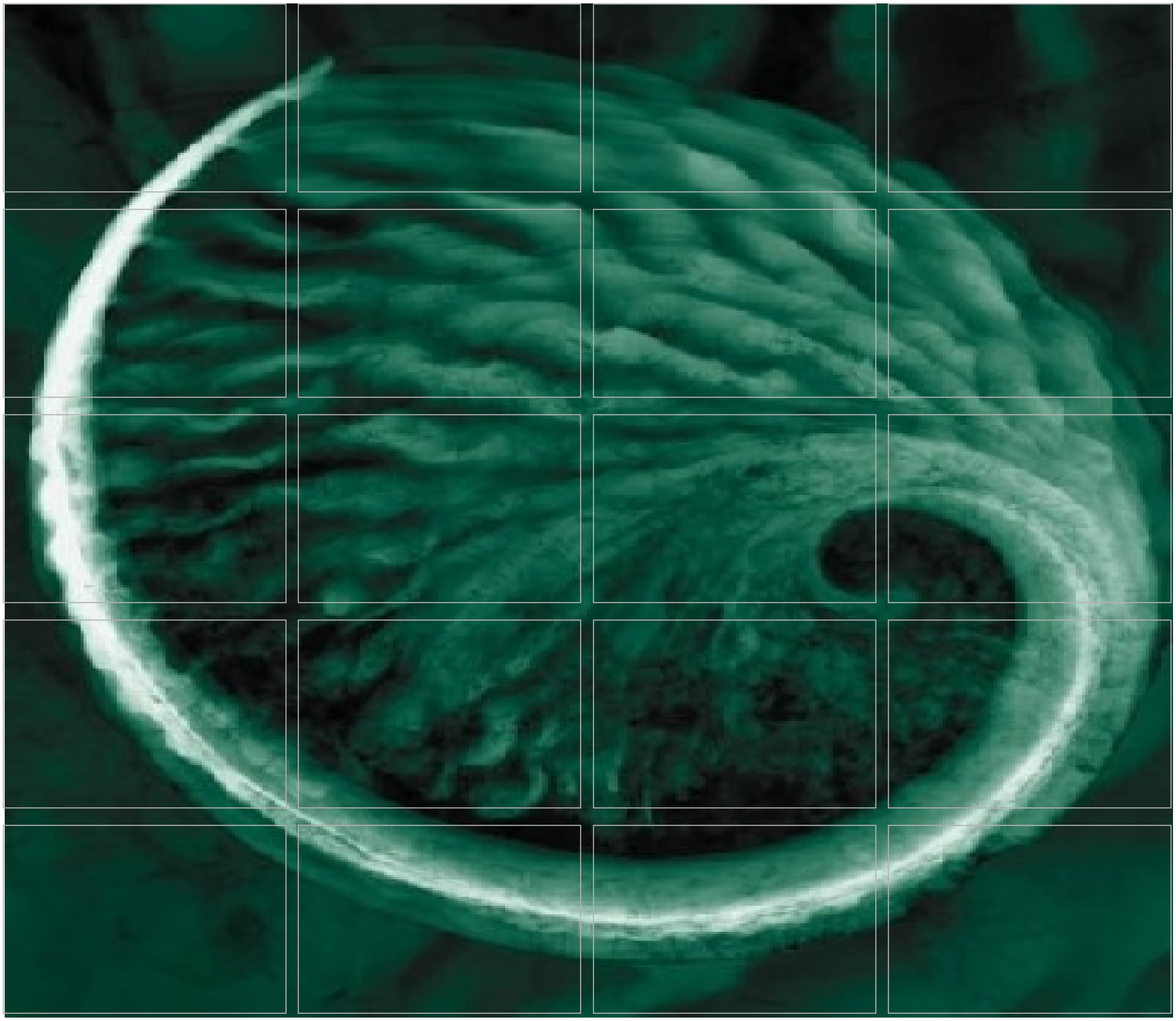

Worcestershire County Council HRA Addendum

Final Report

September 2011

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September 2011

Final Report

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CONTENTS

1 INTRODUCTION

Worcestershire County Council (WCC) is currently finalising its Waste Core Strategy (WCS). Previously, a Habitats Regulation Assessment (HRA) was undertaken to identify the potential constraints on waste management operations in the county due to significant adverse impacts on European Designated Habitats. There are several of these in the county and in neighbouring counties close enough to be impacted by operations of facilities in Worcestershire.

This addendum sets out further consideration of the potential impacts of thermal treatment plants on habitats, and also considers the potential for significant impacts associated with other types of waste management facilities.

2 THERMAL WASTE TREATMENT

2.1 INTRODUCTION

A key element of the HRA was an assessment of the potential for emissions to air from thermal waste treatment plants. For the purposes of this study, this is assumed to be an Energy from Waste plant; however this assessment is equally valid for other plants utilising thermal treatment, as they will be subject to the same emission limits for Energy from Waste plants. These other plants include:

- Gasification plants;
- High and low temperature pyrolysis plants; and
- Mechanical Biological Treatment facilities, incorporating thermal treatment of residual wastes.

In addition, plants utilising Refuse Derived Fuel are also likely to fall within the same regime and can therefore be considered to fall within the same assessment scope. The possible exceptions for waste treatment plant utilising thermal treatment for which the findings of this study would not be applicable are cement plants, landfill sites (through the combustion of landfill gases), and some small specialist incineration plants which are not large enough to be included in the Waste Incineration Directive. However, these types of facility have not been explicitly dealt with in this study.

In undertaking the HRA a number of 'areas of search' were identified by WCC through a short-listing process which represents suitable locations for the construction of thermal treatment plants. These sites were considered in terms of proximity to sensitive habitats. On this basis, a selection of these 'areas of search' were investigated to identify whether there is the potential for Likely Significant Effects (LSE) on European Designated Habitats due to emissions from a facility at these locations. As discussed in the previous report, the sites investigated were considered as these are those most likely to have significant impacts on habitats, due to proximity to habitat sites. A number of potentially suitable sites were identified where development would be constrained by the potential impacts due to emissions to air.

Following on from this assessment, WCC took the decision to amend the approach that was taken in the HRA with regard to the consideration of thermal treatment options (ie Energy from Waste). Instead of identifying 'areas of search' and assessing the potential for constraints, WCC instead sought to understand where development would be constrained due to impacts of emissions on European Designated Habitats. In addition, the revised approach incorporated a number of refinements over and above the previous study, and can be considered to be a more refined interpretation of the evidence pertaining to thermal treatment plants.

