Air pollution in hills from the proposed Gloucestershire incinerator

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We use AERMOD to model emissions from the proposed Gloucestershire incinerator and compare the resulting predictions with those in the original Air Quality Assessment [1]. Our predictions are in very good agreement with those of [1]. One difference is the direction of the most polluted area, caused by the difference between the wind direction in Bristol (used by [1]) and in Gloucestershire (used by us). The other difference is the level of pollution on the hills to the east of the incinerator. We predict higher pollution in these hills, which (in particular) causes the nitrogen deposition rate in the Cotswold Beechwoods to exceed 1% of the critical level. It also causes some elevated towns and villages (including Edge, Randwick, and Minchinhampton) to join the list of places most affected by the incinerator pollution.

1. Methods

We aim to reproduce some of the modelling experiments reported in [1], but there are some unavoidable differences in our methods, which are explained here.

1.1 Software and parameters

The main difference is that we do not use the ADMS software [2], used by the authors of [1], partly because of its prohibitive cost. Instead we use AERMOD [3], with its companion software, AERMET, to preprocess meteorological data. In the remainder of this paper we refer to the AERMOD/AERMET combination as simply “AERMOD”. We use the latest versions of AERMOD and AERMET, dated August 2015.

AERMOD calculates the predicted concentration of a specified pollutant at each location at ground level. In this paper we only calculate annual mean concentrations, by averaging over a period of one year, from hourly weather observations and assuming a constant emission rate.

AERMOD is provided with several parameters of the emissions source, all taken from [1]:

- Stack location (379882, 210464) = (51.7925, -2.2931).
- Stack height (70m).
- Stack diameter (1.81m).
- Stack gas exit velocity (19.91m/s).
- Stack gas temperature (130ºC).
- Emission rate of pollutant.

We use a “pollutant ID” of “other”, which means that AERMOD will not perform any chemical simulations (e.g., converting nitric oxide to nitrogen dioxide). Given the concentration of one pollutant of type “other”, the concentration of another such pollutant can be derived simply by multiplying by the relative emission rate.

AERMOD also requires a few parameters of the area near the emissions source:

- Albedo. We use 0.2, based on guidance in the AERMOD [3] User’s Guide; this is not mentioned in [1].
- Bowen ratio. We use 1.0, based on guidance in the AERMOD [3] User’s Guide; this is not mentioned in [1].
- Roughness length. We use 0.3m, as specified in [1].

Finally, AERMOD has various options that control how the model works. We mostly use the standard “regulatory default” options. However, there are three experimental “beta” options which “address concerns regarding model performance under low wind speed conditions” [3], known as “LOWWIND1”, “LOWWIND2”, and “LOWWIND3”. Because these often reduce the predicted concentrations, we sometimes repeat experiments with all four options (the default options and the three “LOWWIND” options) and report the results that show the minimum concentrations.

The following components (and versions) of the AERMOD system were used:

- AERMOD (v15181).
- AERMET (v15181).
- AERMAP (v11103).
- BPIP (v04274).

1.2 Weather data

AERMOD was supplied with hourly weather observations for the following:

- Wind direction.
- Wind speed.
- Temperature.
- Pressure.
- Solar radiation.
- Cloud cover.

Most of these were obtained from Weather Underground [4], a free source of weather data. Wind speed, direction, temperature, and pressure were obtained hourly from the Quedgeley weather station [5] at (51.824, -2.284) = (380523, 213969), which is very close to the emissions source. Solar radiation is not recorded at Quedgeley, so it was obtained from the Lansdown weather station [6] at (51.895, -2.089) = (393972, 221832). Both of these weather stations are very reliable. In the very few hours when Quedgeley observations were missing, Lansdown observations were used. In the very few hours when Lansdown observations were missing, solar radiation readings from the Horfield/Filton weather station [7] were used instead.

Cloud cover data was obtained from the ERA Interim dataset [8, 9] for the location (51.75, -2.25) = (382838, 205730). This location (in Stroud) is the nearest available.

