An Assessment of Possible Air Quality Impacts on Vegetation from Processes Set out in the Bournemouth, Dorset & Poole Waste Local Plan

Air Quality Consultants

An Assessment of Possible Air Quality Impacts on Vegetation from Processes Set out in the Bournemouth, Dorset & Poole Waste Local Plan

Prepared by

Prof. Duncan Laxen and Dr Ben Marner

on behalf of

The Dorset Waste Planning Authority

April 2005

Contents

1 Introduction

1.1 The Bournemouth, Dorset and Poole Waste Local Plan (DCC, 2004) proposes policies that will reduce the amount of waste going to landfill through promoting alternative processes and technologies. A number of these processes have the potential to release emissions of nitrogen oxides (NOx[1]) and / or ammonia into the air. In some situations, these emissions can have detrimental effects on particularly sensitive vegetation and ecosystems. This report assesses the potential impacts of a range of technologies proposed in the Waste Local Plan on surrounding ecosystems, and examines existing operational sites where appropriate. Because this report is principally related to site proposals in the Local Plan and not to the detail of any specific application, its emphasis is on assessing whether each site has the potential to support the proposed technologies; rather than assessing specific plant details. The report thus uses generic information to show the potential impacts of operating a typical but worst-case plant on each site.

1.2 The waste-processing technologies that are considered in this report are:

- Open (windrow) composting (OWC);
- In-vessel composting (IVC);
- Mechanical and Biological Treatment (MBT);
- Power generation from Refuse Derived Fuel (RDF);
- Power generation from landfill gas.

1.3 The sites, as defined in the Waste Local Plan, that are the focus of this assessment are:

MBT and RDF sites:

- Winfrith;
- Ferndown;
- Bournemouth Airport:
- Canford Magna (this site already supports in-vessel composting) – proposed as an omission site to the Waste Local Plan Inquiry;
- Chapel Lane (this site already supports open composting) - proposed as an omission site to the Waste Local Plan Inquiry.

Open and in-vessel composting sites:

- Chapel Lane (an existing operation).
- Binnegar.

Landfill gas power-generation site:

- Beacon Hill.

---

[1] NOx = the sum of Nitric Oxide (NO) and Nitrogen Dioxide (NO_2).

2 Environmental and Policy Context

2.1 Dorset is characterised by a number of valuable ecological habitats. The most important of these have been given statutory or other protection through designations as sites of national and international significance, as well as through recognition at a county-wide scale by local authorities in conjunction with nature conservation organisations. These sites have been notified in order to maintain selected communities of plants and animals within a broad range of habitats. The Dorset Heaths are amongst the best lowland heathlands in the UK, and are variously designated as candidate Special Area of Conservation (SAC), Special Protection Area (SPA) under the EU Habitats Directive and Birds Directive respectively, and as wetlands of international importance under the Ramsar Convention. They cover an extensive complex of heathland sites surrounding the Principal Urban Area of the county in Bournemouth and Poole, extending westwards to near Dorchester and northwards to Verwood. The designated areas that are close to the sites assessed within this report are shown in Figures 1 - 6. Most of the relevant areas are also designated as Sites of Special Scientific Importance (SSSIs) and are thus also protected under the Countryside & Rights of Way Act 2000 and the Wildlife and Countryside Act (1981), as amended. These areas are also shown in Figures 1 – 6.

2.2 There is considerable evidence that elevated concentrations of both ammonia and NOx can damage some vegetation. In addition, there is evidence that the deposition of nitrogen to the ground can damage certain habitats. Critical levels have been defined to prevent gaseous pollutants directly affecting plants. Defra (2003) define a Critical Level as "*the concentration of a pollutant in the atmosphere, below which vegetation is unlikely to be damaged according to present knowledge*". In addition to the Critical Levels, Critical Loads have been defined to prevent the long-term effects of deposition. Defra (2003) define Critical Loads as "*the amount of pollutant deposited below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge*". Critical Levels and Loads form the basis of international emission reduction negotiations and have been adopted by the UK Government to provide estimates of air pollution and ecosystem damage. The Critical Loads and Levels that apply to lowland dry heath are set out in Table 2.1.

2.3 The Critical Loads are defined for constant long-term deposition rates to steady-state ecosystems. Such conditions do not, in reality, exist and thus many habitats currently exceed their predicted Critical Loads without showing signs of damage. This does not, however, mean that the signs of damage might not appear at some time in the future. The exceedence of a Critical Load is not a quantitative estimate of damage to the environment; it represents the potential for damage. It is not certain that exceedence of the Critical Loads will lead to habitat damage.

2.4 It is recognised that the Critical Loads represent a much more stringent assessment target than the Critical Level for ammonia. This assessment thus focuses on the Critical Loads, although any likely exceedences of the Critical Levels are also highlighted.

2.5 In order to comply with the Habitats Regulations, where a process cannot be shown to have a negligible or insignificant impact on a European wildlife site, an “Appropriate Assessment” should be carried out by a “Competent Authority”. The Competent Authority is usually either the Environment Agency or the Local Authority. Whilst planning and waste management permitting are two separate processes, JNCC has suggested that it would be useful for this current assessment to refer to the Environment Agency guidance on applying the Habitats Regulations to permitting applications (Dr Clare Whitfield, pers comm.). The Environment Agency guidance, the relevant sections of which are summarised in Appendix 1, sets out a 4-stage approach to assessment and permitting. The early stages are screening exercises, while the latter stages, which constitute an Appropriate Assessment, should refer to the specifics of individual processes. This current report does not represent a step-by-step assessment of each of the sites concerned. Moreover, at this stage, there is insufficient information for most of the sites to conduct a full Stage 3 assessment based on the Environment Agency guidelines. This assessment therefore provides indicative information for each site, presented in a format which is largely compatible with Appropriate Assessment.

Table 2.1 Critical Loads and Levels Relevant to the Habitats that are the Focus of this Report [a].

Critical Level for Ammonia Concentrations ($\mu g/m^3$)	8
Critical Level for NOx Concentrations ($\mu g/m^3$)	30
Critical Load for Nitrogen Deposition (kg-N/ha/yr)	10 – 20

[a] As specified in APIS (2005) for Lowland Dry Heaths.

3 Discussion of the Processes and their Emissions

Open (Windrow) Composting

3.1 This method would only be used for green (garden) waste. The waste would be composted in the open air, in “windrows”, which are long piles of material up to 2m high. The process is essentially the same as used in gardens across the country; where material is broken down biologically to form compost. While the material is decomposed, ammonia gas may be produced. The main controlling factor for ammonia emission from compost is the carbon/nitrogen ratio. Ammonia is emitted when nitrogen is in excess. Ammonia emissions therefore tend to be highest when composting materials with a high nitrogen content[2]. The pH also affects ammonia volatilisation, with ammonia emissions much lower under acid conditions. Any emissions of NOx from the composting process itself would be negligible.

3.2 There have been relatively few quantitative measurements of ammonia emissions from composting activities. Even where measurements have been made, because of the diffuse nature of these emissions, quantifying ammonia release per tonne of input material is difficult. When measured data are unavailable, some authors have estimated emission rates based on calculations of available N in compost material. It is, however, felt that measured emission rates should be used in preference to estimates. Table 3.1 sets out a range of estimated and measured emission rates from composting activities from a variety of sources.

Table 3.1 Estimates of Ammonia Emissions from Compost [a].

Author	**Emission Rate (g NH_3 / t Input Material)[b]**	**Notes**
Sutton (2004)	370 - 1665[c]	Estimated from a simple calculation of likely processes.
Wise and Phillips (2005)	402	Estimated following the methodology of Sutton (2004).
Defra (2004)	5 – 120	From a thorough review of available research reports and measurements [d].
Puget Sound Clean Air Agency (2005)[e]	17.9	Measured source test results from inside an enclosed composter treating whole waste (prior to ammonia abatement) in the US.

[a] Without any specific methods of ammonia abatement.
[b] Throughout this report, input material mass data are given as wet weights.
[c] Calculated from the values in the cited letter.
[d] Because of the paucity of available data, Defra present these values as indicative only.
[e] These measurements have only just been made and have not yet been formally published. The PSCAA anticipate publishing their data soon (Claude Williams, PSCAA., pers comm.).

3.3 The estimates made by Sutton (2004) significantly over-predict those given by Defra. The values of Wise and Phillips also over-predict the measured data, but these authors were

---

[2] Garden waste tends to have a much lower nitrogen content than kitchen waste.

constrained to follow the method of Sutton (2004) and have confirmed (Dr Steven Wise, pers comm.) that they believe their estimates to be too high. Furthermore, Defra (2004) note that the largest value in their range (120 g/t) relates to whole waste and will be too high to accurately describe green waste composting (the only type that would be composted in open systems). Emissions are thus more likely to tend toward the lower end of their range. The data presented by Defra (2004) are supported by the recent measurements made in the US (PSCAA, 2005). Much more confidence can be placed in measured data than in estimates and so this assessment makes use of the most stringently peer-reviewed data (Defra, 2004) and presents results for the full range of emission scenarios (5 g/t – 120 g/t).

In-Vessel Composting

3.4 In-vessel composting includes a range of techniques for composting organic materials in enclosed environments. It is suitable for a wider range of waste materials than open composting and might be used for separated wastes or mixed household waste. In-vessel composting is an aerobic process, relying on the presence of air, and is essentially the same as open composting, except that it is more closely controlled. The material that could be composted in these enclosed systems is likely to have a lower carbon to nitrogen ratio (i.e a high nitrogen content) than garden waste and thus the potential for ammonia emissions is greater. There is, however, significantly more potential to control emissions from in-vessel composting, as the emitted gases can be contained and treated and their subsequent release can be controlled. It is also potentially possible to control the carbon/nitrogen ratio to reduce ammonia emissions (DETR, 2001). As with open composting, any emissions of NOx will be negligible. In-vessel composting is a very different process to anaerobic digestion, which is described in paragraph 3.14.

3.5 As discussed above, ammonia emissions from whole waste have been measured at up to 120g per tonne of input waste (Defra, 2004) and at 17.9g per tonne of input waste (PSCAA, 2005). The larger, peer-reviewed, figure has been used for the purposes of this current assessment. This is the emission rate prior to the application of any ammonia abatement techniques. Table 3.2 summarises some of the information presented in the DETR report "*Controlling Ammonia from Non-Agricultural Sources*" (DETR, 2001).

3.6 DETR (2001, p.42) follows on to state that "*biofiltration .. is effective at treating all odours associated with composting, including ammonia and amines. A biofilter fitted to a source of ammonia, such as the air flow from a contained compost facility, uses moist organic materials to absorb and biologically degrade ammonia and other odorous gases. Cooled and humidified compost process air is injected through a grid of perforated pipes into a bed of filtration media. Various materials can be used in the biofilter, such as compost, soil, peat, chipped brush and bark, sometimes blended with an inert material such as gravel to increase porosity*". Previous correspondence between JNCC and English Nature has suggested some uncertainty as to which atmospheric components biofilters can abate (e.g. email from Dr. Clare Whitfield, JNCC to Andrew Nicholson, EN on 17/02/05 at 14:29). DETR report was clearly of the opinion that biofilters can treat more than bioaerosols.

Table 3.2 Options for Abating Contained Ammonia Emissions[a].

Method	**Comments**	**Approximate Costs**
Biofiltration	The lowest cost end-of-pipe ammonia abatement method for small point sources. Only suitable for abating ammonia flows in the region of 1 tonne per year. There have been relatively few studies quantifying the effectiveness of biofilters, but some evidence has shown that anomalously large ammonia flows can pass through with less than optimal abatement (< 90% abatement of ammonia). If the filter is poorly maintained, filtration rates can fall.	£15k initial + £1k per year.
Dilute Acid Scrubber	A versatile and proven technology. A common choice for abating ammonia at flows of 50 to 500 tonnes per year.	Depends on size of source. < £10k initial for a small source; < £100k initial for a large source. Up to £10k running costs/yr.
Pure Water Scrubber	As above but for very low ammonia levels.	At the lower range described above.
Regenerative Thermal Oxidation	Ammonia is effectively flared off and converted to NOx. NOx would then deposit to the heathland (albeit slower than ammonia). (Unlikely to be suitable in this situation)	£100k initial with subsequent fuel costs.
Venturi Scrubber	Only suitable for large gas flows with very large ammonia emissions. (Unsuitable in this situation)	> £1 million initial + around £½ million in running costs/yr.

[a] As Described in DETR (2001).

3.7 As has been explained, the information presented in Table 3.2 was taken from a report published in 2001. This is a rapidly-growing field and not only has technology advanced, but more information has since become available. Dr. John Mullett at Cambridge Recycling Services (CRS) (pers comm.) has explained that their facilities are fully saturated with steam. Because of the high solubility of ammonia, this immediately removes much of the ammonia from inside the facility. The condensate on the cool roof of the facility is collected. Prior to emission into the atmosphere, any gas passes through a biofilter and the additional step of an ammonia scrubber can easily be added. CRS have not conducted any tests on the vented emissions, but expect the discharge to be close to zero.

3.8 Other practitioners in the field have also indicated that emissions from systems employing biofilters (Neil Winship, Alpheco Composting, pers comm) and acid scrubbers in combination with biofilters (Helmut Schneider, Vorarlberger Kraftwerke, pers comm) are likely to be negligible. It is conceded that this information is not supported by measurements. However, ammonia is a highly odorous gas (reported odour thresholds range from 0.4 to 38 $\mu g/m^3$). With frequent human exposure very close to the vented emission source (i.e. a few metres) at many sites, any inefficiency of the abatement technology is likely to have been reported.

