A14.2: Dispersion Model Set Up, Model Verification and Traffic Data

1 Dispersion Model Set Up and Model Verification

1.1 Introduction

1.1.1 The ADMS-Roads model has been developed by Cambridge Environmental Research Consultants Ltd (CERC) and is a version of an atmospheric modelling system that focuses on road traffic as a source of pollutant emissions. Version 3.1 has been used for this study.

1.1.2 The modelling system takes into account the emissions produced by light duty and heavy duty vehicles travelling at a certain speed along a section of road over an average hour and predicts the dispersion of these emissions using appropriate historical meteorological data. The effect of meteorological conditions on dispersion is included within the model. The most significant factors are wind speed and direction and the boundary layer height which is the calculated mixed depth of the lower atmosphere.

1.2 Model Scenarios

1.2.1 In order to quantify the air quality impact of the proposed scheme, the pollutant concentrations resulting from the emissions from existing road traffic on local roads have been compared to those resulting from predicted traffic emissions with the scheme in place.

1.2.2 The following scenarios were modelled:

- Base year (2012) existing situation;
- Assessment year (2019) without proposed scheme – Do-Minimum (DM); and
- Assessment year (2019) with proposed scheme – Do-Something (DS).

Modelling Parameters

Road Links

1.2.3 ADMS Roads requires lengths of road of equal width (and height if specified as a canyon) to be input into the model. Roads can be split into several 'links' to allow for bends and curves in the road layout. Road alignment and width were determined using the Ordnance Survey Mastermap 1:1250 scale data.

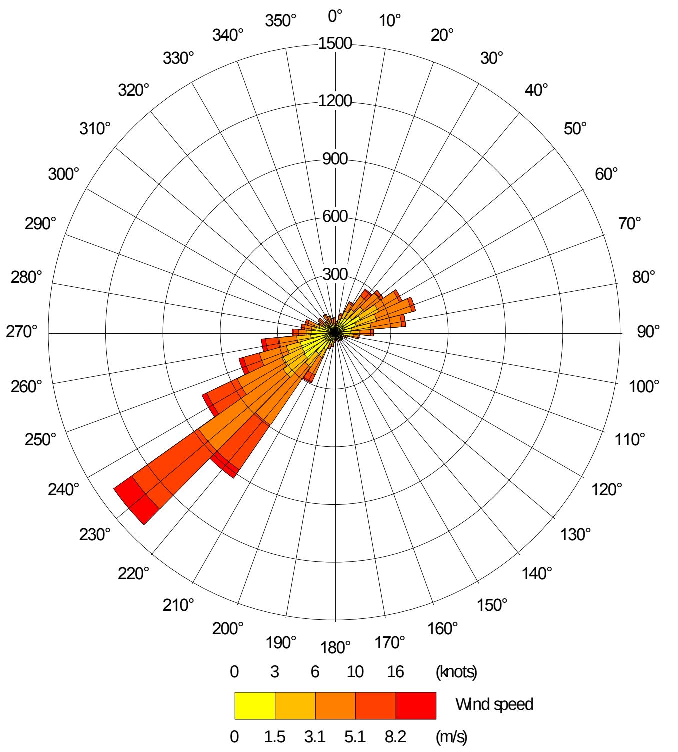
Traffic Emissions

1.2.4 The traffic flow data for the model was prepared by Jacobs. Emission rates representing links in the traffic model were calculated based on the traffic flow, HDV composition, speed and road type with the UK EFT v5.2c by Defra.

Meteorological Data

1.2.5 In order to assess the impact of the development upon local air quality using a dispersion model, it is important to use representative meteorological data. In simple terms, meteorology is the next most significant factor in determining ambient pollutant levels, after emissions.

1.2.6 Meteorological data for the dispersion modelling assessment was taken from Strathallan Airport which is considered to be the most representative source for the study area. The windrose for 2012 is on the following page.



1.2.7 Allowance was made in the model for the difference between the roughness length at the meterological data site, where the wind speeds measurements were made at the airport, and that across the scheme area, which typically has a greater roughness length. Surface roughness varies across the study area. The dispersion site surface roughness and the meteorological data site surface roughness were both set at 0.3m.

Terrain

1.2.8 The terrain has an effect on the flow field in the air above it. It is recommended that the effect of terrain is incorporated into ADMS-Roads where gradients of greater than 10% exist within the modelled area, or a short way outside of it. Therefore, it has not been necessary to include the effect of terrain in the assessment.

