Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS049

Case Study D: Atmospheric nitrogen profile for Mole Gap to Reigate Escarpment SAC

First published 30 October 2015

www.gov.uk/government/publications/improvement-programme-for-englands-natura-2000-sites-ipens

ISBN 978-1-78354-253-6

Atmospheric nitrogen profile for Mole Gap to Reigate Escarpment Special Area of Conservation (SAC)

This document has been produced as part of IPENS049. Please read this site profile in conjunction with the report (Dragosits *et al.* 2014) that explains the methods and background. For more information visit - [Improvement Programme for England's Natura 2000 sites (IPENS)]

Conclusions:

- Mole Gap to Reigate Escarpment SAC site is located in a suburban area of southern England, close to the M25. Its designated habitats, three semi-natural and four woodland features, are sensitive or very sensitive to atmospheric nitrogen (N), with Critical Loads (CL) ≤ 10 kg N ha^{-1} yr^{-1}.
- Current N deposition in the wider area is estimated to exceed the critical load of the most sensitive habitat by up to 26 kg N ha^{-1} yr^{-1}, using the 5 km grid UK dataset. The level of exceedance may be underestimated locally for some areas of the site, given the proximity of likely local emission sources.
- The majority of N deposition received by the site originates from non-agricultural (point) emission sources. No major emission sources (> 1 t N yr^{-1}) have been identified in close proximity to the site (<2 km), and the majority of the larger sources appear to be situated downwind of the site at a greater distance.
- Emissions from road transport contribute ~ 17 % of the total N deposition received by the site. There are two roads which have been designated an Air Quality Management Area (AQMA) that pass within 100 m of the site boundary.
- NO_x emissions from the M25 are estimated to exceed 12 t NO_x-N km^{-1} yr^{-1}. NO_x monitoring around the site shows exceedances to the EU limit value. Measures targeting road transport are therefore suggested as most likely to reduce local emissions for the area.
- Agricultural NH_3 measures are thought to be less relevant here, given that the estimated agricultural emission density is relatively low and no obvious larger agricultural sources were found to be located immediately next to the site boundary during the desk top study.
- Measures targeting the wider area are relevant here and should be considered, given the large proportion of N deposited to the site as wet deposition from medium- to long-range N sources.

1. Site characteristics

***Site area*:** 8.9 km^2

Designated features:

Table 1 - Designated features for Mole Gap to Reigate Escarpment SAC

Interest Code	Interest Lay Name	Sensitivity to nitrogen deposition	Expected Exceedance Impact N
H4030	Dry heaths	Very sensitive (Mapping CL ≤20 kg N ha^{-1} yr^{-1})	Transition from heather to grass dominance, decline in lichens, changes in plant biochemistry, increased sensitivity to abiotic stress
H6211	Dry grasslands and scrublands on chalk or limestone, including important orchid sites	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Increase in tall grasses, decline in diversity, increased mineralization, N leaching; surface acidification
H6210	Dry grasslands and scrublands on chalk or limestone	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Increase in tall grasses, decline in diversity, increased mineralization, N leaching; surface acidification
H91J0	Yew-dominated woodland	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Changes in soil processes, nutrient imbalance, altered composition mycorrhiza and ground vegetation
H5130	Juniper on heaths or calcareous grasslands	Very sensitive (Mapping CL ≤10 kg N ha^{-1} yr^{-1})	Transition from heather to grass dominance, decline in lichens, changes in plant biochemistry, increased sensitivity to abiotic stress
H9130	Beech forests on neutral to rich soils	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Changes in ground vegetation and mycorrhiza, nutrient imbalance, changes soil fauns
S1304 & S1323	Greater horseshoe bat & Bechstein`s bat	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Changes in soil processes, nutrient imbalance, altered composition mycorrhiza and ground vegetation
H5110	Natural box scrub	Sensitive (Mapping CL >10 - 20 kg N ha^{-1} yr^{-1})	Increase in tall grasses, decline in diversity, increased mineralization, N leaching; surface acidification

N.B. - different deposition types (see Figure 2 and Table 2) should be used to assess each feature; semi-natural features are shown in grey, woodland features are shown in green

***Landscape context*:** Suburban area surrounding South London. The site is situated south of the M25 motorway, the main orbital motorway which surrounds London, and is one of the busiest motorways in Europe. Parts of the site are ~ 50 m from the M25. The site is comprised of several distinct parts, which are separated by distances of >500 m. As N emissions from roads are deposited in a relatively small area, the site has been split into three sub-sites comprising 1.2-6 km^2 for the assessment of N threats and potential mitigation measures.