3.9 A useful study has recently been conduced in the US by the Puget Sound Clean Air Agency (2005). Emissions were measured within an enclosed composter fitted with a biofilter only. The emissions prior to biofiltration are those presented in Table 3.1. The biofilter on its own was observed to remove 93% of ammonia from the exhaust stream; bringing real emission rates to almost zero. Another recent study (Omrani *et al.,* 2004) has shown a biofilter made up of peat, soil and sand to remove 97 – 99% of ammonia passing through it. Omrani *et al.* (2004) also tested a biofilter made up of sawdust, clay and straw and showed that it removed 94% of ammonia. These data are without the added benefit of an ammonia scrubber and other in-vessel abatement techniques (e.g. saturation with steam).

3.10 W.H. White plc. has developed a demonstration-and-test in-vessel compost facility that has been running successfully for two years at Canford Magna in Dorset. Their facility is fully enclosed and, prior to release, all gas must pass through both an ammonia scrubber and a biofilter. The abatement system has been developed by First Water UK Ltd and Bioteg. The Organic Resource Agency have conducted detailed measurements of inputs to, and subsequent emissions from, the abatement system on this plant which show a 100% ammonia abatement efficiency (ORA, 2005).

3.11 It cannot be said with any certainty what ammonia abatement methods might be employed at any of the sites assessed in this study, except for the existing site and the planned site at Canford Magna, where both scrubbers and biofilters will be present. It is clear, however, that there are cost-effective methods available that could potentially abate a very large proportion of the volatilised ammonia. Three scenarios have thus been modelled. The first represents no ammonia abatement at all. The second represents abatement using a biofilter only (with an assumed abatement efficiency of 93% (PSCAA, 2005), which is lower, and thus more worst-case, than that measured by Omrani *et al*., (2004). The third scenario represents abatement using a system similar to that supplied by First Water plc. which has been shown to provide 100% ammonia abatement (ORA, 2005). Because ORA (2005) only present their measured results to one decimal place, ammonia abatement efficiency has been assumed to be 99.9%.

3.12 Fugitive ammonia emissions (i.e. emissions that escape without passing through the ammonia filters) from an effectively run fully enclosed facility are likely to be extremely small and have not, therefore, been modelled.

Mechanical and Biological Treatment

3.13 As described in the Waste Local Plan (DCC, 2004), Mechanical Biological Treatment (MBT) facilities would primarily accept residual waste that cannot be recovered for recycling or composting. Every MBT plant could be different, but generally, the treatment would have two main stages, a mechanical stage and a biological stage. During the mechanical stage, material would be segregated into two main fractions: organic matter and combustible material. The former would go to the biological treatment stage and the latter would be used as Refused Derived Fuel (as described below).

3.14 The biological stage can either be in-vessel composting, or anaerobic digestion. Anaerobic digestion would take place in an enclosed container and would result in the production of biogas. This biogas could then be combusted and used to generate electricity. Ammonia emissions from anaerobic digestion and biogas burning are likely to be negligible, but NOx emissions might be significant. Defra (2004) estimate NOx emissions from a typical MBT plant as 72 grammes of NOx per tonne of waste. However, Defra (2004) make clear that this estimate is based on the assumption that the biological stage will be entirely open composting (i.e. with no anaerobic digestion and associated biogas combustion). Defra (2004) suggest that NOx emissions from a typical anaerobic digestion and combustion plant would be 188 grammes per tonne of waste. Here, it has been assumed that these NOx emissions sources are independent of each other and might both occur simultaneously within any MBT plant. This worst-case assumption gives a NOx emission rate from the MBT of 260 grammes per tonne of waste.

3.15 Defra (2004) also present an estimate of ammonia emissions from a typical MBT plant, but as explained above, these emission rates assume that the organic phase would be composted in the open (Defra, 2004 p47). The ammonia emission rate presented is thus the same 120 grammes of ammonia per tonne of input waste as cited for open composting. It is assumed that any MBT-plants would rely entirely on in-vessel technology and thus emissions will be the same as those described for in-vessel composting. This assumes that the entire biological phase is aerobic, while the NOx emissions assumed both aerobic and anaerobic. This is a worst-case approach all-round.

Refuse Derived Fuel

3.16 As described in the Waste Local Plan (DCC, 2004), the use of Refused Derived Fuel (RDF) involves the incineration of the non-biological material separated during the MBT stage. Defra (2004) present data on emissions from sites such as this. Their “best estimate” value is 1,587 grammes of NOx per tonne of waste incinerated, with an upper bound of 1,983 grammes of NOx per tonne of waste incinerated. NSCA (2002) also present a summary of emissions data from waste incineration operations. Their best estimate is 1,106 grammes of NOx per tonne of waste incinerated. Because the Defra upper bound is worst-case, it has been used to represent a typical RDF plant in this study. No ammonia emissions are expected from RDF plants.

Landfill Gas Power-Generation

3.17 This technology would derive electricity from gas that would otherwise be flared off. Ammonia is not emitted in any significant quantity from this technology itself. NSCA (2002) present values of NOx emissions from landfill gas engines that range from 0.2 to 3.4 Kg of NOx per tonne of waste landfilled. These data vary by a factor of more than 10, making it very difficult to predict the emissions from a specific plant without more detailed information.

4 Methodology

Receptors

4.1 Even though nitrogen deposition is conventionally expressed in kg per hectare, effects can impact on relatively small areas (i.e. sub-hectare scales). This assessment thus focuses on specific points at which impacts will be greatest. Generally speaking, these tend to be the closest point of protected heathland to the emission source. Further away from emission sources, impacts will be smaller[3]. The receptors used in this assessment are shown in Figures 1-6.

Process/Plant Details

4.2 The emission rates per tonne of waste throughput from each activity have already been described, and are summarised in Table 4.1. For the purposes of this assessment, the waste throughput rates for each activity given in Table 4.1 have been assumed. For the existing sites, these data have come from the local site operators (Brett Turner, Eco Composting Ltd., pers comm.; Chris Hawkins, W.H. White plc., pers comm.). Activity rates at the proposed sites are thought to be reasonable estimates. It is, however, important to note that impacts will be roughly proportional to activity rates, so altering plant throughputs would alter the magnitude of potential impacts.

4.3 The dimensions of each facility and the release characteristics of each emission source that have been assumed are set out in Table 4.2. The location of each emission source is shown in Figures 1 – 6. For the in-vessel composters and MBTs, it has been assumed that un-abated ammonia emissions would be released from a vent above the facility roof. Abated emissions, however, would be released directly from the biofilter. NOx emissions from MBTs have been added to the emissions from the RDF stack. Where possible, very simplistic site layouts have been assumed, based loosely on the dimensions of existing facilities. Because the purpose of this assessment is to determine whether each site has the potential to support a process, rather than to assess the impacts of a specific plant, this approach is deemed sufficient.

---

[3] Concentration profiles have been produced (not presented here) to show that the maximum ground-level concentration associated with the elevated point-sources modelled here is approximately 150m from the emission source. This is within the distance-range of the worst-case receptors used at all of the sites in this assessment (see Figures 1-6). Any impacts further away than the modelled receptors will thus be smaller than those presented here.

Table 4.1 Assumed Release Rates from Each Facility.

Process	Ammonia Emission Rate (g/tonne)			NOx Emiss. Rate (g/t)	Waste throughput (Kt/yr)	Ammonia Emission Rate (kg/yr)			NOx Emiss. Rate (t/yr)
	low	med	high			low	med	high	
Existing open Compost at Chapel Lane	5	-	120	-	30	150	-	3600	-
Open Compost at Binnegar	5	-	120	-	30	150	-	3600	-
Existing In-Vessel Composting at Canford Magna	-	-	0.12	-	12	-	-	1.4	-
Planned In-Vessel Composting at Canford Magna	-	-	0.12	-	50			6	-
In-Vessel Composting at Binnegar	0.12	8.4	120	-	12	1.4	101	1440	-
Typical MBTs	0.12	8.4	120	260	120	14	1008	14400	31
Typical RDFs	-	-	-	1983	50	-	-	-	99
Landfill Gas Engine at Beacon Hill	-	-	-	na[a]	na[a]	-	-	-	10[a]

[a] Until more information as to the specific emission characteristics of the engine that would be used becomes available, it is not possible to accurately predict emissions.

Table 4.2 Modelled Emissions Release Data[a].

Point Sources	Stack Height	Gas Temp	Stack Diameter (m)	Exit Velocity (m/s)	Building Height[b]	Building Length[b]	Building Width[b]	Buiilding Angle[b]
MBT Vents	15	Ambient	1.8	15	12	70	120	0
RDF emissions	40	140°C	1	15	12	30	45	0
Landfill Gas Engine	5.5	1000°C	0.3	15	na	na	na	na
Area Sources		Length	Width	Release Height		Initial Plume Depth		Angle
Chapel Lane Open Compost		170	150	1		2		0
Binnegar Open Compost A[c]		92	176	1		2		45
Binnegar Open Compost B[c]		155	59	1		2		45
All Biofilters[d]		25	10	3		1		0

[a] The Location of Each source is shown in Figures 1-6.
[b] For modelling plume downwash. The stack/vent is located in the centre of the building.
[c] This was modelled as two separate, but adjoining, rectangular sources. The sole reason for this added detail was that the area required would not fit the site as a single rectangle with zero angle.
[d] i.e. all abated ammonia emissions from in-vessel composters and MBTs.

Dispersion Modelling

4.4 For each of the releases described above, dispersion modelling has been conducted using the US EPA AERMOD model. Meteorological data were taken from Bournemouth Airport for the year 2004. Deposition has not been included within the dispersion model, but has been calculated from the modelled concentration data at each receptor. The effect of this is that the modelled ambient concentrations will have been over-estimated as there is no allowance for loss by deposition, making the approach worst-case. Appendix 2 indicates that the influence of this will not have been significant. Appendix 3 explains how the methodology used here differs from that in another study conducted for the Winfrith site (Entec, 2005). A brief analysis of the potential influence of "down-time" in the abatement technology is given in Appendix 4.

Deposition

4.5 NOx deposits to vegetation mainly via uptake of nitrogen dioxide[1] though stomata. Nitric oxide does not deposit at a significant rate (Nicholson *et al*., 2001). Most NOx is emitted in the form of nitric oxide and subsequently converts to nitrogen dioxide[4] through reaction with ozone. The conversion to nitrogen dioxide can take some time, particularly for industrial emissions, where the plume is confined and ozone is rapidly depleted. Even close to roads, AQEG (2004) show that nitrogen dioxide can make up less than 30% of NOx up to 150m from a typical road. It is very difficult to predict the nitrogen dioxide to nitric oxide ratio close to each of the industrial emission sources assessed here, but it has been assumed that nitrogen dioxide makes up 50% of process-related NOx at each receptor. This is considered to be worst-case this close to the source.

4.6 Dry deposition of ammonia and nitrogen dioxide to heathland has been calculated explicitly from the modelled ambient annual mean concentrations, assuming the deposition velocities presented in Table 4.3. Using annual average data in the deposition rate calculation will introduce a small degree of uncertainty, but the same approach has been used to derive the national nitrogen deposition maps (Smith *et al,* 2000; APIS, 2005). The deposition velocities used are deliberately worst-case. Sutton *et al*. (1992) reported ammonia deposition velocities ranging from zero to 15 mm per second over heathland in humid conditions, with the deposition being replaced by emissions of ammonia from the heathland during dry conditions[5]. Furthermore, if the national nitrogen deposition maps and Critical Loads are accurate, then many of the systems assessed in this study will have become nitrogen-enriched over recent years. This will tend to inhibit the dry deposition of ammonia[6]. The deposition velocity for nitrogen dioxide was derived from land uses with generally greater surface resistance and stomatal activity than characterise heathlands and will thus also be worst-case.

---

[4] A small amount of nitrogen dioxide can also be emitted directly.

[5] In simple terms, whenever the ammonia concentration in the air is greater than the level in the vegetation, ammonia will be deposited; whenever this pattern is reversed, ammonia will be emitted from the vegetation.

[6] For the reason put in footnote 5, whilst ammonia deposits readily to nitrogen-deficient ecosystems, nitrogen-rich ecosystems tend to be net emitters of ammonia. The higher the nitrogen-status of an ecosystem, the smaller its potential to receive additional ammonia inputs will be.

4.7 Wet deposition has been ignored. Wet deposition of the emitted pollutants this close to the emission source will be restricted to wash-out, or below cloud scavenging. For this to occur, rain droplets must come into contact with the gas molecules before they hit the ground. Falling raindrops displace the air around them, effectively pushing gasses away. The low solubility of nitrogen dioxide and nitric oxide means that any scavenging of these gases will be a negligible factor. Because of the high solubility of ammonia, some studies (e.g. Asman and van Jaarsveld, 1992) have concluded that wet deposition of locally-generated ammonia might be significant; but others (e.g. Harrison and Allen, 1991) have found it to be negligible. The conservative and constant ammonia dry deposition velocity that has been assumed will ensure that this study remains worst-case regardless of any effect of wet deposition.

Table 4.3 Deposition velocities Used.

	Deposition Velocity (mm per second)	Reference
Ammonia	19	Duyzer *et al*., (1987)
Nitrogen Dioxide	1.6	Marner and Harrison (2004)

Sources of Nitrogen Deposition that have not been Explicitly Modelled

4.8 Baseline deposition rates have been determined from the national nitrogen deposition maps produced by CEH Edinburgh and accessed via APIS (2005). Each value represents predicted average deposition fluxes over a 5 km x 5 km grid square with significant uncertainty. Close to existing emission sources, deposition rates will be greater than those in the predicted background maps, but Figure A2.1 shows that local emissions will only add significantly to background ammonia levels very close to the emission source. Similarly, it is generally acknowledged for road transport that at distances more than 50m from the centre of a road, nitrogen dioxide concentrations will approach background levels (Hickman *et al.,* 2002). The published background deposition maps are thus likely to present a reasonable picture of baseline levels at most of the sites. This current study accepts that the Critical Loads are likely to be exceeded at most of the sites in the baseline case. The exact baseline levels in each location do not influence the criteria by which the potential impacts have been assessed; i.e. the percentage increment relative to the Critical Load.