Street Canyons

1.2.9 'Street canyons' in air pollution science are roads with continuous high buildings on either side. This arrangement tends to impede the dispersion of pollutants from the road, particularly when the wind is at right angles to it, since a vortex is created in the 'street canyon', retaining the pollution.

1.2.10 No road links were identified as being 'street canyons'. This feature was therefore not included within the modelling assessment.

Receptors

1.2.11 A total of 24 receptors were included in the assessment. The grid reference was selected to represent the worst-case façade of the property. The resulting list was inserted into the model as an asp file. All representative receptor points were given a height of 1.5 m. For model verification purposes, the air quality monitoring locations were included in the model setup.

Output Grid

1.2.12 No contour plots were generated for this assessment.

1.3 Model Verification Adjustment

Introduction

1.3.1 The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification investigates the discrepancies between modelled and measured concentrations, which can arise due to the presence of inaccuracies and/or uncertainties in model input data, modelling and monitoring data assumptions. The following are examples of potential causes of such discrepancy:

- Estimates of background pollutant concentrations;
- Meteorological data uncertainties;
- Traffic data uncertainties;
- Model input parameters, such as 'roughness length'; and
- Overall limitations of the dispersion model.

Model Precision

1.3.2 Residual uncertainty may remain after systematic error or 'model accuracy' has been accounted for in the final predictions. Residual uncertainty may be considered synonymous with the 'precision' of the model predictions, i.e. how wide the scatter or residual variability of the predicted values compare with the monitored true value, once systematic error has been allowed for. The quantification of model precision provides an estimate of how the final predictions may deviate from true (monitored) values at the same location over the same period.

Model Performance

1.3.3 An evaluation of model performance has been undertaken to establish confidence in model results. LAQM TG(09) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess uncertainty. The statistical parameters used in this assessment are:

- Root mean square error (RMSE);
- Fractional bias (FB); and
- Correlation coefficient (CC).

1.3.4 A brief for explanation of each statistic is provided in Table 1, and further details can be found in LAQM TG(09) Box A3.7.

Table 1: Model Performance Statistics

Statistical Parameter	Comments	Ideal value
Root Mean Squared Error (RMSE)	RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared. If the RMSE values are higher than 25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 objective of 40 µg/m^3, if an RMSE of 10 µg/m^3 or above is determined for a model it is advised to revisit the model parameters and model verification. Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4 µg/m^3 for the annual mean NO_2 objective.	0.01
Fractional Bias (FB)	FB is used to identify if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.	0.00

Statistical Parameter	Comments	Ideal value
Correlation Coefficient (CC)	CC is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

1.3.5 The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results.

1.3.6 Alternatively the model may perform poorly against the monitoring data, in which case there is a need to check all the input data to ensure that it is reasonable and accurately represented by the air quality modelling process (Defra, 2009). Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered reasonable, then the modelled results may require adjustment to improve alignment with the monitoring data. This adjustment may be either using by a single verification adjustment factor to be applied to the modelled concentrations across the study area or a range of different adjustment factors to account for different situations in the study area.

1.3.7 These calculations have been carried out prior to, and after adjustment and provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

Air Quality Monitoring Data

1.3.8 The air quality monitoring data collected as part of this assessment is detailed in chapter 14.3 (Baseline Conditions). This was reviewed to determine the suitability of each of the monitoring locations for inclusion in the model verification process.

Verification Methodology - NO_x / NO_2

1.3.9 The verification method followed the process detailed in LAQM TG(09). An initial comparison of the modelled versus monitored results indicated that model tended to under-predict against the monitored concentrations. Additionally, there was a degree of uncertainty or scatter in the model predictions. Model verification adjustment therefore focussed on reducing the under-prediction and uncertainty associated with the modelled results.

1.3.10 The first stage of verification was undertaken by comparing the modelled versus monitored Road NO_x. Monitored Road NO_x was calculated using the latest Defra NOx to NO_2 calculator because diffusion tubes only measure NO_2. Once the modelled Road NOx component had been adjusted, this value was used in the Defra NO_x to NO_2 calculator, and the calculated Road NO_2 component was adjusted following comparison with the monitored Road NO_2.