Since we use an “onsite” file for weather observations, AERMOD treats observations with calm winds as missing observations. We therefore replaced calm winds (those with speed 0 and direction 0 degrees) by very light winds from a random direction. AERMOD replaces these and all other light winds (with speed below 0.28m/s) by increasing the speed to 0.28m/s without changing the direction.

AERMOD also requires upper air observations from the previous midnight (GMT) sounding, for:

- Wind direction.
- Wind speed.
- Temperature.
- Pressure.
- Dewpoint.
- Height.

for various heights in the atmosphere. We use the observations from Camborne, obtained from meteocentre.com.

For the experiments in this paper we have used the period from 1/7/2014 to 30/6/2015, inclusive. This period was chosen because it is the most recent year for which data was available at the time of performing the experiments. (The cloud cover data is released with a 2-month delay.)

1.3 Terrain

In order to model dispersion correctly for the terrain, we obtained the OS Terrain 50 dataset [13] from Ordnance Survey. This was converted to DEM format and preprocessed by AERMAP, AERMOD's terrain preprocessor, to be used by AERMOD.

1.4 Building downwash

We also needed to handle **building downwash**. The report [1] states:

> "*The presence of adjacent buildings can significantly affect the dispersion of the atmospheric emissions in various ways. Wind blowing around a building distorts the flow and creates zones of turbulence. The increased turbulence can cause greater plume mixing. Also, the rise and trajectory of the plume may be depressed slightly by the flow distortion. This downwash leads to higher ground level concentrations closer to the stack than those which would be present without the building.*"

Unfortunately, the authors of [1] did not state how they modelled the incinerator building. Therefore, we measured the building from the plans in the planning applications, and fed the description into AERMOD's BPIP preprocessor. BPIP generated information for AERMOD to correctly model building downwash. The highest part of the incinerator building has a sloping roof whose height varies from 41.75m to 48.195m. It is not clear how to specify a sloping roof in BPIP, so we specified the roof height as 48.195m but also tried heights of 41.75m and 43m.

It is worth noting that **stack tip downwash** is also modelled, but this is just one of AERMOD's regulatory default options.

2. Results

2.1 Comparison

First we compare our predictions with those in [1]. The authors of [1] do not model the conversion of nitric oxide to nitrogen dioxide, but instead multiply the predicted concentrations of nitrogen oxides by 0.7 to arrive at their predicted nitrogen dioxide concentrations. We used the same method to predict nitrogen dioxide concentrations for the year ending 30/06/2015. Figure 1 shows the results, for a 7.5x7.5 km square centred on the incinerator.