The previous HRA utilised air dispersion modelling to ascertain the potential impacts on air quality associated with the operation of a thermal waste treatment plant. This was based upon a conceptual plant design, with two different capacities (250,000 tonnes waste per annum and 150,000 tonnes waste per annum), with two different stack heights (80m and 100m). Emissions were assumed to occur at the emission limits set out in the European Waste Incineration Directive (WID).

In this study, air dispersion modelling has again been used, based upon, initially 250,000 tonnes per annum waste throughput, and an 80m stack height. However, an alternative methodology was developed to ascertain the zone of LSE around the European Designated Habitats of interest to define those areas within which it cannot be concluded that there will be no likely significant effects (LSE) from the development of a thermal treatment facility (referred to in this document as 'LSE zone').

2.2 METHODOLOGY

2.2.1 Introduction

The modelling methodology was the same as previously, insomuch as the model was based upon a 250,000 tonne per annum Energy from Waste plant, with an 80m stack. The details of the conceptual model are set out in the previous HRA. However, the requirement to define LSE zones, rather than investigating 'Areas of Search', necessitated a modification to the modelling process as discussed below.

The critical levels and critical loads used in the study are the same as used in the previous study. For NO_x, SO_2 and NH_3, these are based on the generic critical levels applicable to all habitat sites, and for NN and Acid these are based upon site specific critical loads. The critical loads and critical levels are set out in *Table 2.1*.

Table 2.1 Critical Loads and Critical Levels used in the assessment

Pollutant	Fens Pools	Lyppard Grange Ponds	Bredon Hill	Dixton Wood
NO_x (µg/m^3)	30			
SO_2 (µg/m^3)	20			
NH_3 (µg/m^3)	1 (woodlands for the protection of lichens 3 (other sites)			
NN (kg/ha/yr)	10-20	20-30	10-15	10-15
Acid (keq/ha/yr)	2.05	4.74	2.56	2.58

2.2.2 *Details of the modified modelling apporach*

Overview

The revised modelling approach reflects the requirement to 'reverse' the assessment approach. The opportunity was also taken to refine the assessment approach and improve the accuracy from the previous county-wide study to an assessment focussed more closely on each habitat site of interest. However, the model approach also required assumptions to be made. Where these are made, these are conservative. This approach has led to findings that are more pessimistic than in the original HRA.

This has led to some cases where the interpretation of the findings for an 'Area of Search' identified in the HRA do not exactly match the findings in this addendum. The approach to reconcile this conflict, is that the findings of this Addendum be applied to those 'Areas of Search' where these conflicting results are identified.

Previously, in the HRA those Areas of Search where impacts were >1% of a critical load or critical level were defined as 'cannot conclude no Likely Significant Effect'. This also applies in this case, whereby whilst a site is within the LSE zone, this does not mean that development of a thermal treatment plant cannot necessarily happen here.

Modifications to approach

Dispersion models are designed to identify the impacts on the surrounding environment as a result of emissions from a facility in a given location. In order to develop the LSE zones presented in the addendum, it was necessary to undertake a multi-stage calculation. The calculation, in effect, places conceptual facilities across a grid of points around each habitat and identifies the location around each of the facilities at which the 1% threshold occurs for each of five pollutants, these being:

- Sulphur dioxide (SO_2);
- Oxides of nitrogen (NO_x);
- Ammonia (NH_3);
- Nutrient nitrogen deposition (NN); and
- Acid deposition (Acid).

On this basis, a footprint can be generated around each habitat that represents the point at which 1% of the Critical Load or Critical Level is reached (ie the point of LSE).

In the case of Bredon Hill this approach generated in excess of 40,000 conceptual facilities, with an array of data associated with each point and each pollutant. It was therefore necessary to have limitations in the design to ensure that the amount of data remained manageable. Also, each pollutant generates its own LSE Zone. The extent of this will vary for each site as it is dependant upon the pollutant in question, the size and shape of the European Designated Habitat and the critical load or critical level. The map for each designated habitat shows the extent of the largest LSE zone, and therefore the most pessimistic interpretation of the assessment results.

The methodology used has also been refined in order to produce more accurate results. Several additional considerations have been made:

- The number of receptor locations for each habitat has been increased: this was done to understand better the exact extent of the LSE zone. This is particularly important for Lyppard Grange Ponds, as previously this was defined on the basis of one receptor point in the southwest corner of the site; this approach was appropriate for the county-wide nature of the previous assessment. However, the greater refinement possible with this method improved the overall accuracy of the assessment.

- The definition of the boundary of the LSE zone has been redefinied to 0.9% of the critical load or critical level: defining the LSE zone on the basis of where impacts are exactly 1% or less of the critical load or critical level may, in some cases, lead to the zone being too small (this arises due to a combination of necessary assumptions in the model including receptor grid resolution, number of 'boundary points' used to define the limits of the habitat, and the need to keep data quantity manageable). Instead, the assessment was based upon the definition of the LSE zone being where impacts are greater than 0.9% of the critical load or critical level. This approach is conservative, and means that there is a 'margin of error' in the LSE zone. This approach was adopted so that if site specific studies are undertaken it is less likely that a site previously not in the LSE zone would subsequently fall within the zone, due to uncertainties in the modelling approach.

- The Areas of Search around Lyppard Grange Ponds have been better defined. In the previous assessment the stack location was defined as the centre of the site. In some cases where the sites are large (for example Warndon Business Park) this approach improves the resolution of the results.

One consequence of these slight changes in methodology is that some Areas of Search that were previously just outside the LSE zone are now within the LSE zone. This is particularly apparent around Lyppard Grange Ponds, where several Areas of Search (1-9) were on the cusp of the 1% threshold. Of these the following sites were previously outside the LSE, but are now within it:

- Shire Business Park (2 sites);
- Buckholt Business Centre;
- Warndon Business Park;
- Berkeley Business Park; and
- Diglis Industrial Estate.

In addition, the following sites were within the LSE zone previously, and remain within it:

- Great Western Business Park;
- Shrubhill Industrial Estate;
- Sherriff Street Industrial Estate; and
- Newtown Road Industrial Estate.

As previously discussed, at these sites it cannot be concluded that there is no LSE; however this does not necessarily preclude development at these locations.

