M5 Junction 10 Improvements Scheme

Environmental Statement

Appendix 5.1 – Air Quality Emission Modelling

TR010063 – APP 6.15

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Infrastructure Planning

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The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

M5 Junction 10 Improvements Scheme

Development Consent Order 202[x]

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Appendix 5.1 – Air Quality Emission Modelling

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010063
Application Document Reference	TR010063/APP/6.15
Author:	M5 Junction 10 Improvements Scheme Project Team

Version	Date	Status of Version
Rev 0	December 2023	DCO Application
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1. Air Quality Assessment Emission Modelling

1.1. Emissions from road users

1.1.1. The emission rates used in the local air quality modelling were derived in accordance with DMRB LA 105 (paragraph 2.29 – 2.38 and Appendix A) on speed banding (based on Emission Factor Toolkit (EFT) v10.1). The emission rates for each road links were calculated using the Annual Average Daily Traffic (AADT) flows (in terms of LDV and HDV) obtained from the traffic model and a speed band assigned to each road link. The AADT emissions were used in combination with a time varying 24 hour diurnal traffic profile.

1.1.2. Hourly emissions were calculated for LDV and HDV separately for each road link using the AADT flow, speed and road type and the emission factors from DMRB LA105 for the relevant speed band. Calculated LDV and HDV emissions were then added together to give the total 24hr emission rate for each road link.

1.1.3. The calculated emission factor for each road link were combined with the weekday and weekend 24-hour varying diurnal traffic profile and assigned against the relevant hour of the day in order to provide hour by hour emissions.

1.1.4. Adjustment of assigned speed band where changes in speed did not justify a change in speed band (speed change less than 5 kph) or where a speed band change was considered not to reflect a valid Scheme impact were applied as part of the ARN calculation process.

1.2. Dispersion model set up

1.2.1. The dispersion model was set up based on the following key inputs and assumptions:

- Road sources were modelled using the ADMS-Roads source representation tool.
- Ordnance Survey Master Map base mapping was used to define the road geometry.
- All dual carriageways and motorway links were represented with a centreline included for each carriageway direction. All other roads are represented with a single centreline.
- Road widths have been measured in GIS from Ordnance Survey Master Map data.

1.2.2. Hourly sequential meteorological data for 2019 for Gloucestershire meteorological station were used. The parameters required by the model included: date, time, wind direction (angle wind blowing from), wind speed (at 10 metres above ground level), surface air temperature (degrees Celsius), and cloud cover (oktas – or eighths of sky covered). The wind rose for Gloucestershire presented below in Figure 1-1 indicates that the dominant wind direction for 2019 was from the south west.

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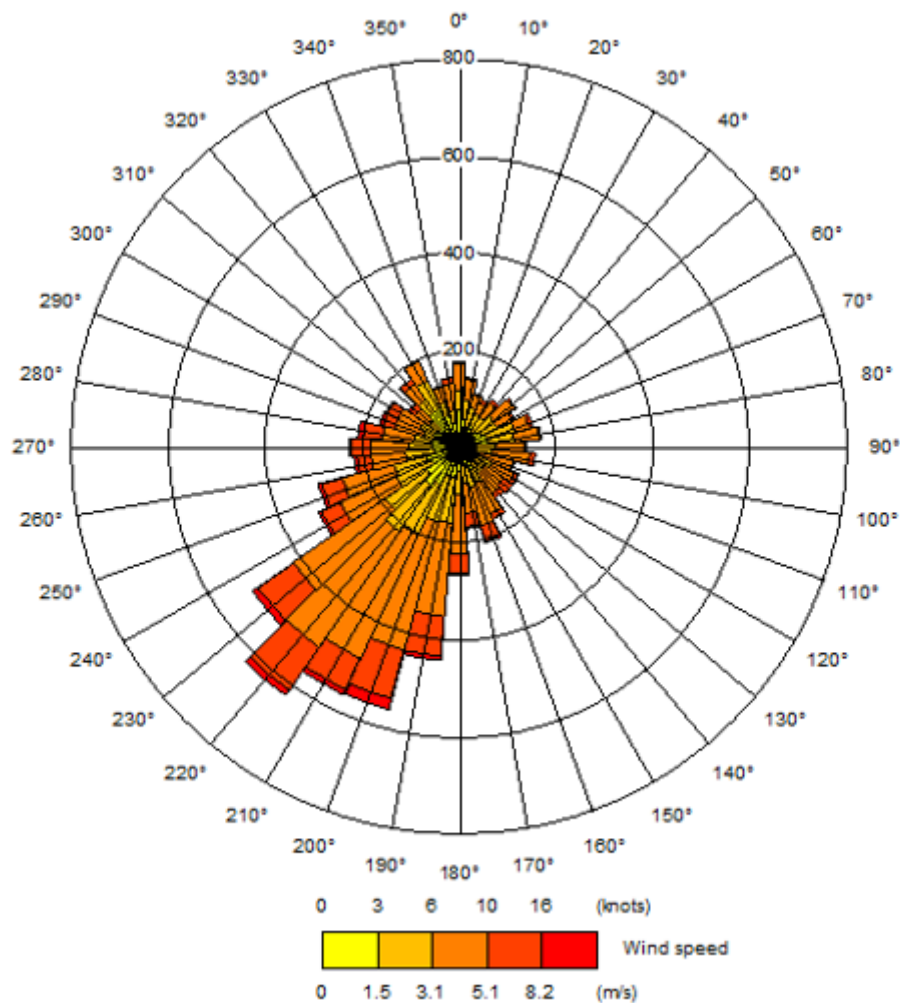
Figure 1-1 – Wind Rose Diagram for Gloucestershire, 2019

1.2.3.   A latitude of 51.9 degrees was selected. This determines times of sunrise and sunset for each day throughout the year, which in turn affects stability calculations.

1.2.4.   Surface roughness coefficients have been defined as 0.5 m (representative of parkland and open suburbia) at both the dispersion site and the meteorological site. The surface roughness is important in the approximation of turbulent conditions within the atmospheric boundary layer and thus in the estimation of pollutant concentrations at receptors.

1.2.5.   Minimum Monin-Obukhov length has been defined as 30 m at both the dispersion site and at the meteorological site (representative of cities and large towns). This parameter limits the occurrence of very stable boundary layer conditions (i.e. when the air is still) to a degree that is appropriate to the general land-use. In general, the potential for very stable conditions is lowest in large urban areas where the 'heat island' effect promoting turbulent motion in the boundary layer is strongest.

1.3.   Modelled receptors

Human health

1.3.1.   There are 90 human health receptors selected for inclusion for assessment in the air quality study area. Most receptors were modelled at a height of 1.5 m above ground to reflect worst case average human exposure. Two receptors were focused on 2nd floor residential occupation and represented at a height of 4.5 m Details of the receptors

assessed are presented in Table 1-1. The locations of these receptors are shown on the results figures shown in Appendix 5.2 (application document TR010063 – APP 6.15) Figure 5.3 – Air quality modelling results for human health receptors and designated habitats.

Table 1-1 – Discrete Human Health Receptor locations included in the Air Quality Model

Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_1	QUEENS HEAD, TEWKESBURY ROAD, GLOUCESTER, GL2 9EJ	383822	220735	Other	Tewkesbury
R_2	119 TEWKESBURY ROAD, GLOUCESTER, GL2 9BN	383983	221208	Other	Tewkesbury
R_3	118 TEWKESBURY ROAD, GLOUCESTER, GL2 9BW	383998	221211	Other	Tewkesbury
R_4	1 THE GREEN , CHELTENHAM, GL51 9SR	391699	224895	Other	Tewkesbury
R_5	OLD LANE COTTAGE, TEWKESBURY ROAD, GLOUCESTER, GL2 9LH	385536	223859	Other	Tewkesbury
R_6	16 MELODY WAY, GLOUCESTER, GL2 0XU	386021	220398	Other	Tewkesbury
R_7	SANDYCROFT COTTAGE, DANCEY ROAD, GLOUCESTER, GL3 1HP	386943	220726	Other	Tewkesbury
R_8	32A VERVAIN CLOSE, GLOUCESTER, GL3 1LT	387156	220991	Other	Tewkesbury
R_9	8 BERRYFIELD GLADE, GLOUCESTER, GL3 2BT	387495	220500	Other	Tewkesbury
R_10	77 CHELTENHAM ROAD EAST, GLOUCESTER, GL3 1JN	387543	221449	Other	Tewkesbury
R_11	THE OLD POLICE STATION, TEWKESBURY ROAD, GLOUCESTER, GL19 4BA	388816	227028	Other	Tewkesbury
R_12	CORNER HOUSE, TEWKESBURY ROAD, GLOUCESTER, GL19 4AZ	388848	227024	Other	Tewkesbury
R_13	PEAR TREE COTTAGE, GLOUCESTER ROAD, CHELTENHAM, GL51 0TF	389081	222438	Other	Tewkesbury
R_14	SALTERS HILL HOUSE, GLOUCESTER ROAD, TEWKESBURY, GL20 7DA	389243	229367	Other	Tewkesbury
R_15	ODESSA INN, GLOUCESTER ROAD, TEWKESBURY, GL20 7DA	389264	229831	Other	Tewkesbury

Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_16	HIGHFIELD FARM LODGE, TEWKESBURY ROAD, GLOUCESTER, GL19 4BP	389301	228768	Other	Tewkesbury
R_17	THE GRANARY, WOODHOUSE FARM, BROCKWORTH ROAD, GLOUCESTER, GL3 4RD	389345	219100	Motorway	Tewkesbury
R_18	ELMHURST, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0TG	389350	222813	Other	Tewkesbury
R_19	WOODBINE COTTAGE, BAMFURLONG LANE, CHELTENHAM, GL51 6SW	389637	221832	Motorway	Tewkesbury
R_20	6 VALLEY COTTAGES, GLOUCESTER ROAD, CHELTENHAM, GL51 0TF	389694	222516	Motorway	Tewkesbury
R_21	STAFFHOUSE, BAMFURLONG LANE, CHELTENHAM, GL51 6SU	389752	221486	Motorway	Tewkesbury
R_22	ANNEXE STANBOROUGH COTTAGE, TEWKESBURY ROAD, CHELTENHAM, GL51 9DN	389879	226036	Other	Tewkesbury
R_23	WITHYBRIDGE END, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0TG	390203	223792	Other	Tewkesbury
R_24	ELM COTTAGE, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0SW	390309	223848	Other	Tewkesbury
R_25	2 BUTLERS COURT COTTAGE, WITHYBRIDGE LANE, CHELTENHAM, GL51 0TH	390462	224714	Other	Tewkesbury
R_26	VINE COTTAGE, GLOUCESTER ROAD, CHELTENHAM, GL51 0SS	390479	222149	Other	Tewkesbury
R_27	MILL HOUSE, WITHYBRIDGE LANE, CHELTENHAM, GL51 0TH	390502	224692	Other	Tewkesbury
R_28	52 ASHCHURCH ROAD, TEWKESBURY, GL20 8BT	390658	233081	Other	Tewkesbury
R_29	6 WESTFIELD COTTAGES, 300084 ROAD TO ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TE	390921	227363	Other	Tewkesbury
R_30	THE WILLOWS, GLOUCESTER ROAD, CHELTENHAM, GL51 0SX	391108	221787	Other	Cheltenham

Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_31	8 REDGROVE COTTAGES, HATHERLEY LANE, CHELTENHAM, GL51 6SH	391123	221574	Other	Cheltenham
R_32	HARROW FARM, 500331 LANE TO HARDWICKE LODGE ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TF	391137	227811	Other	Tewkesbury
R_33	WILLOW MEAD, FIDDLERS GREEN LANE, CHELTENHAM, GL51 0TD	391155	221953	Other	Cheltenham
R_34	BRAMBLE COTTAGE, 500331 LANE TO HARDWICKE LODGE ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TF	391163	227809	Other	Tewkesbury
R_35	18 MILNE PASTURES, TEWKESBURY, GL20 8SG	391190	233185	Other	Tewkesbury
R_36	PILGROVE COTTAGE, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0SW	391339	224154	Other	Tewkesbury
R_37	ROSE COTTAGE, COOKS LANE, CHELTENHAM, GL51 9SU	391360	225014	Other	Tewkesbury
R_38	21 NIMBUS HOUSE, GEMINI CLOSE, CHELTENHAM, GL51 0FH	391520	221932	Other	Cheltenham
R_39	MALVERN HOUSE, SWAN LANE, CHELTENHAM, GL52 7RW	391536	228073	Other	Tewkesbury
R_40	THE OLD DAIRY, THE GREEN, UCKINGTON, CHELTENHAM, GL51 9SR	391729	225020	Other	Tewkesbury
R_41	APARTMENT 4, ASTON COURT, SOTHERBY DRIVE, CHELTENHAM, GL51 0FS	391888	222099	Other	Cheltenham
R_42	APARTMENT 13, CORINNE COURT, SOTHERBY DRIVE, CHELTENHAM, GL51 0FW	391926	222171	Chelt Centre Not AQMA	Cheltenham
R_43	75 MONKSCROFT, CHELTENHAM, GL51 7TU	391993	222144	Chelt Centre Not AQMA	Cheltenham
R_44	DOVE COTTAGE, STOKE ROAD, CHELTENHAM, GL52 7RY	392029	228291	Other	Tewkesbury
R_45	4 ANAPA MEWS, CHELTENHAM, GL51 7RB	392209	222813	Chelt Centre Not AQMA	Cheltenham

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Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_46	1 MILLWAY, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	392730	224316	Other	Tewkesbury
R_47	THE BUNGALOW, STOKE ROAD, CHELTENHAM, GL52 7RU	392980	228063	Other	Tewkesbury
R_48	12 PRINCESS ELIZABETH WAY, CHELTENHAM, GL51 7PE	392997	223628	Chelt Centre Not AQMA	Cheltenham
R_49	254 BROOKLYN ROAD, CHELTENHAM, GL51 8ED	393028	223446	Chelt Centre Not AQMA	Cheltenham
R_50	32 PROVIDENCE PARK, CHELTENHAM, GL51 7NY	393089	223644	Chelt Centre Not AQMA	Cheltenham
R_51	CLEEVE STATION HOUSE, STOKE ROAD, CHELTENHAM, GL52 7RS	393317	227966	Other	Tewkesbury
R_52	LARKFIELD, WYMANS LANE, CHELTENHAM, GL51 9QF	393770	224626	Other	Cheltenham
R_53	WINGMORE LODGE, STOKE ORCHARD ROAD, CHELTENHAM, GL52 7DG	393790	227779	Other	Tewkesbury
R_54	MORRIS HILL, SWINDON LANE, CHELTENHAM, GL50 4PE	393901	224649	Other	Cheltenham
R_55	71 WYMANS LANE, CHELTENHAM, GL51 9QH	393913	224887	Other	Cheltenham
R_56	INGLENOOK, HYDE LANE, CHELTENHAM, GL51 9QN	394091	225039	Other	Cheltenham
R_57	APARTMENT 1, HONEYBOURNE GATE, GLOUCESTER ROAD, CHELTENHAM, GL51 8DW	394238	223004	Chelt Centre AQMA	Cheltenham
R_58	APARTMENT 27, HONEYBOURNE GATE, GLOUCESTER ROAD, CHELTENHAM, GL51 8DW	394253	222997	Chelt Centre AQMA	Cheltenham
R_59	REMBRIDGE COURT, HIGH STREET, CHELTENHAM, GL50 3HY	394303	222976	Chelt Centre AQMA	Cheltenham
R_60	FLAT 2, 422 HIGH STREET, CHELTENHAM, GL50 3JA	394348	222925	Chelt Centre AQMA	Cheltenham
R_61	1 NAILSWORTH TERRACE, CHELTENHAM, GL50 4BE	394492	222991	Chelt Centre AQMA	Cheltenham
R_62	36 FARRIERS REACH, CHELTENHAM, GL52 7UZ	394912	227488	Other	Tewkesbury

Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_63	101 STOKE ROAD, CHELTENHAM, GL52 8RP	395135	227605	Other	Tewkesbury
R_64	6 FOXMOOR, CHELTENHAM, GL52 8SS	395266	227468	Other	Tewkesbury
R_65	34 MIDDLEHAY COURT, CHELTENHAM, GL52 8TE	395285	227447	Other	Tewkesbury
R_66	CEDAR HOUSE FLATS, HIGH STREET, CHELTENHAM, GL52 6DL	395270	222076	Chelt Centre Not AQMA	Cheltenham
R_67	FLATS 1 ST ANNES ROAD, CHELTENHAM, GL52 2SS	395397	222239	Chelt Centre Not AQMA	Cheltenham
R_68	1 SHELDON COTTAGES, STANBORO LANE, CHELTENHAM, GL51 9TN	390374	225783	Other	Tewkesbury
R_69	2 SHELDON COTTAGES, STANBORO LANE, CHELTENHAM, GL51 9TN	390379	225794	Other	Tewkesbury
R_70	INFORMAL TRAVELLERS SITE, NORTH EAST M5 JUNCTION 10	390822	226048	Motorway	Tewkesbury
R_71	BARN FARM, STANBORO LANE, CHELTENHAM, GL51 9TN	390910	226363	Motorway	Tewkesbury
R_72	KNIGHTSBRIDGE LODGE, TEWKESBURY ROAD, CHELTENHAM, GL51 9TA	389415	226655	Other	Tewkesbury
R_73	2 MANOR COTTAGES,TEWKESBURY ROAD,CHELTENHAM,GL51 9SZ	389387	226657	Other	Tewkesbury
R_74	JASMINE COTTAGE,TEWKESBURY ROAD,CHELTENHAM,GL51 9TA	389331	226751	Other	Tewkesbury
R_75	COOMBE END,CHELTENHAM ROAD,GLOUCESTER,GL19 4AZ	388921	226966	Other	Tewkesbury
R_76	61 MARQUIS HOUSE, BROOKBANK CLOSE,GL50 3NS	394067	222935	Chelt Centre Not AQMA	Cheltenham
R_77	561 PRINCESS ELIZABETH WAY,CHELTENHAM,GL51 7PA	392992	223576	Chelt Centre Not AQMA	Cheltenham
R_78	56 PENNSYLVANIA AVENUE,CHELTENHAM,GL51 7JP	392979	223526	Chelt Centre Not AQMA	Cheltenham