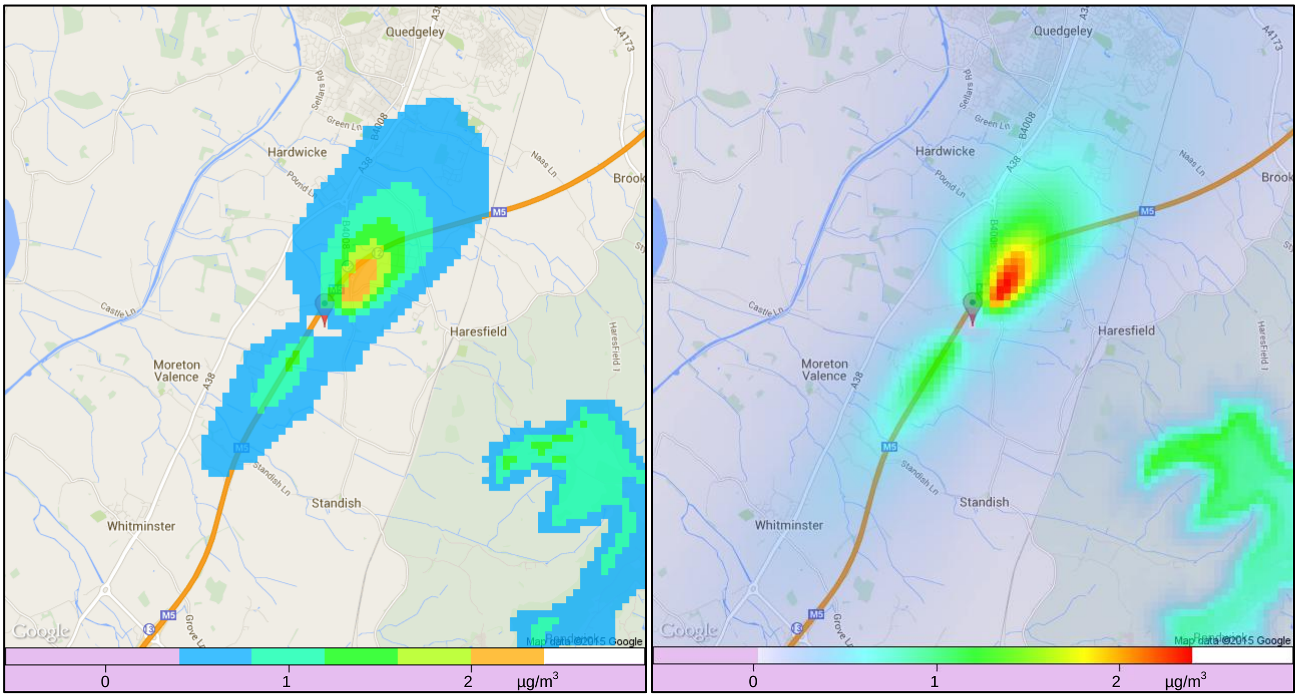

Figure 1. Annual mean ground-level concentration of nitrogen dioxide (1/7/2014-30/6/2015). Left: as contours with 0.4µg/m^3 intervals. Right: as a heatmap. These assume that 70% of the nitrogen oxides are in the form of nitrogen dioxide.

Figure 1 (left) should be compared with Figure C.2 of [1], which uses weather data from Filton for the year 2008. The size and shape of the area with concentration above 0.4µg/m^3 (and the area above 2µg/m^3, etc.) is very similar in the two plots. However, our plot shows the most-polluted area oriented north of NE rather than east of NE; we believe this to be due to the (well-known) difference in the prevailing wind direction between Bristol and Gloucester.

Figure 1 was obtained using a building roof height of 48.195m. When we reduced the roof height, the small highly-polluted area (above 2µg/m^3) near the stack reduced in size. When we removed the building completely, the area with concentration above 0.4µg/m^3 became much smaller and less polluted. Therefore, a building height of 48.195m was used for the remaining experiments.

To further compare our results with those of [1], we predicted nitrogen dioxide concentrations at 22 locations very near the incinerator, featured in Table 4.6 and Figure C.1 of [1]. We exclude the fictional locations referred to as “Kingsway” and “Hunts Grove” because their locations, according to Figure C.1 of [1], are very far from the real places with the same names. Table 1 shows our predicted concentrations of nitrogen dioxide at the 22 locations alongside the predictions of [1]. Like [1], we assume that nitrogen dioxide makes up 70% of the nitrogen oxide pollution. Unlike [1], we use the correct spelling of place names.

Our results are almost the same as those of [1], on average. Our prediction for Colethrop Farm is 169% more than that of [1], but this is explained by the anticlockwise rotation of the cumulative plume, caused by the difference in prevailing wind direction. For the same reason, our prediction for Chestnut Farm is substantially less than that of [1], and we also “underpredict” pollution in other places to the east of the incinerator.

On the whole, our predictions and those of [1] are remarkably similar, except for the pollution in the hills in the SE corner of the map of Figure 1, which does not appear in the map of [1]. We investigate this in Sections 2.2 and 2.3.

Table 1. Annual mean ground-level concentration of nitrogen dioxide (1/7/2014-30/6/2015) at locations near the incinerator.

