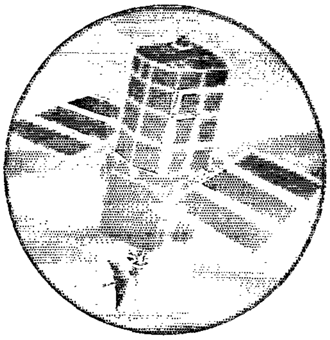
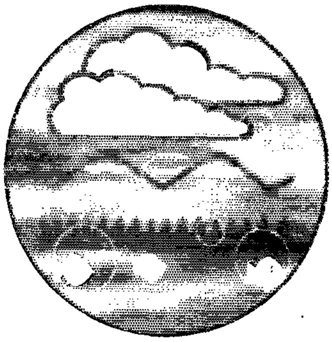
Investigation of the Criteria for, and Guidance on, the Landspreading of Industrial Waste





Research and Development

Technical Report
P193

ENVIRONMENT AGENCY

Investigation of the Criteria for, and Guidance on, the Landspreading of Industrial Waste

R&D Technical Report P193

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EXECUTIVE SUMMARY

Main objectives

The principal objective was to produce a report containing technical, scientific and practical guidance on the spreading of industrial wastes on land. The guidance was to define the criteria for the landspreading of wastes in a manner that is:

- demonstrably beneficial to agriculture or provides ecological improvement;
- consistent with the principles of sustainable development; and
- protects human health and the environment as required by Article 4 of the Waste Framework Directive 91/156/EEC.

Background to the study

Landspreading can represent an economical and environmentally safe way to recover value from a variety of wastes, such as farm slurries and manures, as well as a range of non-farm wastes, such as sewage sludge, food processing wastes, lime and gypsum. However, landspreading needs to be carried out in a manner that protects human health and the environment, and is consistent with sustainable development. This is assisted by providing guidance to waste managers and producers, contractors, regulators and land occupiers involved in the activities. Much legislation and guidance already exists for the management on land of fertilisers, farm wastes and sewage sludge. Some of this is relevant to the controlled wastes exempted for landspreading in the Waste Management Licensing Regulations (1994). However, the sponsors of this study (The DETR, the Environment Agency and MAFF) felt that further specific guidance was required for these exempted wastes.

Main findings

The legislative framework for waste management in the European Union and the UK, together with the landfill tax, promote waste recovery by landspreading where this is environmentally acceptable. It is estimated that controlled wastes contribute about 4% of the waste recycled to land in the UK, the remainder is made up of farm wastes (94%) and sewage sludge (2%), the total quantity of wastes recycled to land being about 22 million tonnes dry solids per annum. These are no more than estimates because authoritative information about quantities and other aspects of controlled waste recycling to land is scarce. For instance, dredgings from inland water were not included in the estimate although it is known that substantial quantities are spread on the land.

Agricultural benefit or ecological improvement have to be achieved as a main requirement of the exemption for landspreading of controlled wastes. The report presents definitions of these terms. Most landspreading operations will set out to achieve agricultural benefit rather than ecological improvement so in this sense the former is more important and needs to be particularly well understood. The assessment of agricultural benefit depends partly on knowledge of how a waste will affect crop growth and quality when applied to the land. In particular, it is important to know what fraction of the total content of nutrients in the waste will become available to crops, and how long this will take. For conventional fertilisers, animal wastes and sewage sludge, agricultural trials over many years have defined their capability to supply nutrients and other effects which contribute to agricultural benefit. For controlled wastes, this information of fundamental importance is largely lacking. It is also evident that the quality of industrial wastes for landspreading is often variable and could be improved for landspreading purposes.

If landspreading of wastes is to be seen as acceptable recycling as opposed to disposal, and is to be viable in the long-term as an economic outlet, then there needs to be investment in such aspects as quality control, treatment, storage and agricultural trials.

Main conclusions

- Agricultural benefit will be achieved when the application of a waste to land improves soil conditions for crop growth whilst ensuring the protection of environmental quality in the broadest sense as required by Article 4 of the Waste Framework Directive 91/156/EEC.

- Agricultural benefit can be assessed on the basis of the known properties of particular categories of wastes, the actual composition of the waste to be spread, and site characteristics including soil conditions. The report lists the properties of wastes associated with benefit and disbenefit and the on-site precautions that must be taken to achieve benefit.

- The report includes general and detailed information on the properties of waste and best practice for landspreading in order to achieve agricultural benefit. Authoritative information is lacking about the performance of the exempted wastes in agricultural trials, their composition and the quantities that are spread on land.

- Agricultural benefit can be measured in terms of improvements to crop yield and quality; to the chemical, physical and biological properties of soil, and to the water content of soil. Land levelling is considered to be beneficial where it achieves more than simply raising the level of the land such as by improving soil drainage.

- Useful guidance relevant to achieving agricultural benefit from landspreading of wastes is to be found in the MAFF Codes of Good Agricultural Practice for the Protection of Water (1991), air (1992) and Soil (1993) and in the DoE Code of Practice for the Agricultural Use of Sewage Sludge (1996). CIRIA Report 157 (1996) provides guidance on the disposal of dredged material to land. New editions of the MAFF Codes of Good Agricultural Practice are to be issued shortly.

- As a general rule, the quantity of total nitrogen applied to the land in applications of waste should be limited to 250 kg N ha^{-1} y^{-1}. This is a recommendation, for all organic materials, in the MAFF Code of Good Agricultural Practice for the Protection of Water (1991) but may be revised in the new edition of the Code. This rule does not take into account the likely amount of crop-available N and its rate of availability, and so may be a conservative value for certain well-stabilised organic wastes especially if composted. Field trials are needed to test the availability of the nutrients in these wastes in order to justify the operational use of rates of application based on the organic matter content rather than the nutrient content of the wastes. Rates of application of waste to agricultural land should normally be set to meet crop requirements for nutrients. Rates of application calculated in this way are likely to be much lower than the currently permitted maxima in the Waste Management Licensing Regulations 1994 of 250 t ha^{-1} y^{-1} (5000 t ha^{-1} y^{-1} in the case of dredgings from inland waters). High rates of application of wastes may be justified to achieve ecological improvement in the reclamation of derelict land.

- To improve the technical basis and justification for landspreading, operators should be required to notify the Environment Agency of proposed landspreading operations at least two weeks (ten working days) before the operation is intended to start.

- Management of the landspreading of waste on the farm can make all the difference between a successful or disastrous landspreading operation. Consequently, consideration should be given to tighter controls such as authorising operators for landspreading on the basis of suitable qualifications and experience, as an alternative to the current system of exempting individual operations.

- Landspreading operations must not adversely affect places of special interest or the countryside in terms of factors such as visual quality, and amenity and landscape value. This applies to operations intended to achieve either agricultural benefit or ecological improvement.

- Ecological improvement is associated with the maintenance of habitats and their biodiversity where these would otherwise deteriorate, the provision of new habitats for wildlife and the development or restoration of existing habitats to give greater biodiversity and sustainability.

- Ecological improvement will rarely be the justification for landspreading of wastes. As a precautionary measure in accordance with sustainability of habitats and biodiversity, it is suggested that landspreading is not permitted in biological and other designated heritage sites. These sites are specified in the report.

- Waste producers using the landspreading outlet must recognize that it is waste recovery not waste disposal. They should be prepared to improve the management of wastes for landspreading by investment as appropriate in storage at the point of production, dewatering and other treatment, monitoring and analysis, and field trials to quantify the agricultural benefit of their wastes.

- The role of a land occupier in the Duty of Care (Section 34 Environmental Protection Act 1990) will vary according to the exact nature of their involvement in the landspreading operation. An occupier who is also a waste contractor will fall fully within the Duty, whereas an occupier who has no involvement in the landspreading operation may not fall within its provisions. Within these two extremes is a range of potentially contentious areas where an occupier's involvement in Duty of Care is unclear and will only be decided by legal precedent. The land occupier's liabilities need to be clarified.

- 'Sludge from biological treatment plants' is a category of exempted waste in Table 2 of Schedule 3, paragraph 7(2) of the 1994 Regulations. This category needs to be defined more precisely in terms of the type and origin of the wastes it includes, such as 'food industry only', and descriptions of the biological treatment processes that are acceptable.

- The current list of exempted wastes should be kept under review and amended where agricultural benefit and the other necessary requirements can be demonstrated. This may lead to some wastes being added to the list and others removed from it.

- Landspreading of certain wastes may be the best practicable environmental option, although they have only a neutral effect on the land and bring no agricultural benefit. These wastes could be considered for landspreading under licence.

1. INTRODUCTION

The principal objective of this report is to develop technical, scientific and practical guidance on the spreading of industrial wastes on land. This guidance is intended to define the criteria for landspreading in a manner that is:

- demonstrably beneficial to agriculture or provides ecological improvement;
- consistent with the principles of sustainable development; and
- protects human health and the environment as required by Article 4 of the Waste Framework Directive 91/156/EEC (CEC 1991).

This report is intended to contain all of the relevant facts clearly explained, to enable the Department of the Environment, Transport and the Regions (DETR), the Environment Agency (the Agency) and the Ministry of Agriculture, Fisheries and Food (MAFF) to produce clear technical and practical guidance on the relevant criteria for the spreading of all industrial wastes on the land. The users of the guidance document will be regulators (including those concerned with wastes, controlled waters and environmental health), those producing and spreading wastes, farmers and other land occupiers and landowners.

The background to the work can be found in, 'Making Waste Work', a strategy for sustainable waste management in England and Wales, produced by the DoE and the Welsh Office (DoE/WO 1995). The strategy deals with waste management in the context of sustainable development defined as:

'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

The strategy also includes application of the precautionary principle, described as follows:

'Where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it'.

Also included in the strategy is the polluter pays principle:

'Government is considering a range of economic instruments to address distortions in the waste market - especially to help ensure that waste management options bear their full environmental costs and, in turn, that the polluter pays'.

More specifically, the strategy is based on three key objectives for waste management:

- to reduce the amount of wastes that society produces;
- to make best use of the waste that is produced; and
- to choose waste management practices which minimise the risks of immediate and future environmental pollution and harm to human health.

The strategy ranks the different waste management options in order of preference:

- reduction;
- re-use;
- recovery- recycling, composting and energy; and
- disposal.

The broad waste recovery category at the third level incorporates materials recycling, composting and recovery of energy from waste. This is to indicate that no one of these should automatically be preferred to any other, as this will depend on the Best Practicable Environmental Option (BPEO) for a particular waste stream.

'Making Waste Work' includes a section specifically dealing with landspreading (p. 51/52). This briefly covers the current situation and identifies the advantages and disadvantages of landspreading.

Potential advantages of landspreading include:

- recovers waste which in the past might have been dumped at sea or landfilled;

- replaces chemical fertilisers - a potentially more sustainable approach than reliance on continuous supplies of nitrogenous fertiliser from energy-intensive processes, and phosphate fertiliser and peat soil conditioners from finite sources; and

- improves soil structure.

There is also an economic advantage in terms of savings on more expensive alternatives for both the waste producer and farmer.

Potential disadvantages of landspreading include:

- hazardous to human and animal health;
- damage to sensitive ecosystems;
- soil contamination from potentially toxic elements or organic compounds;
- deterioration in soil structure;
- pollution of water (including groundwater); and
- nuisance (odour, visual).

The strategy is underpinned by the Government's and Agency's waste management research programme, generating technical and environmental guidance, of which this study is a part and is referred to in the section on landspreading:

'Research to establish the principles of agricultural benefit and ecological improvement, and to provide further technical guidance and good practice for the spreading of off-farm wastes'.