4.9 Emissions from road vehicles travelling to and from each of the proposed facilitates have not been explicitly included in the site-by-site modelling; but ammonia emission rates have been predicted based on the data of Sutton *et al.* (2000), while nitrogen dioxide concentrations have been predicted using the Design Manual for Roads and Bridges screening model (Highways Agency, 2003). These data have been used to show, qualitatively, what the additional impact of site-related road vehicles might be.

5 Baseline Conditions

5.1 Ammonia is emitted from a wide variety of sources, predominantly agricultural. As is shown in Figure A2.1, ammonia concentrations will vary considerably over short distances. Close to emission sources, concentrations may be high, while away from any emission sources, concentrations will be low. Maps of ammonia concentrations have been produced covering the entire UK in a 5 x 5 km grid (NEGTAP, 2001). These 5 x 5 km averages will hide localised areas of high and low concentrations but they are the best available method of estimating the background levels onto which emissions from the proposed waste sites would be added. Table 5.1 sets out the predicted background ammonia concentrations around each of the proposed waste facilities (taken from APIS, 2005).

5.2 National maps have also been produced which predict background NOx and nitrogen dioxide concentrations (Defra, 2005b). These also lack some spatial resolution around roads, where traffic in an important source, but again, are the best available tool for predicting background ambient levels. Table 5.1 also sets out the predicted background NOx and nitrogen dioxide concentrations at each of the proposed facilities (taken from Defra, 2005b).

5.3 Using the ammonia and nitrogen dioxide maps described above, along with interpolated and topography-enhanced bulk deposition data from the UK Acid Deposition Monitoring Network, CEH Edinburgh have produced a map of total nitrogen deposition across the United Kingdom on a 5 km x 5 km grid (NEGTAP, 2001). These background nitrogen deposition estimates are highly uncertain (NEGTAP, 2001; AQEG, 2004; Marner and Harrison; 2004) but they represent the best available estimates. Table 5.1 also includes the background nitrogen deposition rates taken from APIS (2005).

5.4 Nationally, NOx and nitrogen dioxide concentrations are falling and are set to continue to fall into the future. It is difficult to predict future concentrations of ammonia. It is reasonable to assume that the 1999 - 2001 estimates of nitrogen deposition will tend to over-predict current levels; and that this will become more significant into the future. One common approach (Highways Agency, 2005) is to assume that background nitrogen deposition rates have fallen by 2 percent per year since the year 2000. This current assessment has taken the worst-case approach of using the 1999 - 2001 estimates of nitrogen deposition assuming no reduction in recent years.

5.5 Because the Critical Loads are presented as a range, it is not possible to define whether they are exceeded in the baseline case at any of the sites. All of the background nitrogen deposition rates fall within the range of Critical Load values. Winfrith, however, falls in the lower half of the range, while Canford Magna falls near to the top. The worst-case assumption has been made that all sites currently exceed the Critical Loads in baseline case.

Table 5.1 Background Concentration and Deposition Data.

	Ammonia conc (µg/m^3) (1999)	NOx conc (µg/m^3) (2005)	Nitrogen Dioxide conc (µg/m^3) (2005)	Nitrogen Deposition (kg/ha/yr) (1999 –2001)	Critical Load for Nitrogen Deposition (kg/ha/yr)
Winfrith	1.2	11.2	8.8	14.6	10 – 20
Chapel Lane	1.5	26.6	18.5	17.4	10 – 20
Bournemouth Airport	1.5	26.6	18.5	17.4	10 – 20
Ferndown	1.1	28.5	19.4	15.8	10 – 20
Binnegar	1.2	12.8	10.0	15.0	10 – 20
Canford Magna	1.8	32.5	21.2	18.9	10 – 20
Beacon Hill	1.2	22.1	16.3	15.5	10 – 20

6 Results

6.1 In this section, the model results are presented for the seven locations under consideration. The assessment of impact significance is related to the 1% criterion used by the Environment Agency to determine whether an Appropriate Assessment is required. This percentage value refers to the process contribution to the Critical Load, as shown in the last columns in the following tables. JNCC have requested that a Range of Critical Loads should be used, rather than the precise values presented in the national Critical Load maps that are available from the Centre of Ecology and Hydrology. The percentage changes are thus presented as a range. Because the Critical Load is presented as a range, it is not possible to state whether it would be exceeded in the baseline case. This assessment thus makes the worst-case assumption that the Critical Loads are exceeded at every site in the baseline case.

Winfrith

6.2 Table 6.1 sets out the modelled concentrations and deposition rates at each of the worst-case receptors shown in Figure 1. The three modelled scenarios each show a different scale of impacts. Because it has been assumed that unabated ammonia emissions would be emitted from a vent 3m above the 12m high building, exhaust gases are expected to be rapidly dispersed and diluted. Conversely, it has been assumed that abated ammonia emissions would be released much closer to the ground – from the biofilter itself. In this scenario, dispersion is likely to be restricted, giving rise to greater ground-level concentrations close to the plant. Thus, at the receptors that are closest to the proposed plant, release at a height of 15m provides a more effective form of mitigation than a biofilter operating at 93% efficiency. Further away from the plant, the biofilter provides the more effective mitigation. This anomaly is apparent at many of the sites covered by this assessment and appears to be most pronounced when the receptors are south and west of the sources. It is least prominent where the closest receptors are some distance from the source. It is well known that pollutants disperse differently for point sources at some height above the ground compared with area sources at ground level. Clearly, if the unabated emissions were released lower down, impacts would be greater, and if the abated emissions were released at height, any impacts would be smaller[7].

6.3 Appendix 5 sets out the relative contribution made by NOx emissions and ammonia emissions to the total nitrogen deposition rate at each receptor. The relative importance of NOx varies

---

[7] It is relatively easy to quantify what the effects would be in these scenarios. If the ammonia was released through a stack following 99.9% abatement, then the ammonia concentrations would be approximately 0.1% of those related to unabated stack emissions. Similarly, if unabated emissions were released close to the ground, then ammonia concentrations would be one thousand times those predicted from the scrubber system. The Ammonia-specific deposition rates, as presented in Appendix 5, would change proportionally.

depending on the proximity of the receptor to the source and also on the absolute ammonia emission rate.

6.4 Both the vented and the biofiltered scenarios could give rise to significant impacts in relation to the Environment Agency criterion of a 1% contribution to the Critical Load. Clearly, the option with the least impact would be to employ a biofilter and acid scrubber, as has been tested at Canford Magna. This would lead to an insignificant impact at every receptor.

Table 6.1 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to a Generic MBT and RDF Plant at Winfrith.

R	Process Related – Ammonia Conc ($\mu g/m^3$)			Process Related – NOx Conc ($\mu g/m^3$)	Process - Related N Deposition (kg-N/ha/yr)[a]			Predicted Background Deposition (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of the Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.33	0.22	<0.01	0.22	1.65	1.09	0.03	14.6	16.2	15.7	14.6	8-16	5-11	<1
2	0.24	0.10	<0.01	0.27	1.18	0.52	0.03	14.6	15.8	15.1	14.6	6-12	3-5	<1
3	0.72	0.86	0.01	0.17	3.55	4.23	0.07	14.6	18.1	18.8	14.7	18-35	21-42	<1
4	0.59	1.16	0.02	0.04	2.93	5.74	0.09	14.6	17.5	20.3	14.7	15-29	29-57	<1
5	0.35	1.12	0.02	0.04	1.72	5.52	0.08	14.6	16.3	20.1	14.7	9-17	28-55	<1
6	0.37	0.12	<0.01	0.49	1.88	0.63	0.05	14.6	16.5	15.2	14.6	9-19	3-6	<1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

[a] This is the sum of nitrogen deposited from the NOx and nitrogen deposited from the ammonia.

Chapel Lane

6.5 Table 5.1 shows that the background deposition rates tend toward the top of the Critical Load range, even without any local contribution. Emissions from the nearby Bournemouth Airport have been incorporated into the background emission maps, but it is likely that this close to the airport, concentrations, and therefore deposition rates, will be elevated above the 5km x 5km background average. This will not affect the process contribution as a percentage of the Critical Load.

6.6 Table 6.2 shows that the addition of emissions from the existing open composting operation at this site might potentially add a significant contribution to local background deposition rates at each of the worst-case receptors shown in Figure 2. The high estimates are considered to be unrealistically high, but provide an upper bound. The low estimate is likely to be closer to the true value, but is probably an under-prediction. In practice, the process contribution is likely to be somewhere between the low and high levels, and to tend toward the lower values. Even the lower-bound figures represent a fairly substantial rate of nitrogen deposition at the worst-case receptors.

6.7 As noted in Paragraph 2.3, many habitats currently exceed their predicted Critical Loads without showing signs of damage. The Dorset County Ecologist (Dr Phil Sterling, pers comm.) has had a personal interest as manager of the heathlands adjoining Chapel Lane and Bournemouth Airport for many years and has specifically commented that the heathlands appear reasonably stable ecologically around this site, requiring no more management intervention here than elsewhere to the west of the Avon Valley, which has led him to question the validity of the Critical Loads in this area. The Critical Loads are national tools and it is not within the scope of this report to question them.

Table 6.2 Predicted Ammonia Concentrations and Nitrogen Deposition Related to Existing Open Composting Processes at Chapel Lane.

Receptor	Process Related – Ammonia Concentration ($\mu g/m^3$)		Process - Related Deposition (kg-N/ ha/yr)		Backgro-und kg-N/ha/yr	Total Deposition (kg-N/ha/yr)		Process Contribution as % of Critical Load	
	low	high	low	high		low	high	low	high
1	0.09	2.15	0.4	10.6	17.4	17.8	28.0	2-4	53-106
2	0.09	2.19	0.4	10.8	17.4	17.8	28.2	2-4	54-108
3	0.41	9.74 [a]	2.0	48.1	17.4	19.4	65.5	10-20	240-481
4	0.40	9.72 [a]	2.0	48.0	17.4	19.4	65.4	10-20	240-480
5	0.23	5.45	1.1	26.9	17.4	18.5	44.3	6-11	134-269
6	0.15	3.51	0.7	17.3	17.4	18.1	34.7	4-7	87-173
7	0.62	14.99 [a]	3.1	74.0	17.4	20.5	91.4	21-31	493-740
8	0.23	5.56	1.1	27.5	17.4	18.5	44.9	8-11	183-275
9	0.17	4.07	0.8	20.1	17.4	18.2	37.5	6-8	134-201
10	0.55	13.13 [a]	2.7	64.8	17.4	20.1	82.2	18-27	432-648
11	0.03	0.79	0.2	3.9	17.4	17.6	21.3	1-2	26-39
12	0.07	1.63	0.3	8.0	17.4	17.7	25.4	2-3	54-80
Critical Load			**10-20**		**10-20**	**10-20**			

low = derived using the Defra's (2004) upper bound emission rate.
high = derived using the Defra's (2004) lower bound emission rate.
[a] These process contribution data also exceed the relevant Critical Level (8 $\mu g/m^3$).

6.8 Table 6.3 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 2 of a generic MBT and RDF plant at Chapel Lane in the position shown in Figure 2. As discussed for the Winfrith site, the effective lowering of the emission source, that has been assumed would occur if ammonia emissions are abated using a biofilter alone, would exacerbate very local effects. Both the unabated and the biofilter-abated emissions could thus give rise to potentially detrimental impacts. If an ammonia scrubber and biofilter, such as has been tested at Canford Magna, were employed at this site, any impacts would be extremely small, if not insignificant.

Table 6.3 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to a Generic MBT and RDF Plant at Chapel Lane (baseline levels include open composting).

R	Process Related – Ammonia Conc (µg/m^3)			Process Related – NOx Conc (µg/m^3)	Process - Related N Deposition[a] (kg-N/ha/yr)			Predicted Background Deposition[b] (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.54	0.48	0.01	0.31	2.68	2.39	0.06	28.0	31	30	28	13-27	12-24	<1
2	0.45	0.52	0.01	0.33	2.25	2.58	0.06	28.2	30	31	28	11-23	13-26	<1
3	0.94	1.48	0.02	0.28	4.65	7.30	0.13	65.5	70	73	66	23-47	37-73	<1-1
4	0.95	1.34	0.02	0.35	4.70	6.65	0.12	65.4	70	72	65	24-47	33-67	<1-1
5	0.64	0.79	0.01	0.47	3.22	3.92	0.09	44.3	48	48	44	16-32	20-39	<1
6	0.54	0.58	0.01	0.45	2.69	2.91	0.08	34.7	37	38	35	13-27	15-29	<1
7	0.87	1.55	0.02	0.41	4.32	7.70	0.14	91.4	96	99	92	22-43	39-77	<1-1
8	0.51	0.85	0.01	0.47	2.56	4.24	0.10	44.9	47	49	45	13-26	21-42	<1
9	0.45	0.68	0.01	0.45	2.24	3.39	0.08	37.5	40	41	38	11-22	17-34	<1
10	1.65	1.81	0.03	0.37	8.16	8.95	0.16	82.2	90	91	82	41-82	45-90	<1-2
11	0.84	0.33	<0.01	0.77	4.19	1.66	0.08	21.3	25	23	21	21-42	8-17	<1
12	1.25	0.58	0.01	0.78	6.24	2.90	0.10	25.4	32	28	26	31-62	15-29	<1-1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

[a] This is the sum of nitrogen deposited from the NOx and nitrogen deposited from the ammonia.

[b] Assuming the high total from Table 6.2, i.e. with the existing open composting.