Receptor ID	Road Name	X	Y	AQ verification Area	Local Authority
R_79	179 BROOKLYN ROAD, CHELTENHAM,GL51 8DX	392866	223143	Chelt Centre Not AQMA	Cheltenham
R_80	COATES HOUSE,EDINBURGH PLACE,GL51 7RP	392433	222685	Chelt Centre Not AQMA	Cheltenham
R_81	ST GEORGES TERRACE,CHELTENHAM,GL 50 3PT	394600	222412	Chelt Centre Not AQMA	Cheltenham
R_82	64 GLOUCESTER ROAD,CHELTENHAM, GL51 8NZ	393888	222824	Chelt Centre Not AQMA	Cheltenham
R_83	13 BROOKBANK CLOSE, CHELTENHAM, GL50 3NN	394082	222806	Chelt Centre Not AQMA	Cheltenham
R_84	1 MILLWAY, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	392735	224316	Other	Tewkesbury
R_85	11 YEEND CLOSE, CHELTENHAM, GL51 9QW	392710	224334	Other	Tewkesbury
R_86	83 RIVER LEYS,CHELTENHAM, GL51 9SA	392796	224267	Other	Tewkesbury
R_87	ROSENEATH, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	392228	224606	Other	Tewkesbury
R_88	33 HOMECROFT DRIVE, CHELTENHAM, GL51 9SN	392128	224663	Other	Tewkesbury
R_89	WALTON HOUSE, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	392421	224503	Other	Tewkesbury
R_90	CHERRY ORCHARD, TEWKESBURY ROAD, CHELTENHAM	391765	224861	Other	Tewkesbury

Future human receptors

1.3.2. To illustrate the air quality conditions in the strategic housing areas where future development is enabled by the Scheme, detailed air quality modelling has been completed. Several transects of receptors at distances representing the proposed housing boundary up to 200 m from the road centre line of the M5, A4019 and B4634 were selected. All receptors were modelled at a height of 1.5 m above ground to reflect worst case average human exposure. All receptors are located within the background modelling map represented by Tewkesbury and were adjusted using the 'Other' adjustment factor. Details of the receptors assessed are presented in Table 1-2.

Table 1-2 – Potential human health receptor within Scheme dependent development areas included in the future scenario air quality model

Receptor ID	Distance to road, m	Transect location	X	Y
T_1	25	North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	391250	225142
T_2	35		391255	225151
T_3	45		391260	225159
T_4	55		391265	225168
T_5	75		391274	225186
T_6	95		391284	225203
T_7	125		391298	225230
T_8	155		391313	225256
T_9	175		391322	225273
T_10	195		391332	225291
T_11	67	North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	390814	225459
T_12	77		390820	225467
T_13	97		390832	225484
T_14	127		390849	225508
T_15	147		390861	225524
T_16	177		390878	225548
T_17	197		390890	225565
T_18	25	Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	392319	224638
T_19	35		392324	224647
T_20	45		392328	224656
T_21	75		392342	224683
T_22	95		392351	224701

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Receptor ID	Distance to road, m	Transect location	X	Y
T_23	125		392364	224728
T_24	145		392373	224746
T_25	175		392387	224772
T_26	185		392391	224781
T_27	22	West Cheltenham Development Area, south of the B4634	390487	223869
T_28	32		390489	223859
T_29	42		390492	223850
T_30	52		390495	223840
T_31	72		390500	223821
T_32	102		390508	223792
T_33	122		390513	223773
T_34	152		390521	223744
T_35	172		390526	223724
T_36	199		390534	223695
T_37	45	North West Cheltenham Development Area, east of M5 Junction 10	390696	225802
T_38	55		390705	225798
T_39	74		390723	225789
T_40	104		390750	225776
T_41	124		390769	225768
T_42	154		390796	225755
T_43	174		390814	225746
T_44	194		390832	225738

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Designated habitat receptors

1.3.3.   There were eight designated habitats included in the air quality model in the air quality study area. All receptors were modelled at a height of zero metres above ground to reflect a worst case situation of vegetation at ground level exposure. Details of the receptors assessed are presented in Table 1-3.

Table 1-3 – Ecological receptors included in the air quality dispersion model

Recept or ID	Name	X	Y	AQ verification area	Local authority
ECO1	Norton (A38) LWS	386186	224310	Other	Tewkesbury
ECO2	Pegmore Farm, The Leigh 'Meadow 2' LWS	386651	224927	Other	Tewkesbury
ECO3	Cotswold Farm, The Leigh LWS	387677	225912	Other	Tewkesbury
ECO4	Tewkesbury Nature Reserve LWS	390000	232820	Other	Tewkesbury
ECO5	Tewkesbury Nature Reserve LWS	390107	232741	Other	Tewkesbury
ECO6	Tewkesbury Railway Line (Disused) LWS	390930	233266	Other	Tewkesbury
ECO7	Walton Cardiff Ponds LWS	391507	232395	Motorway	Tewkesbury
ECO8	Veteran Tree	390614	224851	Other	Tewkesbury
ECO9	Hayden Sewage Treatment Works (LWS)	390506	222994	Other	Tewkesbury

1.4.   Model verification

Verification for NO_2

1.4.1.   Model verification was undertaken considering monitoring sites within 200 metres of the roads meeting the DMRB LA 105 traffic screening criteria. From the full network of NO_2 diffusion tubes available, only those representative of selected sensitive receptor locations and with sufficient data capture were considered suitable for the purpose of model verification. For the Air Quality Management Area (AQMA) area of Cheltenham town centre additional monitoring sites that fell outside the air quality study area were included to provide a better representation of the range of concentrations identified within this small area.

1.4.2.   Model verification was undertaken for the 2019 base year considering these passive monitoring sites within the air quality study area. A total of 19 monitoring sites were considered (10 Local Authority tubes, 1 Local Authority CMS and 8 tubes from the Scheme Specific Survey). Appendix 5.2 (application document TR010063 – APP 6.15) Figure 5.3 – Air quality modelling results for human health receptors and designated habitats shows the locations of the diffusion tubes used in the verification.

1.4.3.   The annual mean modelled NO_2 concentrations for the 2019 base year were verified by means of comparison against available ratified monitoring data. The modelled road NOx concentrations were adjusted where appropriate, with reference to the methodology set out in Defra's LAQM.TG(16).

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1.4.4.   Uncertainty in modelled estimates has been considered by calculating root mean square error (RMSE) and fractional bias statistics. An air quality model can be considered to perform reasonably well where 95% of modelled concentrations are within 25% of monitored concentrations in accordance with Defra's Technical Guidance LAQM.TG(16). The RMSE should ideally be within 10% of the relevant air quality criterion (less than 4 $\mu g/m^3$) but is acceptable where it is within 25% of the relevant air quality criterion (i.e. 10 $\mu g/m^3$). The Fractional Bias (FB) has an ideal value of 0 but is acceptable in the range between +2 and -2.

1.4.5.   First, unadjusted modelled estimates of total annual mean NO_2 concentrations have been compared against monitored annual means. Out of 19 comparisons, 4 modelled estimates are within +/- 25% of monitored without adjustment, as given in Table 1-4. Substantial and systematic underestimates of more than 25% are indicated for 15 of the sites.

Table 1-4 – Comparison of unadjusted modelled and measures NO_2 concentrations ($\mu g/m^3$)

Site ID	Measured NO_2	Modelled Total NO_2	Modelled – Measured Difference ($\mu g/m^3$)	Ratio (Modelled / Measured)	% Difference
16N	22.0	25.2	+3.2	1.1	+14%
15N	25.7	28.3	+2.6	1.1	+10%
14N	23.6	22.4	-1.2	0.9	-5%
4	43.1	20.0	-23.1	0.5	-54%
5	46.5	20.1	-26.4	0.4	-57%
CM1	36.0	20.1	-15.9	0.6	-0.4
13	30.4	18.2	-12.2	0.6	-40%
28	38.2	23.0	-15.2	0.6	-40%
29	33.7	17.8	-15.9	0.5	-47%
Cor_D10	27.4	16.4	-11.0	0.6	-40%
22	33.4	19.6	-13.8	0.6	-41%
Cor_D2	34.7	22.8	-11.9	0.7	-34%
Cor_D6	32.8	17.9	-14.9	0.5	-45%
Cor_D5	29.9	17.6	-12.4	0.6	-41%
Cor_D8	22.5	13.5	-9.0	0.6	-40%
Cor_D3	19.7	12.2	-7.5	0.6	-38%
Cor_D4	22.6	14.3	-8.4	0.6	-37%
Cor_D7	21.3	14.3	-7.0	0.7	-33%
55N	18.8	16.6	-2.2	0.9	-12%

1.4.6.   For unadjusted modelled estimates of NO_2 compared to monitored concentrations, the RMSE is 13.03 $\mu g/m^3$, which is above the target value according to Defra's LAQM.TG(16) (ideal less than 4 $\mu g/m^3$, acceptable less than 10 $\mu g/m^3$). Overall, the unadjusted model tends to underestimate total concentrations of NO_2, as indicated by a fractional bias value of 0.44.

1.4.7.   The second comparison of modelled estimates of road contributed annual mean NOx with the road NOx component derived from monitoring data is presented in Table 1-5 – Comparison of unadjusted modelled and measures NOx concentrations ($\mu g/m^3$). Analysis requires the estimation of the monitored road NOx component. This has been undertaken using Defra's NO_2 to NOx calculator (version 8.1, August 2020).