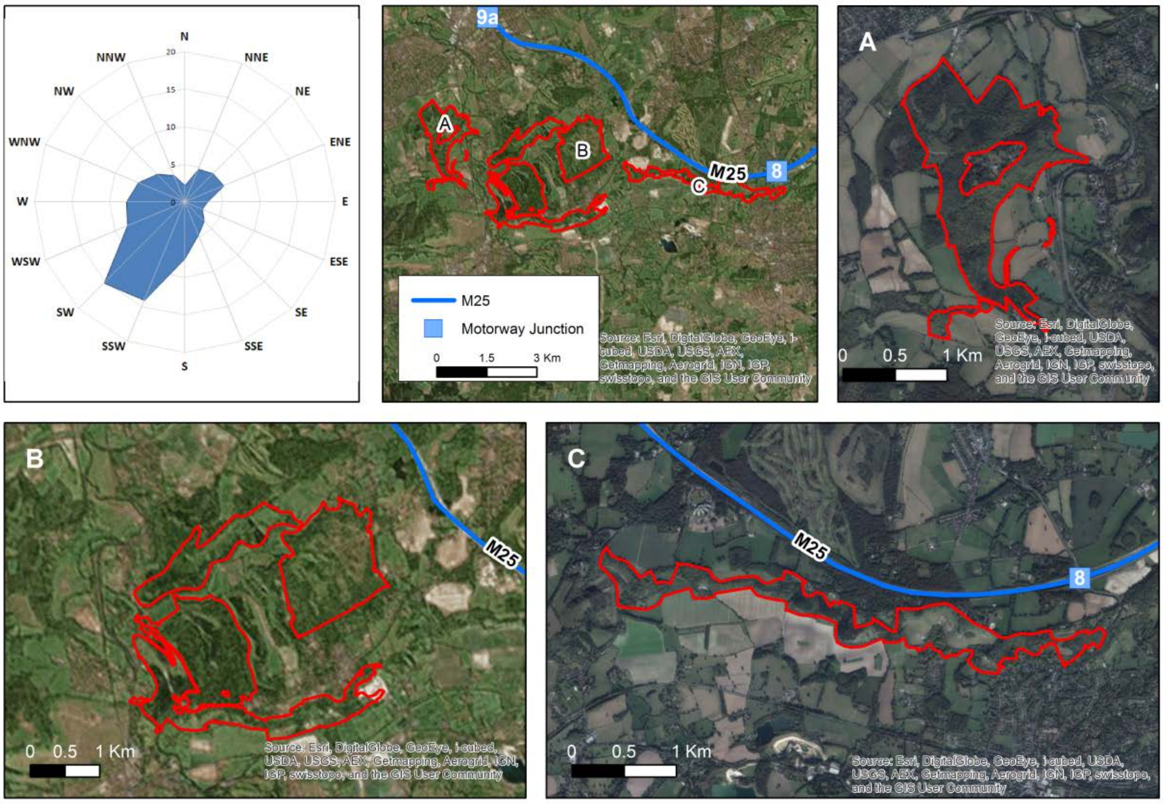

Figure 1 - Location of the sub-sites of Mole Gap to Reigate Escarpment - A) Fetcham Downs; B) Box Hill; C) Reigate Hill;. Wind rose shows the annual average (05/13 - 05/14) wind direction (%) in Mercers Park (located ~4km east of sub-site C), data from Windfinder (accessed 03/07/14).