Bournemouth Airport

6.9 This site is less than 500m from the Chapel Lane site. Concentrations are thus assessed at the same receptors as assessed for Chapel Lane. The baseline levels are those modelled with existing open composting operations at Chapel Lane, but it has been assumed that MBT and RDF operations would not take place at both Chapel Lane and Bournemouth airport, so these cumulative impacts have not been assessed. Table 6.4 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 2 of a generic MBT and RDF at Bournemouth Airport, in the location shown in Figure 2. As noted for the other sites, the height of the ammonia release has a significant influence on concentrations and deposition close to the emission source. Both the unabated and the biofilter-abated emissions could thus give rise to potentially detrimental impacts. If an ammonia scrubber and biofilter, such as has been tested at Canford Magna, were employed at this site, any impacts would be insignificant or extremely small.

Table 6.4 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to a Generic MBT and RDF Plant at Bournemouth Airport (baseline levels include open composting at Chapel Lane).

R	Process Related – Ammonia Conc ($\mu g/m^3$)			Process Related – NOx Conc ($\mu g/m^3$)	Process - Related N Deposition[a] (kg-N/ha/yr)			Predicted Background Deposition[b] (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.16	0.23	<0.01	0.19	0.79	1.12	0.03	28.0	29	29	28	4-8	6-11	<1
2	0.17	0.28	<0.01	0.17	0.83	1.38	0.03	28.2	29	30	28	4-8	7-14	<1
3	0.32	0.27	<0.01	0.40	1.61	1.38	0.05	65.5	67	67	66	8-16	7-14	<1
4	0.36	0.35	<0.01	0.39	1.80	1.75	0.05	65.4	67	67	65	9-18	9-17	<1
5	0.51	0.85	0.01	0.16	2.52	4.20	0.07	44.3	47	48	44	13-25	21-42	<1
6	0.43	1.87	0.03	0.04	2.13	9.24	0.14	34.7	37	44	35	11-21	46-92	<1-1
7	0.54	0.31	<0.01	0.63	2.71	1.56	0.07	91.4	94	93	91	14-27	8-16	<1
8	0.81	0.82	0.01	0.22	4.00	4.07	0.07	44.9	49	49	45	20-40	20-41	<1
9	0.71	1.72	0.02	0.05	3.52	8.47	0.12	37.5	41	46	38	18-35	42-85	<1-1
10	0.44	0.22	<0.01	0.65	2.24	1.14	0.07	82.2	84	83	82	11-22	6-11	<1
11	0.25	0.07	<0.01	0.35	1.28	0.36	0.03	21.3	23	22	21	6-13	2-4	<1
12	0.34	0.12	<0.01	0.51	1.70	0.63	0.05	25.4	27	26	25	9-17	3-6	<1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

[a] This is the sum of nitrogen deposited from the NOx and nitrogen deposited from the ammonia.

[b] Assuming the High total from Table 6.2, i.e. with the existing open composting.

Ferndown

6.10 Table 6.5 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 3 of a generic MBT and RDF in the location shown in Figure 3. All of the worst-case receptors are some distance from this site, and thus impacts would be small even if a biofilter operated on its own. If a biofilter and scrubber were used together, then any impacts would be insignificant. Unabated emissions might still give rise to potentially detrimental impacts at this site.

Table 6.5 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to a Generic MBT and RDF Plant at Ferndown.

R	Process Related – Ammonia Conc (µg/m^3)			Process Related – NOx Conc (µg/m^3)	Process - Related N Deposition[a] (kg-N/ha/yr)			Predicted Background Deposition (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.36	0.12	<0.01	0.53	1.8	0.64	0.05	15.8	17.6	16.4	15.8	9-18	3-6	<1
2	0.42	0.08	<0.01	0.62	2.1	0.80	0.06	15.8	17.9	16.6	15.9	11-21	4-8	<1
3	0.59	0.10	<0.01	0.43	2.9	1.05	0.05	15.8	18.7	16.8	15.8	15-29	5-10	<1
4	0.32	0.09	<0.01	0.44	1.6	0.46	0.04	15.8	17.4	16.3	15.8	8-16	2-5	<1
5	0.57	0.07	<0.01	0.38	2.8	0.93	0.04	15.8	18.6	16.7	15.8	14-28	5-9	<1
6	0.52	0.08	<0.01	0.33	2.6	0.69	0.03	15.8	18.4	16.5	15.8	13-26	3-7	<1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.

stack = emissions are not abated, but are piped through a vent above the building roof.

bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.

scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

[a] This is the sum of nitrogen deposited from the NOx and nitrogen deposited from the ammonia.

Canford Magna

6.11 Table 6.6 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 4 of a generic in-vessel composting operation in the location shown in Figure 4. This represents the existing operation at this site, with emissions augmented to also represent those from a new facility that is currently under construction. Both the existing and the planned facility will be operated by W.H White plc. using a combination of ammonia scrubber and biofilter. The combined impacts of operating both facilities will be very small.

6.12 Table 6.7 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 4 of a generic MBT and RDF site in the location shown in Figure 4. Both the unabated and the biofilter-abated emissions could potentially give rise to detrimental impacts. If an ammonia scrubber and biofilter were used together, any impacts would be extremely small or insignificant.

Table 6.6 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to the Operational and Planned In-vessel Composting site at Canford Magna[a].

Receptor	Process Related – Ammonia Conc (µg/m^3)	Process Related – NOx Conc (µg/m^3)	Process - Related N Deposition (kg-N/ha/yr)	Predicted Background Deposition (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)	Process Contribution as % of Critical Load
1	0.01	na	0.04	18.9	18.9	<1
2	0.01	na	0.04	18.9	18.9	<1
3	0.05	na	0.27	18.9	19.2	1-3
4	0.05	na	0.27	18.9	19.2	1-3
5	0.02	na	0.11	18.9	19.0	<1-1
Critical Load			**10-20**	**10-20**	**10-20**	

[a] W.H. White plc currently operate a small plant on the site, and they are currently constructing a larger facility. This scenario assumes that the combined total emissions from both facilities are present. The control technology to be used at both facilities uses both a scrubber and biofilter and thus provides more than 99.9% ammonia abatement.

Table 6.7 Predicted Ammonia and NOx Concentrations and Nitrogen Deposition Related to a Generic MBT and RDF Plant at Canford Magna (baseline values include in-vessel composting).

R	Process Related – Ammonia Conc (µg/m^3)			Process Related – NOx Conc (µg/m^3)	Process - Related N Deposition[a] (kg-N/ha/yr)			Predicted Background Deposition[b] (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.15	0.11	0.00	0.09	0.74	0.53	0.01	18.9	19.7	19.5	18.9	4-7	3-5	<1
2	0.26	0.15	0.00	0.16	1.30	0.76	0.02	18.9	20.2	19.7	19.0	6-13	4-8	<1
3	0.66	1.98	0.03	0.32	3.30	9.80	0.16	19.2	22.5	29.0	19.3	16-33	49-98	<1-2
4	0.58	0.90	0.01	0.45	2.88	4.49	0.10	19.2	22.0	23.7	19.3	14-29	22-45	<1
5	0.67	0.30	0.00	0.45	3.34	1.53	0.06	19.0	22.3	20.5	19.1	17-33	8-15	<1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

[a] This is the sum of nitrogen deposited from the NOx and nitrogen deposited from the ammonia.

[b] Assuming the total from Table 6.6, which includes emissions from the existing facility and that under construction.

Binnegar

6.13 Table 6.8 sets out the predicted process contributions to concentrations and deposition rates at each of the worst-case locations shown in Figure 5 of a generic in-vessel composting plant in the location shown in Figure 5. Unabated emissions, if released at height, would only give rise to a small impact. For reasons explained above, biofilter-abated emissions, if released close to the ground, could potentially cause significant impacts. If an ammonia scrubber and biofilter were used together, any impacts would be insignificant or extremely small.

Table 6.8 Predicted Ammonia Concentrations and Nitrogen Deposition Related to a Generic In-vessel Composting Site at Binnegar.

R	Process Related – Ammonia Conc (μg/m^3)			Process Related – NOx Conc (μg/m^3)	Process - Related N Deposition (kg-N/ha/yr)			Predicted Background Deposition (kg-N/ha/yr)	Total Deposition (kg-N/ha/yr)			Process Contribution as % of Critical Load		
	stack	bio	scrub		stack	bio	scrub		stack	bio	scrub	stack	bio	scrub
1	0.02	0.21	<0.01	na	0.08	1.03	0.01	15	15.1	16.0	15.0	<1	5-10	<1
2	0.04	0.32	<0.01	na	0.18	1.56	0.02	15	15.2	16.6	15.0	<1-2	8-16	<1
3	0.02	0.15	<0.01	na	0.12	0.76	0.01	15	15.1	15.8	15.0	<1-1	4-8	<1
4	0.03	0.40	0.01	na	0.16	1.97	0.03	15	15.2	17.0	15.0	<1-2	10-20	<1
5	0.09	0.59	0.01	na	0.44	2.92	0.04	15	15.4	17.9	15.0	2-4	15-29	<1
6	0.09	0.89	0.01	na	0.44	4.41	0.06	15	15.4	19.4	15.1	2-4	22-44	<1
7	0.11	0.98	0.01	na	0.56	4.82	0.07	15	15.6	19.8	15.1	3-6	24-48	<1
8	0.16	1.47	0.02	na	0.80	7.25	0.10	15	15.8	22.2	15.1	4-8	36-72	<1-1
9	0.06	0.73	0.01	na	0.32	3.61	0.05	15	15.3	18.6	15.1	2-3	18-36	<1
Critical Load					**10-20**			**10-20**	**10-20**					

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
scrub = emissions are treated first with an ammonia scrubber and then with a biofilter, similar to the systems supplied by First Water plc. This system has been shown to provide more that a 99.9% abatement of ammonia. 99.9% ammonia abatement has been assumed. Emissions are released directly from the biofilter.

6.14 Table 6.9 sets out the additional impact that a generic open composting operation might have at this location at each of the worst-case receptors shown in Figure 5. The high estimates are considered to be unrealistically high, but provide an upper bound. The low estimate is likely to be closer to the true value, but is probably an under-prediction. In practice, the process contribution is likely to be somewhere between the low and high levels, and to tend toward the lower values. Even the lower-bound figures represent a significant rate of nitrogen deposition at the worst-case receptors.

Table 6.9 Predicted Ammonia Concentrations and Nitrogen Deposition Related to a Generic Open Composting Operations at Binnegar.

Receptor	Process Related – Ammonia Concentration (µg/m^3)		Process - Related Deposition (kg-N/ ha/yr)		Background[a] kg-N/ha/yr	Total Deposition (kg-N/ha/yr)		Process Contribution as % of Critical Load	
	low	high	low	high		low	high	low	high
1	0.10	2.49	0.5	12.3	15.0	15.5	27.3	3-5	61-123
2	0.15	3.67	0.8	18.1	15.1	15.8	33.2	4-8	91-181
3	0.04	0.88	0.2	4.4	15.0	15.2	19.4	1-2	22-44
4	0.42	10.20[b]	2.1	50.3	15.1	17.2	65.4	10-21	252-503
5	0.23	5.49	1.1	27.1	15.1	16.2	42.2	6-11	135-271
6	0.48	11.43[b]	2.4	56.4	15.2	17.5	71.6	12-24	282-564
7	0.14	3.47	0.7	17.1	15.2	15.9	32.3	4-7	86-171
8	0.17	4.17	0.9	20.6	15.3	16.1	35.8	4-9	103-206
9	0.07	1.62	0.3	8.0	15.1	15.5	23.1	2-3	40-80
Critical Load			**10-20**		**10-20**	**10-20**			

low = derived using the Defra's (2004) upper bound emission rate.

high = derived using the Defra's (2004) lower bound emission rate.

[a] The total "scrub" column from Table 6.8.

[b] These process contribution data also exceed the relevant Critical Level (8 µg/m^3).

Beacon Hill

6.15 As has been shown in section 3 of this report, measured NOx emissions from landfill gas engines vary by more than a factor of 10 at different sites. It is thus impossible to accurately assess the potential impacts on heathlands based purely on the same generic data used elsewhere in this assessment. It is understood that at an appropriate assessment will be carried out for this site at a suitable time and that emissions limits will be set by the Environment Agency.

6.16 The potential for impacts on heathlands will vary based on a range of factors; emission rate being only one. However, based on the parameters set out in Table 4.2, dispersion modelling has shown that an emission rate of 10 tonnes of NOx per year would have an extremely small or insignificant impact (<1 – 1% of the Critical Load); while an emission rate of 100 tonnes per year would have only a small impact (6 – 11% of the Critical Load). This does not necessarily mean that a greater emission rate would have a more significant impact, as there are a large number of relevant parameters that will need to be considered in a full assessment.

Motor Vehicles

6.17 The Waste Local Plan sets out the number of vehicles that would be associated with operating each site. The maximum number of vehicles associated with any of the proposals assessed in this report is 380 Heavy Goods Vehicles (HGVs) and 100 cars per day (as 2-way flows). This compares, for example, with existing flows of >4000 HGVs and >66000 cars per day on the A31 east of Ferndown, and >1000 HGVs and >11000 cars on the A352 south of Binnegar (roughly approximated from the year 2000 and 1997 count data provided by Defra (2005a)). At most of the sites, the access roads are more than 100m from the nearest protected habitats. The exceptions to this are Winfrith, Binnegar and Chapel Lane. The proposed access route at Winfrith would pass within approximately 40m of the protected habitats. The existing roads at Binnegar and Chapel Lane pass just a few metres from protected habitats.

6.18 Table 6.10 sets out the predicted nitrogen dioxide concentrations and associated deposition rates that would be expected from 380 HGVs and 100 cars at various distances from the centre of a road (assuming 2005 emission rates and worst-case vehicle speeds). Also shown, for comparative purposes, are hypothetical scenarios using the numbers of vehicles on existing roads. Site-related vehicles would cause, at most, a very small additional impact.