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1.4.8. Modelled road NOx concentrations can be adjusted by taking the slope of the linear regression line that has been forced through zero. Due to the model performing differently in the study area and the geographical extent of the latter, the verification was spilt into four zones (as described in Table 1-5 – Comparison of unadjusted modelled and measures NOx concentrations (µg/m³)), resulting in four different adjustment factors for the full study area (19 sites).

1.4.9. The model was split into four verification zones. The factors used to adjust the model results in these areas are shown below in Table 1-5.

Table 1-5 – Comparison of unadjusted modelled and measures NOx concentrations (µg/m³)

Site ID	Zone	Modelled Road NOx	Measured Road NOx	Modelled - Measured	Measured / Modelled	Measured / Modelled % Difference
16N	motorway	31.3	24.9	+6.4	0.8	+26%
15N	motorway	28.0	22.7	+5.3	0.8	+23%
14N	motorway	20.7	23.1	-2.5	1.1	-11%
4	AQMA	15.2	64.7	-49.6	4.3	-77%
5	AQMA	10.7	67.5	-56.8	6.3	-84%
CM1	AQMA	10.6	43.3	-32.6	4.1	-75%
13	Chelt Centre not AQMA	9.6	33.9	-24.3	3.5	-72%
28	Chelt Centre not AQMA	18.7	50.8	-32.0	2.7	-63%
29	Chelt Centre not AQMA	11.1	43.5	-32.4	3.9	-74%
Cor_D10	Chelt Centre not AQMA	9.2	31.0	-21.7	3.4	-70%
22	Other	13.3	41.4	-28.1	3.1	-68%
Cor_D2	Other	20.7	45.6	-24.9	2.2	-55%
Cor_D6	Other	13.1	43.3	-30.1	3.3	-70%
Cor_D5	Other	13.3	38.1	-24.7	2.9	-65%
Cor_D8	Other	6.4	23.6	-17.2	3.7	-73%
Cor_D3	Other	7.4	21.7	-14.3	2.9	-66%
Cor_D4	Other	10.0	26.1	-16.1	2.6	-62%
Cor_D7	Other	7.8	21.1	-13.3	2.7	-63%
55N	Other	11.7	15.9	-4.2	1.4	-26%

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Table 1-6 – Model verification adjustment factors

Zone	Zone name	Number of Monitoring Sites	Adjustment Factor
1	Motorway	3	1.0
2	Cheltenham AQMA	3	4.73
3	Cheltenham not AQMA	4	3.14
4	Other	9	2.59

1.4.10.   The third comparison of the adjusted modelled estimates of total annual mean NO_2 with monitored concentrations is presented in Table 1-7 and Figure 1-2. All the comparisons except one are within +/- 25% of the monitored values at the same site. The majority (11 of 19 sites) are within 10% of monitored concentrations. Overall, this suggests that the model is performing well at all locations in accordance with Defra Technical Guidance LAQM.TG(22).

1.4.11.   The RMSE for the adjusted modelled NO_2 concentrations compared to monitored concentrations is 3.52 $\mu g/m^3$ i.e., below the Defra's target value (4 $\mu g/m^3$). Adjustment has therefore improved model performance. Overall, the adjusted model has tended to slightly underestimate total concentrations of NO_2, as indicated by a fractional bias value of 0.01.

Table 1-7 – Comparison of adjusted modelled and measured NO_2 concentrations ($\mu g/m^3$)

Site ID	Measured NO_2	Modelled Total NO_2	Modelled – Measured Difference ($\mu g/m^3$)	Ratio (Modelled / Measured)	% Difference
16N	22.0	25.2	+3.2	1.14	+14%
15N	25.7	28.3	+2.6	1.10	+10%
14N	23.6	22.4	-1.2	0.95	-5%
4	43.1	46.0	+2.9	1.07	+7%
5	46.5	39.3	-7.2	0.84	-16%
CM1	36.0	39.1	+3.1	1.09	+9%
13	30.4	28.2	-2.2	0.93	-7%
28	38.2	40.7	+2.5	1.07	+7%
29	33.7	29.2	-4.5	0.87	-13%
Cor_D10	27.4	26.1	-1.4	0.95	-5%
22	33.4	30.2	-3.2	0.90	-10%
Cor_D2	34.7	38.3	+3.6	1.10	+10%
Cor_D6	32.8	28.4	-4.4	0.87	-13%
Cor_D5	29.9	28.2	-1.7	0.94	-6%
Cor_D8	22.5	18.9	-3.6	0.84	-16%
Cor_D3	19.7	18.4	-1.3	0.93	-7%
Cor_D4	22.6	22.5	-0.1	0.99	-1%
Cor_D7	21.3	20.8	-0.5	0.98	-2%
55N	18.8	26.1	+7.3	1.39	+39%
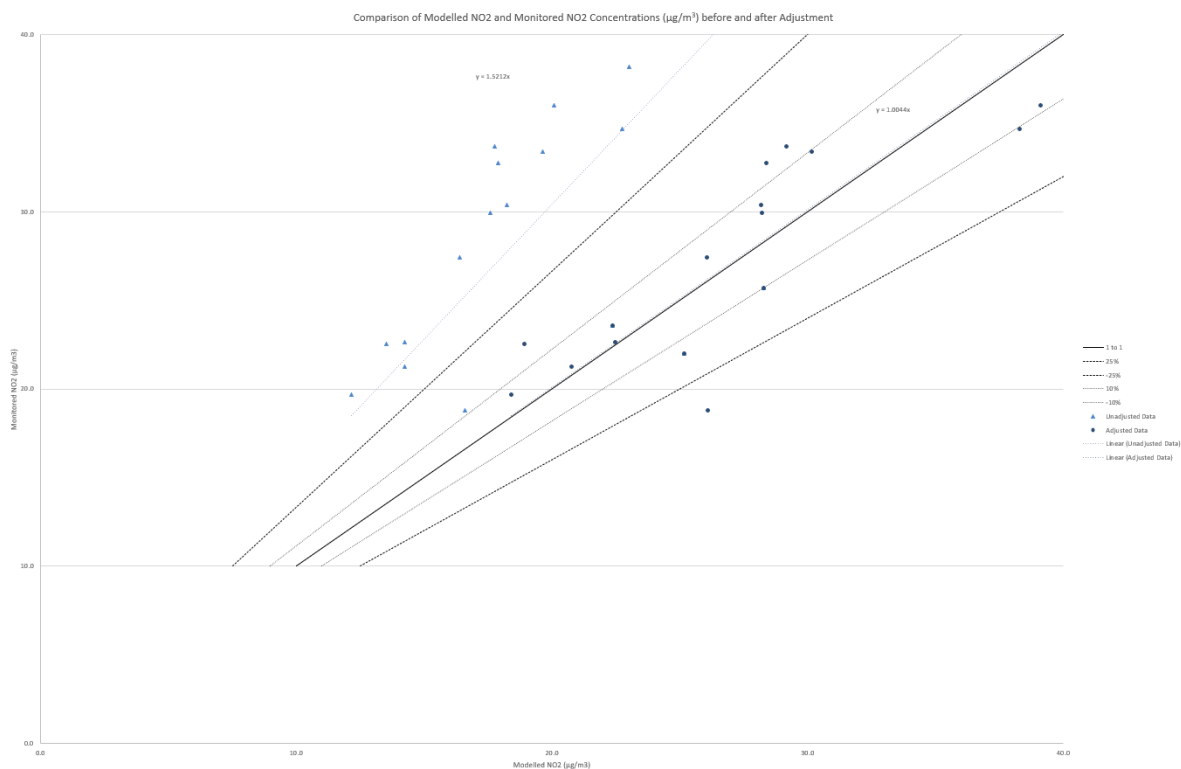
Figure 1-2 – Comparison of modelled and measured NO$_2$ concentrations (μg/m^3) before and after adjustment

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1.5.   National Highways DMRB LA105 gap analysis

1.5.1.   Table 1-8 below provide details of the derivation of the gap factor between the base year 2019 and opening year, for human health and designated habitats receptors respectively.