2.3 *RESULTS*

Figure 2.1 to *Figure 2.5* illustrate the maximum extent of the LSE zone for each habitat where emissions cannot be concluded as having 'no Likely Significant Effect'. As previously discussed, this does not mean that development of a thermal treatment plant cannot happen here, but that the development may be constrained. This would need to be determined by a site specific assessment.

2.4 *CONCLUSION*

The modelling demonstrates that there are sizable areas, primarily to the south west (upwind) of each of the European Designated Habitats, where there may be constraints associated with the development of thermal treatment plants.

Comparison with the previous HRA assessment, which was based upon specific 'Areas of Search', illustrates that in this case the results are slightly more conservative. The reasons for this have been described in detail in the methodology section and arise out of refinement of the model methodology and the inclusion of a small margin or error to avoid potential conflicts in the future if site specific assessments are undertaken.

However, it is acknowledged that this conservative approach has changed some conclusions, particularly around Lyppard Grange Ponds where Areas of Search not previously associated with LSE are now within the LSE zone. This serves to highlight that for those Areas of Search that are close to the cusp of the 1% boundary of critical load or critical level, detailed consideration of potential impacts on habitats would be required.

3 DEVELOPMENT OF OTHER WASTE MANAGEMENT TECHNOLOGIES

3.1 INTRODUCTION

The aim of this discussion is to identify those waste treatment methods that generate air emissions and which may result in LSE at European Designated Habitats and how their development might consequently need to be constrained through policy. LSE zones have been developed on the basis of the best available information for each waste management technology.

The following technologies and processes have therefore been considered here:

- Open and in-vessel composting
- Anaerobic digestion
- Recycling
- Autoclave
- Mechanical biological treatment
- Waste transfer stations

No consideration is made of landfill sites.

Where there are emissions of dust and bioaerosols these have been considered separately in *Section 4*, and cross-references have been included as appropriate.

A review has been undertaken of two key sources of information in order to identify the key emissions of interest for each technology:

- ERM has undertaken a major report on behalf of Defra which quantified emissions from waste management processes. This report has been finalised, and is currently awaiting publication by Defra; and

- the APIS website which brings together information on impacts to habitats.

Other sources of information have been considered where necessary in support of specific topics.

This section is developed on the most up to date information available, primarily research undertaken in developing the Defra 2011 report. When discussing some waste management technologies the information is more up to date than in the HRA report, and the LSE zones defined in this section should be used in preference to those defined in the HRA.

3.2 COMPOSTING

3.2.1 *Overview*

Composting is widely used for the stabilisation of organic waste such as food and plant wastes. The technology is characterised by the biological breakdown of putrescible wastes in the presence of oxygen. Composting processes may encompass a wide range of process designs and technologies:

- Open windrow composting is routinely used for low hazard wastes, such as green and garden waste, where composting is undertaken in the open with little more processing than shredding and turning. Control of emissions is typically achieved by good control of the composting process to ensure adequate aeration and maturation time, and suitable mixing of wastes.

- In-vessel composting may be undertaken using a range of equipment and is more complex and contained than open windrow composting. Typically the process is used for wastes that are of higher hazard including raw MSW, animal by-products or food wastes which may contain human pathogens. In-vessel composting will typically use forced aeration and emissions will be controlled with the use of biofilters; however there are numerous iterations of the technology utilising a range of solutions to control emissions.

Composting may also be used as an integral element of Mechanical Biological Treatment for treatment of the organic residues.

Composting processes require careful control to avoid the development of anaerobic conditions, where oxygen levels become depleted. These conditions are typically associated with the generation of odour but are not specifically associated with increases of emissions that may adversely impact on habitats, and therefore development of anaerobic conditions have not been specifically considered here.

3.2.2 *Emissions of interest*

Based upon a review of Defra 2011, and a review of APIS the emissions of interest, with regard to impacts on habitats, include:

- Bioaerosols;
- Volatile Organic Compounds (VOCs);
- Dust;
- Nitrous oxide; and
- Ammonia.

Bioaerosols and dust are considered separately in *Section 4*, and this section deals with the remaining emissions.

3.2.3 *Volatile Organic Compounds (VOCs)*

Composting processes are associated with emissions of VOCs, which are generated as waste materials are decomposed. APIS specifies that the following VOC species are of interest with regards to impacts on habitats:

- Benzene
- Toluene
- Xylene
- Styrene
- Chlorinated Solvents
- Ethylene
- Formaldehyde
- Alcohols

The work undertaken for Defra 2011 identified the following:

- Benzene: emissions are in the range of 7.1 $x10^{-8}$ grams/tonne of waste. These emissions are considered to be low, in the context of other VOC emissions, and are considered unlikely to be significant in terms of impacts on habitats.

- Toluene: emissions are in the range of 8.9 $x10^{-8}$ grams/tonne of waste. These emissions are considered to be low, in the context of other VOC emissions, and are considered unlikely to be significant in terms of impacts on habitats.

- Xylene: no data on emissions were identified.

- Styrene: no data on emissions were identified.

- Chlorinated Solvents: no data on emissions were identified.

- Ethylene: no data on emissions were identified.

- Formaldehyde: no data on emissions were identified.

- Alcohols: emissions of several species of alcohols were identified, and comprised some of the proportionately highest emissions of VOCs:
    - 2-butanol emissions are in the range of 1.9 grams/tonne of waste;
    - 2-propanol emissions are in the range of 67 grams/tonne of waste;
    - Ethanol emissions are in the range of 67 grams/tonne of waste;
    - isobutanol emissions are in the range of 3.0 grams/tonne of waste

With regard to alcohols, APIS states:

> *"Short-chain alcohols and aldehydes are produced and emitted by some plants. There is evidence that methanol applied to leaves may be beneficially metabolised. Biochemical pathways exist in plants to regulate formaldehyde concentrations, and experiments with trees have suggested that many species are tolerant of high concentrations (microlitre/litre or ppm) on short-term (hours) exposure."*

On this basis, whilst emissions of alcohol are proportionately high in terms of overall VOC emissions from composting plants, the evidence suggests plants are tolerant of alcohols and therefore adverse impacts are unlikely.

On the basis of the evidence identified and reviewed, it is considered unlikely that VOC emissions from composting plants will result in LSE at habitats.

3.2.4 *Nitrous oxide and ammonia*

Nitrous oxide and ammonia both have the potential to impact on habitats, directly through the airborne pathway, and also due to changes in soil chemistry associated with deposition of acid and nutrient nitrogen. These impacts are well understood and critical levels and critical loads are set for the protection of habitats in Worcestershire for all of these impacts. In the UK context, these pollutants are of particular concern as baseline concentrations are elevated in many locations, and, as described in *Section 2*, the habitats of interest in Worcestershire are sensitive to these pollutants.