Place name	Annual mean ground-level conc NO_2		
	Ref [1]	Our prediction	Difference %
Broadfield Farm	0.190	0.199	+5
Chestnut Farm	0.910	0.275	–70
Colethrop Farm	0.340	0.913	+169
Gables Farm	0.260	0.321	+23
Haresfield	0.200	0.155	–23
Haresfield Court	0.150	0.175	+17
Hill View Farm	0.230	0.419	+82
Hiltmead Farm	0.280	0.410	+46
Lindas Home	0.240	0.294	+23
Little Haresfield	0.150	0.178	+19
Lodge	0.720	0.517	–28
Newhouse Farm	0.300	0.420	+40
Old Airfield Farm	0.410	0.506	+23
Parkend Farm	0.160	0.209	+31
Pool Farm	0.390	0.518	+33
Putloe	0.290	0.281	–3
Road Farm	0.300	0.422	+41
Round House	0.450	0.204	–55
Royston	0.940	0.320	–66
Summer House Farm	0.490	0.919	+88
Travellers Park	0.280	0.312	+11
Warren Farm	0.280	0.246	–12
Average	0.362	0.373	+18

2.2 The Cotswold Beechwoods

Several environmentally sensitive areas are examined in [1]. The authors predict the nitrogen deposition and acid deposition, as well as the concentration of nitrogen oxides, sulphur dioxide, hydrogen flouride, and ammonia, at each site. They conclude that all predictions at all sites are below the respective "screening benchmarks", and so there will be no significant pollution. Since the Cotswold Beechwoods SAC comes closest to the benchmarks, we reexamine this here, focusing only on the nitrogen deposition rate and the concentration of nitrogen oxides and ammonia.

Figure 2 shows the location of the Cotswold Beechwoods (as a red rectangle) and Table 2 lists the coordinates of 28 locations within this rectangle taken from Table 4.16 of [1].

We used AERMOD to predict the concentrations of nitrogen oxides and ammonia at these locations and compared them with the "critical levels for the protection of vegetation and ecosystems" [10], which are 30µg/m^3 for nitrogen oxides and 3µg/m^3 for ammonia. We also calculated the deposition rate of nitrogen at each of the locations and compared this with the critical level, which according to [1] is 10kgN/ha/year.

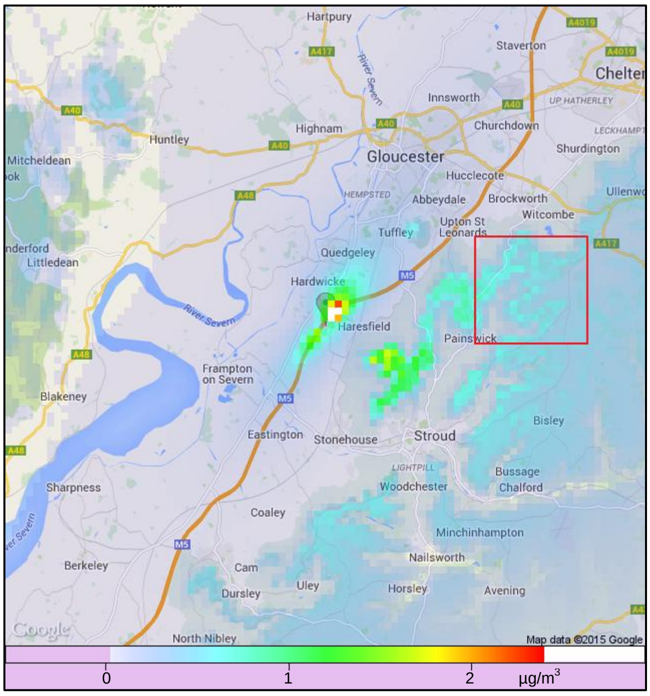

Figure 2. Map showing the area (in red) containing the Cotswold Beechwoods, with heatmap showing the predicted annual mean ground-level concentration of nitrogen dioxide (1/7/2014-30/6/2015), assuming that 70% of the nitrogen oxides are in the form of nitrogen dioxide.