Table 1-8 – Derivation of gap factor in accordance with National Highways LTTE6 projection factors for road NO_2 at human health receptors

Receptor ID	Base 2019 NO_2	2027 Projected Base NO_2	2027 Projected Base NO_2 / Base 2019 NO_2 (Ratio A)	2027 Long Term Adjustment Factor / 2019 Long Term Adjustment Factor (Ratio B)	Gap Factor (Ratio B / Ratio A)
R_1	27.3	15.4	0.6	0.8	1.5
R_2	20.0	11.7	0.6	0.8	1.4
R_3	25.7	14.4	0.6	0.8	1.5
R_4	21.4	12.3	0.6	0.8	1.5
R_5	14.3	8.8	0.6	0.8	1.4
R_6	21.5	12.5	0.6	0.8	1.4
R_7	25.5	14.7	0.6	0.8	1.5
R_8	18.2	11.6	0.6	0.8	1.3
R_9	25.4	14.2	0.6	0.8	1.5
R_10	25.0	14.3	0.6	0.8	1.5
R_11	15.7	9.2	0.6	0.8	1.4
R_12	21.7	11.9	0.5	0.8	1.5
R_13	26.0	15.2	0.6	0.8	1.4
R_14	17.6	10.0	0.6	0.8	1.5
R_15	22.3	12.1	0.5	0.8	1.6
R_16	15.7	9.2	0.6	0.8	1.4
R_17	20.2	11.5	0.6	0.8	1.5
R_18	23.1	13.8	0.6	0.8	1.4
R_19	25.6	15.2	0.6	0.8	1.4
R_20	30.4	16.6	0.5	0.8	1.5
R_21	23.6	14.5	0.6	0.8	1.4
R_22	17.2	10.0	0.6	0.8	1.5
R_23	24.4	13.8	0.6	0.8	1.5
R_24	24.8	13.9	0.6	0.8	1.5
R_25	16.8	10.1	0.6	0.8	1.4
R_26	24.5	13.8	0.6	0.8	1.5
R_27	17.0	10.2	0.6	0.8	1.4
R_28	19.3	11.4	0.6	0.8	1.4

Receptor ID	Base 2019 NO$_2$	2027 Projected Base NO$_2$	2027 Projected Base NO$_2$ / Base 2019 NO$_2$ (Ratio A)	2027 Long Term Adjustment Factor / 2019 Long Term Adjustment Factor (Ratio B)	Gap Factor (Ratio B / Ratio A)
R_29	14.1	8.7	0.6	0.8	1.4
R_30	37.2	20.6	0.6	0.8	1.5
R_31	26.1	15.8	0.6	0.8	1.4
R_32	16.5	9.7	0.6	0.8	1.4
R_33	28.1	16.8	0.6	0.8	1.4
R_34	19.5	11.0	0.6	0.8	1.5
R_35	29.5	18.2	0.6	0.8	1.4
R_36	21.0	12.2	0.6	0.8	1.5
R_37	22.9	12.8	0.6	0.8	1.5
R_38	29.4	17.1	0.6	0.8	1.4
R_39	25.8	13.4	0.5	0.8	1.6
R_40	15.1	9.4	0.6	0.8	1.3
R_41	30.5	17.0	0.6	0.8	1.5
R_42	24.8	14.6	0.6	0.8	1.4
R_43	31.5	17.6	0.6	0.8	1.5
R_44	20.8	11.8	0.6	0.8	1.5
R_45	30.9	17.4	0.6	0.8	1.5
R_46	22.5	13.2	0.6	0.8	1.4
R_47	16.9	10.1	0.6	0.8	1.4
R_48	30.5	17.3	0.6	0.8	1.5
R_49	22.7	14.7	0.6	0.8	1.3
R_50	35.8	20.8	0.6	0.8	1.4
R_51	13.8	9.2	0.7	0.8	1.3
R_52	28.2	17.8	0.6	0.8	1.3
R_53	14.4	9.5	0.7	0.8	1.3
R_54	22.8	15.5	0.7	0.8	1.2
R_55	29.7	18.4	0.6	0.8	1.4
R_56	23.8	13.4	0.6	0.8	1.5
R_57	34.4	19.7	0.6	0.8	1.5
R_58	45.5	25.9	0.6	0.8	1.5
R_59	60.6	33.8	0.6	0.8	1.5
R_60	32.1	19.5	0.6	0.8	1.4

Receptor ID	Base 2019 NO$_2$	2027 Projected Base NO$_2$	2027 Projected Base NO$_2$ / Base 2019 NO$_2$ (Ratio A)	2027 Long Term Adjustment Factor / 2019 Long Term Adjustment Factor (Ratio B)	Gap Factor (Ratio B / Ratio A)
R_61	43.8	25.3	0.6	0.8	1.5
R_62	22.2	12.9	0.6	0.8	1.4
R_63	20.7	12.4	0.6	0.8	1.4
R_64	18.8	11.6	0.6	0.8	1.4
R_65	16.9	10.8	0.6	0.8	1.3
R_66	50.9	28.2	0.6	0.8	1.5
R_67	50.4	28.0	0.6	0.8	1.5
R_68	19.7	11.0	0.6	0.8	1.5
R_69	19.4	10.8	0.6	0.8	1.5
R_70	29.1	14.8	0.5	0.8	1.7
R_71	16.0	9.3	0.6	0.8	1.4
R_72	20.7	11.6	0.6	0.8	1.5
R_73	14.0	8.6	0.6	0.8	1.4
R_74	18.8	10.8	0.6	0.8	1.5
R_75	14.1	8.6	0.6	0.8	1.4
R_76	31.3	19.3	0.6	0.8	1.4
R_77	29.2	16.8	0.6	0.8	1.5
R_78	21.2	13.1	0.6	0.8	1.4
R_79	18.0	11.7	0.7	0.8	1.3
R_80	20.3	12.9	0.6	0.8	1.3
R_81	25.9	16.5	0.6	0.8	1.3
R_82	25.2	16.0	0.6	0.8	1.3
R_83	25.6	16.6	0.6	0.8	1.3
R_84	24.2	14.0	0.6	0.8	1.5
R_85	23.7	13.8	0.6	0.8	1.4
R_86	22.2	13.1	0.6	0.8	1.4
R_87	19.4	11.8	0.6	0.8	1.4
R_88	18.7	11.6	0.6	0.8	1.4
R_89	19.6	12.0	0.6	0.8	1.4
R_90	23.6	13.3	0.6	0.8	1.5

Table 1-9 – Derivation of gap factor in accordance with National Highways LTTE6 projection factors for road NO_2 at designated habitats

Receptor ID	Base 2019 NO_2	2027 Projected Base NO_2	2027 Projected Base NO_2 / Base 2019 NO_2 (Ratio A)	2027 Long Term Adjustment Factor / 2019 Long Term Adjustment Factor (Ratio B)	Gap Factor (Ratio B / Ratio A)
ECO1	18.1	10.4	0.6	0.8	1.5
ECO2	9.7	6.7	0.7	0.8	1.2
ECO3	22.4	12.3	0.5	0.8	1.5
ECO4	10.9	7.7	0.7	0.8	1.2
ECO5	11.0	7.7	0.7	0.8	1.2
ECO6	13.2	8.8	0.7	0.8	1.3
ECO7	27.1	14.2	0.5	0.8	1.6
ECO8	15.8	9.7	0.6	0.8	1.4
ECO9	15.7	10.1	0.6	0.8	1.3

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2. Air Quality Assessment Results

2.1. Local air quality results

Opening year NO_2 concentrations

Table 2-1 – Annual mean NO_2 results (µg/m^3) for discrete receptors (including gap factor)

Receptor ID	Base 2019 NO$_2$	2027 DM NO$_2$	2027 DS NO$_2$	2027 DS-DM	2027 NO$_2$ Change Criteria
R_1	27.3	23.9	22.4	-1.5	Not significant
R_2	20.0	17.3	16.2	-1.1	Not significant
R_3	25.7	22.2	20.4	-1.8	Not significant
R_4	21.4	18.3	17.1	-1.2	Not significant
R_5	14.3	12.2	11.5	-0.7	Not significant
R_6	21.5	19.1	19.2	+0.1	Not significant
R_7	25.5	21.7	21.2	-0.5	Not significant
R_8	18.2	15.4	14.9	-0.5	Not significant
R_9	25.4	23.6	24.3	+0.7	Not significant
R_10	25.0	21.2	20.5	-0.7	Not significant
R_11	15.7	14.2	13.6	-0.6	Not significant
R_12	21.7	20.6	20.1	-0.5	Not significant
R_13	26.0	22.3	21.7	-0.6	Not significant
R_14	17.6	14.5	15.2	+0.7	Not significant
R_15	22.3	18.9	19.9	+1.0	Not significant
R_16	15.7	13.1	13.5	+0.4	Not significant
R_17	20.2	18.1	18.3	+0.2	Not significant
R_18	23.1	20.7	19.9	-0.8	Not significant
R_19	25.6	22.8	23.3	+0.5	Not significant
R_20	30.4	27.6	28.2	+0.6	Not significant
R_21	23.6	21.1	21.7	+0.6	Not significant
R_22	17.2	14.4	17.0	+2.6	Not significant
R_23	24.4	22.6	20.1	-2.5	Not significant
R_24	24.8	22.5	20.3	-2.2	Not significant
R_25	16.8	14.9	14.3	-0.6	Not significant
R_26	24.5	21.7	20.2	-1.5	Not significant
R_27	17.0	15.2	14.2	-1.0	Not significant
R_28	19.3	17.3	16.5	-0.8	Not significant
R_29	14.1	12.4	13.5	+1.1	Not significant
R_30	37.2	34.3	33.4	-0.9	Not significant