Defra 2011 identified that emissions of nitrous oxide occur at around 7.2 $\times 10^{-3}$ grams/tonne of waste material processed with an order of magnitude variation; and emissions of ammonia occur at around 170 grams/tonne of waste material processed, with much higher peak emissions. These emissions are considered as being of potential importance with regard to impacts on habitats. Emissions from composting plants typically occur at ground level or only a small distance above ground. This means that dispersion of emissions is poor and therefore ground level concentrations close to the composting plant are likely to be high in proportion to the source term.

Given the sensitivity of habitats to nitrogen (as NO_x, nutrient nitrogen and acid deposition); the potentially high levels of emissions; and the common occurrence of elevated baseline NO_x and nitrogen deposition, it is considered appropriate to conclude that composting plants may have LSE on habitats, due to emissions of nitrous oxide and ammonia.

The review did not directly identify information that would be relevant in the setting of an LSE zone for nitrous oxides and ammonia from composting plants. However, adopting the worst case LSE zones are set at:

- 500m (NO_x); and
- 500m (ammonia).

The basis of these LSE zones being that as a sources are low height, and tending to be low release velocity or passive, emissions will tend to decline rapidly.

3.2.5 *Summary*

On the basis of the review undertaken, it is concluded that composting plants are likely to result in LSE zones being required around habitats. This arises due to emissions of NO_x and ammonia and, as discussed in more detail in *Section 4*, dust and bioaerosols. On the basis of the worst case an the LSE zone is 500m.

3.3 *ANAEROBIC DIGESTION*

3.3.1 *Overview*

Anaerobic digestion (AD) is used for the treatment of putrescible wastes, with the aim of producing an off-gas (biogas) that may be combusted to generate heat and/or electricity, and a stable organic mulch suitable for landspreading or other use. The technology involves the biological degradation of putrescible waste in a sealed vessel in an oxygen free environment. This produces a methane and carbon dioxide rich biogas which is then collected and burned.

As the process occurs in a closed vessel, pollution emissions are usually well controlled and emission of bioaerosols and volatile organic compounds are typically minimal, occurring only for a short period when wastes and residues are being handled. The biogas is typically used to fuel a reciprocating (internal combustion) engine or a boiler and therefore emissions of combustion gases (primarily carbon dioxide and oxides of nitrogen) will arise from the process. In addition there is the potential for trace volatile organic compounds and sulphur dioxide to be emitted from the combustion process. Whilst the AD process and associated combustion technology is designed to contain and combust 100% of the biogas generated, there is evidence that fugitive emissions of biogas can occur and in some cases may therefore be an important source of emissions to air. On this basis, it is therefore considered appropriate to consider both emissions that arise in a controlled manner from the combustion of biogas, but also those emissions that have the potential to arise from the fugitive emission of biogas.

3.3.2 *Emissions of interest*

Based upon a review of Defra 2011, and a review of APIS the emissions of interest, with regard to impacts on habitats, include:

- Oxides of nitrogen; and
- Volatile Organic Compounds (VOCs).

Whilst there is the potential for bioaerosols to arise, due to the handling of wastes and mulch, these emissions are considered insignificant in comparison to other emissions.

3.3.3 Oxides of nitrogen

As discussed in detail in *Section 2* and *Section 3.2.4*, oxides of nitrogen are important in the context of potential impacts on habitats. Defra 2011 identified that emissions of oxides of nitrogen occur at around 116 grams/tonne of waste material processed (with a range of 10-515 grams/tonne). In addition, Defra 2011 identified emissions of nitrous oxides at around 18.6 grams/tonne waste processed. On the basis of the evidence identified, emissions of oxides of nitrogen from anaerobic digestion plants will result in LSE zones around habitats.

The review did not directly identify information that would be relevant in the setting of an LSE zone for oxides of nitrogen around anaerobic digestion plants. This is because the LSE zone associated with an anaerobic digestion plant would depend specifically on plant design and operational capacity, as this directly dictates the quantities of biogas generated and therefore the emissions to air of oxides of nitrogen from the combustion process.

However, it is considered likely that even for a large AD plant, significant impacts are unlikely to occur at distances greater than 1,000m from the plant, and on this basis the LSE zone is set at this distance.

3.3.4 Volatile Organic Compounds (VOCs)

The emissions arising from the combustion of biogas do not typically result in significant emissions of VOCs. However, there is the potential for fugitive emissions of biogas to occur, which do contain VOCs. Defra 2011 cites a study which identified fugitive loss of biogas of around 3.4% of total biogas generated, but acknowledged that this may vary considerably between plants.

APIS specifies that the following VOC species are of interest with regards to impacts on habitats:

- Benzene
- Toluene
- Xylene
- Styrene
- Chlorinated Solvents
- Ethylene
- Formaldehyde
- Alcohols

The work undertaken for Defra 2011 identified the following:

- Benzene: no data on emissions were identified.

- Toluene: no data on emissions were identified.

- Xylene: emissions are in the range of 0.0325 grams/tonne of waste. These emissions are considered to be low, in the context of other VOC emissions, and are considered unlikely to be significant in terms of impacts on habitats.

- Styrene: no data on emissions were identified.

- Chlorinated Solvents: emissions of chloroform are in the range of $1x10^{-4}$ grams/tonne of waste. There is almost no information on the potential impacts of chlorinated solvents on plant health. APIS states: *"Damaging concentrations would only be observed if there were a major accident or leak of solvent into the atmosphere".* On this basis, chlorinated solvents are considered unlikely to be significant in terms of impacts on habitats.

- Ethylene: no data on emissions were identified.

- Formaldehyde: no data on emissions were identified.

- Alcohols: emissions of several species of alcohols were identified, and comprised some of the proportionately highest emissions of VOCs:
    - 2-butanol emissions are in the range of 0.400 grams/tonne of waste;
    - 2-propanol emissions are in the range of 1.4 grams/tonne of waste;
    - Ethanol emissions are in the range of 2.2 grams/tonne of waste;
    - isobutanol emissions are in the range of 0.400 grams/tonne of waste

As noted previously, APIS states:

> *"Short-chain alcohols and aldehydes are produced and emitted by some plants. There is evidence that methanol applied to leaves may be beneficially metabolised. Biochemical pathways exist in plants to regulate formaldehyde concentrations, and experiments with trees have suggested that many species are tolerant of high concentrations (microlitre/litre or ppm) on short-term (hours) exposure."*

Emissions of alcohol are low in terms of overall VOC emissions from anaerobic plants and, given the insensitivity of plants to alcohols, it is concluded that adverse impacts are unlikely.