The need for guidance on landspreading of exempted wastes is referred to also in the nineteenth report of The Royal Commission on Environmental Pollution entitled *Sustainable Use of Soil* (RCEP 1996).

Landspreading of wastes is likely to increase because it is a preferred option to disposal in the hierarchy of waste management options, and because of the landfill tax which has altered the balance of costs between landspreading and landfilling of wastes. In this report an estimate has been made of the quantities of wastes currently spread on land. The details are to be found in Appendix E. It is estimated that about 22 million tonnes (dry weight basis)of waste is recycled to land each year in the UK. Of this, 94% is waste from farm animals, 2% is sewage sludge and 4% is industrial waste of which half is paper industry waste. Wastes for which no estimate could be made through lack of information included dredgings from inland waters, waste soil or compost, and waste wood, bark or other plant matter. The quantities of these wastes which are currently spread on land are probably substantial in relation to the quantities of other exempted wastes. Nevertheless, a perspective is provided by the predominance of farm animal slurry and manure amongst the wastes currently spread on land.

2. LEGISLATION AND EXISTING GUIDANCE

This Section lists and gives a brief resumé of all current regulations and guidance documents so far as they are relevant to the application of all wastes to land.

2.1 The Waste Framework Directive

The 'Waste Framework Directive' (91/156/EEC amending 75/442/EEC on waste) incorporates the polluter pays concept and includes the principle of the waste hierarchy referred to above in 'Making Waste Work'. As mentioned in the introduction, Article 4 is particularly pertinent to landspreading of wastes and reads as follows - Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular:

- without risk to water, air, soil and plants and animals;
- without causing a nuisance through noise or odours; and
- without adversely affecting the countryside or places of special interest.

Member States shall also take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of waste.

Annex 11 B of 91/156/EEC lists the operations which may lead to recovery, including R10 - spreading on land resulting in benefit to agriculture or ecological improvement, including composting and other biological transformation processes, except in the case of waste excluded under Article 2 (1) (b) (iii). The latter includes animal carcasses and the following agricultural waste: faecal matter and other natural, non-dangerous substances used in farming (see Table 3.1 for licensing exemptions).

2.2 The Waste Management Licensing Regulations

The Waste Framework Directive was implemented in the UK by the Environmental Protection Act 1990 and the Waste Management Licensing Regulations (WMLR) 1994.

Landspreading of industrial wastes is normally carried out under the exemptions from licensing given in paragraph 7 of Schedule 3 of WMLR to permit the beneficial recovery of certain wastes. This study focuses on the controlled wastes listed in Table 2 of paragraph 7 of Schedule 3 of the Regulations which are as follows:

Part I

- Waste soil or compost.
- Waste wood, bark or other plant matter.

Part II

- Waste food, drink or materials used in or resulting from the preparation of food or drink.
- Blood and gut contents from abattoirs.
- Waste lime.
- Lime sludge from cement manufacture or gas processing.
- Waste gypsum.
- Paper waste sludge, waste paper and de-inked paper pulp.
- Dredgings from any inland waters.
- Textile waste.
- Septic tank sludge.
- Sludge from biological treatment plants.
- Waste hair and effluent treatment sludge from a tannery.

The Regulations are further explained in a Joint Circular from the DoE (11/94), Welsh Office (26/94) and Scottish Office Environment Department (10/94) of 19 April 1994 entitled 'Environmental Protection Act 1990: Part II, Waste Management Licensing and The Framework Directive on Waste'.

2.3 Policy and practice for the protection of groundwater

The National Rivers Authority (NRA), now incorporated into the Environment Agency, had a duty under the Water Resources Act 1991 to monitor and protect the quality of groundwater and to conserve its use for water resources. It also had a duty to maintain and where appropriate, enhance conservation of the surface water environment. These duties related only to England and Wales and were transferred to the Agency from 1 April 1996 as amended by the Environment Act 1995. The NRA gave high priority to promoting a national framework policy for groundwater protection which is set out in this document. Tables 1 and 2 in the policy document present an informative summary of, respectively, groundwater protection legislation directly implemented by the NRA, and of bodies with responsibility for aspects of groundwater protection in England and Wales. This national framework policy for groundwater protection is currently being reviewed by the Environment Agency.

For its implementation, the policy relies partly on a series of vulnerability and protection zone maps which are now being prepared. Already available are Guides to groundwater Protection Zones in England and Wales (1995) and to Groundwater Vulnerability Mapping in England and Wales (1995). The 53 Groundwater Vulnerability Maps are being published by HMSO on a sequential basis whilst Groundwater Protection Zone map details are available from local offices of the Agency.

The Government is about to introduce Regulations **(Draft Groundwater Regulations 1998)** that seek to fully transpose the **EC Groundwater Directive (80/68/EC)** into UK law, and prevent the entry of all List I substances into groundwater, and limit the entry of List II substances, so as to avoid pollution. As the range of substances allocated to these lists is extremely broad, and includes all pesticides, inorganic phosphorus, and ammonia, a wide range of materials spread onto agricultural land could be affected. For activities where there is material containing List I or II substances, and there is a discharge, or disposal or tipping for the purposes of disposal, an '*authorisation*' will be required. It will become an offence under Section 85 of the **Water Resources Act 1991** (WRA 1991) to discharge or dispose of such material without an *authorisation*. The Regulations will not seek to control material containing radioactive substances, domestic effluent from isolated dwellings outside of source protection areas, or disposal or tipping activities subject to controlled waste regulations within the meaning of **Part II of the Environmental Protection Act 1990**. An authorisation cannot be made without "prior investigation" and "requisite surveillance" of the groundwater. An authorisation must also include technical precautions/conditions to prevent the indirect discharge of List I substances or pollution of groundwater by List II substances. These can take account of any purifying properties of the soil or subsoil. Authorisations must be reviewed at least every four years.

Where activities on land such as exempt waste spreading are taking place in accordance with the provisions and conditions of the exemption, and the waste does not contain significant concentrations of Listed substances (and it provides agricultural benefit and does not therefore constitute 'disposal'), an authorisation will not be required under the Regulations. Therefore, providing sufficient details are submitted and sufficient account is taken of groundwater at the pre-notification stage, the spreading of "exempt" wastes will not require authorisation. Where existing controls are found to be inadequate, or not being followed, there is provision for serving a "notice" prohibiting or modifying the activity concerned.

Of relevance here is the designation of **Nitrate Vulnerable Zones** (NVZs) under the **EC Nitrate Directive (91/676/EC)**. Measures will be implemented by the end of 1999 as required by the Directive. Draft measures were presented in a consultation paper in November 1995 (DoE, MAFF, WO). These included restrictions on organic manures in NVZs- limits of 210 kg N ha^{-1} y^{-1}, reducing later if necessary to 170 kg N ha^{-1} y^{-1}, and closed periods on shallow or sandy soils when liquid slurries containing readily available N should not be applied to the land. The statutory provisions have now been published in the Protection of Water Against Agricultural Nitrate Pollution (England and Wales) Regulations 1996 (SI 1996/888).

The NRA Policy and Practice for the Protection of Groundwater includes a section (7E, p. 34) on the application of liquid effluents, sludges and slurries to land (see Section 6.3.4).

2.4 Code of Good Agricultural Practice for the Protection of Water

This a practical guide to help farmers and growers avoid causing water pollution, which is a Statutory Code under Section 97 of The Water Resources Act 1991(and before that under Section 116 of the Water Act 1989). Section 6 deals with 'Other Organic Wastes'. It recommends a limit of 250 kg ha^{-1} y^{-1} of total nitrogen in organic materials applied to the land. Organic materials should not be applied on non-spreading areas, and restricted to 50 m^3 ha^{-1} (slurries) and 50 t ha^{-1} (consolidated organic materials such as manure) per application in high-risk areas. These non-spreading and high-risk areas are defined in paragraphs 25 to 27, 30 and 31 of the Code. This Code is likely to be updated in 1998. It is understood that the revision will permit application of 500 kg ha^{-1} of total nitrogen in one application every two years of wastes containing little plant available nitrogen (such as compost) in catchments less sensitive to nitrate leaching.

2.5 Code of Good Agricultural Practice for the Protection of Air

This practical guide is to help farmers and growers avoid causing air pollution from odours, ammonia and smoke, or from greenhouse gases which cause global warming. It includes a section on 'Precautions when spreading manure and slurry', with advice on methods of application which reduce odour emission. It advises that landspreading should be avoided in fields close to and upwind of houses unless it is liquid slurry that can be band spread or injected, or has been treated to effectively reduce its odour. No more than 50 m^3 ha^{-1} (slurries) or 50 t ha^{-1} (solids) of waste should be applied at one time in locations where odour could be a problem.

2.6 Code of Good Agricultural Practice for the Protection of Soil

To help farmers and growers avoid causing long-term damage to the soils which they farm, this guide gives general guidance on practices which will maintain the ability of soil to support plant growth. The background to the report makes reference to The Council of Europe and its agreement to the Recommendation on Soil Protection in May 1992. Section 4 on contamination contains guidance on 'Other industrial and domestic wastes' in paragraphs 104-107, and on 'Dredging materials' in paragraph 115. Broad guidance is given in this section on fertiliser value, beneficial conditioning of soil, and avoidance of water pollution and soil contamination.

2.7 Sewage sludge legislation and guidance

Recycling of sewage sludge to agricultural and other land is a well-established practice which accounts for about 50% of UK production (or 430 000 tonnes on a dry solids basis, about 2.9 million wet tonnes as spread per annum) and is controlled by statutory requirements and detailed recommendations in various guideline documents. Much of this is relevant to landspreading of industrial wastes since it covers sludge quality in terms of content of nutrients, contaminants, pathogenic micro-organisms, odour and treatment processes, and land management to protect soil and water quality and prevent environmental problems. Monitoring, record-keeping and reporting are also covered. The relevant documents are:

- 86/278/EEC Council Directive on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. Official Journal of the European Communities 4.7.86 No L 181/6-12;

- The Directive was implemented in the UK by The Sludge (Use in Agriculture) Regulations (as amended) S. I. 1263. HMSO, London (1989);

- These statutory regulations have been complemented by the Code of Practice for Agricultural Use of Sewage Sludge first published by DoE in 1989. A revised Code (second edition) was issued in April 1996 to take account of the DoE/MAFF review of food safety / animal health and soil fertility aspects of the rules for applying sewage sludge to agricultural land, which reported in 1995. A MAFF booklet on general information on the application of sewage sludge to agricultural land was published in 1996 (MAFF 1996). The Water Services Association has recently (WSA 1996) produced a leaflet on recycling sewage sludge / biosolids to agriculture; and

- As regards non-agricultural land, guidance includes Forestry Commission Bulletin 107, 'A Manual of Good Practice for the Use of Sewage Sludge in Forestry', HMSO, London (Wolstenholme *et al,* 1992). In addition to practical guidance, Appendix 1 of the manual includes a useful checklist of stages in the use of sewage sludge as a forest fertiliser with actions on the Forest Manager and Sludge Producer under the headings: initiation, site identification, consultation, pre-application monitoring, planning, operational and post-application (see Section 7.2.2). A manual of good practice for the use of sewage sludge in land reclamation is available in draft form (Wolstenholme and Hall 1996).

A relevant theme throughout the regulations and guidelines for landspreading of sewage sludge is the onus on the sludge producer to monitor sludge and soil and keep records of operational details (specified in SI 1263) in a register.