The nitrogen deposition rate for woodland is defined by:

$$d = 315.36\left(0.003 \times \frac{14}{46} c_{NO_2} + 0.0003 \times \frac{14}{46} c_{NO} + 0.03 \times \frac{14}{17} c_{NH_3}\right)$$

[1], where c_{NO_2}, c_{NO}, and c_{NH_3} are the predicted concentrations (in μg/m^3) of nitrogen dioxide, nitric oxide, and ammonia, respectively, and *d* is the deposition rate in kgN/ha/year. Although they do not say so, it seems that the authors of [1] assume that nitrogen dioxide constitutes the same fraction (70%) of the nitrogen oxides as they assume for the locations near the incinerator; therefore, we make the same assumption.

Table 2 shows our predicted concentrations of nitrogen oxides and ammonia, and the derived nitrogen deposition rate, at each of the 28 locations. The average value of all of these values (columns 3-5) is well above the 1% benchmark; in fact, the deposition benchmark is exceeded at *every* location. To determine whether this finding depends on the AERMOD options used, we show in columns 6-8 the same values computed by AERMOD with the options that produce the lowest concentrations. Even with these options, the 1% benchmark for nitrogen oxides concentration is exceeded at some locations and the deposition benchmark is exceeded at almost all locations.

Since the predicted pollution is above the benchmarks, one solution would be to increase the stack height. Figure 3 shows that the stack height would need to increase to at least 140m (using the regulatory default options) or 120m (using AERMOD's most optimistic options).

Table 2. Annual mean ground-level concentration of nitrogen oxides and ammonia (1/7/2014-30/6/2015) and nitrogen deposition rates at 28 locations in the Cotswold Beechwoods.

Easting	Northing	Regulatory Default Options			Least Polluting Options		
		Concentration		Deposition	Concentration		Deposition
		NOx	NH_3	N	NOx	NH_3	N
388090	209584	0.543	0.027	0.325	0.263	0.013	0.158
390502	210750	0.514	0.026	0.309	0.218	0.011	0.131
388334	209937	0.448	0.022	0.268	0.220	0.011	0.132
389824	211210	0.417	0.021	0.250	0.188	0.009	0.113
387846	213053	0.565	0.028	0.339	0.292	0.015	0.175
388442	213351	0.630	0.032	0.378	0.311	0.016	0.186
389093	210723	0.470	0.023	0.282	0.228	0.011	0.137
386979	212349	0.797	0.040	0.478	0.397	0.020	0.238
387304	213053	0.479	0.024	0.287	0.270	0.013	0.162
392264	214598	0.443	0.022	0.265	0.180	0.009	0.108
388578	211427	0.549	0.027	0.329	0.269	0.013	0.161
389852	210181	0.209	0.010	0.125	0.106	0.005	0.063
389879	210967	0.552	0.028	0.331	0.249	0.012	0.149
388632	213866	0.601	0.030	0.360	0.290	0.014	0.174
391180	213026	0.298	0.015	0.179	0.129	0.006	0.077
389472	212322	0.440	0.022	0.264	0.218	0.011	0.131
391505	213812	0.299	0.015	0.179	0.146	0.007	0.088
389499	209964	0.437	0.022	0.262	0.207	0.010	0.124
390475	211698	0.343	0.017	0.206	0.149	0.007	0.089
388795	213433	0.414	0.021	0.248	0.198	0.010	0.119
387548	212891	0.599	0.030	0.359	0.292	0.015	0.175
390095	210235	0.548	0.027	0.328	0.233	0.012	0.140
389391	213379	0.572	0.029	0.343	0.270	0.014	0.162
390529	212566	0.427	0.021	0.256	0.186	0.009	0.111
388957	211780	0.436	0.022	0.262	0.221	0.011	0.132
391071	211617	0.387	0.019	0.232	0.162	0.008	0.097
387521	212701	0.584	0.029	0.350	0.285	0.014	0.171
390909	211346	0.453	0.023	0.272	0.189	0.009	0.114
Average		0.481	0.024	0.288	0.227	0.011	0.136
Maximum		0.797	0.040	0.478	0.397	0.020	0.238
Critical level		30.000	3.000	10.000	30.000	3.000	10.000
Max % critical level		2.657	1.329	4.781	1.323	0.661	2.380
Benchmark %		1.000	1.000	1.000	1.000	1.000	1.000

2.3 Most polluted towns and villages

Because the AERMOD modelling predicted substantial pollution on hills, we ran AERMOD with and without terrain data, to predict the concentration of nitrogen oxides at the towns and villages in the area. All towns and villages within a 60x60 km square, centred on the incinerator, were extracted from the OS gazetteer [11], with their coordinates (to 500m resolution), and used as receptors. Two places that are not in the gazetteer were added manually: Hunts Grove (381400, 212300) and Kingsway (381500, 214000).