6.19 Such a simple analysis is not possible for ammonia. Sutton *et al.* (2000) have suggested a range of ammonia emission factors from road transport sources. Table 6.11 sets out a worst-case predicted emission scenario for ammonia from road vehicles and compares it with the emissions modelled for the MBT plants. Emissions have been assigned per 100m of road, because road emissions are unlikely to have any significant effect at distances greater than 50m. This highly simplistic analysis is sufficient to show that emissions from site-related vehicles are a very small fraction of those from the modelled process sources. These added impacts would not, therefore, significantly alter the conclusions for any site.

Table 6.10 Oxidised Nitrogen Deposition Associated with Site-related Vehicles[a].

	Distance from Road Centre (m)	Ambient Nitrogen Dioxide Concentration (μg/m^3)	Associated N deposition (kg-N/ha/yr)	N deposition as a % of a representative Critical Load (15 kg-N/ha/yr)
Site-related Vehicles	10	2.5	0.38	3
	40	1.2	0.18	1
	100	0.3	0.05	0
A352[b]	10	8.5	1.31	9
	40	4.2	0.64	4
	100	1.1	0.17	1
A31[c]	10	14.4	2.21	15
	40	7.5	1.15	8
	100	2	0.31	2

[a] Calculated using the DMRB screening model V1.02 (Highways Agency, 2003).
[b] Traffic data from 1997 have been used without adjustment. Current traffic volumes will be greater than this.
[c] Traffic data from 2000 have been used without adjustment. Current traffic volumes will be greater than this.

Table 6.11 Ammonia Emissions Associated with Site-related Vehicles.

	mg NH_3-N/veh/km	Vehicles / day[a]			Kg / 100m /yr		
		Site	A352	A31	Site	A352	A31
Petrol Car with catalytic converter	70.3[b]	100	11000	66000	0.25	28	169
Petrol Car no catalytic converter	1.8	-			-		
Diesel Car	1.0	-			-		
Average Heavy Goods Vehicle	2.4	380	1000	4000	0.03	0.09	0.35
Total	-	480	12000	70000	**0.29**	**28**	**170**
Total Modelled for MBT plants with ammonia scrubber and biofilter (kg/yr)					14		

[a] Assumes 7 days per week

[b] Assuming that all non-HGVs are petrol cars with catalytic converters is a worst-case assumption that will double count a significant portion of the N counted in Table 6.10.

7 Conclusions

7.1 An analysis of the air quality impacts of a range of proposed waste-management technologies at seven potential sites in Dorset has been carried out. The analysis has used detailed dispersion modelling to quantify the potential impacts of nitrogen deposition to the protected habitats that surround each site. The analysis has focused on the worst-case locations within each protected site. These are generally the very edges of the protected habitat nearest to the process. Wider-scale impacts caused by these sites will be much smaller than those described here and beyond a few hundred metres will be insignificant.

7.2 Most of the sites assessed would use enclosed composting methods. The principal concern related to these technologies that has been raised by JNCC, English Nature and their advisors appears to be that cost-effective methods of ammonia emissions abatement might be inefficient. This report has presented evidence to show that there are cost-effective ammonia abatement measures available that operate at a very high level of efficiency. Data have been presented both with and without the most commonly used ammonia abatement methods. The assessment has drawn on the results from a number of studies to refine its estimates of emission rates. Worst-case assumptions have been used throughout the assessment. Table 7.1 sets out the potential impacts at the worst-case locations for each site both with and without ammonia abatement.

7.3 Without mitigation, and assuming worst-case emission rates, all of the proposed processes have the potential to impact significantly on adjacent protected habitats. However, all but one of the proposed processes can potentially be mitigated using the same technology that has been successfully employed for the last 2-years at another site in Dorset. If similar technology were to be applied to each of the proposed sites, then their impacts would either be insignificant or of very low significance.

7.4 Open composting processes are difficult to mitigate. A tree belt surrounding a site can recapture a large amount of emitted ammonia, but it is very difficult to predict how effective this might be in practice. An open composting operation at Binnegar could thus impact significantly on the immediately adjacent heathland.

7.5 It has not been possible, at this stage, to assess the potential impacts associated with the Beacon Hill landfill gas engine in any detail, but it can be concluded that, so long as emissions can be controlled within certain levels, then the process has the potential to operate without any significant impact on adjacent habitats. It is understood that the Environment Agency will conduct a more detailed assessment of what the permissible releases might be.

7.6 Overall, and with the exception of the open composting operations, the conclusions of this assessment agree with the non-area-specific comment of Defra (2004): that composting is most likely to have a beneficial ecological impact, through reducing the amount of peat cutting that takes place internationally for compost production.

Table 7.1 Summary of Assessment Results at the Worst-Case Receptors.

Site	Process	Process-Related Deposition at the worst-case receptor (kg-N/ha/yr)	Process-Related Deposition (% of Critical Load)	Subjective Assessment Potential Impact Significance
Without Mitigation				
Winfrith	MBT + RDF	3.6	18-35	Moderate -High
Chapel Lane	MBT + RDF	8.2	41-82	High
Bournemouth Airport	MBT + RDF	4.0	20-40	Moderate - High
Ferndown	MBT + RDF	2.9	15-29	Moderate - High
Canford Magna	MBT + RDF	3.3	17-33	Moderate -High
Binnegar	In-vessel compost	0.8	4-8	Low
Binnegar	Open Compost	2.4 – 56.4	12-564	Moderate – High
With Mitigation				
Winfrith	MBT + RDF	<0.1	<1	Insignificant
Chapel Lane	MBT + RDF	0.2	<1-2	Insignificant - Very Low
Bournemouth Airport	MBT + RDF	0.1	<1-1	Insignificant - Very Low
Ferndown	MBT + RDF	<0.1	<1	Insignificant
Canford Magna	MBT + RDF	0.2	<1-2	Insignificant - Very Low
Binnegar	In-vessel compost	0.1	<1-1	Insignificant - Very Low

References

APIS (2005) Air Pollution Information System. www.apis.ac.uk.

Asman, W.A.H. and Van-Jaarsveld, H.A. (1992) A variable-resolution transport model applied for NHx in Europe. Atmospheric Environment 26A. 445-464.

Air Quality Expert Group (2004). Nitrogen Dioxide in the United Kingdom.

Defra (2005a). National Atmospheric Emissions Inventory. www.naei.org.uk

Defra (2005b). National Air Quality Archive. www.airquality.co.uk.

Defra (2004). Review of Environmental and Health Effects of Waste Management. With Peer Review by the Royal Society.

DETR (2001). Controlling Ammonia from non-agricultural Sources.

Dorset County Council (2004). Bournemouth, Dorset and Poole Waste Local Plan.

Duyzer, J.H., Bouman, A.M.H, Diederen, H.S.M.A. and Van Aalst, R.M. (1987) Measurement of dry deposition velocities of NH_3 and NH_4^+ over natural terrains. Report R 87/273. MT-TNO, Delft, The Netherlands.

ENTEC (2005). Study of Nitrogen Deposition for a possible MBT and RDF Energy Recovery Plant, Winfrith.

Environment Agency (2005) Policy for Implementing the Habitats Directive. www.environment-agency.gov.uk.

Harrison, R.M and Allen, A.G. (1991) Scavenging ratios and deposition of sulphur, nitrogen and chlorine species in Eastern England. Atmospheric Environment 25A. 1719-1723.

Highways Agency (2003), Design Manual for Roads & Bridges, spreadsheet version 1.02, November 2003. Available from Defra, 2003b.

Highways Agency (2005), Guidance for Undertaking Environmental Assessment of Air Quality for Sensitive Ecosystems in Internationally Designated Nature Conservation Sites and SSSIs (Supplement of DMRB 11.3.1). Interim Advice Note 61/05. March, 2005.

Marner, B.B and Harrison, R.M. (2004) A spatially refined monitoring based study of atmospheric nitrogen deposition. Atmospheric Environment 38. 5045-5056.

National Expert Group on Transboundary Air Pollution (2001). Transboundary Air Pollution: Acidification, Eutrophication and Ground-Level Ozone in the UK.

National Society for Clean Air and Environmental Protection (2002) Comparison of Emissions from Waste Management Options.

Nicholson. J.P.; Weston, K.J., and Fowler, D. (2001) Modelling horizontal and vertical concentration profiles of ozone and oxides of nitrogen within high-latitude urban areas. Atmospheric Evironment 35. 2009-2022.

Omrani, G., Safa, M. and Ghaghazy, L. (2004) Utilization of Biofilter for Ammonia Elimination in Composting Plant. Pakistan Journal of Biological Sciences 7. 2009-2013.

Organic Resource Agency Ltd. (2005). Development of a dynamic housed windrow composting system: Performance testing and review of potential use of end products. Report for Canford Environmental, Dorset.

Puget Sound Clean Air Agency (2005). Unpublished data supplied by email from Claude William of the PSCAA.

Smith, R.I, Fowler, D., Sutton, M.A., Flechard, C. and Coyle, M. (2000) Regional estimation of pollutant gas dry deposition in the UK: model description, sensitivity analyses and outputs. Atmospheric Environment 34. 3757 – 3777.

Sutton, M.A., Milford, C., Dragosits, U., Place, C.J., Singles, R.J., Smith, R.I., Pitcairn, C.E.R., Fowler, D., Hill, J., ApSimon, H.M., Ross, C., Hill, R., Jarvis, S.C., Pain, B.F., Phillips, V.C., Harrison, R., Moss, D., Webb, J., Espenhahn, S.E., Lee, D.S., Hornung, M., Ullyett, J., Bull, K.R., Emmett, B.A., Lowe, J. and Wyeres, G.P. (1998) Dispersion, Deposition and Impacts of Atmospheric Ammonia: Quantifying Local Budgets and Spatial Variability. Environmental Pollution 102. 349-361.

Sutton, M.A., Dragosits, U., Tang, Y.S., and Fowler, D. (2000) Ammonia Emissions From non-agricultural Sources in the UK.

Sutton, M.A., Fowler, D., Hargreaves, K.J. and Storeton-West, R.L. (1992) Effects of land-sue and environmental conditions on the exchange of ammonia between vegetation and the atmosphere. In: Field measurements and interpretation of species related to acid deposition. Air Pollution report 39(eds: Angeletti, G., Beilke, S. and Slanina, J.) 211 – 217.

Sutton M.A., (2004). Letter to Andrew Nicholson of English Nature, 6 October 2004.

Hickman, A.J., McCrae, I.S., Cloke, J. and Davies, G.J. (2003). Measurements of Roadside Air Pollution Dispersion. Transport Research Laboratory Ltd. PR/SE/445/02.

Wise S., and Phillips, G. (2004) Report on the potential for significant impact on Stokeford Heath from proposed composting processes.

Appendix 1: Environment Agency Policy Guidance

A1.1 The Environment Agency, in consultation with English Nature and the Countryside Council for Wales, has defined a range of policy measures in order to comply with the Habitats Directive. These policy measures add to, and consolidate, previous and existing statutory obligations to protect SSSIs. The measures involve an assessment of any proposed operations that the Environment Agency consents and that might affect SPAs, SACs, or SSSIs. The Environment Agency guidance assumes that in most cases, the assessment for permitted processes will be carried out by the Environment Agency itself. However, the Environment Agency considers that where planning permission will be required for the development in question, it is likely to be more appropriate for the Local Planning Authority (LPA) to undertake the assessment.

A1.2 Appendix 6 to the Environment Agency's guidance on applying the habitats regulations deals specifically with waste management. It states that where a regulated activity takes place on or immediately adjacent to a European Site or when there is any doubt about the relevance of the waste activity, a four stage screening procedure should be implemented to determine the significance of the activity. The first stage is a simple identification of whether the proposal is in the vicinity of a protected site or whether it is likely to be of any relevance to the protected site. The second stage is a risk assessment to determine if the proposal is likely to have a significant effect on the protected site. Stage 3 is an Appropriate Assessment of the likely impacts identified under Stage 2. These need to be considered in sufficient detail to determine whether it can be ascertained that they will not adversely affect the integrity of a protected site. The fourth stage is the determination of the application. A permit / licence will not be granted unless the Agency is satisfied that it will not adversely affect the integrity of a European site. Where conditions can be attached to a permit which will ensure no adverse effect, the permit can be granted rather than refused.

A1.3 The Environment Agency guidance makes clear that treating and/or disposing of waste in a manner that results in significant emissions to air should also be considered under the requirements of Appendix 7. With regard to the Stage 2 assessment, the guidance states that *"Where the concentration within the emission footprint in any part of the European Site is less than 1% of the relevant benchmark, the emission is unlikely to have a significant effect irrespective of the background levels".* It is assumed that this 1% criterion applies equally to deposition flux rates as it does to ambient concentrations. Should the contribution of a particular process exceed this 1% criterion in areas where exceedence of the critical loads is expected, then a Stage 3 assessment would be required.

A1.4 The Environment Agency guidance makes it clear that Stage 3 assessments should be specific to the case in question, taking account of actual operational practice and site specific data. The purpose of the assessment is to ascertain, that the proposal would not have an adverse effect on the integrity of the protected site. Since the assessment concentrates on the specific interest features of the relevant European Sites, standards and assessment protocols applied under current functional procedures designed to ensure broad environmental protection, may not be adequate. It is not possible to derive generic national thresholds or standards to determine whether a proposal would adversely effect the integrity of a European Site. Decisions must be made on a case by case basis in the light of the conservation objectives and local conditions. The Environment Agency guidance notes that each situation would have to be treated on an individual basis but as a general rule the decision could be summarised as follows:

- If the process contribution plus background concentration is less than the appropriate environmental criteria then it can be assumed there will be no adverse effect.