Apart from the European Union, landspreading of sewage sludge is widely practised in the USA and much information based on risk assessment using the latest research data, is to be found in the United States Environmental Protection Agency's Part 503 standards for the use and disposal of sewage sludge, and supporting documentation (USEPA 1993a, 1993b).

Further guidance relevant to landspreading of wastes is contained in:

- A report on legislative requirements for landspreading of industrial wastes entitled, 'Controlling the landspreading of wastes'. This was a guidance document produced by the National Association of Waste Regulation Officers and National Rivers Authority Technical Liaison Group (NAWRO/NRA 1996). The final draft of this report has been used in the preparation of Section 3 below on Regulation of Landspreading;

- CIRIA Report 157 - Guidance on the disposal of dredged material to land; and

- The Royal Commission on Environmental Pollution in its nineteenth report on 'Sustainable Use of Soil' (RCEP 1996) has made a number of recommendations concerning landspreading of sewage sludge and industrial wastes.

2.8 Environmental legislation/obligations relating to protected areas

(See also Sections 6.3 and 7.2)

The Environment Act 1995 places duties on the Environment Agency with respect to conservation. When carrying out its waste management activities, the Agency must consider the following conservation duties, namely to:

have regard to the desirability of:

- conserving and enhancing natural beauty
- conserving flora, fauna and geological or physiographical features of special interest
- protecting and conserving buildings, sites and objects of archaeological, architectural, engineering and historic interest.

The 1995 Act also places specific obligations on the Agency in respect of Sites of Special Scientific Interest (SSSIs). It is required to consult with English Nature (EN) or the Countryside Council for Wales (CCW) before undertaking or authorising any activity which is likely to damage or destroy the features for which an SSSI is notified.

There is a similar duty in respect of National Parks, and the Agency is required to consult with the National Park authority (or Broads authority) if specified land is likely to be affected by Agency activities or authorisations.

2.8.1 Wildlife sites

The main legislation giving protection to wildlife conservation sites in Britain is contained within Part II of the 1981 Wildlife and Countryside Act. This gives a statutory duty to the designated conservation bodies (English Nature in England, the Countryside Council for Wales and Scottish Natural Heritage) to establish a network of protected sites that reflects the full range of habitats, species and geological features occurring in Britain.

The two main site designations are National Nature Reserves (NNRs) and Sites of Special Scientific Interest (SSSIs). NNRs represent the real 'gems' of the country's natural finery and are either owned or managed by the statutory conservation bodies (SCBs) or held by approved bodies such as Wildlife Trusts, the National Trust or RSPB etc. Four categories of NNR can be recognised:

a) owned by the SCBs freehold;

b) leased to the SCBs;

c) managed by the SCBs by agreement with the landowner; and

d) managed by the landowner, to specific standards, as an 'approved body'.

SSSIs may be managed by the freeholder, the leaseholder or a third party under agreement. SSSIs are protected by the issuing of lists of Potentially Damaging Operations, which the landowner, leaseholder or third parties appointed by either cannot undertake without the permission of the SCB. PDOs are selected for a particular site from a general list (see Appendix F) according to the site-specific attributes that need to be protected.

Other important types of protected sites are Forest Nature Reserves (FNRs), Local Nature Reserves (LNRs) and private reserves, the latter being the most numerous category of all. FNRs are managed on behalf of the Forestry Commission by the relevant SCB by 'exchange of letters', since it is not legally possible for them to make formal agreements with the Forestry Commission (who are also a government body). The concept of LNRs was established under the 1949 Act, largely for educational purposes. They have to be approved by the relevant SCB and the Local Authority (LA) must have an interest in the land. After designation, LNRs are protected by LA bye-laws. Private reserves, such as those owned by the RSPB, National Trust and County Wildlife Trusts, are preserved by the will of the landowner but protected only by the law of trespass (unless they carry NNR or SSSI designation); however, it can be argued that this arrangement is the safest for Britain's natural heritage.

2.8.2 Recreation/amenity sites

The two principal designations of protected area with respect to recreation and amenity are National Parks (NPs) and Areas of Outstanding Natural Beauty (AONBs), both established under the 1949 National Parks and Access to the Countryside Act. Sites are designated on the basis of outstanding landscape value. The larger areas that are less vulnerable to development have been made into NPs (for example, Snowdonia and the Peak District), whilst the smaller, high risk areas have been made AONBs (for example, the Chilterns and the South Downs). In coastal areas, a new designation of Heritage Coast has been added to the protected area network, in order to conserve the landscape value.

Protection of these areas is meant to be effected through the planning process. An NP Committee operates within each NP, which screens planning applications and can insist that buildings and associated developments are in keeping with the character of the area. In addition, they distribute grants for activities that maintain the traditional landscape. There is no such committee arrangement for AONBs.

2.8.3 Agricultural grant schemes with nature conservation and/or landscape/ amenity objectives (Agri-Environment Schemes)

The designation of Environmentally Sensitive Area allows grants to be awarded to the rural community for farming in traditional ways that are essential to the landscape (and also ecological) character of the area. The ESA scheme was initiated in 1987 and is the responsibility of MAFF, with advice from the SCBs and English Heritage. The ESA scheme is described in MAFF publication 'Our living heritage' (1993). Examples of ESAs include the Suffolk River Valleys, the South Downs, the Shropshire Hills and the Upper Thames tributaries. Activities that attract grants vary from ESA to ESA, but may include reduced fertiliser applications and low-intensity grazing. There are 22 designated ESAs in England and Wales.

The MAFF Habitat Scheme applies to former Set-Aside land that has developed nature conservation value. Participation is voluntary but depends upon an agreement to manage the land to the benefit of wildlife - this includes refraining from:

1. applying 'lime, slag or other substances used to reduce soil acidity';
2. applying 'inorganic or organic (including livestock excreta and sewage sludge) fertilisers, except on sites which have been agreed as feeding areas for wildfowl'; and
3. improving land drainage.

The Countryside Stewardship scheme has recently been brought under the umbrella of MAFF, being another voluntary grant scheme that applies to certain types of habitat. Land entered into the scheme is subject to a number of restrictions (which vary from habitat to habitat) including some relating to the application of fertilisers and other substances (such as pesticides).

2.8.4 Outline of international obligations and implementation in the UK

There is a range of international obligations involving wildlife site protection to which successive Governments have committed the UK. A brief outline of the principal ones is given below.

Ramsar Convention - Signed in 1971 in Ramsar, Iran, this convention was drawn up to stop the progressive decline of wetland through activities such as development and agricultural improvement. Signatories are required to identify and list all wetlands of international importance, using agreed criteria. Within these sites, signatories are asked to promote conservation, promote the establishment of nature reserves and inform the Secretariat of changes in status. Around 60 Ramsar sites have so far been designated across the UK, and conservation has been promoted through SSSI designation.

Berne Convention - Signed in 1979, all signatories are required to conserve the habitats of species listed in Appendix I (strictly protected flora) and Appendix II (strictly protected fauna) of the convention. The requirements specify that planning and development law takes account of these areas.

The site protection aspects of the convention were ratified in the UK by designation of NNR and SSSI status. The Berne Convention has now been superseded by the EC Birds Directive with respect to important bird habitats, and will soon be superseded by the Habitats Directive for all other habitats.

EC Birds Directive - Adopted in 1979, this directive seeks to establish the protection, management and control of all bird species naturally occurring in Member States. It involves the designation of Special Protection Areas (SPAs), the criteria for which are specified by the importance of breeding and overwintering bird populations (as percentages of the national total).

This Directive was formally implemented in the UK by the 1981 Wildlife and Countryside Act. The DoE stated that 'the statutory framework of bird protection and conservation provided by the [1981 Act] meets (and in many respects exceeds) the requirements of the Birds Directive in terms of species protection'. In the UK, 113 SPAs had been designated by 1995 covering over 355 000 hectares of land.

EC Habitats Directive - Adopted in 1994, Member States are required to maintain (or achieve) the 'favourable conservation status' of species and habitats listed in the Directive's Technical Annexes through the designation of Special Areas for Conservation, SACs (and through measures to conserve particular species). Species and habitats are listed as being of 'community interest' or 'priority', with the latter carrying the most importance. Priority habitats occurring principally in the UK include yew woods, active raised and blanket bog, dune heath and grassland, Caledonian forest and limestone pavement. Proposals for SACs have been sent to the European Commission, which must be agreed and designated by 2004. There will be very strict regulation of activities which are likely to affect the special interests of these sites. SACs will combine with SPAs to form a European network of protected areas called Natura 2000.

The main legislation for implementing the Directive in the UK is the Conservation (Natural Habitats &c.) Regulations 1994. These regulations tighten the SSSI legislation but only for SACs and not the wider SSSI network. This has given rise to fears that non-SAC SSSIs will receive less attention and suffer as a consequence. The regulations require a mandatory review of planning consents or other development permissions that threaten SACs, with the implication that consents may be withdrawn as a consequence. Planning controls will be stronger for SACs than SSSIs, and new Conservation Order and bye-law-making powers have also been introduced.

Biodiversity Convention - The aim of this convention was to stem losses of biodiversity at the global level by placing obligations on signatory states to protect their biological resources and to use them sustainably. It was signed by more than 150 heads of state at the 'Earth Summit' in Rio de Janeiro and was ratified by the UK in 1994.

A UK Action Plan on Biodiversity has been published by the Government in response to its obligations under this convention. It contains an important objective to 'conserve and where possible enhance the quality and range of habitats, and also the biodiversity of these habitats where this has diminished over recent past decades'. It also commits the Government to setting costed targets for key species and habitats, published in 1995. A Biodiversity Action Plan Steering Group has been established to implement the Action Plan. In their response to proposals put forward by the Steering Group in May 1996, Government welcomed the report and encouraged implementation of the plans to take positive action for 116 species and 14 habitats (plans for an additional 186 species and 24 habitats will be prepared during the next two years). In all cases the aim is to enhance the area of habitats and the number of individual species. This will require positive action, led by the SCBs but also involving a wide range of individuals and organisations including the private sector.

3. REGULATION OF LANDSPREADING

3.1 The statutory duties of regulators

3.1.1 Waste management licensing

The Waste Framework Directive (75/442/EEC, as amended by 91/156/EEC) provides the basis on which all waste is managed (see Section 2.1).

In the UK, landspreading of industrial wastes is controlled by the WMLR 1994 (see Section 2.2 above)

3.1.2 The responsible authority

The Agency is the lead authority responsible for enforcing the WMLR 1994 in England and Wales. In Scotland, the responsible authority is the Scottish Environment Protection Agency (SEPA). These agencies are also responsible for the prevention of pollution of surface and groundwaters. Other competent authorities are listed in paragraph 3 of Schedule 4 of WMLR 1994.

3.1.3 Control of waste disposal to land

Many wastes, including sludges, slurries, effluents and solid matter arising from sewage treatment works, industrial and commercial activities, agricultural activities and domestic premises may be deposited on land, subject to compliance with the WMLR 1994.

If not specifically exempted, a waste management licence will be required for such activities. Guidance on the licensing of waste management facilities is provided in Waste Management Paper (WMP) No.4 (DoE 1994).

It should be noted that in relation to Regulation 17 of WMLR 1994 (or any other regulations or exemptions that apply), there will remain the statutory requirement to consult the SCB (see Section 2.8.1 above) over any proposal to deposit or spread waste within an SSSI or NNR.

Regulation 17 of WMLR 1994 provides for exemptions from waste management licensing and paragraph 7 of Schedule 3 details the conditions for these exemptions, where the spreading of certain wastes to agricultural land is carried out. The process of determining an exemption is covered in Section 3.2 below.