Verification Summary: NOx / NO_2

1.3.11 In total 5 sites were used in the model verification process. Sites 1, 2, 3, 8 and 9 from the project monitoring survey were not included in the assessment because they were not in the study area or representative of roadside exposure locations. The summary results and model performance statistics defined in LAQM TG(09) are provided in Table 2.

Table 2: Verification Zone Model Performance Statistics – NO_2

Parameter	No adjustment	With adjustment
No. of monitoring sites	5	5
NO_x road adjustment factor	-	1.335

Parameter	No adjustment	With adjustment
NO_2 road adjustment factor	-	1.005
RMSE	4.5	3.4
FB	0.2	0.0
CC	0.06	0.06
No. sites within +/- 25%	3	4

1.3.12 The statistics show that the RMSE and FB are improved when an adjustment factor is used, compared to the RMSE and FB for unadjusted results.

Verification Methodology - PM_{10}

1.3.13 There were no representative roadside PM_{10} monitoring locations within the study. Therefore the Road NO_x adjustment factor was applied to the Road PM_{10} model predictions, following guidance in LAQM TG(09).

2 Traffic Data Utilised Within Air Quality Model

2.1.1 Traffic data for each local air quality assessment model scenario is provided in Table 3 on the following page.

2.1.2 Two schematics showing the locations of each Link ID follow the table.

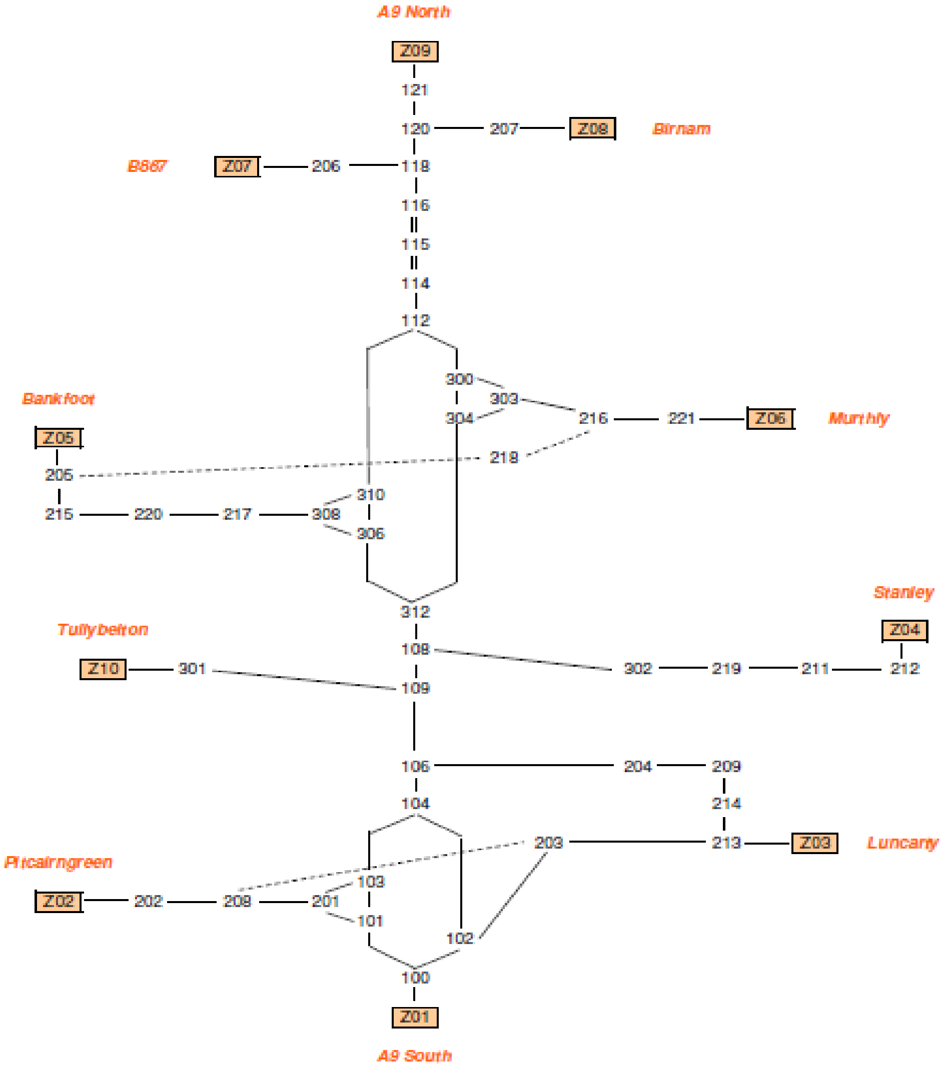
Appendix A14.4: Traffic Data Utilised Within Air Quality Model