- If the background concentration is less than the appropriate environmental criteria, but a small process contribution leads to an exceedence then a decision should be made on the basis of local circumstances. If the process contribution is very small, or there is considerable uncertainty in the assessment it may be appropriate for the authorisation to include an improvement condition requiring the operator to undertake ambient monitoring.

- If the background concentration is currently exceeding the appropriate environmental criteria and the new process contribution will cause an additional small increase then a decision will have to be made based on the individual circumstances.

- If the background concentration is less than the appropriate environmental criteria, but the process contribution is significant and leads to an exceedance then the application should be refused. However, the process may be authorised on grounds that there are no alternative solutions and there are imperative reasons of overriding public interest why the consent must be given. Referral to the Secretary of State or National Assembly for Wales is required under these circumstances.

Appendix 2: Modelled & Measured Concentration Profiles

A2.1 Figure A2.1 shows the extent to which ambient ammonia concentrations fall with distance from an emission source. The data presented are the modelled outputs from the two area source scenarios included in this assessment, the modelled outputs from a typical poultry unit, and measured data which are presented (amongst other places) in NEGTAP (2001). All of the data have been normalised to the concentration at 15m from the source, and are thus relative, not actual concentrations. The measured data will include a certain degree of emission from the ground; which probably explains why the measured data are greater than the modelled data at 270m from the emission source. Apart from this, the modelled data show very close agreement with the measurements, but will tend to over-predict ammonia concentrations slightly.

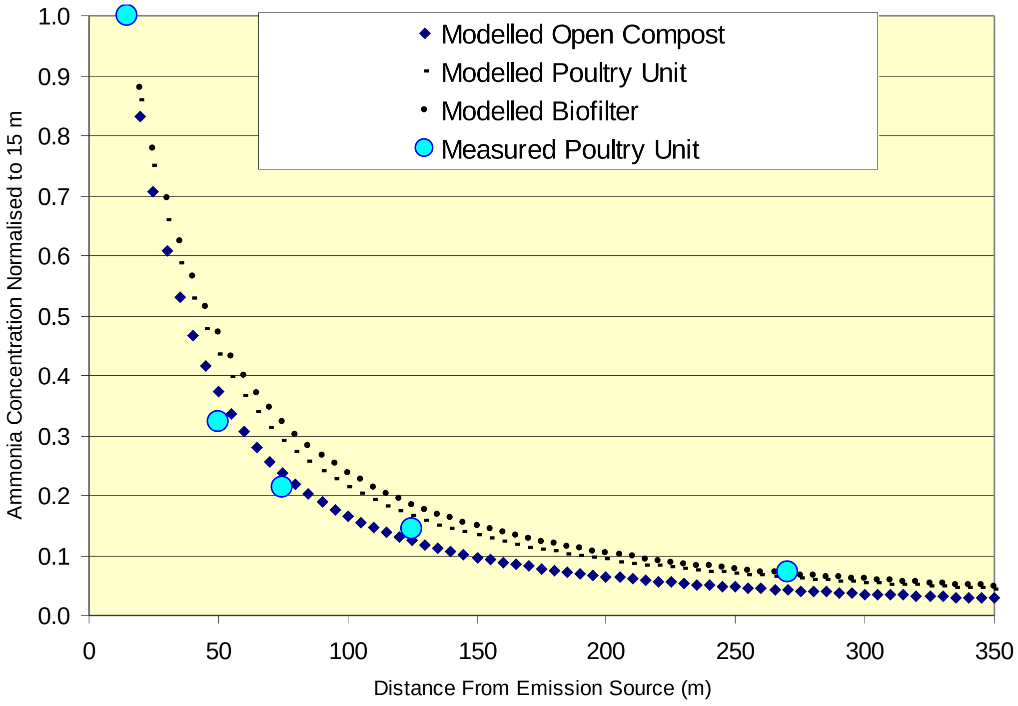

Figure A2.1 Modelled and Measured (NEGTAP, 2001) Ammonia Concentrations at Distance from Emission Sources, Normalised to the Concentration at 15m.

Appendix 3

A3.1 A recent report by Entec (2005) also assessed the potential impacts of a proposed MBT and RDF plant at Winfrith on nitrogen deposition to sensitive habitats. Entec assumed annual production rates of 120,000 tonnes per year for the MBT and 50,000 tonnes per year from the RDF. These seam to be reasonable assumptions and have also been used in this assessment.

A3.2 Entec predicted NOx emission rates from the RDF plant based on emission limits set under the Waste Incineration Directive. Their modelled emission rate, expressed in the units used in this current report, was 1,430 grammes of NOx per tonne of waste incinerated. This agrees very well with the “best estimate” figure of Defra (2005). This current assessment has used the upper bound estimate from the same source.

A3.3 Entec predicted ammonia emission rates from the MBT plant by consulting a single process supplier. They took the maximum possible emission rate as a constant throughout the year. This is a worst-case approach. Their modelled emission rate was thus higher than the post-abatement figures used in this current assessment, which draw on more detailed emission data. Entec did not account for NOx emissions from the MBT, but this current study has shown that, even assuming worst-case figures, these are likely to be relatively small.

A3.4 Entec carried out dispersion modelling using ADMS 3.2. This dispersion model is equally robust as the AERMOD model used in this current assessment. They used meteorological data from Yeovilton, while Bournemouth Airport was used in this current studies. Both sites are likely to be equally representative. Entec did, however, assume that all ammonia would be released at a height of 15m. This current study has shown that local impacts will be very different for different release heights. Even though Entec potentially underestimated the impact of a biofilter at abating their emissions, they did assume that a biofilter would be present. It would, therefore, have been more realistic to model the MBT emissions as a low-level area source than as a raised point-source. Because such a large, and deliberately worst-case, initial release rate was assumed by Entec, this technical detail has not compromised their assessment.

A3.5 As explained in the main text of this current report, in this environment ammonia dry deposits very rapidly, nitrogen dioxide deposits somewhat slower, and nitric oxide hardly (net) deposits at all (NOx is the sum of nitrogen dioxide and nitric oxide). Entec modelled all of their emissions as nitrogen, rather than any particular nitrogenous species. This approach constrained them to assume a single deposition velocity for all three of their modelled pollutants. The deposition rate that they assumed was 5 mm/s. This current study has used the rates of 19 mm/s for ammonia, 1.6 mm/s for nitrogen dioxide, and 0 mm/s for nitric oxide. Entec will have overestimated the impact of the RDF and, had they used a less conservative emission rate, would have underestimated the impact of the MBT.

A3.6 Entec present an average result for the entire modelled domain, as well as for "the nearest point of the designated sites to the possible facility". Their result for Winfrith Heath in Table 4.1 (1.15 kg-N/ha/yr) can thus be compared with the results for Receptors 3,4 and 5 in Table 6.1 of the current report (0.08 – 6.1 kg-N/ha/yr). Their result for River Frome (0.97 kg-N/ha/yr) will roughly equate to the position of Receptor 6 in Table 6.1 (0.05 – 1.99 kg-N/ha/yr). The results of Entec clearly fall comfortably within the range of results provided in this current report, but for the reasons explained above; over-predict the likely impact of a plant employing both a biofilter and an ammonia scrubber.

A3.7 Overall, even though the Entec study takes a rather simplistic approach, it adequately fulfils its objective of providing a worst-case assessment of possible impacts.

Appendix 4

A4.1 The effects of exposure to nitrogen are related to the total deposition over a long period, which is why the Critical Loads refer to an amount deposited per year. Short-term levels are less important than the long-term cumulative deposition rate. This is clearly not the case with all environmental pollutants which the Environment Agency assess; for example one of the Government's Air Quality Objectives for sulphur dioxide refers to a 15-minute mean concentration, which relates to the time frame over which impacts associated with this gas might occur.

A4.2 JNCC has commented that, for PPC applications, the Environment Agency require applicants to predict environmental impacts with their mitigation technology in place; and also with the mitigation not operational. This is to ensure that even if the technology temporarily stops operating for any reason, impacts would remain within acceptable levels. Clearly, the assessment of abnormal operating conditions is most important for pollutants that impact over shorter time periods; but short-term peak emissions can still potentially augment annual mean values. As noted in the introduction to the report, even a calendar year is possibly too short a time frame to assess nitrogen deposition against the critical loads, which assume constant rates of nitrogen deposition over decades. The most important factor when assessing nitrogen deposition is thus likely to be a "typical" rather than an "atypical" year.

A4.3 As explained in the main text, the assessment does not refer to any specific application. It is not known what technology would be employed and thus it is impossible to predict how efficiently any site would be managed. Furthermore, there have been very few studies of emissions from the technologies assessed here, and none of them have taken place over sufficient periods of time to quantify the impacts that might be associated with abnormal operating conditions. It is, however, possible to make some broad-brush assumptions in terms of potential faults in the ammonia scrubber and biofilter abatement method.

A4.4 This assessment has assumed that a scrubber and biofilter operate at a combined 99.9% efficiency. This assumption is based on a worst-case interpretation of a measured 100% efficiency (ORA, 2005). If the scrubber were to fail, then emissions would pass through the biofilter alone, which is assumed in the main text to have a 93% abatement efficiency. A biofilter is not a difficult technology to maintain, but should it fail, the scrubber is likely to still be present. The scrubber alone is assumed to have a 99% abatement efficiency[1].

---

[1] Because it is assumed that the biofilter allows 7% of ammonia to pass through, but the biofilter with scrubber allow just 0.1% of ammonia to pass through. In very rounded numbers 0.1 is roughly 1% of 7.

A4.5 It is a reasonable assumption that the scrubber would not be inoperative for more than 7 days (168 hours) in a "typical" year. Similarly, the biofilter is unlikely to be inoperative for more than 7 days in a "typical" year. It would be very unfortunate for both abatement methods to malfunction simultaneously, and in a "typical" year it is assumed that this does not occur. Thus, after accounting for potential malfunction of the ammonia abatement systems, the scrubber and biofilter method would operate at 99.9% efficiency for 96% of the year; at 99% efficiency for 2% of the year; and at 93% efficiency for 2% of the year. Overall, this amounts to an average 99.75% annual mean abatement efficiency. Table A4.1 sets out the modelled concentrations at the worst-case receptor at each site after accounting for potential down-time of the ammonia abatement system.

A4.6 This analysis is clearly hypothetical, but is intended to demonstrate that if a more detailed and robust assessment was conducted for a specific site and a known operator, taking account of scrubber and biofilter downtime, then it is possible that impacts could be slightly greater, although they would remain very low, if not negligible.

Table A4.1 Summary of Assessment Results at the Worst-Case Receptors, With and Without Down-Time in the Mitigation Technology.

Site	Process	Process-Related Deposition at the worst-case receptor (kg-N/ha/yr)	Process-Related Deposition (% of Critical Load)	Subjective Assessment Potential Impact Significance
Without Down-Time				
Winfrith	MBT + RDF	<0.1	<1	Insignificant
Chapel Lane	MBT + RDF	0.2	<1-2	Insignificant - Very Low
Bournemouth Airport	MBT + RDF	0.1	<1-1	Insignificant - Very Low
Ferndown	MBT + RDF	<0.1	<1	Insignificant
Canford Magna	MBT + RDF	0.2	<1-2	Insignificant - Very Low
Binnegar	In-vessel compost	0.1	<1-1	Insignificant - Very Low
With Down-Time				
Winfrith	MBT + RDF	0.2	1-2	Very Low
Chapel Lane	MBT + RDF	0.3	2-3	Very Low
Bournemouth Airport	MBT + RDF	0.3	2-3	Very Low
Ferndown	MBT + RDF	<0.1	<1	Insignificant
Canford Magna	MBT + RDF	0.4	2-4	Very Low
Binnegar	In-vessel compost	0.3	1-3	Very Low

Appendix 5

A5.1 The following Tables set out the relative contribution made by NOx and ammonia to the total predicted process-relate nitrogen deposition at each of the sites where both NOx and ammonia are likely to be emitted.

Table A5.1 Relative Contributions of Oxidised-N and Reduced-N to the Total Process-Related Nitrogen Deposition from a Generic MBT and RDF Plant at Winfrith.

R	Process Related – Ammonia Conc (µg/m^3)			Process - Related Ammonia-N Deposition (kg-N/ha/yr)[a]			Process Related – NOx Conc (µg/m^3	Process - Related NOx-N Deposition (kg-N/ha/yr)[a]	% Contribution of NOx to total Process-Related N deposition		
	stack	bio	scrub	stack	bio	scrub			stack	bio	scrub
1	0.33	0.22	<0.01	1.63	1.08	0.02	0.22	0.02	1.0	1.5	51.8
2	0.24	0.10	<0.01	1.16	0.50	0.01	0.27	0.02	1.7	4.0	74.2
3	0.72	0.86	0.01	3.53	4.22	0.06	0.17	0.01	0.4	0.3	18.0
4	0.59	1.16	0.02	2.92	5.74	0.08	0.04	<0.01	0.1	0.1	3.8
5	0.35	1.12	0.02	1.72	5.52	0.08	0.04	<0.01	0.2	0.1	3.9
6	0.37	0.12	<0.01	1.84	0.60	0.01	0.49	0.04	2.0	5.9	81.5

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
Scrub = emissions are treated first with an ammonia scrubber and then with a biofilter.

Table A5.2 Relative Contributions of Oxidised-N and Reduced-N to the Total Process-Related Nitrogen Deposition from a Generic MBT and RDF Plant at Chapel Lane.