Again we ran the model with AERMOD's regulatory default options and most optimistic (lowest pollution) options. Without terrain (the non-default "FLAT" option of AERMOD), the most polluted towns and villages are listed in Table 3. These are downwind (NE or SW) from the incinerator. With terrain, the list is shown in Table 4: several places in the hills to the east are now shown as polluted.

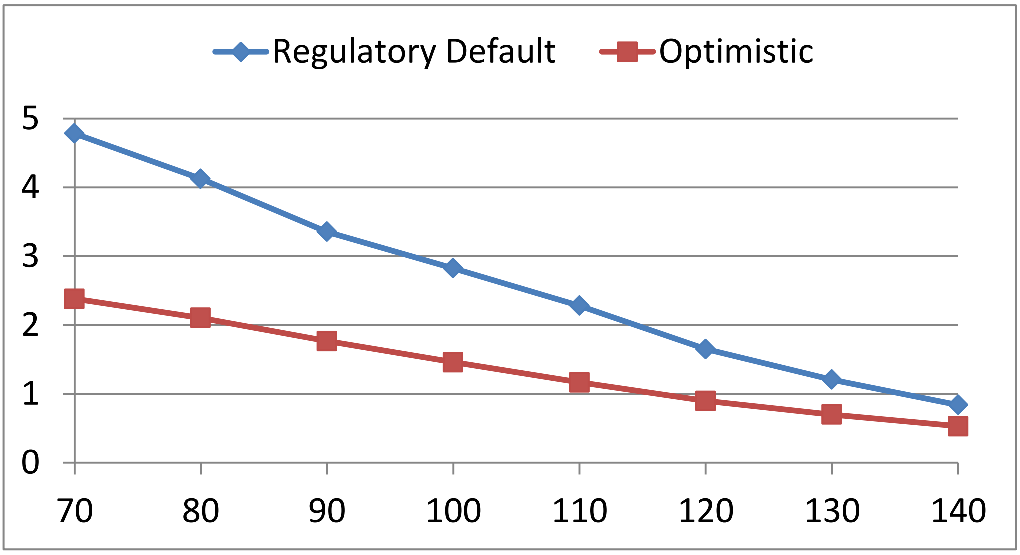

Figure 3. Relation between stack height (metres) and predicted maximum nitrogen deposition rate in the Cotswold Beechwoods, as a percentage of the critical level. The regulatory default options of AERMOD and its most optimistic options are compared.

Table 3. Most polluted towns and villages, without modelling of terrain.

Rank	**Regulatory Default Options**		**Least Polluting Options**	
	Place name	**Conc NOx**	**Place name**	**Conc NOx**
1	Hunts Grove	0.764	Hunts Grove	0.709
2	Moreton Valence	0.485	Moreton Valence	0.415
3	Kingsway	0.399	Kingsway	0.357
4	Quedgeley	0.310	Quedgeley	0.251
5	Whitminster	0.273	Whitminster	0.230
6	Haresfield	0.250	Haresfield	0.208
7	Tuffley	0.228	Tuffley	0.206
8	Brookthorpe	0.175	Brookthorpe	0.152
9	Hempsted	0.158	Hempsted	0.133
10	Barnwood	0.135	Barnwood	0.123
11	Matson	0.135	Matson	0.119
12	Gloucester	0.129	Gloucester	0.116
13	Eastington	0.126	Hucclecote	0.102
14	Hucclecote	0.114	Longlevens	0.102
15	Longlevens	0.112	Eastington	0.098
16	Abbeydale	0.110	Abbeydale	0.098
17	Innsworth	0.104	Innsworth	0.094
18	Churchdown	0.101	Churchdown	0.091
19	Elmore	0.095	Longford	0.074
20	Longford	0.084	Staverton	0.072

Table 4. Most polluted towns and villages, including modelling of terrain.