On the basis of the evidence identified and reviewed, it is considered unlikely that VOC emissions from anaerobic digestion plants will result in LSE at habitats.

3.3.5 *Summary*

On the basis of the review undertaken, it is concluded that anaerobic digestion plants will result in LSE zones being required around habitats. This is due to emissions of oxides of nitrogen from combustion of the biogas. As a worst case, the LSE zone is recommended at 1,000m.

3.4 *RECYCLING*

The Defra 2011 report identified that recovery and recycling of domestic waste is potentially associated with the generation of dust due to the handling of dry materials. However, as discussed in more detail in *Section 4*, emissions of dust associated with such facilities are minimal. No other potentially significant emissions were identified with recovery and recycling facilities.

On this basis, it is concluded that the operation of recovery and recycling facilities are unlikely to result in LSE on habitats.

3.5 *AUTOCLAVE*

3.5.1 *Overview*

Autoclave technology is primarily used with general MSW and is typically incorporated as a front end component of Mechanical Biological Treatment systems. The autoclaving process produces a solid residue containing cleaned metals, size reduced plastics, inert materials such as glass and grit and a fluffy 'flock' containing organic matter, paper and other materials. Autoclave plants are typically associated with a more extensive waste management process; however here emissions have been considered for the process in isolation and not associated with another process.

The process occurs in a rotating cylinder, or a fixed cylinder with a rotating arm, where waste is processed in the presence of steam through a combination of heat and mechanical action. Pollutant emissions occur during the application of steam and also during loading and unloading of the autoclave. As the autoclave process utilises steam and operates at relatively low temperatures (approximately 80-160 degrees Celsius) there are no direct emissions of combustion gases, although these pollutants may be generated by the unit used to produce the steam for the process. Emissions of volatile organic compounds may occur during the process as they can be forced from the waste due to the elevated temperature and subsequently vented to air.

3.5.2 *Emissions of interest*

Based upon a review of Defra 2011, and a review of APIS, the emissions of interest, with regard to impacts on habitats, include:

- Bioaerosols;

- Volatile Organic Compounds (VOCs); and
- Oxides of nitrogen.

Bioaerosols are considered separately in *Section 4*, and this section deals with the remaining emissions.

3.5.3 *Oxides of nitrogen*

As discussed in detail in *Section 2* and *Section 3.2.4*, oxides of nitrogen are important in the context of potential impacts on habitats. Defra 2011 identified that emissions of oxides of nitrogen occur at around 70 grams/tonne of waste material processed.

As discussed in Defra 2011, at the present time there are few operational autoclave plants in the UK and those that are operational are small. However, there are proposals for plants of up to 300,000 tonnes/annum capacity. As emissions of oxides of nitrogen occur due to the generation of steam for use in the process, the emissions are proportionately related to the size of the plant. On the basis of the evidence identified, emissions of oxides of nitrogen from larger autoclave plants will result in LSE zones around habitats.

The review did not directly identify information that would be relevant in the setting of an LSE zone for oxides of nitrogen around autoclave plants. This is because the LSE zone associated with autoclave plants depends specifically on operational capacity, as this directly dictates the quantities of steam required in the process and therefore the emissions to air of oxides of nitrogen from the combustion process. The LSE zones could be quantified for specific autoclave plants, but again, this would require a more detailed study utilising dispersion modelling.

The review did not directly identify information that would be relevant in the setting of an LSE zone for oxides of nitrogen around autoclave plants. This is because the LSE zone associated with an anaerobic digestion plant would depend specifically on plant design and operational capacity, as this dictates the requirement for steam raising capacity.

However, it is considered likely that even for a large autoclave plant, significant impacts are unlikely to occur at distances greater than 1,000m from the plant, and on this basis the LSE zone is set at this distance.

3.5.4 *Volatile Organic Compounds (VOCs)*

The operation of an autoclave plant may result in emissions of VOCs. There is a paucity of data relating to emissions of VOCs from autoclave plants, and Defra 2011 did not identify any species specific VOC emissions data.

On this basis, it is not possible to state categorically whether VOC emissions from autoclave plant would result in LSE zones around habitats. However, the

LSE for autoclave plants associated with NO_x would adequately protect again impacts associated with any releases of VOCs.

3.5.5 Summary

On the basis of the review undertaken, it is concluded that autoclave plants will result in LSE zones being required around habitats. This is due to emissions of oxides of nitrogen from combustion of gas to generate steam. As a worst case, the LSE zone is recommended at 1,000m.

3.6 MECHANICAL BIOLOGICAL TREATMENT (MBT)

In this context MBT plants are considered to consist of facilities for batching of waste for reuse of further treatment, and may include biological treatment using composting or anaerobic digestion. On this basis it is relevant to consider emissions associated with recycling plants, composting plants and anaerobic digestion plants. LZE zones for these facilities are set at:

recycling plants: No LSE required;
composting plants: 250m (bioaerosols); and
anaerobic digestion plants 1,000m (oxides of nitrogen).

3.7 WASTE TRANSFER STATIONS

The Defra 2011 report considered waste transfer stations at a high level due to a paucity of information. However, the review identified that emissions of VOCs and bioaerosols may occur, and dust emissions may be significant for waste transfer stations handling construction and demolition wastes. Dust and bioaerosols are discussed in more detail in *Section 4*.

On the basis of the review, LSE zones for waste transfer stations are set at:

- Bioaerosols: 250m
- Dust: 500m

4 *IMPACTS ASSOCIATED WITH DUST, BIOAEROSOLS AND TRAFFIC EMISSIONS*

4.1 *INTRODUCTION*

In this section, specific consideration is given to the potential impacts on habitats of emissions of dust and bioaerosols from waste management facilities and emissions arising from traffic associated with operation of waste sites. Typically, for these sources of emissions there is a paucity of information available which tends to reflect the lower risk of damage occurring to habitats as a result of these emissions, and the consequential lower priority given to these emissions.

This section identifies waste processes associated with the emissions of interest, cross referenced with *Section 3* as appropriate, and presents an evidence base discussing the potential for impacts on habitats and, where appropriate, LSE zones based upon the evidence provided.