R	Process Related – Ammonia Conc (µg/m^3)			Process - Related Ammonia-N Deposition (kg-N/ha/yr)[a]			Process Related – NOx Conc (µg/m^3	Process - Related NOx-N Deposition (kg-N/ha/yr)[a]	% Contribution of NOx to total Process-Related N deposition		
	stack	bio	scrub	stack	bio	scrub			stack	bio	scrub
1	0.54	0.48	0.01	2.66	2.36	0.03	0.31	0.02	0.9	1.0	41.1
2	0.45	0.52	0.01	2.23	2.56	0.04	0.33	0.03	1.1	1.0	41.0
3	0.94	1.48	0.02	4.63	7.28	0.10	0.28	0.02	0.5	0.3	17.0
4	0.95	1.34	0.02	4.68	6.62	0.09	0.35	0.03	0.6	0.4	22.2
5	0.64	0.79	0.01	3.18	3.89	0.06	0.47	0.04	1.1	0.9	39.4
6	0.54	0.58	0.01	2.66	2.87	0.04	0.45	0.03	1.3	1.2	45.8
7	0.87	1.55	0.02	4.29	7.67	0.11	0.41	0.03	0.7	0.4	22.2
8	0.51	0.85	0.01	2.52	4.21	0.06	0.47	0.04	1.4	0.9	37.5
9	0.45	0.68	0.01	2.21	3.36	0.05	0.45	0.03	1.5	1.0	41.6
10	1.65	1.81	0.03	8.13	8.93	0.13	0.37	0.03	0.4	0.3	18.4
11	0.84	0.33	<0.01	4.13	1.60	0.02	0.77	0.06	1.4	3.5	72.0
12	1.25	0.58	0.01	6.18	2.84	0.04	0.78	0.06	1.0	2.1	59.5

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
Scrub = emissions are treated first with an ammonia scrubber and then with a biofilter.

Table A5.3 Relative Contributions of Oxidised-N and Reduced-N to the Total Process-Related Nitrogen Deposition from a Generic MBT and RDF Plant at Bournemouth Airport.

R	Process Related – Ammonia Conc (µg/m^3)			Process - Related Ammonia-N Deposition (kg-N/ha/yr)[a]			Process Related – NOx Conc (µg/m^3	Process - Related NOx-N Deposition (kg-N/ha/yr)[a]	% Contribution of NOx to total Process-Related N deposition		
	stack	bio	scrub	stack	bio	scrub			stack	bio	scrub
1	0.16	0.23	<0.01	0.78	1.11	0.02	0.19	0.01	1.8	1.3	47.2
2	0.17	0.28	<0.01	0.82	1.37	0.02	0.17	0.01	1.5	0.9	39.4
3	0.32	0.27	<0.01	1.58	1.35	0.02	0.40	0.03	1.9	2.2	61.4
4	0.36	0.35	<0.01	1.77	1.72	0.02	0.39	0.03	1.7	1.7	54.8
5	0.51	0.85	0.01	2.51	4.19	0.06	0.16	0.01	0.5	0.3	16.7
6	0.43	1.87	0.03	2.13	9.24	0.13	0.04	<0.01	0.1	0.0	2.2
7	0.54	0.31	<0.01	2.66	1.51	0.02	0.63	0.05	1.8	3.1	69.3
8	0.81	0.82	0.01	3.99	4.06	0.06	0.22	0.02	0.4	0.4	22.3
9	0.71	1.72	0.02	3.52	8.46	0.12	0.05	<0.01	0.1	0.0	3.1
10	0.44	0.22	<0.01	2.19	1.09	0.02	0.65	0.05	2.2	4.4	76.3
11	0.25	0.07	<0.01	1.25	0.33	0.00	0.35	0.03	2.1	7.5	85.1
12	0.34	0.12	<0.01	1.66	0.59	0.01	0.51	0.04	2.3	6.2	82.1

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
Scrub = emissions are treated first with an ammonia scrubber and then with a biofilter.

Table A5.4 Relative Contributions of Oxidised-N and Reduced-N to the Total Process-Related Nitrogen Deposition from a Generic MBT and RDF Plant at Ferndown.

R	Process Related – Ammonia Conc (µg/m^3)			Process - Related Ammonia-N Deposition (kg-N/ha/yr)[a]			Process Related – NOx Conc (µg/m^3	Process - Related NOx-N Deposition (kg-N/ha/yr)[a]	% Contribution of NOx to total Process-Related N deposition		
	stack	bio	scrub	stack	bio	scrub			stack	bio	scrub
1	0.36	0.12	<0.01	1.77	0.60	0.01	0.53	0.04	2.2	6.3	82.5
2	0.42	0.08	<0.01	2.08	0.76	0.01	0.62	0.05	2.3	6.0	81.6
3	0.59	0.10	<0.01	2.89	1.01	0.01	0.43	0.03	1.1	3.1	69.3
4	0.32	0.09	<0.01	1.59	0.42	0.01	0.44	0.03	2.1	7.4	84.8
5	0.57	0.07	<0.01	2.79	0.90	0.01	0.38	0.03	1.0	3.2	69.6
6	0.52	0.08	<0.01	2.57	0.66	0.01	0.33	0.03	1.0	3.7	72.8

R = Receptor Number.
stack = emissions are not abated, but are piped through a vent above the building roof.
bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.
Scrub = emissions are treated first with an ammonia scrubber and then with a biofilter.

Table A5.5 Relative Contributions of Oxidised-N and Reduced-N to the Total Process-Related Nitrogen Deposition from a Generic MBT and RDF Plant at Canford Magna.

R	Process Related – Ammonia Conc (µg/m^3)			Process - Related Ammonia-N Deposition (kg-N/ha/yr)^a			Process Related – NOx Conc (µg/m^3	Process - Related NOx-N Deposition (kg-N/ha/yr)^a	% Contribution of NOx to total Process-Related N deposition		
	stack	bio	scrub	stack	bio	scrub			stack	bio	scrub
1	0.15	0.11	0.00	0.74	0.53	0.01	0.09	0.01	0.9	1.2	46.9
2	0.26	0.15	0.00	1.29	0.74	0.01	0.16	0.01	1.0	1.7	54.1
3	0.66	1.98	0.03	3.27	9.77	0.14	0.32	0.02	0.8	0.3	15.2
4	0.58	0.90	0.01	2.85	4.46	0.06	0.45	0.03	1.2	0.8	35.4
5	0.67	0.30	0.00	3.30	1.49	0.02	0.45	0.03	1.0	2.3	61.8

R = Receptor Number.

stack = emissions are not abated, but are piped through a vent above the building roof.

bio = emissions are treated with a biofilter operating at 93% efficiency and are released directly from the biofilter.

Scrub = emissions are treated first with an ammonia scrubber and then with a biofilter.

Figures

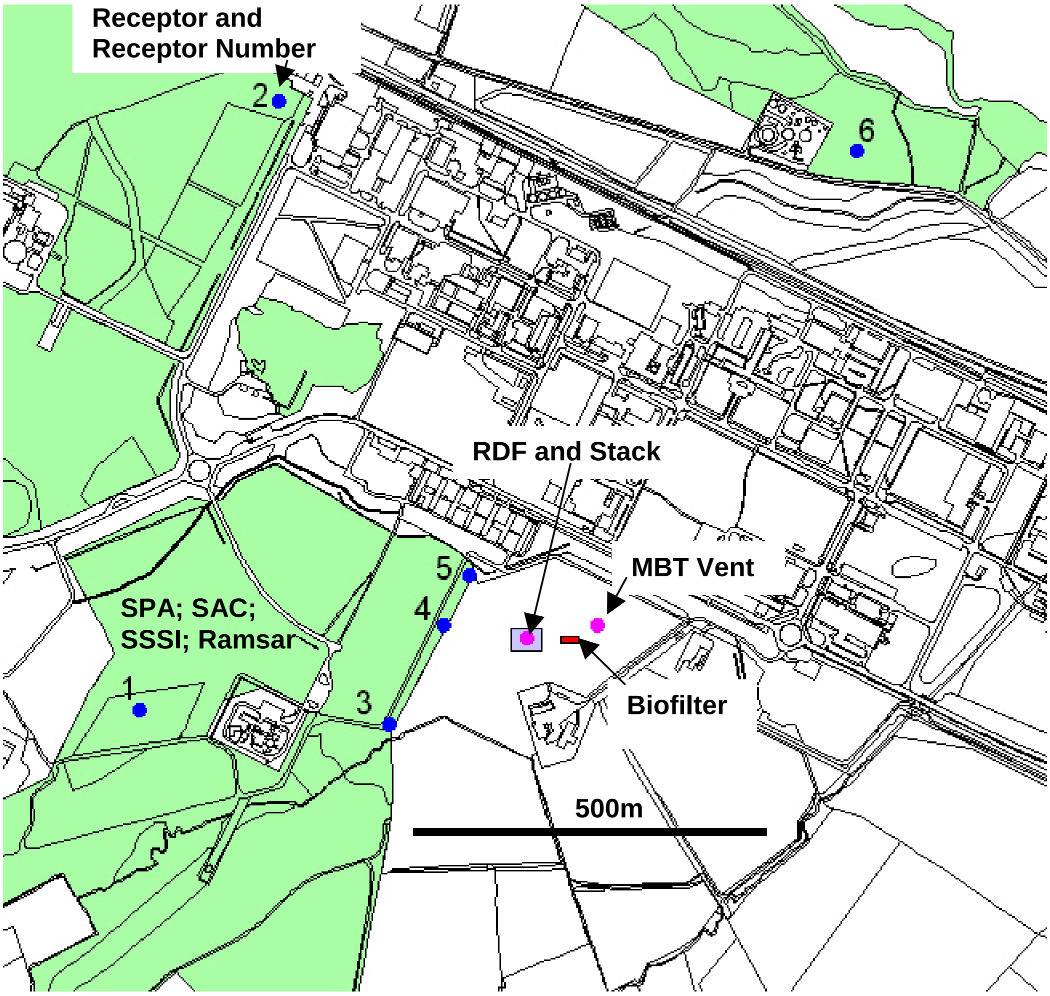

Figure 1 Locations Included in the Dispersion Modelling for Winfrith

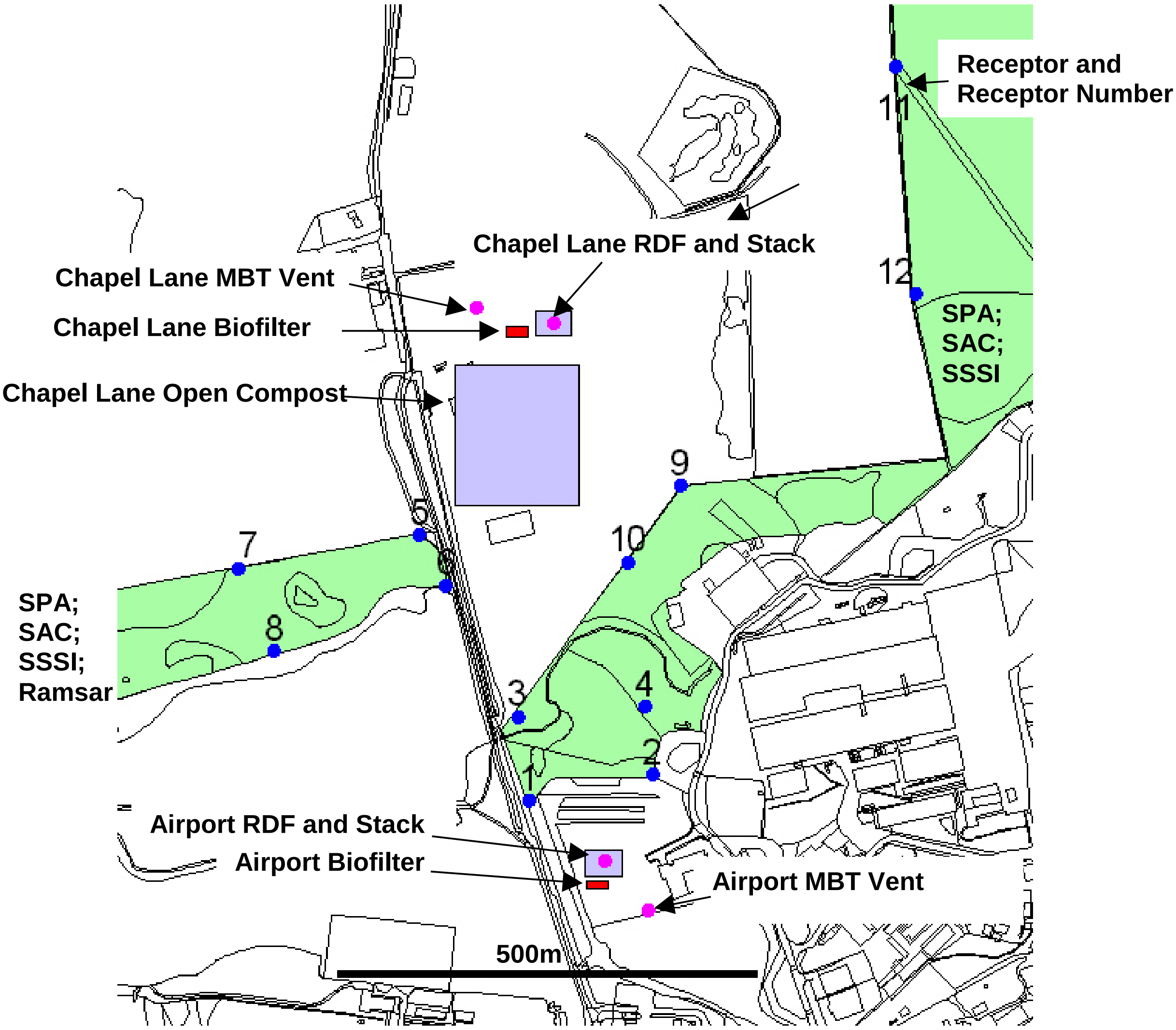

Figure 2 Locations Included in the Dispersion Modelling for Chapel Lane and Bournemouth Airport