Rank	Regulatory Default Options		Least Polluting Options	
	Place name	Conc NOx	Place name	Conc NOx
1	Edge	0.996	Hunts Grove	0.706
2	Randwick	0.787	Edge	0.507
3	Hunts Grove	0.760	Randwick	0.469
4	Cranham	0.511	Moreton Valence	0.399
5	Nympsfield	0.478	Kingsway	0.356
6	Moreton Valence	0.469	Nympsfield	0.263
7	Amberley	0.413	Quedgeley	0.244
8	Eastcombe	0.399	Cranham	0.238
9	Kingsway	0.398	Whitminster	0.230
10	Bisley	0.365	Tuffley	0.210
11	Bussage	0.358	Amberley	0.208
12	Thrupp	0.315	Haresfield	0.205
13	Kingscote	0.309	Uley	0.183
14	Minchinhampton	0.305	Thrupp	0.183
15	Quedgeley	0.300	Eastcombe	0.166
16	Uley	0.288	Bussage	0.164
17	Miserden	0.285	Minchinhampton	0.152
18	Whitminster	0.273	Brookthorpe	0.152
19	Drybrook	0.251	Bisley	0.145
20	Haresfield	0.247	Kingscote	0.144

3. Discussion

We have tried to reproduce some of the experiments from [1] but using a different modelling system, AERMOD, instead of ADMS, and a different source of weather data. As far as possible, we have deliberately made the same assumptions as [1]: for example, the proportion of nitrogen oxides that are nitrogen dioxide, the roughness length used, etc. Nevertheless, we found that two important conclusions of [1] do not hold:

1. "*The impact* [in terms of pollutant concentrations] *of the facility at all of the sensitive habitats within the H1 screening distance is ... less than 1% of long term benchmarks*"
2. "*the facility will not contribute more than 1% of the critical loads for nitrogen deposition ... at any of the sites*"

We found (Table 2) values of 2.657% (nitrogen dioxide concentration) and 4.781% (nitrogen deposition), for the worst-affected locations in the Cotswold Beechwoods. We also found that, using the non-regulatory default options of AERMOD, we could reduce these to 1.323% and 2.380%, respectively, which are still well above 1%.

It is worth considering whether these results are robust to any other choices that we could have made. We discuss some alternatives here.

Building downwash. We modelled the incinerator building from the plans because the authors of [1] did not reveal their method of modelling it. To check whether our results could be affected by our method, we repeated the experiments with different heights for the main part of the incinerator building and with no building at all. The greatest difference was observed when the building was removed, but even then the predicted concentration at every location in the Cotswold Beechwoods differed by a very small amount: 1% at most. The results reported in Table 2 would change by less than 0.1%, as shown in Table 5.

Table 5. Annual mean ground-level concentration of nitrogen oxides (1/7/2014-30/6/2015) and nitrogen deposition rates at most-affected location in the Cotswold Beechwoods. Effect of removing incinerator building from model.

	Regulatory Default Options		**Least Polluting Options**	
	NOx conc	**N deposition**	**NOx conc**	**N deposition**
Table 2	2.657	4.781	1.323	2.380
No building	2.656	4.779	1.320	2.376

Stack tip downwash. AERMOD models stack tip downwash by default. We repeated the experiments with this feature turned off, but the resulting values were unchanged.

Site characteristics. AERMET allows three parameters to describe the area around the emissions source: albedo, Bowen ratio, and roughness length. It also allows these to be specified for different directions from the source and for different times of year. We use a roughness length of 0.3m (in all directions at all times), as specified in [1]. Unfortunately, the authors of [1] did not reveal what albedo or Bowen ratio they used. For all of our experiments reported above, we chose 0.2 for albedo and 1.0 for Bowen ratio, following guidance in the AERMOD User's Guide. However, to check whether this choice affects our conclusions, we also repeated the Cotswold Beechwoods experiment for some other, extreme, values of these two parameters; see Table 6. The results varied from a 1.2% decrease (using a high Bowen ratio, more suitable for desert shrubland) to a 5.2% increase in the amount of pollution predicted.