2. Deposition and concentration estimates

5 km deposition modelling: The most recent available model estimate of N deposition at the site is in exceedance of the designated features' critical loads by ~ 26 kg N ha^{-1} yr^{-1} (CBED model output for 2010-2012, also available on APIS) It should be noted that the 2010-2012 estimates of N deposition are marginally higher than those predicted for 2005, the most recent year with source attribution data. Given the large spatial variability of N at the landscape scale, the exceedance values presented in Table 2 may be an underestimate in close proximity to N sources near the site boundary, for example, the contribution of road transport to N deposition in the immediate vicinity of the M25 motorway (sub-site C), is likely to be higher than the 5km source attribution estimate. It is estimated that over 40 % of the total N deposition come from NO_x sources, reflecting the high proportion of deposition from non-agricultural (point) sources and road transport.

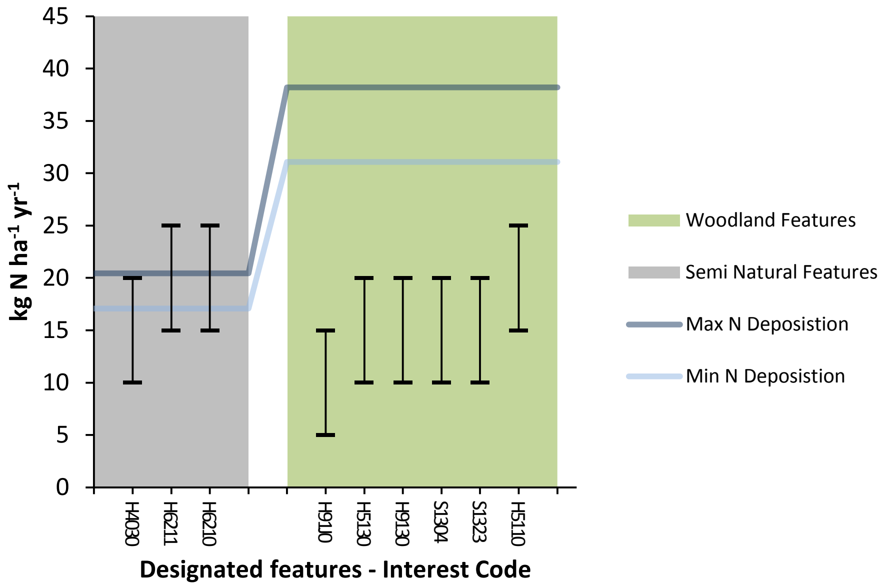

Figure 1 - Critical load exceedance for Mole Gap to Reigate Escarpment SAC, designated semi-natural features (grey) and woodland features (green), from APIS. N deposition values are derived from the 2010-2012 CBED model output.

1 km NH_3 concentration modelling: The 1 km grid resolution NH_3 dataset (FRAME model output) shows that the central part of the site (sub- site B) is estimated to have an NH_3 concentration of < 1 µg m^{-3}, which is below the critical level for the most sensitive species (lichens and mosses). Given the sub-urban location of the site, this suggests that NO_x sources contribute a higher proportion of the N deposition than for designated sites that are surrounded by intensive agriculture. This further illustrates that a relatively high proportion of the total N deposition arrives as from medium/long-range source areas, compared with intensive agricultural areas which have higher local proportions of NH_3 dry deposition.