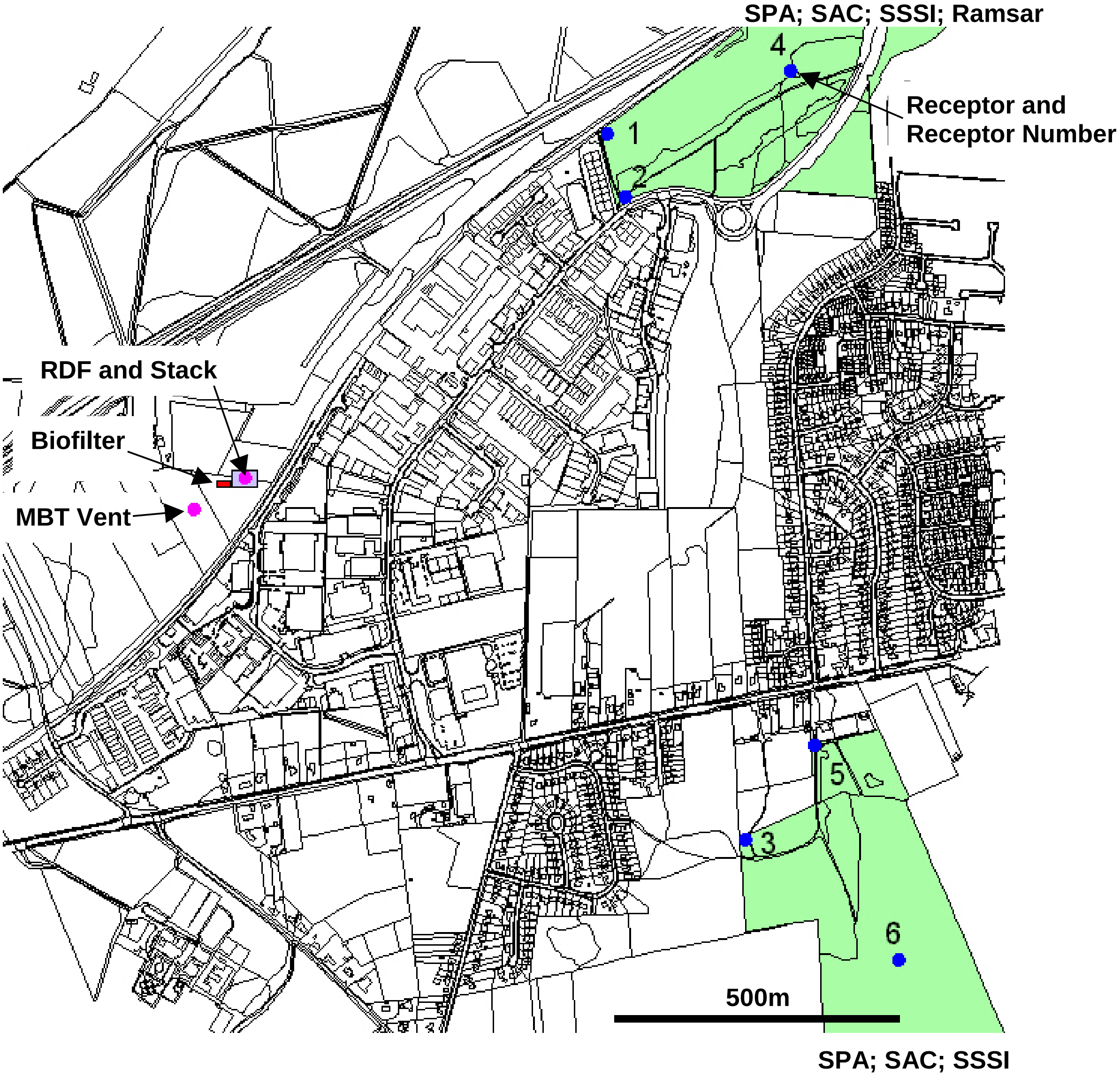

Figure 3 Locations Included in the Dispersion Modelling for Ferndown

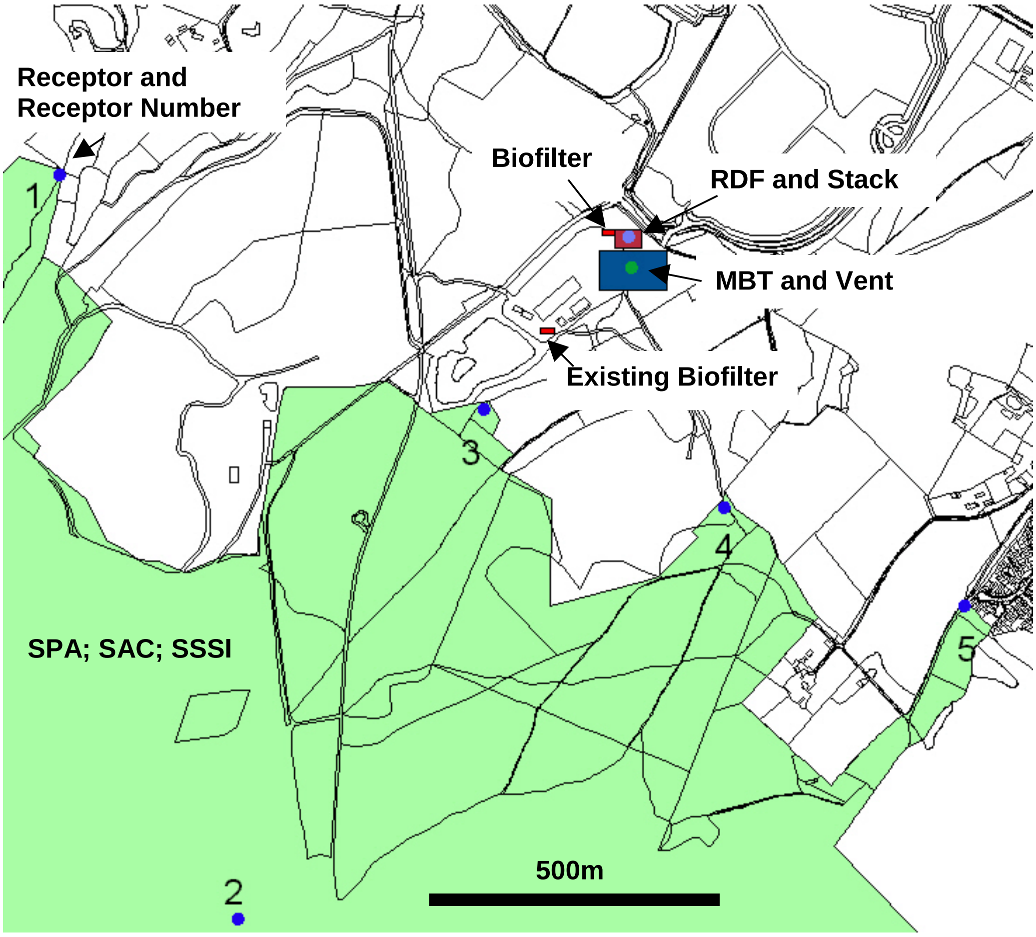

Figure 4 Locations Included in the Dispersion Modelling for Canford Magna

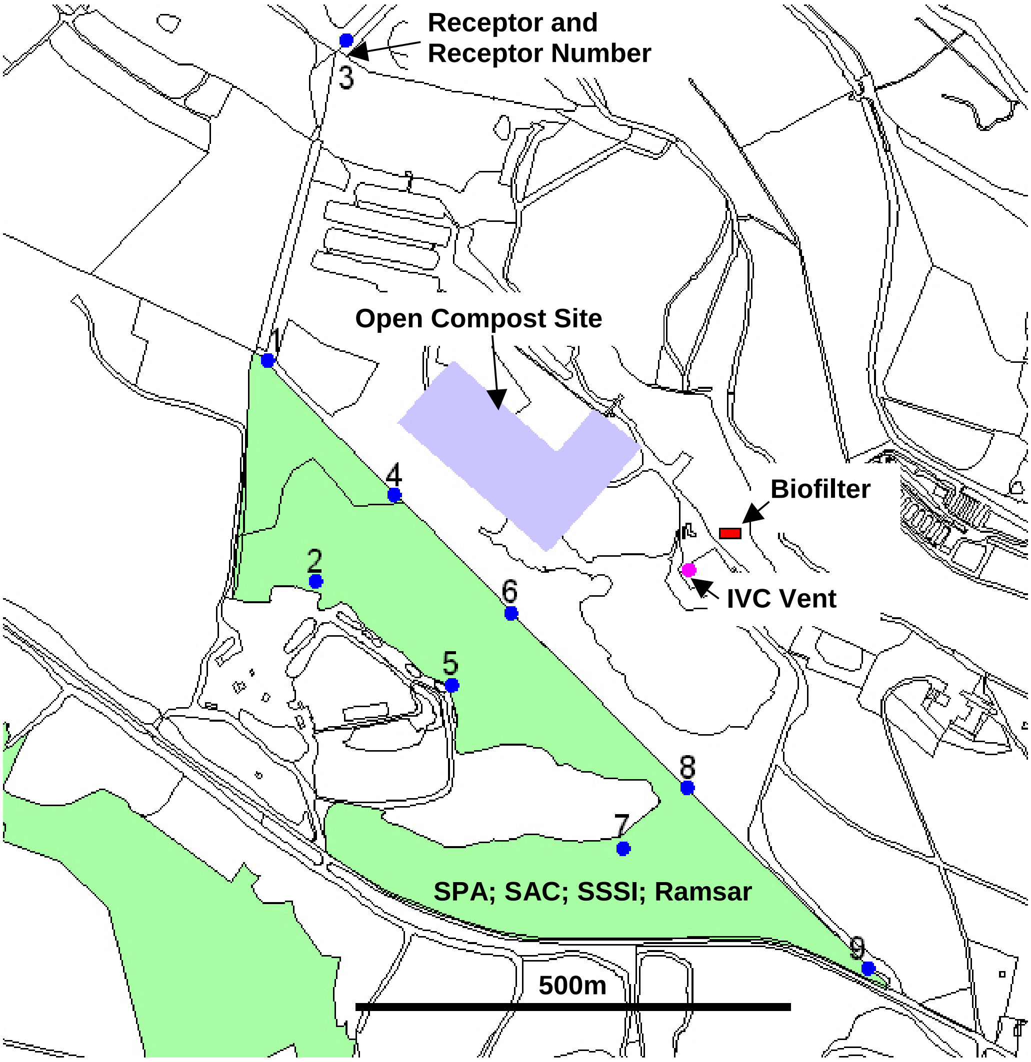

Figure 5 Locations Included in the Dispersion Modelling for Binnegar

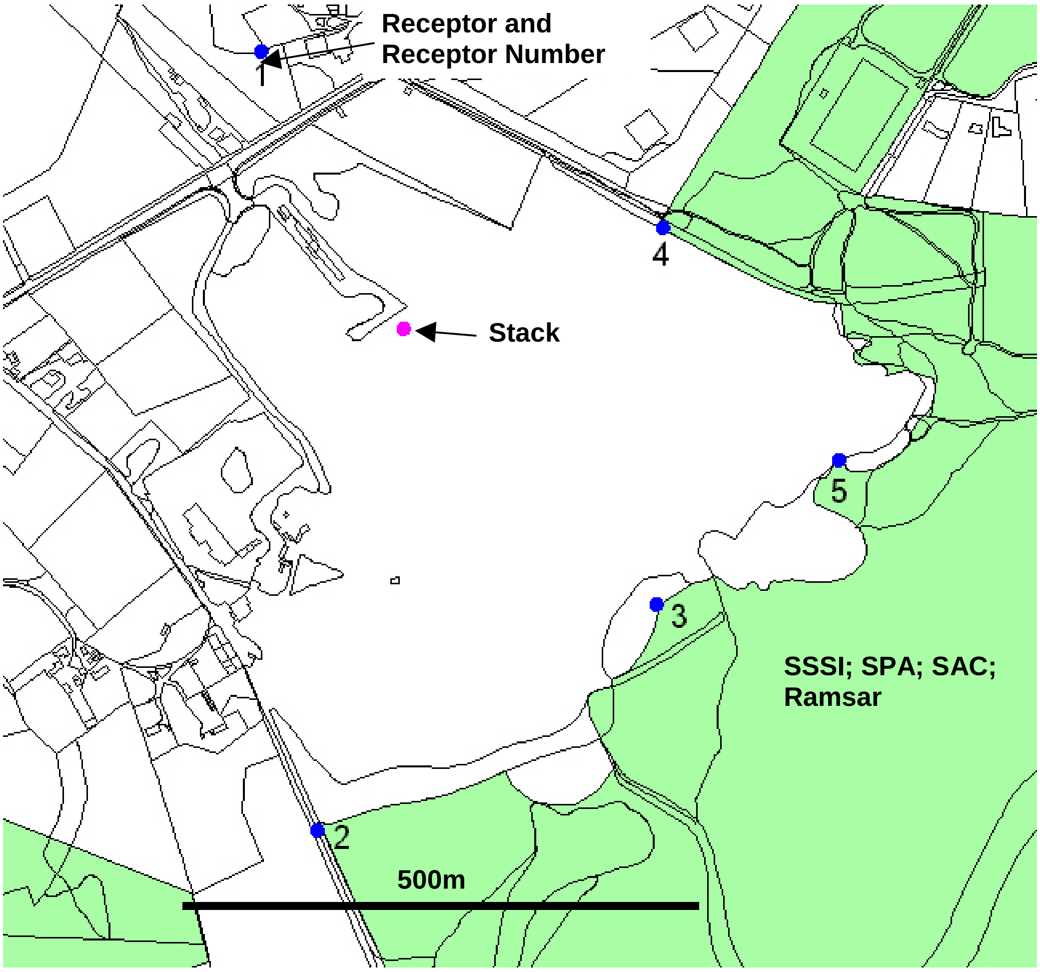

Figure 6 Locations Included in the Dispersion Modelling for Beacon Hill