Table 6. Annual mean ground-level concentration of nitrogen oxides (1/7/2014-30/6/2015) and nitrogen deposition rates at most-affected location in the Cotswold Beechwoods. Effect of varying albedo and Bowen ratio.

Albedo	**Bowen ratio**	**Regulatory Default Options**		**Least Polluting Options**	
		NOx conc	**N deposition**	**NOx conc**	**N deposition**
0.1	0.1	2.690	4.841	1.364	2.453
0.1	1.0	2.643	4.755	1.316	2.368
0.1	6.0	2.624	4.722	1.302	2.342
0.2	0.1	2.705	4.868	1.369	2.464
0.2	1.0	2.657	4.781	1.323	2.380
0.2	6.0	2.640	4.751	1.308	2.353
0.6	0.1	2.797	5.033	1.419	2.553
0.6	1.0	2.752	4.951	1.377	2.477
0.6	6.0	2.739	4.928	1.365	2.457

Weather data. All experiments above were performed with weather data from the Quedgeley weather station for the year 1/7/2014-30/6/2015. The weather varies in different years and different locations, so we repeated the Cotswold Beechwoods experiment for a different year (1/7/2013-30/6/2014) and a different weather station (Lansdown [6]). Results are shown in Table 7. All three combinations produced higher pollution values than our previous experiment (Quedgeley 2014-15).
The values are reasonably similar in the two different years, but the values using the Lansdown data are substantially higher than those using the Quedgeley data. This appears to be because the Lansdown weather station reports more hours with very light winds than the Quedgeley one does.

For example, in 2014-15, there were 3750 hours with wind below 1m/s in Lansdown but only 2022 hours in Quedgeley. This could be caused by a genuine difference in wind speed, in which case the Quedgeley results should be preferred because the location is closer to the incinerator. Alternatively, it could be due to a difference in sensitivity or accuracy of the equipment used by the respective weather stations.

Table 7. Annual mean ground-level concentration of nitrogen oxides and nitrogen deposition rates at most-affected location in the Cotswold Beechwoods. Effect of using weather data from different years and weather stations.

Station	Year	Regulatory Default Options		Least Polluting Options	
		NOx conc	N deposition	NOx conc	N deposition
Quedgeley	2013-14	3.020	5.433	1.565	2.816
Quedgeley	2014-15	2.657	4.781	1.323	2.380
Lansdown	2013-14	4.220	7.593	2.591	4.662
Lansdown	2014-15	5.183	9.325	2.950	5.308

4. Conclusions

Our results reveal substantial pollution in the hills to the east of the incinerator, which is greater than predicted in the Air Quality Assessment [1]. In Section 3 we tried to reduce this by changing various parameters, but our results proved robust to these changes. The most likely reason for the predicted high pollution is the difference between the ways in which terrain is modelled in AERMOD [3] and ADMS [2]. Indeed, the authors of [1] dismiss AERMOD on the grounds that "*AERMOD is not considered appropriate due to the topography around the site*", citing [12] (a paper by the developers of ADMS). On the other hand, they express no doubts about the correctness of the predictions from the ADMS modelling reported in [1].

We do not have any opinion about the relative correctness of predictions from ADMS and AERMOD. There is no way to verify either set of predictions except by building the incinerator. We only observe that AERMOD, like ADMS, is a very widely used and respected system and its predictions should not be ignored. Indeed, in a comparison of ADMS and AERMOD, an Environment Agency report [14] quoted a recommendation: "*for regulatory purposes, it is advisable to make use of two models to increase confidence in the model predictions*".

Unlike the authors of [1], we have ensured that our experiments are reproducible. To this end, all command files and data files are available online at `plumeplotter.com/news/hills`.

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