It is an offence under s.33(1) of the Environmental Protection Act 1990 to spread waste on land where this is outside the requirements for an exemption in paragraph 7 of

Schedule 3 and there is no waste management licence. Under such circumstances the penalties would be a fine of up to £20 000 and/or six months imprisonment.

3.1.4 Pre-notification and the WRA register

Regulations 17 and 18 in WMLR 1994 deal respectively with exemptions from waste management licensing and with registration in connection with exempt activities. For landspreading, Regulation 18 (7) applies. It is an offence to carry on an exempt activity involving the recovery or disposal of waste without being registered with the Agency. Information about the proposed landspreading operation must be supplied to the Agency in advance. Section 3.3 below describes the information which the Agency requires.

3.2 Initial determination of an exemption

3.2.1 Responsible parties

The Agency administers the processes of exempt activity registration and licensing.

3.2.2 Preliminary decisions

The determination of whether or not the proposed activity is exempt from waste management is an important first step. Appendix A (Process Map to Aid Decision-Making), and Appendix B (Proforma) provide a means of making this first stage decision.

Schedule 3, paragraph 7 of the WMLR 1994 lists, at Table 2, wastes that are exempt from site licensing and which can be spread on agricultural land, provided that 'benefit to agriculture' or 'ecological improvement' can be demonstrated and achieved (see Section 7). For the list, see Section 2.2, above.

If not used for agriculture, only Table 2 Part I wastes apply, and then only for the types of land specified in Schedule 3, paragraph 7 (2a and b) of WMLR 1994.

The spreading of the listed wastes is subject to the provisions of Regulation 17 and the specific conditions and limitations contained in Schedule 3, paragraph 7. No more than 250 tonnes or, in the case of dredgings from inland waters, 5,000 tonnes of waste per hectare may be spread on the land in any period of twelve months. Where more than one waste type is to be spread, the quantities applied must be taken together. These limits are reserve ceilings. On most land and for most wastes, quantities approaching these figures are likely to cause a breach of other conditions of the exemption. Other factors besides the quantity limit will determine the amount of waste that can be spread on land (see Section 7).

The initial determination of exemption is made by the operator (see Sections 4 and 5), with the assistance, if necessary, of properly qualified advice (PQA) prior to the notification (DoE Circular 11/94, paragraph 5.74). PQA should take account of the environmental protection objectives stated in Schedule 4, paragraph 4(1a) of WMLR 1994 (see Section 9.1).

Table 3.1 provides additional advice on processing exemptions from licensing.

Table 3.1 Guidance on waste licensing exemptions and exclusions

Waste Type	Guidance
Special Waste (Special Waste Regulations 1996).	Not exempt and subject to the licensing process administered by the Agency.
Aqueous radioactive waste (Radioactive Substances Act 1993, s.13 and s.16).	Authorisation required from the Agency. Not considered further in this document.
Wastes arising from cesspits (cesspools) for land application.	Not exempt and subject to the licensing process administered by the Agency[1].
Wastes arising from some farming activities (see the Waste Framework Directive 91/156/EEC Article 2(1)(b)(iii).	Not Controlled Wastes and therefore excluded from to WMLR 1994 controls[2,3] but may be subject to the new Agricultural Waste Regulations.

Notes:

[1] The Waste Management Licensing (Amendment etc.) Regulations 1995 amend the Controlled Waste Regulations 1992 in relation to septic tank sludge, which is exempt.

[2] An explanation of how these wastes should be stored and disposed of is given in the Code of Good Agricultural Practice for the Protection of Water (MAFF 1991).

[3] It is understood that the Agency intends to bring forward regulations to bring into control those Directive wastes that are not currently controlled wastes.

3.3 Record keeping and access

3.3.1 Information requirements

Where there is an intention to deposit waste on agricultural land, specific details must be furnished to the Agency prior to the commencement of operations (WMLR 1994; Schedule 3, paragraph 7 (3c and 4), and for regular applications this must be repeated every six months or when the nature of the waste changes.

When the Agency is informed by the operator of the intent to deposit waste, the following particulars are required for registration:

- the operator's name, address, telephone (and FAX) number(s);
- a description of the waste, including the process from which it arose;
- where the waste is being and will be stored pending spreading;
- an estimate of the quantity of the waste or, in the case of a frequent spreading, an estimate of the total quantity of waste to be spread during the next six months; and
- the location and intended date and, in the case of a regular spreading, the frequency of the spreading of the waste.

Notification must be given to the Agency in advance of the spreading taking place. An example of a proforma for collecting this information is provided in Appendix B. An establishment or undertaking should not notify the Agency until such time as they are able to demonstrate that an activity meets all the provisions and conditions of exemption.

In practice it would be open to any establishment or undertaking to furnish particulars more frequently than every six months if that was more convenient, simply by regarding the next spreading as a single spreading or as the beginning of a new series.

To allow a more considered and systematic approach than is possible under the current Regulations, a statutory period of advance notice (minimum of two weeks or ten working days), along with a more detailed and regular analysis, would improve the technical basis and justification for landspreading.

3.3.2 The public register

Once notified to and accepted by the Agency, the activity will be registered as exempt. The register is then available for public scrutiny.

As stated in 3.1.4 above, it is an offence to carry on an exempt activity involving recovery or disposal of waste unless registered with the Environment Agency. This applies to Schedule 3, paragraphs 8, 9 and 12 (other than composting for mushroom cultivation where currently covered by a Part I authorisation and registered by the local authority).

3.4 Site inspections and other monitoring activities

3.4.1 Statutory duty of the Agency

Schedule 4, paragraph 13 of WMLR 1994, describes the duty of the Agency regarding appropriate periodic inspection of exempted activities. DoE Circular 11/94 at paragraph 1.85, 1.86 and 1.87 describe the government's view on how this duty is to be approached.

The spreading of waste on land can present a considerable pollution threat and should be appropriately monitored.

3.4.2 Monitoring activities of the Agency

The Agency needs to be satisfied that the objectives of the Waste Framework Directive and the requirements set out in Sections 9.2.3 and 9.2.4 are complied with. The necessary actions are as follows:

- request that operators give notification using the proforma (Appendix B) together with a written report based on properly qualified advice (PQA) at least 10 full working days before operations are due to commence, and at least 3 working days before repeat deposits;

- once notified, the activity must be registered;

- consider the associated potential impacts on the water environment;

- if the technical case is not convincing, the operator will be advised and requested to provide further information;

- ensure that any written notification includes written consent by the land owner (attach to the proforma - Appendix B). Otherwise, contact the occupier of the relevant land to ensure that his consent is given;

- request details of any associated waste storage arrangements and check, as necessary, to establish if 'secure' and that no more than 500 tonnes will be stored in any one container or lagoon (WMLR 1994 Regulation 17(3) and Schedule 3 paragraph 7(5 and 6);

There is concern about inadequate storage capacity on ***producers' premises****. Many producers have less than 24 hours storage capacity, some having less waste storage than a single shift's output. This situation leads to companies pressurising contractors to remove the wastes as quickly as possible. Measures similar to those applying to farm wastes, which require a minimum storage capacity for waste, would allow a more flexible approach to spreading and give more strength to the arguments for agricultural benefit.*

- check the site to ensure compliance with all relevant criteria of the exemptions (and in the case of 1994 Regulations Schedule 3 paragraph 9 that planning approval has been given);

- ensure, with regard to Schedule 3 paragraph 7, that the necessary prenotification information is satisfactory (see the proforma in Appendix B);

- where sewage sludge is spread on non-agricultural land, secure periodic soil analyses in accordance with Schedule 2 of the 1989 Sludge Regulations (SI 1263, 1989);

- request (non statutory) periodic appropriate information on the wastes being dealt with and/or carry out own investigations;

- request (non statutory) periodic results of environmental quality control monitoring to ensure continued compliance with Schedule 4 Part 1 paragraph 4(1a) of the 1994 Regulations (see Section 3.1.1) and/or carry out own investigations; and

- take appropriate enforcement action in the event of a breach of exemption conditions.

3.4.3 Powers available under the Water Resources Act 1991

The Agency is the competent authority for the Groundwater Directive 80/68/EEC with respect to waste disposal activities. When pollution of groundwater and/or surface water has occurred as a result of an exempted activity, the Agency has powers under the Water Resources Act 1991 (as amended by the Environment Act 1995) to pursue prosecution of the polluter, (described at ss.85-89 of the 1991 Act). These powers include:

- inspections of areas, sites and facilities in water catchments, principally with the aim of preventing and controlling water pollution (s.4 of the 1991 Act); and

- initiation and completion of anti-pollution works, the costs of carrying out such works being recovered from the polluter (ss. 161-162 of the 1991 Act).

The Agency may take measures to prevent pollution from landspreading of controlled wastes by:

- conducting periodic catchment inspections at appropriate times, in locations where these wastes are known to be deposited;

- comparing the findings of these inspections with criteria specified in the MAFF Codes of Good Agricultural Practices, and Agency (NRA) Policy and Practice for the Protection of Groundwater;

- identifying the risk of pollution of controlled waters from exempted activities, as a result of consultations or of findings of catchment inspections;

- carrying out internal liaison, making reference to register entries, relating to surface water and groundwater catchments, to ascertain the operators, landowners, nature and scale of waste spreading activities; encourage informal consultations with major operators to agree a working plan to prevent pollution;

- making reference to waste spreading activities, and the Agency's preferred controls, in Local Environment Plans (LEAP's);

- sampling surface watercourses and groundwaters in these areas when pollution is thought to be occurring;

- taking legal proceedings against operators and landowners polluting controlled waters as a result of non-authorised application of wastes to land, or as a result of a breach of license conditions; and

- compiling a database of notification details.

The Groundwater Regulations 1998 (now in draft form (see Section 2.3)) must be taken into account.

4. WASTE PRODUCER RESPONSIBILITIES

4.1 A duty of care

Section 34 of the Environmental Protection Act 1990 imposes a duty of care on persons concerned with **controlled waste.** The duty applies to any person who produces, imports, carries, keeps, treats or disposes of controlled waste, or as a broker has control of such waste. Breach of the duty of care is an offence, with a penalty of an unlimited fine if convicted on indictment.

The holder of waste must keep it under control, store it safely and securely, and prevent it causing pollution or harming anyone. Some action to achieve this are:

First - make the waste secure. Keep it in a suitable container. Loose waste in a skip or lorry should be covered.

Second - if the waste is to be given to someone else, check that they have authority to take it. The law says the person to whom you give waste must be authorised to take it. Table 4.1 explains who is allowed to take waste and how you can check.

Third - you must fill in and sign a transfer note for it which includes a description of the waste. You must keep a copy of the transfer note. To save on paperwork, you can write your description of the waste on the transfer note (see Section 4.2.2, below).

Three documents amplify on these basic legal provisions. These are:

- The Environmental Protection (Duty of Care) Regulations 1991, SI 1991 No. 2839 which include documentation requirements for waste transfers.
- DoE Circular 1991, Environmental Protection Act 1990 Section 34: The Duty of Care, HMSO.
- A statutory code of practice for giving practical guidance on the duty of care (Waste Management : The Duty of Care - A Code of Practice, March 1996, ISBN 0 11 753210 X, HMSO); and

In law, the responsibilities for waste under the duty are divided between all those who, at some stage, hold that waste. But the responsibilities are not spread evenly. Some holders will have greater or less responsibility for some aspects of the duty, according to their connection with the waste. The following section offers summary guidance on the responsibilities of waste producers. The three documents listed above should be consulted for more detailed information.