4.2 *SOURCES OF EMISSIONS*

The Defra 2011 report has again been used as a basis for establishing those technologies for which emissions of bioaerosols may be important. Potentially important sources of dust emissions are considered to a limited extent in the Defra report, but these have been primarily identified on the basis of other sources of information and professional experience. Emissions of traffic have been considered on a separate basis, as discussed in *Section 4.5*.

Emissions of bioaerosols are associated with processes that utilise biological degradation of waste materials. Based upon the findings of the Defra report, these are:

- Autoclave;
- Composting;
- Mechanical Biological Treatment; and
- Waste Transfer Stations.

Any process that handles raw Municipal Solid Waste (MSW) is also potentially associated with emissions of bioaerosols from the raw waste. However, these are not considered here as the process design for any such facility should be such that emissions are contained and controlled, for example in an Energy from Waste facility, the air from the tipping hall is typically used in the combustion process and therefore any bioaerosols that arise will be taken into the process and destroyed.

Emissions of dust are associated with processes that handle dry and dusty wastes in uncontained or semi-contained facilities. These are primarily:

- Outdoor (windrow) composing facilities; and
- Waste transfer stations handling construction and demolition waste.

Recovery and recycling is potentially associated with the generation of dust due to the handling of dry materials (this may also be included in mechanical biological treatment facilities and other large waste management facilities with waste pre-treatment). However in the Defra study the information identified indicated that environmental concentrations of dust associated with these facilities are minimal, and therefore no consideration of recovery and recycling facilities have been made.

4.3 *BIOAEROSOLS*

4.3.1 *Overview*

Emissions of bioaerosols are particularly associated with operation of composting facilities, and specifically open windrow composting sites at which emissions are uncontained. Bioaerosols emissions are less important for closed vessel plants where emissions are better contained and controlled. Where composting plants are an integral element of MBT plants, emissions of bioaerosols may be important; however in this context MBT and composting plants are considered in the same context.

The Defra 2011 review identified that emissions of bioaerosols may arise from autoclave plants and waste transfer stations. However, no information for emissions from these processes was identified. In the light of an absence of emissions information for these processes, emissions are assumed to occur at a similar level to composting plants, although this is likely to be a worst case assumption.

4.3.2 *Potential for impacts on habitats*

A review undertaken by ERM failed to identify any evidence for the potential impacts on sensitive habitats arising from emissions of bioaerosols from waste management facilities. On this basis, no judgement can be made as to the sensitivity of habitats to bioaerosol emissions.

However, the Environment Agency states in its (now superseded) position statement[1] on potential health effects that bioaerosol concentrations typically reduce to background concentration within 250m of the compost facility. In the current Environment Agency note on bioaerosols[2], the Agency states:

(1) [1] Environment Agency (2007) Policy number 405_07 Our position on composting and potential health effects from bioaerosols

(1) [2] Environment Agency (2010) Composting and potential health effects from bioaerosols: our interim guidance for permit applicants Position statement 031 http://www.environment-agency.gov.uk/static/documents/Research/Composting__bioaerosols.pdf

> *"The acceptable levels are 300, 1000 and 500 cfu m-3 for gram-negative bacteria, total bacteria and Aspergillus fumigatus respectively, as measured by the standardised monitoring protocol [at 250m from the composting facility] "*

In the absence of any better information, the recommendation is made that LSE zones of 250m are established in relation to bioaerosols associated with composting plants.

4.4 *Dust*

4.4.1 *Introduction*

In the Defra 2011 report evidence is set out indicating that facilities handling construction and demolition wastes, and composting plants where dry wastes are being processed, are potentially significant sources of dust[1]. MBT plants are also potential sources of dust emissions, as these may also incorporate composting facilities.

There is a very limited amount of information available relating to the potential impacts of dust on sensitive habitats. A review of the Air Pollution Information Service (APIS) website, which sets out the criteria for assessing impacts on habitats from a range of pollutants (including the critical loads and critical levels used previously), states:

> *"Quarry dusts, like dusts in general, affect vegetation by both physical and chemical processes. Physically, dust may cover the leaf surface and reduce the amount of light available for photosynthesis, or may occlude stomata. Occlusion may lead to increased resistance to gas exchange, or may prevent full stomatal closure, leading to water stress. Increased transpiration is a common response to dust exposure.*
>
> *Chemically, quarry dusts may be relatively inert (from operations involving hard acidic rocks or some sandstones) or may be strongly alkaline (limestone). Alkaline quarry dusts may have detrimental chemical effects on leaf surfaces. Infestation by pests and pathogens is likely to be enhanced.*
>
> *Indirect effects may be caused through the soil, especially for the deposition of alkaline quarry dust on acid soils, which can increase the pH and available calcium, leading to changes in vegetation and invertebrate community composition. For agricultural systems where lime and fertilizer are applied the indirect effects of alkaline dust will be marginal. For unmanaged ecosystems which have been acidified by atmospheric deposition of sulphuric and nitric acids, there may be local beneficial effects if the quarry dust is alkaline, or can supply limiting minerals (e.g. calcium or magnesium). The subject has been reviewed by Farmer (1993)."*

(1) [1] Bexley Council (2003) Manor Road Air Quality Management Area Stage 4 Review and Assessment of Air Quality and Air Quality Action Plan http://www.uwe.ac.uk/aqm/review/examples/bexley/stage4_consultationdraft_full-0503.pdf

On the basis of the information available from APIS, the paper by Farmer 1993 was reviewed.

4.4.2 *Evidence base*

Impacts on sensitive species

Farmer (1993) reviewed a wide range of sources, with the intention of identifying the level of dust exposure required to cause damage to plants. Farmer studied a number of plant species, separated primarily into arable crops and trees, associated with a number of types of dust and identified the dust deposition rates, levels and concentrations required to cause negative impacts on the species of interest. The results presented by Farmer are set out in *Table 4.1*.