Road Link ID	Base 2012			DM 2019			Road Link ID	DS 2019		
	AADT (24hr)	HDV (%)	Speed (KPH)	AADT (24hr)	HDV (%)	Speed (KPH)		AADT (24hr)	HDV (%)	Speed (KPH)
100_101	12288	7.3	101	13248	7.3	101	*100_101*	13248	7.3	101
101_103	7502	9.8	106	8090	9.8	106	*101_103*	8090	9.8	106
103_104	7637	9.8	103	8234	9.8	103	*103_104*	8316	9.8	103
104_106	15509	10.8	84	16723	10.8	84	*104_318*	8316	9.8	105
106_109	15840	10.7	84	17078	10.7	83	*318_320*	8076	9.8	102
109_108	15749	10.6	85	16978	10.6	84	*320_306*	8198	10.2	102
108_312	15626	10.7	84	16846	10.7	84	*306_310*	6552	11.7	105
312_306	7606	9.8	83	8198	9.8	82	*310_114*	6732	11.5	101
306_310	6077	11.2	86	6552	11.2	86	*114_115*	6732	11.5	103
310_112	6242	11.0	82	6732	11.0	82	*115_116*	6732	11.5	102
112_114	13013	12.0	85	14033	12.0	85	*116_118*	14033	12.3	83
114_115	6242	11.0	103	6732	11.0	103	*118_120*	14894	12.0	84
115_116	6242	11.0	103	6732	11.0	102	*120_121*	13387	12.9	83
116_118	13013	12.0	84	14033	12.0	83	*121_120*	13387	12.9	83
118_120	13814	11.7	84	14894	11.7	84	*120_118*	14894	12.0	84
120_121	12415	12.6	84	13387	12.6	83	*118_116*	14033	12.3	83
121_120	12415	12.6	84	13387	12.6	83	*116_115*	7301	12.9	102
120_118	13814	11.7	84	14894	11.7	84	*115_114*	7301	12.9	102
118_116	13013	12.0	84	14033	12.0	83	*114_300*	7301	12.9	106
116_115	6770	12.9	102	7301	12.9	102	*300_304*	7092	13.3	107
115_114	6770	12.9	104	7301	12.9	104	*304_314*	8647	11.5	105
114_112	13013	12.0	85	14033	12.0	85	*314_316*	8186	12.0	107
112_300	6770	12.9	89	7301	12.9	89	*316_104*	8489	11.7	105
300_304	6578	13.3	90	7092	13.3	90	*104_102*	8489	11.7	105
304_312	8021	11.5	85	8647	11.5	84	*102_100*	13505	8.6	102
312_108	15626	10.7	84	16846	10.7	84	*203_102*	5016	3.3	76
108_109	15749	10.6	85	16978	10.6	84	*101_201*	5158	3.4	76
109_106	15840	10.7	84	17078	10.7	83	*201_103*	228	10.7	80
106_104	15509	10.8	84	16723	10.8	84	*201_208*	5386	3.7	77
104_102	7872	11.7	105	8489	11.7	105	*208_201*	5386	3.7	77
102_100	12526	8.6	103	13505	8.6	102	*208_202*	1872	4.2	64
203_102	4654	3.3	77	5016	3.3	76	*202_208*	1872	4.2	64
101_201	4783	3.4	77	5158	3.4	76	*208_203*	6019	9.9	77
201_103	134	7.1	80	144	7.1	80	*203_208*	6019	9.9	77
201_208	4918	3.5	77	5302	3.5	76	*203_213*	10236	3.3	44
208_201	4918	3.5	77	5302	3.5	76	*213_203*	10236	3.3	44
208_202	1735	4.2	64	1872	4.2	64	*213_214*	274	5.1	48
202_208	1735	4.2	64	1872	4.2	64	*214_213*	274	5.1	48
208_203	5503	2.2	77	5935	2.2	77	*214_209*	274	5.1	69
203_208	5503	2.2	77	5935	2.2	77	*209_214*	274	5.1	69
203_213	9418	3.3	44	10154	3.3	44	*209_204*	274	5.1	65
213_203	9418	3.3	44	10154	3.3	44	*204_209*	274	5.1	65
213_214	331	7.1	48	358	7.2	48	*204_302*	274	5.1	79
214_213	331	7.1	48	358	7.2	48	*302_204*	274	5.1	79
214_209	331	7.1	69	358	7.2	69	*314_324*	461	2.3	79