4.2 The implications for waste producers

4.2.1 Who is a waste producer?

A 'producer' of waste is anyone whose activities produce waste (as defined in the framework Directive on waste - 75/442/EEC), or who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of a waste (Regulation 1(3) of WMLR 1994).

4.2.2 Waste producer duties

Waste security

Waste producers are solely responsible for the care of their waste while they hold it. As such, it should be suitably contained. Likewise, producers bear the responsibility for packing waste securely to prevent its escape in transit, and in a way that subsequent holders can rely on.

Waste transfer and handling

If waste is transferred to someone else, the waste producer must check that they have authority to handle it. The following table explains who is allowed to take waste and how checks can be made on their authorisation.

Table 4.1 Who is authorised to take waste from a producer?

Council waste collector	Checking is not required but paperwork is.
Registered waste carriers	Most have to be registered with the Agency. Look at the carrier's certificate of registration or check with the Agency.
Exempt waste carriers	Most exempt carriers need to register their exemption with the Agency. If someone tells you they are exempt, ask them why. You can also check with the Agency that their exemption is registered.
Registered waste brokers	Anyone who arranges the recycling or disposal of waste, on behalf of someone else, must be registered with the Agency as a waste broker. Brokers are not authorised to take waste from a producer.
Exempt waste brokers	As for exempt waste carriers, above. Brokers are not authorised to take waste from a producer.

A producer wishing to transfer his waste to a carrier will need to check that the carrier is registered or is exempt from registration. A registered carrier's authority for transporting waste is either his certificate of registration or a copy of his certificate of registration if it was provided by the Agency. The certificate or copy certificate will show the date on which the carrier's registration expires. All copy certificates must be numbered and marked to show that they are copies and have been provided by the Agency. Photocopies are not valid and do not provide evidence of the carrier's registration.

In all cases other than those involving repeated transfers of waste, the waste producer should ask to see, and check the details of, the carrier's certificate or copy certificate of registration. In addition, before using any carrier for the first time, the waste producer should check with the Agency that the carrier's registration is still valid, even if his certificate appears to be current. The waste producer should provide the Agency with the carrier's name and registration number as shown on the certificate.

Full checks on carriers do not need to be repeated if transfers of waste are repetitive - the same type of waste from the same origin to the same destination. However, it would be advisable to make occasional checks to see that the contents or composition of the waste which is being transferred under cover of a 'season ticket' remains consistent with the waste description.

The producer and the disposer may sometimes make all the arrangements for the disposal or recovery of waste, and then contract with a carrier simply to convey the waste from one to another. Such a case is very little different in practice from where no intermediate carrier is involved. If a producer arranges disposal or recovery then he should exercise the same care in selecting the disposer or recoverer as if he were delivering the waste himself.

Waste description and paperwork

Waste producers have a duty to know what their waste is, and to choose the disposal, treatment of recovery method, if necessary with expert help and advice (PQA). They bear the main responsibility for ensuring that the description of the waste which leaves them is accurate and contains all the information necessary for safe handling, disposal, treatment or recovery. It therefore follows that waste passed from one person to another will be accompanied by a **Duty of Care transfer note (DCTN).** A transfer note must be filled in and signed by both persons involved in the transfer.

The waste description is entered on the transfer note. A model transfer note is contained in the Duty of Care Code of Practice (see Section 4.1 for reference).

Repeated transfers of the same kind of waste between the same parties can be covered by one transfer note for up to 12 months.

The transfer note must include:

- what the waste is and how much there is (Note: the written description must provide as much information as someone else might need to handle the waste safely). See also Section 5.2;
- what sort of container it is in.;
- the time and date the waste was transferred;
- where the transfer took place
- the names and addresses of the parties involved in the transfer;
- whether the person transferring the waste is the importer or producer of the waste;
- details of which category of authorised person each one is;
- if either or both parties is a registered waste carrier, the certificate number and details of the Agency office which issued it;
- the reasons for any exemption from the requirement to register or have a licence; and
- where appropriate, the name and address of any broker involved in the transfer of waste.

Both parties involved in the transfer must keep copies of the transfer note and the description of the waste for 2 years. They may have to prove in Court where waste came from and what they did with it. A copy of the transfer note must be made available to the Agency if they ask to see it.

Other general considerations

It is not possible to draw a line at the gate of producers' premises and say that their responsibility for waste ends there. If the producer selects a final disposal, treatment or recovery destination then he shares with the waste manager of that destination responsibility for ensuring that the waste falls within the terms of any licence or exemption relevant to that final destination including landspreading.

A producer is responsible according to what he knows or should have foreseen. So, if he hands waste to a carrier not only should it be properly packed when transferred, but the producer should take account of anything he sees or learns about the way in which the carrier is subsequently handling it. The producer would not be expected to follow the carrier but he should be able to see whether the waste is loaded securely for transport when it leaves, and he may come to learn or suspect that it is not ending up at a legitimate destination. For instance, a producer may notice a carrier's lorries returning empty for further loads in a shorter time than they could possibly have taken to reach and return from the designated disposal site; or a producer may notice his carrier apparently engaged in the unlawful dumping of someone else's waste. The cost may be significantly lower than other quotations. These would be grounds for suspecting illegal disposal of his own waste.

A producer should act on knowledge to stop the illegal handling of waste. The following notes summarise advice given in the Duty of Care Code of Practice:

- A waste producer who only suspects that his waste is not being dealt with properly should first of all check the facts, in the first place with the next holder. This may involve asking for further details concerning entries on the transfer note, or simply where the waste went to;

- If the waste producer is not satisfied with the information provided or suspects that the waste is being wrongly handled by another person then his first action should normally be to stop further consignments of waste to the waste handler or disposer. This legal obligation cannot be obstructed in any contract between the producer and waste handler or disposer;

- Where the waste producer suspects inconsistencies between waste transfer agreement and practice, he must take remedial action. For example, where waste characteristics have changed significantly and appear wrongly described on the transfer note, he should analyse further consignments and supply the relevant data on characterisation; where waste has been collected and delivered without being properly packed he should inspect each further load; and where it has not reached its legitimate destination he should check that each subsequent load arrives at the appointed place; and

- Activities outside his direct control must be brought to the attention of the Agency.

5. WASTE DISPOSAL OPERATOR/HOLDER/ CARRIER RESPONSIBILITIES

5.1 General

Waste operators and holders, like waste carriers, should normally be able to rely on the description of waste supplied to them. However, in disposing, treating or recovering waste, they are in a stronger position to notice discrepancies between documented descriptions and the waste as delivered. They therefore bear a greater responsibility for checking descriptions of waste received. Sample checks on the composition of waste received should be normal practice and are to be encouraged by all parties in the handling chain(see Section 5.2).

A waste management operator is responsible for acting on evidence of previous misconduct, just as he is for subsequent mismanagement of waste. This assumes that he knew or should have foreseen it and that he has some degree of control.

5.2 The audit trail

5.2.1 General

Three levels of input control should be provided by the waste disposal operator:

- documentation check;
- on-site verification testing by visual inspection or other simple test to confirm that the waste description on the consignment documentation matches the waste received; and
- retention of samples for retrospective compliance testing (periodic sampling and testing of consigned waste to determine whether the material complies with permit conditions and/or specific reference criteria).

These are discussed in the following sections.

5.2.2 Documentation and waste carrier responsibilities

The key document is the Duty of Care Transfer Note (DCTN) described above in Section 4.2.2.

On arrival at the site, the vehicle driver presents his copy of the DCTN, signed by the waste producer's representative, to confirm the quantity of waste and the date and time of waste collection. The disposal operator compares the two documents. The vehicle is not allowed to proceed to the point of disposal unless the comparison is satisfactory.

In outline, the responsibilities of the waste carrier are as follows:

- Responsible for the adequacy of the waste packaging and vehicle loading arrangements while the waste is under his control-(it is not adequate to rely on how it was packed or handed over by the previous holder).

- Not normally expected to provide a new description of the carried waste, but advised to make a visual inspection on acceptance of a fresh consignment to see whether it matches the description on the paperwork and seek further advice if an anomaly is suspected.

- If the waste is altered by the carrier (e.g. mixing, treating, re-packing etc.) he will need to consider whether a new description is necessary. Generally, if the material has decomposed or the chemistry has altered then a new description must be given. Compaction or mixing with the same type of waste should not normally require a new description.

- The waste carrier should check whether a contract exists between the waste producer and the waste manager. If this does exist he may rely on the producer checking the scope of the license or exemption of the waste manager. In all other cases the carrier will need to check this himself.

5.2.3 On-site verification

Procedures for on-site verification testing may vary from simple visual examination to a range of physical and chemical tests. The basis of the procedures, by waste category, should be specified in a Working Plan or Site Operating Procedure (SOP).

It is normal practice to inspect and test every load of waste. Testing may be less frequent if previous results have provided a statistical basis for demonstrating the consistency of the waste.

Tests should ensure:

- that the waste broadly matches the description on the documents;

- is within the terms of the prenotice

- that the waste will not cause any immediate health and safety problems during disposal.

On-site tests for liquid wastes nearly always include:

- pH;
- odour; and
- visual check for non-aqueous liquid of appearance and colour.

The results of on-site testing should be recorded on the DCTN.

5.2.4 Retrospective testing

Preamble

Every load should be sampled for retrospective testing and the sample retained for a specified period such as three months. The purpose of these samples would primarily be for compliance testing on a proportion of the samples selected at random but also in case of a query about any individual waste.

General procedures for testing and acceptance of waste are outlined in the proposal for a Landfill Directive (CEC 1997) in paragraphs 3-5 of the Annex. A three level hierarchy is given for general characterisation:

Level 1 - Basic characterisation
Level 2 - Compliance testing
Level 3 - On-site verification.

Reference is made to the serious problems of sampling waste owing to the fact that it will often be heterogeneous in nature. It is intended to develop a European Standard for sampling of waste from the work of CEN 292, the European Standards initiative entitled 'Characterisation of Wastes'.

Frequency of testing

The frequency of testing should be specified in the DCTN on an objective basis taking account of:

- the process source;
- the expected variability of the waste; and
- the consequences of significant changes in its composition.

A possible scheme for specifying the frequency of testing would be to assign a ranking number to each waste, e.g. from 1 to 50:

- a ranking of 1 would require every load (i.e. 1 in 1) to be tested. this might be applied, for instance, to a waste arising from a new source with doubtful properties as regards agricultural benefit or ecological improvement;
- as more information accumulates about a particular waste, its ranking number could be increased. A ranking of 10 would require 1 in every 10 loads to be tested; and
- on the basis of results obtained a statistically based ranking (frequency of testing) can be developed for particular wastes which will characterise the waste to a specified confidence limit such as 95%.

Retention of samples

In current practice, samples are retained for periods from two weeks to one month; the proportion of samples analysed varies from approximately 1% to 25%. The proportion will be variable, depending on the ranking assigned to individual wastes.

5.3 Health and safety considerations

5.3.1 Legislative background

The Health and Safety at Work Act 1974 imposes a general duty on employers to ensure, so far as is reasonably practical, the health, safety and welfare at work of all employees. A duty is also placed on employees to take reasonable care to ensure they do not endanger themselves or others by their work activities and to co-operate with employers and others in meeting statutory requirements. The general duty to other people rests with the employer and the self- employed operator as well as the employee and includes members of the public, children, service engineers and road users. The Health and Safety Executive (HSE) is the body responsible for these matters. Health and safety aspects specific to landspreading of wastes are considered below.