Table 4.1 Impacts on plants associated with exposure to dust (Farmer 1993)

Species	Dust source	Deposition rate ($g/m^2/day$)	Level (g/cm^2)	Concen-tration (ug/m^3)	Effect
Tsuga Canadenis	Limestone quarry	14.2			Chlorotic needles
Acer rubrum, Quercus primus, Quercus Rubra	Limestone quarry	14.2			Reduced growth
Liriodendron tulipifera	Limestone quarry	14.2			Increased growth
Psidium guayava	Cement		1.8 to 47.5		Increased tissue Ca, K, Na and P
Populus tremula	inert silica gel		1		Reduced diffusive resistance
Populus tremula, Acer campestre, Betula pendula, Almus glutinosus, Prunus avium, Quercus spp.	Urban Road		1 to 1.5	500-1200	Increased leaf temperature
Abies alba	Urban Road			25 to 100	Reduced growth, compounded by Pb and NOx
Viburnum tinis	Motor vehicle exhaust		>0.5		Reduced photosynthesis and diffusive resistance
Magnifera indica	Coal dust		4.5 to 30		Reduced growth, fruit set and leaf lesions and partial defoliation
Citrus limon	Coal dust	0.03-6.3	1.5 to 12		Reduced growth, fruit set and leaf lesions and partial defoliation
Daphne laureola	Urban area		2.5 to 104.4		Blocked Stomata

Species	Dust source	Deposition rate ($g/m^2/day$)	Level (g/cm^2)	Concen-tration (ug/m^3)	Effect
Quercus petraea	smokeless fuel factory	0.2 to 0.6			Blocked Stomata, Reduced diffusive resistance, promotion of leaf senesance and chlorophyll degredation and enhanced uptae of SO2
Phaseolus vulgaris	Cement	0.6			Reduced photosynthesis and increased leaf necrosis
Triticum aesivum	Cement	7			reduced vegetative and reproductive growth reduced tissue N, Ca and P and reduced transpiration and growth
Zea mays	Cement		0.2 to 1.2		reduced seed set
Zea mays	Cement	0.2 to 10.9	0.2 to 8.4		Reduced vegetative and reproductive growth
Gossypium hirsutum	cement	0.4			Blocked Stomata, increased chlorophyll and tissue cation levels, reduced tissue starch, vegetative and reproductive growth
Helianthus annus	Cement	0.5 to 1			Reduced growth, photosynthesis and catalase activity
Brassica campestris	Cement	3.0 to 7.0			Reduced growth

The review by Farmer identified that there is varying susceptibility of plants to airborne dust, with typical sensitivity being around 2000mg/m²/day, and the most sensitive species being adversely affected around 30mg/m²/day.

Migration of dust from source

Table 4.2 sets out a summary of a number of sources which identify the distances travelled by dust. This evidence is based on the criterion of 200mg/m²/day that is typically used to identify the level at which dust deposition is likely to result in nuisance to sensitive human receptors.

Table 4.2 ***Summary of guidance for dust migration and nuisance***

Guidance document or source	Distance at which dust issues become insignificant	Basis or justification	Reference

Guidance document or source	Distance at which dust issues become insignificant	Basis or justification	Reference
EA M17	200-500 m	There is no sharp dividing line between the sizes of suspended particulates and deposited particulates, although particles with diameters >50µm tend to be deposited quickly and particles of diameter <10µm have an extremely low deposition rate in comparison (DoE, 1995). Intermediate-sized particles (10–30µm) are likely to travel up to 200–500m. Smaller particles (<10µm) can travel up to 1km from the source, although very small particles can travel much further (DETR, 2000a).	Environment Agency (2004) M17 Monitoring of particulate matter in ambient air around waste facilities
USEPA AP-42 emission factors	30-90m	AP-42 states: "[dust particles 10-30µm in diameter] are likely to settle within a few hundred feet [30-90m]… from the edge of the road or other point of emission"	USEPA AP-42 Clearinghouse for Emission Factors: Section 13.2 Fugitive Dust Sources http://www.epa.gov/ttnchie1/ap42/
Farmer (1993)	<30m	For unpaved roads, Everett (1980) found that there was a rapid decline in particle size in the first 8m from the road causing a loss of particles greater than 50µm diameter. At 30m a further decline took place, this time in particles greater than 20µm.	Reported in Farmer M (1993) The Effects of Dust on Vegetation – A review *Environmental Pollution 79*
Good Quarry	200-500 m	Large dust particles (greater than 30µm), that make up the greatest proportion of dust emitted from mineral workings will largely deposit within 100m of sources. Intermediate sized particles (10 - 30µm) are likely to travel up to 200 - 500m. Smaller particles (less than 10µm) which make up a small proportion of the dust emitted from most mineral workings, are only deposited slowly.	Good Quarry http://www.goodquarry.com/article.aspx?id=55&navid=2

4.4.3 *Setting the LSE zone*

On the basis of the evidence set out in *Table 4.2*, and the deposition rates at which dust is likely to result in adverse impacts on plants set out in *Table 4.1*, the worst case would be that the LSE zone for waste management facilities associated with dust emissions is 500m. However, pragmatically, there is good evidence to suggest that most plants are relatively insensitive to dust deposition and that a LSE zone of 200m or less would be acceptable in the large majority of cases for the mitigation of impacts from dust.

4.5 TRAFFIC

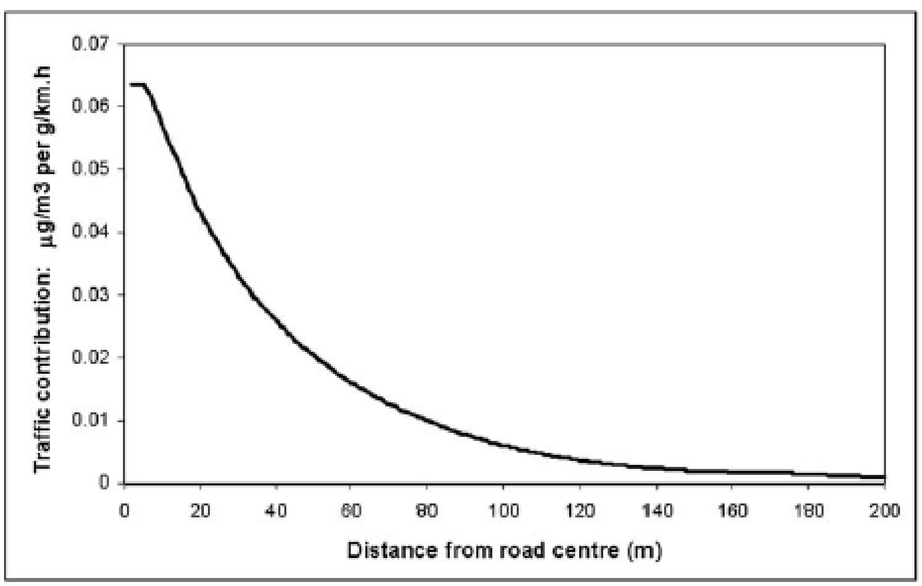
4.5.1 Introduction

The impacts of road traffic on habitats are not well understood as the primary focus of traffic related impacts has been on human health. However, traffic emissions account for a substantial proportion of UK emissions of oxides of nitrogen, the key pollutant in terms of impacts on habitats (54% of total emissions of NO_x in 2006). On the basis of the fact that NO_x is a key pollutant in terms of impacts to habitats, and the fact that traffic accounts for the majority of NO_x emissions in the UK, it is reasonable to assume that traffic sources have the potential to adversely impact upon habitats.

