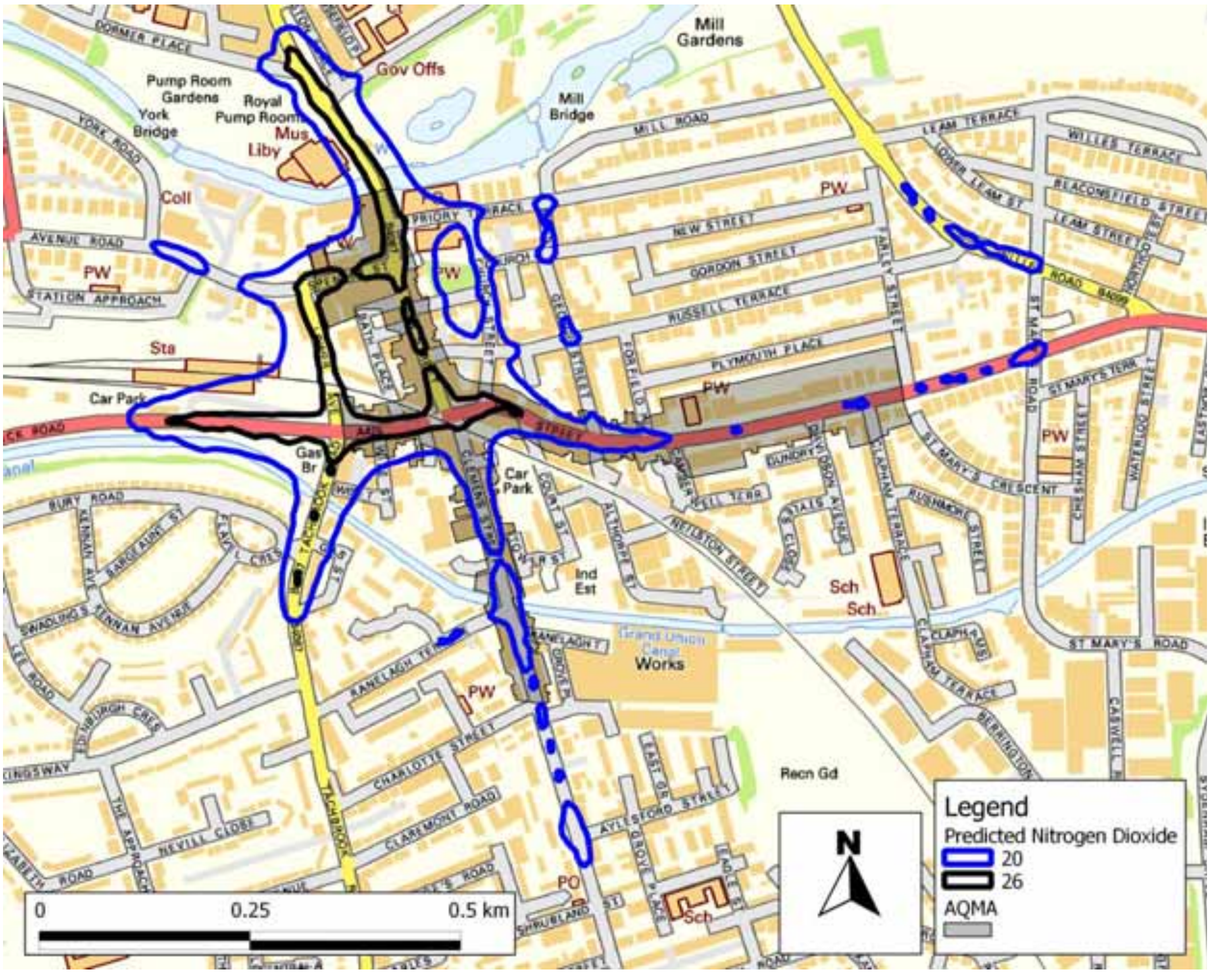

Figure A4.8: 2028 Revised Allocation minus Warwick Town Centre Improvements Annual Mean Nitrogen Dioxide Concentrations Leamington Spa