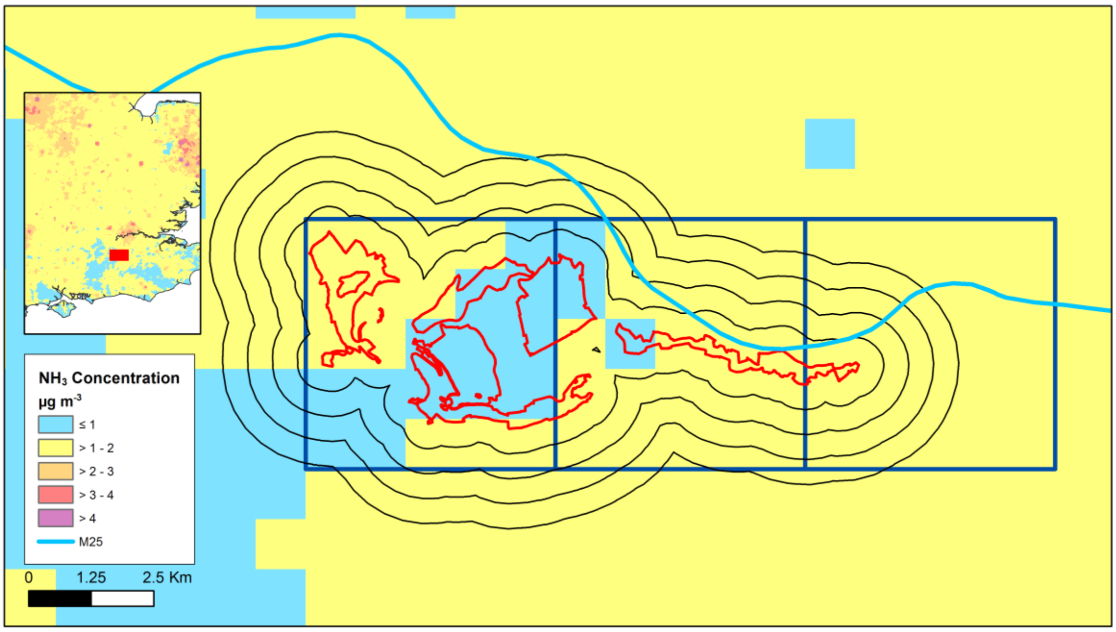

Figure 3 - Ammonia concentrations at Mole Gap to Reigate Escarpment SAC (FRAME 1 km dataset for 2011), with the M25 motorway marked. The outlines of the 5 km grid squares used in the deposition modelling and source attribution datasets are superimposed in blue.

3. Source attribution calculations

***5 km Source attribution calculations*:** The initial scenario approach (using the source attribution dataset from 2005), shows non-agricultural (point) sources contributing approximately 35 - 40 % of the total N deposition, across the three 5 km grid squares containing the site. Roads are estimated to contribute 13 - 18 % of the total N deposition, with several A-roads located < 10 m from the site boundary. A significant fraction (39 - 51%) of the total N deposition to the site is estimated to arrive as wet deposition, which is more indicative of medium/long range N sources, rather than local sources.

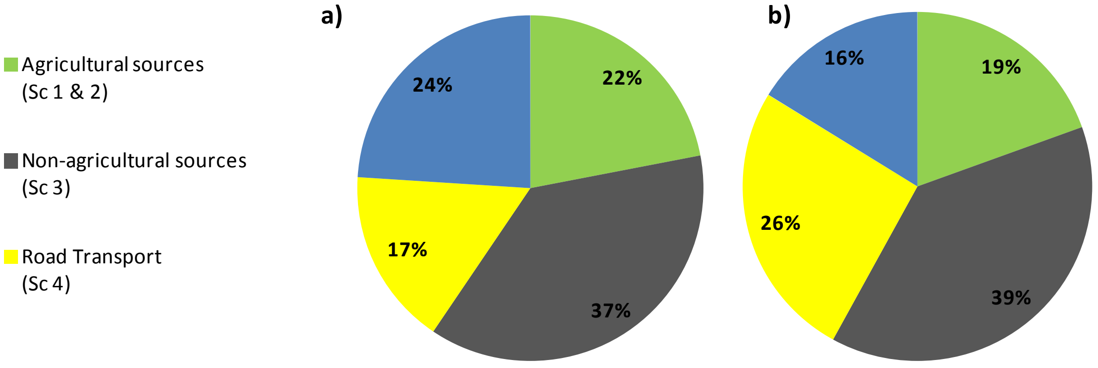

Figure 4 - Source attribution chart, showing the mean contributions to the N deposition estimated for a) semi-natural features, b) woodland features across the 5 km grid squares which contain Mole Gap to Reigate Escarpment SAC.

Table 1 - Mole Gap to Reigate Escarpment SAC: Scenario allocation derived from the source attribution dataset (2005) using the initial scenario approach