4.5.2 Extent of influence of traffic emissions around roads

The Highways Agency Design Manual for Roads and Bridges (DMRB)[1] sets out an example of typical reduction in pollution with increasing distance from road sources. This is reproduced in *Figure 4.1*, and is representative of the decrease in impacts away from the road for oxides of nitrogen.

Figure 4.1 Reduction in traffic pollution contribution with increasing distance from roads



This data, along with other evidence provided in DMRB sets a limit of 200m from the roadside at which impacts are potentially significant in terms of

(2) [1] Highways Agency (2007) Design Manual for Roads and Bridges: Volume 11 Environmental Assessment: Section 3: Environmental Assessment Techniques: Part 1 air Quality: Annex C

impacts to human health. Given the rapid decline in pollution concentration set out in *Figure 4.1*, it is reasonable to conclude that impacts on habitat sites are also likely to become insignificant at a distance of greater than 200m from a road. However, there is some uncertainty associated with this conclusion. In terms of oxides of nitrogen (which incorporates nitrogen dioxide and nitric oxide), the air quality standard for the protection of habitats is 30µg/m^3; conversely the air quality standard for the protection of human health for nitrogen dioxide (which does not include nitric oxide) is 40µg/m^3. Therefore the point at which emissions of oxides of nitrogen become insignificant in the context of human health occurs closer to the road than the point at which emissions of oxides of nitrogen become insignificant with regard to habitats.

4.5.3 *Assessment of road sources on habitats*

Based upon the evidence set out in *Section 4.5.2*, it is reasonable to conclude that emissions from vehicles accessing a waste management site would only be an issue if the vehicles are using a road that passes through, or close to, a habitat site. However, there is also no clear threshold at which a certain number of vehicles will result in a significant impact on the habitat. This is because emissions from traffic are dependant upon vehicles type, vehicle speed and road type (ie single or dual carriageway). DMRB states that, in terms of human health, additional traffic of less than 1000 vehicles per day or 200 heavy goods vehicles per day is unlikely to have a significant adverse impact on human health at receptors living alongside the road. Again, assuming that impacts are approximately comparable for human health and habitats, this suggests that the same criteria could be used to estimate the numbers of vehicles that would be required to have a significant impact on the habitat, irrespective of existing impacts.

In a recent study for a 600,000 tonne per annum Energy from Waste facility undertaken by ERM, approximately 320 additional HGVs/day were generated on the access road to the facility. Given that the proposed maximum design capacity for an Energy from Waste plant in Worcestershire is 250,000 tonnes per annum, then it is reasonable to conclude that a maximum of around 150 HGVs per day may be expected. On this basis, and using the DMRB criteria, it is likely that there will not be significant impacts on habitats associated with the planned facilities. This conclusion would likely hold even where all traffic accesses a site directly through the habitat site. For other types of waste management facilities it is likely that traffic numbers will be substantially less and therefore impacts would be less.

4.5.4 *Summary*

On the basis of the evidence identified, it is unlikely that traffic emissions arising from vehicles accessing waste management facilities of the size planned will result in significant impacts on habitats, and therefore LSE zones in the vicinity of access roads.

However, as impacts are related primarily to emissions of oxides of nitrogen, it cannot be stated definitively that there will be no LSE without further specific study, and in terms of the worst case, an LSE zone of 200m is considered appropriate.

5 SUMMARY

There is good evidence to support the conclusions that LSE zones will exist around habitat sites in relation to a number of waste management technologies. This study identified the LSE zones that arise due to the implementation of thermal waste treatment based upon the assessment of a conceptual Energy from Waste plant with emissions at the limits specified in the European Waste Incineration Directive. Furthermore, the likely occurrence of LSE zones has been established for other waste management processes, and in some cases the sizes of these have been quantified based upon the evidence identified.

However, in several cases, the LSE zones are dependant upon specific process design or capacity, or information on which an LSE zone could be based is not available. In these cases, LSE zones could be established, but this would require bespoke studies, similar to that undertaken for the thermal processes.

Table 5.1 presents a summary of the findings of the study, identifying where the LSE zones are likely to occur, and the extents of these where suitable data is available.

Table 5.1 Summary of study findings - likely LSE zones associated with different waste management technologies

Process	**Emission**					
	Oxides of nitrogen and nitrous oxide[1]	**Bioaerosols**	**Dust**	**VOCs**	**Ammonia**	**Maximum LSE**
Thermal treatment	See detailed review in *Section 2*	n/a	n/a	n/a	See detailed review	**See detailed review**
Composting	500m	250m	500m	no LSE	500m	**500m**
Anaerobic Digestion	1000m	250m	n/a	no LSE	n/a	**1000m**
Autoclave	1000m	250m	n/a	1000m	n/a	**1000m**
Recycling	n/a	n/a	no LSE	n/a	n/a	**no LSE**
MBT	500m	250m	500m	no LSE	500m	**500m**
Waste Transfer Stations (Construction/ Demolition)	n/a	n/a	500m	n/a	n/a	**500m**
Road traffic						
Traffic	*200m*	*n/a*	*n/a*	*n/a*	*n/a*	***200m***

Note 1: includes impacts arising directly from pollutants in air and also impacts arising indirectly due to changes in soil chemistry, in combination with ammonia where required.

The study identified that the majority of waste management processes have the potential to result in some impacts to habitats, if they are located sufficiently close to habitat sites. Of key interest are those processes that include a combustion element which, in addition to Energy from Waste, gasification and pyrolysis, also includes anaerobic digestion, MBT and autoclave.

The study concluded that with regard to traffic, it is unlikely that traffic emissions arising from vehicles accessing waste management facilities will result in significant impacts on habitats and therefore LSE zones in the vicinity of access roads. However, as impacts are related primarily to emissions of oxides of nitrogen, it cannot be concluded there will be no LSE, and in terms of the worst case, an LSE zone of 200m may be considered appropriate.

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