Receptor ID	Base 2019 NO_2	2027 DM NO_2	2027 DS NO_2	2027 DS-DM	2027 NO_2 Change Criteria
R_31	26.1	22.5	23.0	+0.5	Not significant
R_32	16.5	14.8	15.8	+1.0	Not significant
R_33	28.1	24.2	23.8	-0.4	Not significant
R_34	19.5	18.1	21.7	+3.6	Not significant
R_35	29.5	25.7	24.8	-0.9	Not significant
R_36	21.0	18.9	18.3	-0.6	Not significant
R_37	22.9	19.6	18.0	-1.6	Not significant
R_38	29.4	28.0	27.2	-0.8	Not significant
R_39	25.8	23.8	24.4	+0.6	Not significant
R_40	15.1	12.9	13.2	+0.3	Not significant
R_41	30.5	27.7	27.3	-0.4	Not significant
R_42	24.8	22.3	21.7	-0.6	Not significant
R_43	31.5	28.7	27.7	-1.0	Not significant
R_44	20.8	19.1	21.3	+2.2	Not significant
R_45	30.9	30.9	27.4	-3.5	Not significant
R_46	22.5	20.9	19.7	-1.2	Not significant
R_47	16.9	15.2	16.6	+1.4	Not significant
R_48	30.5	29.5	27.1	-2.4	Not significant
R_49	22.7	19.8	20.2	+0.4	Not significant
R_50	35.8	34.8	31.8	-3.0	Not significant
R_51	13.8	12.0	12.5	+0.5	Not significant
R_52	28.2	25.1	24.5	-0.6	Not significant
R_53	14.4	12.7	13.4	0.7	Not significant
R_54	22.8	19.8	19.8	<0.1	Not significant
R_55	29.7	28.5	27.4	-1.1	Not significant
R_56	23.8	22.9	22.2	-0.7	Not significant
R_57	34.4	29.8	29.7	-0.1	Not significant
R_58	45.5	39.8	39.6	-0.2	Not significant
R_59	60.6	**53.8**	**52.2**	-1.6	Small decrease
R_60	32.1	28.0	27.6	-0.4	Not significant
R_61	43.8	37.9	37.7	-0.2	Not significant
R_62	22.2	19.5	21.2	+1.7	Not significant
R_63	20.7	18.1	18.3	+0.2	Not significant
R_64	18.8	16.4	16.8	+0.4	Not significant
R_65	16.9	14.8	15.1	+0.3	Not significant
R_66	50.9	**44.0**	**43.4**	-0.6	Small decrease

Receptor ID	Base 2019 NO_2	2027 DM NO_2	2027 DS NO_2	2027 DS-DM	2027 NO_2 Change Criteria
R_67	50.4	**44.4**	**43.5**	-0.9	Small decrease
R_68	19.7	17.6	18.5	+0.9	Not significant
R_69	19.4	17.3	18.1	+0.8	Not significant
R_70	29.1	27.0	26.1	-0.9	Not significant
R_71	16.0	14.2	14.2	<0.1	Not significant
R_72	20.7	16.9	18.0	+1.1	Not significant
R_73	14.0	11.7	12.1	+0.4	Not significant
R_74	18.8	15.4	16.3	+0.9	Not significant
R_75	14.1	11.9	12.2	+0.3	Not significant
R_76	31.3	26.7	26.8	+0.1	Not significant
R_77	29.2	27.4	26.4	-1.0	Not significant
R_78	21.2	19.0	18.8	-0.2	Not significant
R_79	18.0	15.5	16.0	+0.5	Not significant
R_80	20.3	19.0	18.0	-1.0	Not significant
R_81	25.9	22.3	21.3	-1.0	Not significant
R_82	25.2	21.2	22.3	+1.1	Not significant
R_83	25.6	22.3	22.9	+0.6	Not significant
R_84	24.2	22.6	21.2	-1.4	Not significant
R_85	23.7	22.1	20.7	-1.4	Not significant
R_86	22.2	20.5	19.9	-0.6	Not significant
R_87	19.4	16.5	15.1	-1.4	Not significant
R_88	18.7	15.9	15.4	-0.5	Not significant
R_89	19.6	16.4	14.8	-1.6	Not significant
R_90	23.6	19.9	17.3	-2.6	Not significant
Values in bold exceed annual mean air quality objective					

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Future year NO_2 concentrations

Table 2-2 – Annual mean NO_2 results (µg/m³) in base and 2042 for existing and potential future receptors with the Scheme and dependent development

Receptor No.	Receptor Description	Base 2019 NO_2	Future 2042 Sceanrio _R NO_2	Future 2042 NO_2 as % of Objective
R_1	QUEENS HEAD, TEWKESBURY ROAD, GLOUCESTER, GL2 9EJ	27.3	12.1	30.3
R_2	119 TEWKESBURY ROAD, GLOUCESTER, GL2 9BN	20.0	9.4	23.5
R_3	118 TEWKESBURY ROAD, GLOUCESTER, GL2 9BW	25.7	11.0	27.5
R_4	1 THE GREEN , CHELTENHAM, GL51 9SR	21.4	10.8	27.0
R_5	OLD LANE COTTAGE, TEWKESBURY ROAD, GLOUCESTER, GL2 9LH	14.3	7.4	18.5
R_6	16 MELODY WAY, GLOUCESTER, GL2 0XU	21.5	11.1	27.8
R_7	SANDYCROFT COTTAGE, DANCEY ROAD, GLOUCESTER, GL3 1HP	25.5	11.5	28.8
R_8	32A VERVAIN CLOSE, GLOUCESTER, GL3 1LT	18.2	9.8	24.5
R_9	8 BERRYFIELD GLADE, GLOUCESTER, GL3 2BT	25.4	13.1	32.8
R_10	77 CHELTENHAM ROAD EAST, GLOUCESTER, GL3 1JN	25.0	11.2	28.0
R_11	THE OLD POLICE STATION, TEWKESBURY ROAD, GLOUCESTER, GL19 4BA	15.7	8.0	20.0
R_12	CORNER HOUSE, TEWKESBURY ROAD, GLOUCESTER, GL19 4AZ	21.7	10.6	26.5
R_13	PEAR TREE COTTAGE, GLOUCESTER ROAD, CHELTENHAM, GL51 0TF	26.0	12.8	32.0
R_14	SALTERS HILL HOUSE, GLOUCESTER ROAD, TEWKESBURY, GL20 7DA	17.6	8.3	20.8
R_15	ODESSA INN, GLOUCESTER ROAD, TEWKESBURY, GL20 7DA	22.3	9.9	24.8
R_16	HIGHFIELD FARM LODGE, TEWKESBURY ROAD, GLOUCESTER, GL19 4BP	15.7	7.7	19.3

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Receptor No.	Receptor Description	Base 2019 NO_2	Future 2042 Sceanrio _R NO_2	Future 2042 NO_2 as % of Objective
R_17	THE GRANARY, WOODHOUSE FARM, BROCKWORTH ROAD, GLOUCESTER, GL3 4RD	20.2	10.2	25.5
R_18	ELMHURST, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0TG	23.1	12.3	30.8
R_19	WOODBINE COTTAGE, BAMFURLONG LANE, CHELTENHAM, GL51 6SW	25.6	15.1	37.8
R_20	6 VALLEY COTTAGES, GLOUCESTER ROAD, CHELTENHAM, GL51 0TF	30.4	14.9	37.3
R_21	STAFFHOUSE, BAMFURLONG LANE, CHELTENHAM, GL51 6SU	23.6	13.4	33.5
R_22	ANNEXE STANBOROUGH COTTAGE, TEWKESBURY ROAD, CHELTENHAM, GL51 9DN	17.2	9.1	22.8
R_23	WITHYBRIDGE END, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0TG	24.4	11.3	28.3
R_24	ELM COTTAGE, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0SW	24.8	11.4	28.5
R_25	2 BUTLERS COURT COTTAGE, WITHYBRIDGE LANE, CHELTENHAM, GL51 0TH	16.8	8.9	22.3
R_26	VINE COTTAGE, GLOUCESTER ROAD, CHELTENHAM, GL51 0SS	24.5	11.4	28.5
R_27	MILL HOUSE, WITHYBRIDGE LANE, CHELTENHAM, GL51 0TH	17.0	8.9	22.3
R_28	52 ASHCHURCH ROAD, TEWKESBURY, GL20 8BT	19.3	9.7	24.3
R_29	6 WESTFIELD COTTAGES, 300084 ROAD TO ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TE	14.1	8.4	21.0
R_30	THE WILLOWS, GLOUCESTER ROAD, CHELTENHAM, GL51 0SX	37.2	17.5	43.8
R_31	8 REDGROVE COTTAGES, HATHERLEY LANE, CHELTENHAM, GL51 6SH	26.1	13.2	33.0