Sub-site	Area (km^2)	Deposition Type	Scenarios allocated (number, IDs)	Range in total N deposition for sub-site (kg N ha^{-1} yr^{-1})	Scenario allocations for sub-site (in **bold)**				Nearest Features (m)	
					Source Attribution (% of total N deposition)			Total wet N deposition		
					Agriculture (fertiliser & livestock)	Non-Agricultural sources	Roads	Long Range N deposition	Intensive farm	Major road
A	1.83	Semi-natural vegetation	4 (Sc1, Sc3, Sc 4, Sc5)	17.8	**23.2**	**35.7**	**13.8**	**51.5**	> 10,000	**183**
		Woodland	3 (Sc1, Sc3, Sc4)	34.5	**20.7**	**38.6**	**22**	29.2		
B	1.47	Semi-natural vegetation	4 (Sc1, Sc3, Sc 4, Sc5))	17.8 - 18.8	**21.1**	**36.7**	**18.1**	**44.9**	> 10,000	**Intersects**
		Woodland	2 (Sc3, Sc4)	34.5 - 37.7	18.6	**37**	**28.1**	26.4		
C	2.21	Semi-natural vegetation	3 (Sc1, Sc3, Sc4)	18.8 - 20.3	**21.5**	**40.1**	**17.7**	39.4	> 10,000	**Intersects**
		Woodland	2 (Sc3, Sc4)	34.5 - 40.1	19.1	**39.9**	**27.15**	23.3		

N.B. ***the source attribution data refers to the 5 km grid square with higher estimated N deposition at each sub-site. Scenario totals will not add up to 100%, due to rounding and other small source categories, which are not included in the scenario definitions (e.g. dry deposition from imported emissions and offshore installations). The colour coding shows allocated scenarios in red and scenarios below the threshold are un-shaded.***

4. Inventory of most likely local emissions sources (desk based study)

Road Transport Emissions:

Estimated NO_x emissions from the road links surrounding Mole Gap are presented in Figure 5. Cape et al. (2004) found that NO_x concentrations tend to decrease to near background concentrations at around 200 m away from the road verge, therefore sites which are < 200m from the road are considered at risk from elevated concentrations and local deposition of emissions from road transport. The emissions for the M25 (< 200 m from sub-site C) are estimated to be in excess of 12 t NO_x-N km^{-1} yr^{-1}, using the Defra Emission Factor Toolkit (ref or footnote) This stretch of the M25 (between Junctions 7 and 9a) was declared an Air Quality Management Area (AQMA) in 2002 by Reigate and Barnstead Borough Council in 2002, after a study[1] had identified that NO_2 concentrations were unlikely to meet the Government's 2005 annual average objective for NO_2 of 40 µg m^{-3}, which is equivalent to the 2010 EU limit value. 2010 monitoring data of the AQMA show annual mean NO_2 concentrations of 26.5-31.1 µg m^{-3} near the site[2]. The annual average daily traffic flow of the M25 by site C (between Junctions 8 -9a) exceeds 140,000 vehicles daily (AADF, 2012), 9 % of which are HGVs which contribute 37% of total NO_x emissions for this stretch of this M25 (Figure 6).