Road Link ID	Base 2012			DM 2019		
	AADT (24hr)	HDV (%)	Speed (KPH)	AADT (24hr)	HDV (%)	Speed (KPH)
209_214	331	7.1	69	358	7.2	69
209_204	331	7.1	65	358	7.2	65
204_209	331	7.1	65	358	7.2	65
204_106	331	7.1	65	358	7.2	65
106_204	331	7.1	65	358	7.2	65
108_302	550	4.5	63	593	4.5	63
302_108	550	4.5	63	593	4.5	63
302_219	550	4.5	73	593	4.5	73
219_302	550	4.5	73	593	4.5	73
219_211	550	4.5	66	593	4.5	66
211_219	550	4.5	66	593	4.5	66
211_212	550	4.5	46	593	4.5	46
212_211	550	4.5	46	593	4.5	46
109_301	346	7.6	63	372	7.6	63
301_109	346	7.6	63	372	7.6	63
306_308	1529	4.5	79	1646	4.5	79
308_310	166	5.4	80	180	5.4	80
308_217	1694	4.6	79	1826	4.6	79
217_308	1694	4.6	79	1826	4.6	79
217_220	1694	4.6	63	1826	4.6	63
220_217	1694	4.6	63	1826	4.6	63
220_215	1694	4.6	63	1826	4.6	63
215_220	1694	4.6	63	1826	4.6	63
215_205	1694	4.6	46	1826	4.6	45
205_215	1694	4.6	46	1826	4.6	45
205_218	1546	3.3	48	1666	3.3	48
218_205	1546	3.3	48	1666	3.3	48
218_216	1546	3.3	67	1666	3.3	67
216_218	1546	3.3	67	1666	3.3	67
216_221	358	3.3	70	384	3.3	70
221_216	358	3.3	70	384	3.3	70
216_303	1634	3.3	78	1762	3.3	77
303_216	1634	3.3	78	1762	3.3	77
300_303	192	1.6	80	209	1.6	80
303_304	1442	3.5	79	1553	3.5	79
118_206	854	6.9	64	917	6.9	64
206_118	854	6.9	64	917	6.9	64
120_207	1522	4.4	69	1639	4.4	69
207_120	1522	4.4	69	1639	4.4	69

Road Link ID	DS 2019		
	AADT (24hr)	HDV (%)	Speed (KPH)
324_316	302	5.6	80
324_332	763	3.6	80
332_324	763	3.6	80
332_302	828	4.8	75
302_332	828	4.8	75
302_219	593	4.5	76
219_302	593	4.5	76
219_211	593	4.5	66
211_219	593	4.5	66
211_212	593	4.5	46
212_211	593	4.5	46
318_326	242	9.0	80
326_320	125	7.2	80
326_331	367	8.4	80
331_326	367	8.4	80
331_301	372	7.6	71
301_331	372	7.6	71
331_332	554	4.4	75
332_331	554	4.4	75
306_308	1646	4.5	79
308_310	180	5.4	80
308_217	1826	4.6	79
217_308	1826	4.6	79
217_220	1826	4.6	63
220_217	1826	4.6	63
220_215	1826	4.6	63
215_220	1826	4.6	63
215_205	1826	4.6	45
205_215	1826	4.6	45
205_218	1666	3.3	48
218_205	1666	3.3	48
218_216	1666	3.3	67
216_218	1666	3.3	67
216_221	384	2.3	74
221_216	384	2.3	74
216_303	1762	3.3	77
303_216	1762	3.3	77
300_303	209	1.6	80
303_304	1553	3.5	79
118_206	917	6.9	64
206_118	917	6.9	64
120_207	1639	4.4	69
207_120	1639	4.4	69

Schematic 1: Base 2012 and DM 2019 Road Network



Schematic 2: DM 2019 Road Network