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R_32	HARROW FARM, 500331 LANE TO HARDWICKE LODGE ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TF	16.5	9.1	22.8
R_33	WILLOW MEAD, FIDDLERS GREEN LANE, CHELTENHAM, GL51 0TD	28.1	15.2	38.0
R_34	BRAMBLE COTTAGE, 500331 LANE TO HARDWICKE LODGE ELMSTONE HARDWICKE, TEWKESBURY, GL51 9TF	19.5	11.5	28.8
R_35	18 MILNE PASTURES, TEWKESBURY, GL20 8SG	29.5	15.6	39.0
R_36	PILGROVE COTTAGE, OLD GLOUCESTER ROAD, CHELTENHAM, GL51 0SW	21.0	11.2	28.0
R_37	ROSE COTTAGE, COOKS LANE, CHELTENHAM, GL51 9SU	22.9	10.9	27.3
R_38	21 NIMBUS HOUSE, GEMINI CLOSE, CHELTENHAM, GL51 0FH	29.4	15.3	38.3
R_39	MALVERN HOUSE, SWAN LANE, CHELTENHAM, GL52 7RW	25.8	11.7	29.3
R_40	THE OLD DAIRY, THE GREEN, UCKINGTON, CHELTENHAM, GL51 9SR	15.1	9.1	22.8
R_41	APARTMENT 4, ASTON COURT, SOTHERBY DRIVE, CHELTENHAM, GL51 0FS	30.5	14.2	35.5
R_42	APARTMENT 13, CORINNE COURT, SOTHERBY DRIVE, CHELTENHAM, GL51 0FW	24.8	12.5	31.3
R_43	75 MONKSCROFT, CHELTENHAM, GL51 7TU	31.5	14.6	36.5
R_44	DOVE COTTAGE, STOKE ROAD, CHELTENHAM, GL52 7RY	20.8	11.7	29.3
R_45	4 ANAPA MEWS, CHELTENHAM, GL51 7RB	30.9	14.8	37.0
R_46	1 MILLWAY, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	22.5	11.4	28.5
R_47	THE BUNGALOW, STOKE ROAD, CHELTENHAM, GL52 7RU	16.9	9.8	24.5

Receptor No.	Receptor Description	Base 2019 NO$_2$	Future 2042 Sceanrio _R NO$_2$	Future 2042 NO$_2$ as % of Objective
R_48	12 PRINCESS ELIZABETH WAY, CHELTENHAM, GL51 7PE	30.5	14.2	35.5
R_49	254 BROOKLYN ROAD, CHELTENHAM, GL51 8ED	22.7	13.2	33.0
R_50	32 PROVIDENCE PARK, CHELTENHAM, GL51 7NY	35.8	17.1	42.8
R_51	CLEEVE STATION HOUSE, STOKE ROAD, CHELTENHAM, GL52 7RS	13.8	8.7	21.8
R_52	LARKFIELD, WYMANS LANE, CHELTENHAM, GL51 9QF	28.2	15.4	38.5
R_53	WINGMORE LODGE, STOKE ORCHARD ROAD, CHELTENHAM, GL52 7DG	14.4	9.2	23.0
R_54	MORRIS HILL, SWINDON LANE, CHELTENHAM, GL50 4PE	22.8	13.9	34.8
R_55	71 WYMANS LANE, CHELTENHAM, GL51 9QH	29.7	16.6	41.5
R_56	INGLENOOK, HYDE LANE, CHELTENHAM, GL51 9QN	23.8	12.0	30.0
R_57	APARTMENT 1, HONEYBOURNE GATE, GLOUCESTER ROAD, CHELTENHAM, GL51 8DW	34.4	15.6	39.0
R_58	APARTMENT 27, HONEYBOURNE GATE, GLOUCESTER ROAD, CHELTENHAM, GL51 8DW	45.5	20.5	51.3
R_59	REMBRIDGE COURT, HIGH STREET, CHELTENHAM, GL50 3HY	60.6	25.3	63.3
R_60	FLAT 2, 422 HIGH STREET, CHELTENHAM, GL50 3JA	32.1	16.2	40.5
R_61	1 NAILSWORTH TERRACE, CHELTENHAM, GL50 4BE	43.8	19.6	49.0
R_62	36 FARRIERS REACH, CHELTENHAM, GL52 7UZ	22.2	12.2	30.5
R_63	101 STOKE ROAD, CHELTENHAM, GL52 8RP	20.7	11.1	27.8
R_64	6 FOXMOOR, CHELTENHAM, GL52 8SS	18.8	10.6	26.5
R_65	34 MIDDLEHAY COURT, CHELTENHAM, GL52 8TE	16.9	9.9	24.8

Receptor No.	Receptor Description	Base 2019 NO$_2$	Future 2042 Sceanrio _R NO$_2$	Future 2042 NO$_2$ as % of Objective
R_66	CEDAR HOUSE FLATS, HIGH STREET, CHELTENHAM, GL52 6DL	50.9	21.0	52.5
R_67	FLATS 1 ST ANNES ROAD, CHELTENHAM, GL52 2SS	50.4	21.1	52.8
R_68	1 SHELDON COTTAGES, STANBORO LANE, CHELTENHAM, GL51 9TN	19.7	10.1	25.3
R_69	2 SHELDON COTTAGES, STANBORO LANE, CHELTENHAM, GL51 9TN	19.4	9.9	24.8
R_70	INFORMAL TRAVELLERS SITE, NORTH EAST M5 JUNCTION 10	29.1	13.0	32.5
R_71	BARN FARM, STANBORO LANE, CHELTENHAM, GL51 9TN	16.0	8.4	21.0
R_72	KNIGHTSBRIDGE LODGE, TEWKESBURY ROAD, CHELTENHAM, GL51 9TA	20.7	9.5	23.8
R_73	2 MANOR COTTAGES,TEWKESBURY ROAD,CHELTENHAM,GL51 9SZ	14.0	7.5	18.8
R_74	JASMINE COTTAGE,TEWKESBURY ROAD,CHELTENHAM,GL51 9TA	18.8	8.9	22.3
R_75	COOMBE END,CHELTENHAM ROAD,GLOUCESTER,GL19 4AZ	14.1	7.4	18.5
R_76	61 MARQUIS HOUSE, BROOKBANK CLOSE,GL50 3NS	31.3	16.0	40.0
R_77	561 PRINCESS ELIZABETH WAY,CHELTENHAM,GL51 7PA	29.2	13.9	34.8
R_78	56 PENNSYLVANIA AVENUE,CHELTENHAM,GL51 7JP	21.2	11.4	28.5
R_79	179 BROOKLYN ROAD, CHELTENHAM,GL51 8DX	18.0	10.6	26.5
R_80	COATES HOUSE,EDINBURGH PLACE,GL51 7RP	20.3	11.5	28.8
R_81	ST GEORGES TERRACE,CHELTENHAM,GL50 3PT	25.9	13.8	34.5

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Receptor No.	Receptor Description	Base 2019 NO_2	Future 2042 Sceanrio _R NO_2	Future 2042 NO_2 as % of Objective
R_82	64 GLOUCESTER ROAD,CHELTENHAM, GL51 8NZ	25.2	14.0	35.0
R_83	13 BROOKBANK CLOSE, CHELTENHAM, GL50 3NN	25.6	14.8	37.0
R_84	1 MILLWAY, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	24.2	11.9	29.8
R_85	11 YEEND CLOSE, CHELTENHAM, GL51 9QW	23.7	11.8	29.5
R_86	83 RIVER LEYS,CHELTENHAM, GL51 9SA	22.2	11.5	28.8
R_87	ROSENEATH, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	19.4	10.1	25.3
R_88	33 HOMECROFT DRIVE, CHELTENHAM, GL51 9SN	18.7	10.3	25.8
R_89	WALTON HOUSE, TEWKESBURY ROAD, CHELTENHAM, GL51 9SL	19.6	9.7	24.3
R_90	CHERRY ORCHARD, TEWKESBURY ROAD, CHELTENHAM	23.6	10.5	26.3
T_1	transect receptor at 25 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	18.6	12.7	31.8
T_2	transect receptor at 35 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	17.7	11.4	28.5
T_3	transect receptor at 45 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	17.0	10.7	26.8
T_4	transect receptor at 55 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	16.6	10.2	25.5
T_5	transect receptor at 75 m, North West Cheltenham Development Area, north of A4019 between	15.9	9.7	24.3

Receptor No.	Receptor Description	Base 2019 NO$_2$	Future 2042 Sceanrio _R NO$_2$	Future 2042 NO$_2$ as % of Objective
	M5 Junction 10 and Withybridge Lane			
T_6	transect receptor at 95 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	15.5	9.3	23.3
T_7	transect receptor at 125 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	15.1	9.0	22.5
T_8	transect receptor at 155 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	14.8	8.8	22.0
T_9	transect receptor at 175 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	14.7	8.7	21.8
T_10	transect receptor at 195 m, North West Cheltenham Development Area, north of A4019 between M5 Junction 10 and Withybridge Lane	14.6	8.6	21.5
T_11	transect receptor at 67 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	18.4	9.8	24.5
T_12	transect receptor at 77 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	17.9	9.6	24.0
T_13	transect receptor at 97 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	17.3	9.3	23.3
T_14	transect receptor at 127 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	16.6	9.0	22.5
T_15	transect receptor at 147 m, North West Cheltenham Development Area, north of	16.4	8.9	22.3

Receptor No.	Receptor Description	Base 2019 NO$_2$	Future 2042 Sceanrio _R NO$_2$	Future 2042 NO$_2$ as % of Objective
	A4019 between Withybridge Lane and The Green			
T_16	transect receptor at 177 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	16.1	8.8	22.0
T_17	transect receptor at 197 m, North West Cheltenham Development Area, north of A4019 between Withybridge Lane and The Green	15.9	8.7	21.8
T_18	transect receptor at 25 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	17.6	12.0	30.0
T_19	transect receptor at 35 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	16.9	11.2	28.0
T_20	transect receptor at 45 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	16.4	10.7	26.8
T_21	transect receptor at 75 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	15.5	9.9	24.8
T_22	transect receptor at 95 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	15.1	9.6	24.0
T_23	transect receptor at 125 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	14.7	9.4	23.5
T_24	transect receptor at 145 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	14.6	9.3	23.3
T_25	transect receptor at 175 m, Safeguarded land to the north-west of Cheltenham, north of the	14.3	9.1	22.8