5.3.2 General considerations

The Act requires the site operator, as an employer, to issue a health and safety policy statement which clearly outlines the responsibilities of the employer, the duties of the employee and general advice on basic safety, emergency procedures and other more specific hazards relevant to the operation of a landspreading site. The health and safety policy should refer to more specific and detailed procedural documents such as Site Operating Procedures.

5.3.3 Site operating procedures

For many aspects of landspreading operations (e.g. supervision and off-loading of liquid waste tankers) it will be necessary to prepare written Site Operating Procedures (SOPs). A SOP is a step-by-step description of the task or process which takes into account the hazards likely to be encountered. It must detail the precautions necessary to avoid or minimise the risks to the health and safety of individuals working on those tasks or processes. It must also take account of others, such as visitors, contractors and bystanders who could be affected by the activity.

The SOP should take account of the employer's responsibilities with respect to the Control of Substances Hazardous to Health (COSHH) Regulations 1988. An assessment system for waste materials should be in place and the information generated made available to those employed in handling wastes, as well as those visiting or sub-contracted to work on the site.

Inventories will be required and assessments performed under the supervision of the site manager on wastes and any other substances entering the site. The manager may be assisted in this task by staff designated and trained as 'COSHH representatives'. Each SOP should be assigned a specific Hazard/Risk code which can be used to identify appropriate Personal Protective Equipment (PPE) for the task.

Some safety aspects covered by SOPs may be the subject of pre-notification inquiries by the Agency (see Section 3.1.4) or be included in the Working Plan/Application Scheme. They should include:

- staffing level and chain of responsibility (including training);
- vehicle off-loading and disposal operations; and
- safety equipment and emergency procedures.

These are discussed in the following sections.

5.3.4 Staffing levels and chain of responsibility

Minimum staffing levels to be maintained for particular operations should be specified and the chain of responsibility clearly indicated.

The operator must demonstrate that hazards connected with the site operations have been evaluated and communicated to all site staff. This must be backed up with training and adequate supervision. For many operational staff, special training may be needed in first-aid techniques and the use of specialist safety equipment. Additional training may be needed for clerical staff dealing with the transfer note documentation and with the keeping of records. Traffic control, supervision, and marshalling of the disposal operations themselves, are normally carried out by personnel who have received safety training in first-aid and the use of specialist equipment and have attended specialised courses on waste management.

5.3.5 Vehicle off-loading and disposal operations

In some cases it will be necessary for qualified staff to be present on site for waste inspection, sampling and testing and for vehicle off-loading and waste emplacement. Such supervision is often backed up by radio contact with a site control centre throughout the off-loading procedure. Precautions taken to prevent accidents during the handling of waste vary and will include physical safeguards during the discharge of wastes, the positioning of fencing and warning signs and the provision of emergency first-aid equipment and washing facilities. Steps must be taken to avoid water pollution by wastes both during normal operations and in the event of spillage or other accident. Details of all these aspects should be provided by the operator in SOPs and the Working Plan/Application Scheme.

5.3.6 Safety equipment and emergency procedures

Safety equipment and Personal Protective Equipment (PPE) should be provided and maintained. These should be appropriate to the degree of risk but may include first- aid equipment, first- aid station, and a range of personal protection equipment. At the very least Class 1 PPE should be available to operating staff (i.e. protective overalls, PVC gloves, safety helmet, goggles or visor to BS 2092 CDM grade 2, safety footwear to BS 1870 incorporating steel toe-cap and mid-sole).

Emergency accident procedures should be established and should be familiar to all site personnel. Where appropriate these should be reinforced with practice drills. Regular liaison on emergency procedures should be held between the management and representatives of the relevant emergency services.

Emergency procedures should include environmental impacts and plans for events such as:

- Vehicles in road accidents.
- Spillage on the highway.
- Spillage during loading or unloading.
- Faulty equipment causing leakage.
- Spillages on land especially where there is risk of contamination of land drains, water courses, groundwater or boreholes (private and public).

6. LAND OCCUPIERS INTERESTS

6.1 Obligations and benefits of legislation to land occupiers

According to WMLR 1994 Regulation 17(2) the exempt (landspreading) activity must be conducted with the consent of the occupier of the land where the activity is carried on; or the person carrying on the exempt activity is otherwise entitled to do so on that land. It is unlikely that land occupiers will be implicated in any waste management legislation, unless they are actively involved in the landspreading operation as contractors or subcontractors. Normally, most of the responsibility will be with the contractor spreading the waste.

6.1.1 Duty of Care

This outlines the responsibilities of those involved in the process of recycling waste to land and states that 'it is the duty of any person who imports, produces, carries, keeps, treats or disposes of controlled wastes or, as broker, has control of such waste, to take all such measures applicable to him/her in that capacity as are reasonable in the circumstances' (see Section 4.1).

The role of a land occupier in the Duty of Care will therefore vary according to the exact nature of their involvement in the landspreading operation. An occupier who is also a waste contractor will fall fully within the Duty, whereas an occupier who has no involvement in the landspreading operation may not fall within its provisions. Within these two extremes is a range of potentially contentious areas where an occupier's involvement in Duty of Care is unclear and will only be decided by legal precedent. The land occupier's liabilities need to be clarified.

For instance:

- Does an occupier who actively pursues a waste contractor for the application of a waste material fall under Duty of Care?
- Would an occupier who receives compensatory payments to leave land fallow fall within the Duty?
- Does an occupier who moves waste stored on his land, or supplies storage capacity become involved under the provisions of Duty of Care?

An occupier should be informed of his/her position by the contractor, including their responsibilities and liabilities. In the case of any doubt the Agency should be consulted.

The land occupier should advise the waste contractor at the planning stage about any site factors relevant to the proposed landspreading operation. Such factors include the cropping regime, amounts of fertiliser or other waste which have been or are to be applied, and the presence of land drains. The land occupier will be responsible for ensuring that the agreed land- use practice is followed after the waste has been applied and the contractor has left the site. For instance, a 'no-grazing' period may be required after spreading waste on the surface of grassland before it is safe for cattle to graze the grass. The land occupier has to ensure that the 'no-grazing' period is observed.

Land occupiers who have knowledge of specific management agreements, e.g. SSSI, ESA on their land may be implicated in any action by a regulatory body if:

- they do not tell the contractor of the presence of such areas; and
- the application of the waste results in harm to human health or damage to the environment.
- the application of waste does not achieve agricultural benefit or ecological improvement.

6.2 Land occupancy

Land may be occupied by either the owner, his/her manager or a tenant. It is estimated that approximately one third of agricultural land is rented. Where this is the case the land occupier is likely to have a written agreement (tenancy) outlining the conditions on which the land is rented. Tenanted land is likely to be held under one of five types of agreement as follows;

6.2.1 Succession

Provided certain requirements can be fulfilled this form of tenancy allows for up to two successions (three generations) of a family.

6.2.2 Lifetime

This allows for a tenancy for the lifetime of the agreement holder.

6.2.3 Grazers and movers

This allows for a tenancy of up to 364 days and is usually the preferred option for short term grazing.

6.2.4 Gladstone and Bowers

This allows for a tenancy of up to 2 years and is usually the preferred option when land is let on a short term basis for the growing of arable crops.

6.2.5 Farm business tenancies

Came into effect on 1 September 1995 replacing all of the above and applicable to all tenancies agreed after 1 September 1995.

There is a requirement for all tenants to farm the land which they occupy according to the principles of Good Agricultural Practice. The need to gain consent from a landlord prior to the application of a waste material may be laid down in the tenancy agreement. However, many tenancy agreements contain blanket consents allowing 'routine improvements' such as the application of lime, fertiliser, slurries and manures. It is unlikely that any provision will have been made for the application of non- farm wastes. The tenant will need to discuss the requirement for consent with his/her landlord if the application of non-farm waste is considered to fall outside the definition of fertilising or liming, or in instances where there is no blanket consent for these activities. If in doubt tenants and land owners should seek PQA.

6.2.6 Non-agricultural occupiers

Similar principles will apply to the owners or occupiers of land in non-agricultural use , for example, recreational amenity or derelict land. If it is proposed to apply waste to non agricultural land included in the exemptions of Schedule 3 of the WMLR 1994, then land ownership, tenancy and local planning conditions should be fully investigated by the waste contractor.

6.3 Implications for agricultural occupiers who own or farm land with statutory and non statutory designations

There are a number of statutory and non-statutory designations that exist, in particular for agricultural land, which have implications for the application of waste materials. This information should be sought, in the first instance, by the disposal operator and will under normal circumstances be available from the occupier. Failure by the occupier to submit relevant information with regard to existing management agreements will, in the case of grant aided or subsidised schemes, usually result in financial penalties being incurred by the occupier.

Most of the designations likely to be encountered by waste disposal operators are described in Sections 2.8 and 7.2.2. It is highly improbable that a contractor will seek to use SSSIs for the application of wastes, as consent from English Nature, or other SCB, for their use is required and is unlikely to be granted. Additional categories are as follows.

6.3.1 Set-aside

During the set-aside period (15 January - 31 August (locally variable)), there should be no application of fertiliser, manure or organic waste with the exception of slurry, manure or organic waste generated on the farm holding.

Organic waste, generated on the farm holding may be stored on set-aside land prior to spreading on the field in question. Set-aside fields must not be used to store larger quantities of waste than would normally be expected to be spread on that field.

Set-aside land must not be used for the application of industrial waste except in the case of waste lime and gypsum. This is provided that there is no disturbance to soil or green cover before 1 May, and that a derogation for this operation has been authorised by MAFF. More detailed information can be obtained from local MAFF Regional Service Centres.

Breach of these regulations could result in a claim for the return of part, or possibly all of the set-aside payments made to the occupier.

6.3.2 Nitrate Vulnerable Zones (NVZs)

This scheme operates under EC Directive 91/676 (CEC 1991). It recently completed its consultation stages and zones have now been designated (SI 1996/888). Further zones may be designated in the future. It aims to establish a mandatory, non compensatory programme of measures which farmers within designated zones should follow in order to reduce nitrate pollution. The scheme will encompass, and in some areas, supersede the NSA scheme. It stipulates rules covering closed periods when no fertiliser may be applied, manure storage capacities and recommended rates of fertiliser addition.

The basic rate for the addition of nitrogen is 170 kg ha^{-1} y^{-1}, though a derogation of up to 210 kg ha^{-1} y^{-1} is available for the first four years. This applies to both farm and non-farm waste materials. Restrictions also apply to nitrogen addition to different cropping regimes and soil types (see Section 2.3).

6.3.3 Nitrate Sensitive Areas (NSAs)

This scheme is a compensatory approach to limiting the application of nitrogen, from organic and inorganic sources, to agricultural land. It is designed to protect groundwater resources from nitrate pollution. Maximum total nitrogen applications are set at 250 kg ha^{-1} y^{-1}, but are variable and affected by the three land use options which an occupier may select under the scheme. The landspreading of organic wastes within NSAs should take account of these management options. If the rules of the management agreement are deliberately breached through over application of nitrogen, there will be a requirement to repay some, or all of the compensatory payments received. Detailed information with regard to this scheme is available from local MAFF Project Officers.

6.3.4 Groundwater Protection Zones

These are non-statutory designations for the management and protection of groundwater. Although non-statutory the NRA designed the scheme to influence the policies and decisions of those whose actions may affect the quality of groundwater, including recycling wastes to land. The zones centre around the concept of different areas of groundwater vulnerability, which are called source protection zones. These are defined as Zone I (Inner source protection), Zone II (Outer source protection) and Zone III (Source catchment), which covers the complete catchment area of a groundwater source. The zones are constructed on the basis that the proximity of an activity to a groundwater abstraction is one of the most important factors in assessing the risk to an existing groundwater source. The protection zones are then followed by a series of policy statements which relate to specific threats to groundwater contamination. One identified threat is the application of liquid effluents, sludges and slurries to land. Advice with regard to their existence and the policies which they invoke should be sought from the Agency (see Section 2.3).