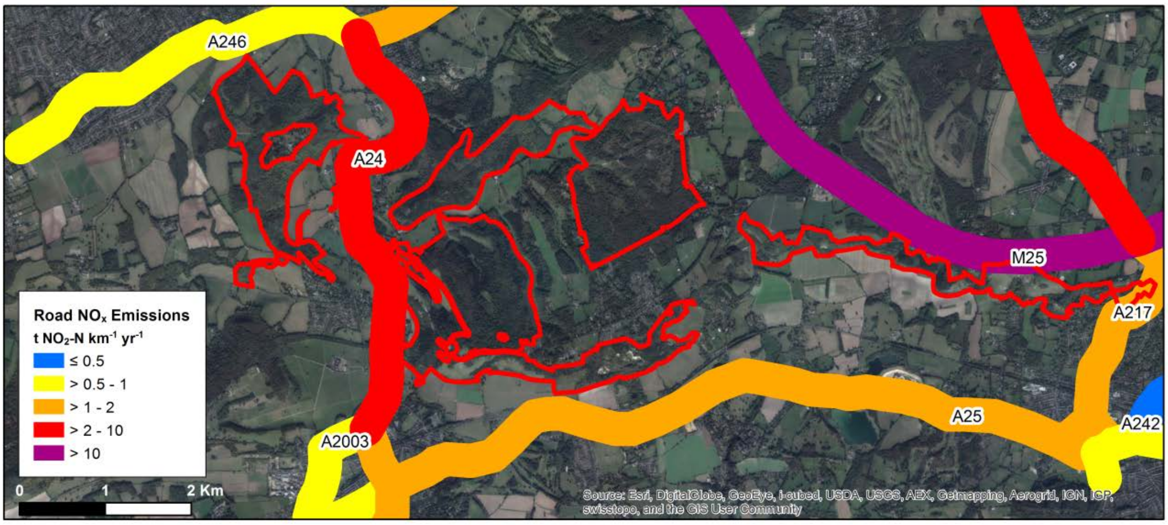

Figure 5 - Estimated annual NO_x emissions (Defra EFT, 2014 and DfT AADF 2012) from road links surrounding Mole Gap to Reigate Escarpment SAC. Roads buffered to 200 m (following work by Cape et al. 2004).

[1] Air Quality Consultants (2001) Stage 3 Local Air Quality Review and Assessment - NO_2 and PM10. Report No. A35870100/yb/1743/final. Bristol, UK. Available at: https://www.reigate-banstead.gov.uk/Images/stage3_tcm9-4873.pdf

[2] AQC (2011) Progress report on Air Quality within the Borough of Reigate and Banstead. Available at http://www.reigate-banstead.gov.uk/Images/2010_26054_RPR_003_Final_2011Progress%20Report_tcm9-44270.pdf

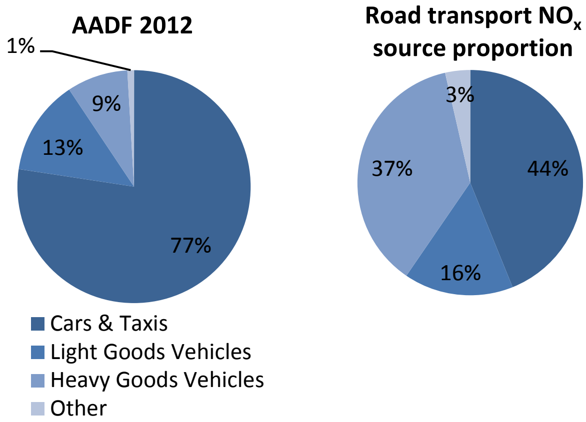

Figure 6 - 2012 annual average daily traffic flow (DfT, 2013) for M25 (J 8 - 9a) and estimated NO_x source apportionment (using the Emission Factor Toolkit v.6.0.1, Defra, 2014)

To the west of the site, the A217 (Reigate Hill) is also designated an AQMA (AQMA11). Sections of the A217 are < 10 m away from the boundary of the site. 2010 monitoring data[3] from the A217 shows annual mean NO_2 concentrations of 42.9 µg m^{-3}, exceeding EU limit values. The DfT estimates the average daily traffic flow of the A217 at over 19,000 vehicles for 2012, with 25 % of emissions being produced from HGVs.

Agricultural emissions:

From the agricultural census analysis, it appears that there are relatively few agricultural holdings located in a 2 km zone around Mole Gap to Reigate Escarpment SAC. The proportion of sectors which contribute to the agricultural NH_3 emissions for the area is presented in Figure 7. The agricultural emission densities for the sub-sites are relatively low; ranging from 1.1 (sub-site B) to 6.3 kg ha^{-1} yr^{-1} (sub-site A), with sub-site C at 3.3 kg ha^{-1} yr^{-1}.

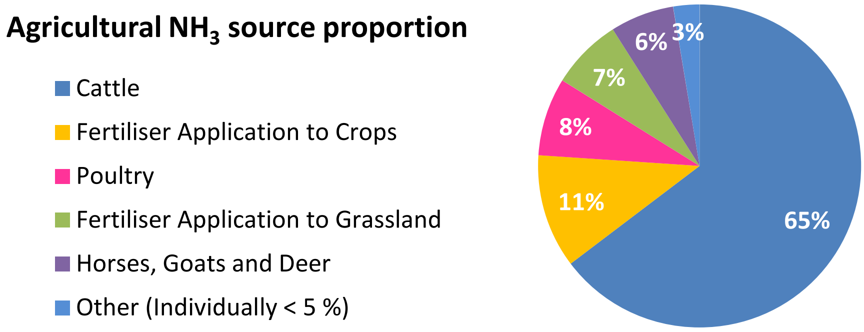

Figure 7 - Agricultural NH_3 emission sources in the 2km is surrounding Mole Gap to Reigate Escarpment derived from 2012 agricultural census

A visual inspection of Google Earth imagery indicates that there are no major agricultural sources close to the site boundary, therefore considering the low emission density it appears that targeting non-agricultural sources is more appropriate for this site.