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Receptor No.	Receptor Description	Base 2019 NO_2	Future 2042 Sceanrio _R NO_2	Future 2042 NO_2 as % of Objective
	A4019 between The Green and Gallagher Retail Park			
T_26	transect receptor at 185 m, Safeguarded land to the north-west of Cheltenham, north of the A4019 between The Green and Gallagher Retail Park	14.3	9.1	22.8
T_27	transect receptor at 22 m, West Cheltenham Development Area, south of the B4634	17.9	10.2	25.5
T_28	transect receptor at 32 m, West Cheltenham Development Area, south of the B4634	17.2	9.8	24.5
T_29	transect receptor at 42 m, West Cheltenham Development Area, south of the B4634	16.8	9.6	24.0
T_30	transect receptor at 52 m, West Cheltenham Development Area, south of the B4634	16.5	9.5	23.8
T_31	transect receptor at 72 m, West Cheltenham Development Area, south of the B4634	16.2	9.3	23.3
T_32	transect receptor at 102 m, West Cheltenham Development Area, south of the B4634	15.9	9.2	23.0
T_33	transect receptor at 122 m, West Cheltenham Development Area, south of the B4634	15.8	9.1	22.8
T_34	transect receptor at 152 m, West Cheltenham Development Area, south of the B4634	15.6	9.0	22.5
T_35	transect receptor at 172 m, West Cheltenham Development Area, south of the B4634	15.6	9.0	22.5
T_36	transect receptor at 199 m, West Cheltenham Development Area, south of the B4634	15.5	9.0	22.5
T_37	transect receptor at 45 m, North West Cheltenham Development Area, east of M5 Junction 10	30.1	13.0	32.5
T_38	transect receptor at 55 m, North West Cheltenham Development Area, east of M5 Junction 10	28.0	12.3	30.8
T_39	transect receptor at 74 m, North West Cheltenham Development Area, east of M5 Junction 10	25.0	11.4	28.5

Receptor No.	Receptor Description	Base 2019 NO_2	Future 2042 Sceanrio _R NO_2	Future 2042 NO_2 as % of Objective
T_40	transect receptor at 104 m, North West Cheltenham Development Area, east of M5 Junction 10	22.2	10.5	26.3
T_41	transect receptor at 124 m, North West Cheltenham Development Area, east of M5 Junction 10	20.8	10.1	25.3
T_42	transect receptor at 154 m, North West Cheltenham Development Area, east of M5 Junction 10	19.3	9.7	24.3
T_43	transect receptor at 174 m, North West Cheltenham Development Area, east of M5 Junction 10	18.6	9.5	23.8
T_44	transect receptor at 194 m, North West Cheltenham Development Area, east of M5 Junction 10	18.0	9.3	23.3

Particulate concentrations

Table 2-3 – Annual mean PM_{10} and $PM_{2.5}$ results (µg/m^3) for discrete receptors (including verification factor)

Receptor ID	2019 Base PM_{10}	2019 Base Number of 24hr Mean PM_{10} Exceedances	2019 Base Estimated $PM_{2.5}$^
R_1	16.3	0	11.4
R_2	15.2	0	10.6
R_3	16.1	0	11.3
R_4	15.2	0	10.6
R_5	14.1	0	9.8
R_6	16.9	1	11.8
R_7	17.7	1	12.4
R_8	15.7	0	11.0
R_9	17.4	1	12.1
R_10	16.8	1	11.7
R_11	13.7	0	9.6
R_12	14.6	0	10.2
R_13	18.4	2	12.9
R_14	14.4	0	10.1
R_15	15.7	0	11.0
R_16	14.4	0	10.1
R_17	16.4	0	11.5
R_18	17.4	1	12.2
R_19	17.4	1	12.2
R_20	18.1	2	12.7
R_21	17.2	1	12.0
R_22	15.3	0	10.7
R_23	16.0	0	11.2
R_24	16.1	0	11.2
R_25	15.3	0	10.7
R_26	15.9	0	11.1
R_27	15.3	0	10.7
R_28	14.8	0	10.3
R_29	13.9	0	9.7
R_30	19.3	3	13.5
R_31	16.9	1	11.9
R_32	16.2	0	11.3
R_33	17.3	1	12.1

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Receptor ID	2019 Base PM_{10}	2019 Base Number of 24hr Mean PM_{10} Exceedances	2019 Base Estimated $PM_{2.5}$^
R_34	16.6	1	11.6
R_35	18.3	2	12.8
R_36	15.6	0	10.9
R_37	16.1	0	11.2
R_38	17.4	1	12.2
R_39	18.2	2	12.7
R_40	14.9	0	10.4
R_41	17.2	1	12.0
R_42	16.1	0	11.2
R_43	17.2	1	12.0
R_44	15.8	0	11.0
R_45	17.8	1	12.5
R_46	15.8	0	11.1
R_47	15.5	0	10.9
R_48	17.7	1	12.4
R_49	16.1	0	11.2
R_50	18.5	2	12.9
R_51	16.1	0	11.3
R_52	16.8	1	11.7
R_53	16.3	0	11.4
R_54	15.8	0	11.0
R_55	17.2	1	12.0
R_56	15.8	0	11.1
R_57	18.3	2	12.8
R_58	20.4	4	14.3
R_59	23.8	10	16.7
R_60	17.6	1	12.3
R_61	20.0	3	14.0
R_62	16.1	0	11.3
R_63	15.8	0	11.1
R_64	15.4	0	10.8
R_65	15.1	0	10.6
R_66	22.5	7	15.7
R_67	22.4	7	15.7
R_68	17.3	1	12.1

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Receptor ID	2019 Base PM$_{10}$	2019 Base Number of 24hr Mean PM$_{10}$ Exceedances	2019 Base Estimated PM$_{2.5}$^
R_69	17.2	1	12.1
R_70	17.1	1	12.0
R_71	15.6	0	10.9
R_72	15.9	0	11.1
R_73	14.9	0	10.4
R_74	15.6	0	10.9
R_75	13.8	0	9.7
R_76	17.3	1	12.1
R_77	17.5	1	12.2
R_78	16.0	0	11.2
R_79	15.4	0	10.8
R_80	15.9	0	11.1
R_81	16.5	0	11.5
R_82	16.1	0	11.2
R_83	16.4	0	11.5
R_84	16.2	0	11.3
R_85	16.1	0	11.2
R_86	15.8	0	11.0
R_87	15.1	0	10.6
R_88	15.0	0	10.5
R_89	15.1	0	10.6
R_90	15.5	0	10.9

^ Estimated 2019 PM$_{2.5}$ value has been estimated by multiplying the ratio of 0.7 to the 2019 PM$_{10}$ concentration in line with guidance provided in LAQM.TG(22)

PM$_{10}$ Criteria - 24-hour mean concentration should not exceed 50 µg/m^3 more than 35 times a year; Annual mean concentration should not exceed 40 µg/m^3

PM$_{2.5}$ Criteria - UK (Except Scotland) annual mean concentration should not exceed 20 µg/m^3

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2.2.   Nitrogen deposition results

Table 2-4 – Estimated total nitrogen deposition (kg/n/ha/yr) for all ecological receptors, (including modelled road NO_2 contributions including National Highways LTTE6 projection factors and estimated ammonia contribution using National Highways ammonia deposition tool)

ID Ref.	Name	Designated Habitat(s)	Lowest Critical Load (kg N/ha/yr)	Background nitrogen deposition rate (1km forest APIS[1] (kg N/ha/yr)	Change in N deposition rate (kg N/ha/yr)	Significance of effect
ECO1	Norton (A38)	Broadleaved Mixed and Yew Woodland	10	30.1	-0.86	Not Significant
ECO2	Pegmore Farm, The Leigh 'Meadow 2' U LWS	Broadleaved Mixed and Yew Woodland	10	30.1	-0.07	Not Significant
ECO3	Cotswold Farm, The Leigh LWS	Broadleaved Mixed and Yew Woodland	10	29.7	-1.24	Not Significant
ECO4	Tewkesbury Nature Reserve U LWS	Broadleaved Mixed and Yew Woodland	10	28.9	-0.02	Not Significant
ECO5	Tewkesbury Nature Reserve U LWS	Broadleaved Mixed and Yew Woodland	10	28.9	-0.02	Not Significant
ECO6	Tewkesbury Railway Line (Disused) LWS	Broadleaved Mixed and Yew Woodland	10	28.8	-0.08	Not Significant
ECO7	Walton Cardiff Ponds LWS	Broadleaved Mixed and Yew Woodland	10	28.8	-0.47	Not Significant
ECO8	Veteran Tree	Broadleaved Mixed and Yew Woodland	10	29.5	-0.19	Not Significant
ECO9	Hayden Sewage Treatment	Broadleaved Mixed and Yew Woodland	10	29.9	-0.03	Not Significant

[1] Obtained from APIS website on 17/07/2023

ID Ref.	Name	Designated Habitat(s)	Lowest Critical Load (kg N/ha/yr)	Background nitrogen deposition rate (1km forest APIS[1] (kg N/ha/yr)	Change in N deposition rate (kg N/ha/yr)	Significance of effect
	Works (LWS)					

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