6.4 Land occupiers requirements from the disposal operator

6.4.1 Agricultural benefit conferred by a material

The agricultural benefit expected from the application of a waste material should be clearly explained. The occupier should be provided, by the waste operator, with sufficient information and time to make a judgement as to the suitability of the material for application to his/her land on the basis that it will provide agricultural benefit without causing nuisance or environmental problems. It would be in the best interests of an agricultural occupier to receive the following information.

Waste origin and characteristics

This should include information about the origin of the waste, a description of it (solid or liquid; type- paper sludge, biological treatment sludge etc.), adequate details of its chemical composition and any other properties of relevance to its use on the land. Much of this information should be on the DCTN (see Section 4.1 and 5.2).

Agricultural benefit

A description should be provided of the benefits expected from application of the material, i.e. nutrient content and likely availability, liming or soil conditioning properties. This may also include information on how the assessment has been carried out, i.e. chemical analysis, bioassay, field trial and previous operational experiences with the same category of waste. Where possible, the farmer should be advised whether the waste is likely to have an immediate or longer-term effect.

Method statement

This should include a description of the quantity of waste to be applied and the method and date of application. A farmer will preferably receive details of any site evaluations carried out prior to spreading. This may include proposed storage areas, field access points, soil analysis results (where appropriate) together with interpretation, applicable 'Codes of Practice' and regulatory/legislative requirements. Best practice is described in Section 9.

Effect on farm management

A description of the implications of the waste application on stocking, cultivations, cropping, fertiliser use and future use of farm or off-farm wastes.

Contact points

These are necessary in relation to queries regarding the benefits from the application of the waste material or other matters, and contacts in the event of emergencies.

6.4.2 During landspreading a waste

Contractors should be prepared to consult regularly with an occupier on whose land they are working.

6.4.3 Following the deposit.

Following the application of a waste material a field site should be inspected by the waste contractor and the owner/occupier, or their representatives, to check that the operation has been completed as planned. Written documentary evidence regarding the completed operation should, where possible, be agreed between parties (see Section 9.11).

6.4.4 Non-agricultural land occupiers

In the case of land in non- agricultural ownership or occupancy the requirements of the land owner/occupier will be the same as the requirements for an agricultural occupier, particularly in terms of waste characteristics, method statement etc.

The justification for the application of waste to non- agricultural land will usually be based on the ecological improvement arising from the application. This information should be provided by the waste contractor (see Section 7.2).

6.5 What information the land owner/occupier should provide.

Information provided by the land occupier is likely to be vital to the assessment of any site to which a waste material is to be applied. The land occupier/owner may be able to provide information on the history of the site of which the contractor or his adviser would otherwise be unaware, and which may have a bearing on whether the waste can be applied. Prior to a site assessment the following information should be sought from the land owner/occupier. This information will already be available where a good farm wastes management plan has been prepared and is up-to-date.

6.5.1 Location of the site

This will enable the contractor to check the precise location of the site and take account of statutory designations and applicable management agreements.

6.5.2 Application of other wastes

An occupier should provide information as to any previous applications of non- farm or farm wastes, and include where possible the date and type of waste application. This will enable the contractor to evaluate the suitability of a site to receive the deposit. It will also allow accurate application rates to be determined, so as not to exceed recommended guidelines for plant nutrients and the addition of potentially toxic elements (PTEs) to soil.

6.5.3 Other physical characteristics

There may be physical characteristics of a site which the contractor needs to be aware of for the assessment of the suitability of the site to receive waste. For instance, areas of poor drainage, heavy textured or stony soils, adverse ground stability or topography.

6.5.4 Springs, wells and boreholes

The 'Code of Good Agricultural Practice for the Protection of Water' (COGAP/W 1991) recommends that waste is not applied within a minimum distance of 10 m from a watercourse or 50 m from a spring, well or borehole that supplies water for human consumption or is to be used in farm dairies. Whilst the presence of watercourses can be assessed during a site visit the location of drains, springs, wells and boreholes may not be as obvious. It is likely that the occupier will be aware of springs, wells or boreholes on his/her own land but may not be aware of such features on neighbouring land. Where the occupier cannot give such information advice should be sought from the local office of the Agency, where detailed records of borehole locations are maintained. Guidance is given in the NRA policy document for the protection of groundwater and the Groundwater Regulations 1998 must be considered (see Section 2.3).

6.5.5 Statutory designations and management agreements

Proposed field sites may be subject to statutory designations and agreements as detailed in Sections 6.3 and 7.2.3. In the majority of cases a farmer will be able to provide relevant information, but more specific information with regard to NVZs, GPZs etc. may not be available to the occupier. In this event, a contractor should consult the local office of the Agency.

6.5.6 Written agreements

There is no statutory requirement for the land occupier/owner to sign an agreement with the contractor prior to application of a waste material to his/her land. They may, however, wish to do so in order to formalise any agreement made with the contractor. Details could include where and how the waste may be spread, and where individual responsibilities lie with regard to the waste application. In order to complete a paper audit trail from producer to recovery, and to comply with Duty of Care Regulations, the disposal operator may wish to ask the land occupier to sign a form of receipt for the waste. Under these circumstances, the occupier may be required to be supplied with waste transfer notes, DCTN (Section 6.4.1). Written agreements with regard to liability and legal obligations can be complex. Professional advice should be sought if either party has any concerns regarding such agreements.

Where the land occupier has provided information for a site assessment and this cannot be fully verified by a site visit, it may prove useful for a contractor to receive a declaration from the occupier/owner that the information is, to the best of the occupier's knowledge, true and correct.

6.5.7 Non-agricultural land occupiers

Information provided by non- agricultural owners or occupiers should include all of the details which are applicable to agricultural land. In certain circumstances, for instance in land reclamation schemes, it may prove useful to disclose relevant site information such as existing planning conditions, ground investigations undertaken, analytical data etc.

6.6 Integration with the farming system (see also Section 9.4)

6.6.1 Integration with farm wastes

Utilisation of farm wastes should be based on an advisory maximum application of 250 kg ha^{-1} y^{-1} of total nitrogen from organic sources and should be adjusted according to crop requirements for nutrients. Where it is intended that off- farm wastes will be applied, account should be taken of the nitrogen content of the waste at the proposed application rate, and adjustments made to the plan. Where a farm waste management plan indicates that the available land area is only just sufficient to utilise manures and slurries produced by the farm, the application of off-farm wastes should be carefully considered to ensure compliance with COGAP/W. PQA should then be sought with regard to suitable application rates or the need for additional inorganic fertiliser where waste containing low levels of crop-available N is to be applied to the land.

6.6.2 Adjustments to fertiliser planning.

Waste materials may contain essential plant nutrients other than N, in particular P, K, Mg and S. The application of these nutrients should be accurately adjusted to crop requirements and incorporated into an occupier's fertiliser planning. The responsibility for making this adjustment should remain with the occupier who will manage the land in the long-term. The waste contractor, however, bears the responsibility for providing the occupier with sufficiently accurate information to allow this judgement to be made. In most cases this will be in the form of a summary of the approximate quantity of nutrients contained in the waste, and their likely availability. PQA should be sought if there is uncertainty. Waste contractors may be capable of providing PQA if they are suitably qualified to do so, holding for instance a Fertiliser Advisers Certification and Training Scheme (FACTS) qualification.

It is likely to be difficult for a land occupier to make adjustments for nitrogen supplied by a waste material unless most of the nitrogen is in a readily available form. Where it is largely unavailable at the time of application, it may prove difficult to assess when and how much will become available over a season. In this instance an occupier may benefit from properly qualified advice. There is a need for field trials to quantify the rate of release of nitrogen (N availability) from industrial wastes applied to the land.

6.6.3 Integration with other 'Codes of Good Agricultural Practice'

In addition to the Code of Good Agricultural Practice for the Protection of Water (COGAP/W), MAFF has produced Codes of Practice for the Protection of Air (COGAP/A) and Soil (COGAP/S). Waste disposal operators are advised to be familiar with these codes of practice which are described in Sections 2.4 - 2.6.

7. EXEMPTION FROM LICENSING

Waste legislation in Europe is based on the Waste Framework Directive 75/442/EEC as amended by 91/156/EEC. Article 3 of this Directive encourages:

- the prevention or minimisation of waste;

and secondly:

- the recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials; and
- the use of waste as a source of energy.

Article 4 requires Member States to take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular:

- without risk to water, air, soil and plants and animals;
- without causing a nuisance through noise or odours; and
- without adversely affecting the countryside or places of special interest.

Article 4 concludes by requiring Member States to take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of wastes.

The Waste Framework Directive therefore sets out the basic rules for waste recovery.

In Annex IIB, it lists recovery operations as they are carried out in practice. It repeats at this point that, in accordance with Article 4, waste must be recovered without endangering human health and without the use of processes or methods likely to harm the environment. This further emphasises the importance that the Directive gives to protection of human health and the environment. One of the operations which may lead to recovery listed in Annex IIB is number R10. This is, spreading on land resulting in benefit to agriculture or ecological improvement, including composting and other biological transformation processes, except in the case of waste excluded under Article 2 (1) (b) (iii) - animal carcasses and the following agricultural waste: faecal matter and other natural, non-dangerous substances used in farming. Benefit to agriculture and ecological improvement are not defined any further.

This philosophy of recovery and environmental protection is taken forward in UK regulations and guidelines on waste management as described in Section 2 above on legislation and existing guidance. However, agricultural benefit and ecological improvement need practical explanation in order to enable satisfactory implementation and development of recovery by recycling to land of the exempted wastes listed in Table 2 of Schedule 3 of the WMLR 1994 (see Section 2.2 above).

This section is intended to give a clear explanation of the terms 'benefit to agriculture' and 'ecological improvement', the principles behind these terms and how they should be applied, including situations where they appear to be mutually incompatible. These terms are central to the acceptability of landspreading of industrial wastes as is quite clear from the legislation and guidelines cited above. Following on from the definitions, it should be possible to decide whether agricultural benefit or ecological improvement would be achieved by a proposed landspreading operation on the basis of the properties of the waste, the quantity to be applied, method of application and location, and overriding need to protect human health and the environment.

The MAFF/Welsh Office Code of Good Agricultural Practice for the Protection of Soil (COGAP/S) draws attention to the fact that the UK is a member of the Council of Europe which adopted the European Soil Charter in 1972 and agreed to the Recommendation on Soil Protection in 1992. These emphasise that soil is a limited natural resource which is easily destroyed, and needs to be protected against damaging farming practices, erosion, pollution and degradation caused by human settlement and civil engineering.

The Code defines the importance of soil as follows: '*Soil is a basic, limited resource that will continue to be essential for many human activities. It includes both topsoil and subsoil to a depth of at least 1 metre. The biological, physical and chemical characteristics of soil need to be protected for it to perform its important functions. These include producing food, raw materials and energy. Soils also provide a filtering and buffering action to protect water and the food chain from potential pollutants.*'

It must be emphasised that landspreading of industrial wastes under the terms of an exemption is not waste disposal. It is the recycling of wastes since their application to the land achieves recovery of components which provide agricultural benefit or ecological improvement. In order to secure a sustainable long-term future for landspreading, waste producers need to demonstrate commitment to the quality of products and of recycling operations. Wastes exempted for landspreading must represent a material of established quality and benefit.