[3] AQC (2011) Progress report on Air Quality within the Borough of Reigate and Banstead. Available at http://www.reigate-banstead.gov.uk/Images/2010_26054_RPR_003_Final_2011Progress%20Report_tcm9-44270.pdf

Other N sources:

From the NAEI dataset of NO_x and NH_3 point sources, it appears that there is only one non-agricultural source < 2 km from the site. This (commercial combustion) source only produces ~ 30 kg NO_x-N yr^{-1}. More significant sources are present >2 km from the site, e.g. a number of landfill sites with gas combustion with emissions >15 t NO_x-N yr^{-1} per site east of Reigate and Redhill (East of sub-site C). However these sources are located > 2.5 km downwind of the prevailing wind and are therefore less likely to significantly impact the site. In the source attribution database (available via APIS), almost 24 % of the total N deposition to the site is imported emissions (almost all of the other sources category, Figure 4). The high-proportion of N arriving as wet deposition (> 40 %) further suggests that medium/long-range sources are contributing substantially to N deposition at the site. Concerns were raised about the impact air-traffic from/to London Gatwick Airport may have on the site, as the airport is situated just over 10 km from the site. In this case, the N deposition due to aircraft movement may be underestimated, as the UK emission inventory only includes aircraft emissions from take-offs and landings (defined as < 914 m in altitude). Therefore the full N deposition due to emissions related to Gatwick may not be included in the source attribution dataset.

5. Selection of potential measures

Local road emissions appear to contribute significantly to the N deposition at Mole Gap to Reigate Escarpment SAC. Road measures are therefore shown here as likely to be most effective for reducing N deposition through spatially targeted measures, given that local sources in other sectors appear to be relatively minor or situated downwind of the prevailing wind. Reigate and Barnstead Borough Council have proposed a number of measures to address the expected exceedance of EU limit values produced by the M25 and A217. Since the M25 AQMA was designated, improvements have been made to signage and road markings at Junction 7 (east of sub-site C) and the installation of overhead signs to allow hard shoulder running to increase capacity and reduce congestion ('smart motorway'). The relevant report (AQC, 2011) also states that one of the most cost effective measures would be to target emissions from articulated vehicles at source, as they produce disproportionate emissions. The Government response (DfT) was that new measures to address HGV emissions were unlikely to be introduced before 2011.

Table 3 summarises local and national-scale measures which could help to reduce N deposition to the site. Given that the agricultural emission density surrounding the site is minor (1.1 to 6.3 kg ha^{-1} yr^{-1}), measures to target these sources locally were therefore not included in the table. As no significant non-agricultural point sources were identified close to the site, it would be difficult to reduce non-agricultural emissions at the local scale (especially given that a large proportion is estimated to be imported emissions), therefore these measures are also not listed here.

Table 3 - Potential local measures for decreasing local concentrations and deposition of nitrogen to Mole Gap to Reigate Escarpment SAC for the main local sources, selected from a list of potential measures.

N source	Measure	Mitigation effect
Road Transport	Introduction of demand management technique (e.g. congestion charge or low emission zones (LEZs)	12
Road Transport	Installation of bunds/screens	Not determined under this study
Road Transport	Installation of a photo-catalytic barrier next to the road, to recapture NO_x emissions from vehicular exhausts. The barrier is coated with a titanium dioxide catalyst, which oxidises NO_x	≤ 75
Road Transport	Realignment of roads	N/A
Road Transport	Improve signage and access to real time traffic information	N/A
Road Transport	Promote greener technologies (alternative fuels and end of pipe technologies)	N/A
Road Transport	Implement a dynamic traffic signal system	N/A

References:

Dragosits U., Carnell E.J., Misselbrook T. and Sutton M. (2014a) Site categorisation for nitrogen measures. Final report to Natural England for project IPENS049. 20 pp. http://publications.naturalengland.org.uk/publication/5802656649969664