Landspreading of industrial wastes must be managed to ensure protection of soil quality in the broadest sense. Agricultural benefit must be provided in the form of improved fertility of soils in crop production (see Section 7.1). Landspreading of industrial wastes will not achieve ecological improvement in natural environments where the content of nutrients, organic matter and other constituents valuable for agriculture will disturb the natural balance and biodiversity of the soil ecosystem putting at risk the survival of sensitive species. However, landspreading can achieve ecological improvement in managed environments associated with planned soil improvement. For example, restoration of poor soils on marginal land destined for agricultural or amenity use, and on derelict land resulting from human activities (e.g. mining), for the purpose of landscaping, amenity development or agriculture. These definitions are discussed in more detail below (Sections 7.1 and 7.2).

Wastes listed in Part 1, Table 2 of Schedule 3 of the WMLR 1994 are exempted for spreading on additional, specified categories of land. These wastes are: Waste soil or compost, and waste wood, bark or other plant matter. The specified categories of land are: Operational land of a railway, light railway, internal drainage board or the National Rivers Authority (now part of the Agency); or land which is a forest, woodland, park, garden, verge, landscaped area, sports ground, recreation ground, churchyard or cemetery.

7.1 Agricultural benefit

7.1.1 Where do the benefits apply, and what are they?

This applies to agricultural and other land managed for profit which would normally receive applications of fertilisers and manures. It does not include set-aside land. According to DoE Circular 11/94, for the purposes of Schedule 3 paragraph 7 of the WMLR 1994, the definition of 'agriculture' is a wide and inclusive one as defined in the Agriculture Act 1947 (Section 109 (3)):

'Agriculture includes horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of the land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of the land for woodlands where that use is ancillary to the farming of land for other agricultural purposes.'

Agricultural benefit will be achieved when the application of a waste to land improves soil conditions for crop growth whilst ensuring the protection of environmental quality in the broadest sense.

The benefits can be measured in terms of:

- **Crop yield and quality.** The most important indicator of agricultural benefit to which the other benefits each make some contribution;

- **Soil chemical properties.** Benefits that the waste will bring to the soil in terms of addition of plant nutrients in particular, and improvements in soil pH value;

- **Soil physical properties.** Addition of organic matter; improvements in water holding capacity, porosity, stability, tilth, and workability. Addition of chemicals such as gypsum can also improve the workability of some soils;

- **Soil biological properties.** Addition of organic matter improves water retention and aeration, conditions for root growth and populations of worms and micro-organisms;

- **Soil water content.** Application of watery wastes can bring benefit when there is a soil moisture deficit limiting crop growth;

- **Land levelling.** The bulk application of waste to raise the level of the land can bring benefit by improving soil conditions for agricultural use. Simply raising the level of the land does not qualify (DoE Circular 11/94, para 5.74, 1994), there has to be added benefit. An example would be levelling of damp depressions such as the furrows left behind from historic ridge and furrow farming. These furrows can hinder farm machinery and may have impeded drainage causing poor root development and harbouring diseases such as liver fluke of sheep. Suitable waste for levelling would be waste soil or compost and dredgings from inland waters. No more than 250 t ha^{-1} y^{-1} of waste soil can be spread (WMLR Schedule 3 paragraph 7(3) which is equivalent to a depth of about 2.5 cm (depending on density) if spread evenly over a hectare. For dredgings, the maximum is 5000 t ha^{-1} y^{-1}. In other circumstances than this, bulk application of waste to raise land levels does not equate to agricultural benefit;

- These benefits must be achieved in compliance with Article 4 of the Waste Framework Directive 91/156/EEC. That is, without endangering human health and without using processes or methods which could harm the environment, and in particular:

  - without risk to water, air, soil and plants and animals;
  - without causing a nuisance through noise or odours; and
  - without adversely affecting the countryside or places of special interest.

7.1.2 Properties of wastes that can bring benefits.

Content of nutrients

The major nutrients are nitrogen, phosphorus, potassium and magnesium, calcium and sulphur. Information should be sought on the total concentration of nutrients in the waste and also on how much of the total content is soluble and therefore likely to be available for crop uptake in the same year in which the waste is applied to the land. At least part of the content of these elements supplied in wastes should be available, or become available, for plant uptake within three years provided this does not introduce deficiencies in the meantime. The rate of application of the waste to the land should be determined on the basis of the nutrient content of the waste and the nutrient requirements of the crop(see Section 9.7). These crop requirements for nutrients have been defined in the Fertiliser Recommendations published by MAFF (Reference Book 209, 1994). Nutrient requirements, and hence rates of application, vary according to the type of crop, type of fertiliser material, time of application, type of soil and soil index. The latter is an estimate of the current nutrient content of the soil based on previous cropping history (for nitrogen) and soil analysis. For some nutrients, such as phosphorus, no further addition may be needed or justified if the index shows that adequate reserves are already in the soil. Determining the correct application rate therefore requires some expertise even for conventional fertilisers. The nutrient supplying powers to crops of conventional fertilisers, and to some extent of organic materials like animal manures and sewage sludge, have been determined from knowledge gained over many years of operational practice and field experiments. MAFF RB 209 (1994) contains a section on animal manures and sewage sludge. For most of the exempted wastes there is little or no evidence from field experience or trials with which to optimise rates of application to the land to meet crop requirements for nutrients. Until this information is available, PQA (see Section 9.1) should be sought to estimate suitable rates of application to the land of those wastes whose intended agricultural benefit is to contribute to crop requirements for nutrients.

Trace elements

Wastes may also provide the trace elements iron, manganese, copper, zinc, molybdenum, boron and chloride required by crops in small quantities. Details of crop requirements are set out in the Fertiliser Recommendations (MAFF Reference Book 209) (see Section 9.7.1).

Organic matter

This will generally improve soil conditions for plant root growth, increase moisture-holding capacity and stabilise light soils. Instability of structure can develop when soil organic matter falls below 3% (Strutt Report, Agricultural Advisory Council, 1970) so for these soils in particular, application of organic matter is likely to bring agricultural benefit. For soils with an organic matter content of more than 5%, benefit will be confined mainly to the nutrients in the added organic matter. The recent RCEP report on Sustainable Use of Soil (RCEP, 1996) noted that there was still concern about the slow decline in soil organic matter, especially in the arable soils on the eastern side of the country. **Applications of organic matter of 20 tds ha^{-1} y^{-1} or more will be needed to improve soil conditions.** Organic matter contains plant nutrients which will be of benefit to crop growth if they are released slowly into the soil as the organic matter stabilises. The plant nutrient content of organic wastes should be taken into account when estimating suitable rates of application to the land. The MAFF COGAP/W (1991) recommends a limit of 250 kg total N ha^{-1} y^{-1} for organic materials applied to farmland but this does not take into account the likely amount of crop- available N and its rate of availability, and so may be a conservative value for certain well-stabilised organic wastes. The revision of COGAP/W may make some allowance for this (see Section 2.4). Field trials are needed to test the availability of the nutrients in these wastes in order to justify the operational use of rates of application based on the organic matter content rather than the nutrient content of the wastes (see Sections 6.6.1 and 9.11.2).

Lime potential

This application would make use of the lime potential of a waste to raise the pH value of acid soils to a level more beneficial for crop growth. This will be of benefit only to acid soils with a lime requirement. The efficacy of a waste to satisfy the lime requirement of a soil is estimated on the basis of its neutralising value (NV). Guidance on this subject is given in MAFF/ADAS publication Lime and Liming (Reference Book 35, 1981). There may be occasional circumstances where an acidic waste, such as one rich in sulphur, could be used beneficially on the land to reduce soil pH value (see Section 9.10.1).

Chemistry that improves soil structure

For example, gypsum (calcium sulphate) application to heavy land will make the soil more workable. Calcium and other soluble sulphates can also be beneficial in the reclamation of saline and alkaline soils (Foth and Turk, 1972) (see Section 9.10.3).

Soil forming properties

Soil forming properties for land levelling as described above in 7.1.1. The only types of waste suitable for this purpose are likely to be waste soil or compost and dredgings from inland waters.

Irrigation

Use of watery wastes for irrigation. This will be of benefit only at times of the year when there is a soil moisture deficit which is likely to be in the period May - September inclusive (see Section 9.7.5).

7.1.3 Properties of wastes that can bring disbenefits

Content of nutrients

This can be a constraint because content of nutrients will often be the factor limiting quantities of waste that can be applied to the land. Rates of application need to be based on crop requirements as set out in fertiliser recommendations Reference Book 209, and to take account of the limit for organic materials of 250 kg total N ha^{-1} y^{-1}. These actions are necessary to obtain a beneficial crop response and protect water quality. Further restrictions will be required in Nitrate Vulnerable Zones and Nitrate Sensitive Areas (see Sections 2.3 and 6.3.3-5). Rates of application calculated in this way are likely to be much lower than the currently permitted maxima in the WMLR 1994 of 250 t ha^{-1} y^{-1} (5000 t ha^{-1} y^{-1} in the case of dredgings from inland waters).

Content of potentially toxic contaminants

Various contaminants may occur according to the type of waste and the process which produced it. Those monitored in sewage sludge spread on the land are a starting point as to what to consider monitoring in other wastes and include: cadmium, copper, nickel, zinc, mercury, lead, chromium, arsenic, selenium, molybdenum and fluoride. All of these will accumulate in top soil so their concentration in soil will increase progressively following repeated applications of wastes that contain them. Guidance on this subject in terms of permissible limits and monitoring requirements are fully described in the DoE publication, Code of Practice for Agricultural Use of Sewage Sludge (1996). Using the information in the Code and the known concentration of contaminant in the waste, a permissible maximum rate of application of the waste to land can be calculated based on contaminant content. This can then be compared with the maximum permissible rate of application based on the nutrient content of the waste. If contaminant content would be the principal limiting factor determining the rate of application of a waste to land then agricultural benefit would not be achieved (see Section 9.8).

Vigilance is needed also to be aware of other contaminants, including toxic organic compounds, which could be present in some wastes according to their origin. If information is lacking and their presence in a waste is suspected then PQA should be sought before any decision is taken about landspreading (see Section 9.9 and Appendix D).

Excessive acidity or alkalinity

A waste with a pH value of < 5.0 should not be applied to the land. Alkaline wastes should only be applied to soils with a lime requirement and then in accordance with the guidance in Lime and Liming (MAFF/ADAS, 1981).

Sodium content and conductivity

Although sodium enhances the growth of some crops (Fertiliser recommendations Reference Book 209), excessive amounts can adversely affect soil structure and crop growth as can excess salinity from other soluble salts. These parameters should be measured in wastes and the findings checked against recommended limits (ADAS, 1981) (see Sections 9.7.1 and 9.7.5).

Smell

Wastes with strong or offensive odours should either be treated by a stabilisation process, such as anaerobic digestion or composting, which will reduce their odour potential, or otherwise managed on the land so that odour emission is minimised. In practical terms this means that odorous wastes should be applied to the land by subsurface soil injection or incorporated (ploughed in) immediately after surface application. See Section 9.6.

Visual appearance including colour and litter content

This is likely to be a potential problem with septic tank waste, paper sludges and some food and other wastes which may contain strong dyes. Wastes such as septic tank sludge which may contain litter, including non-degradable plastics, should be screened to remove it before landspreading.

Microbiological quality; content of human, animal and plant pathogens

The DoE Code of Good Practice for the Agricultural Use of Sewage Sludge (1996) provides guidance on how to prevent disease transmission when wastes potentially containing pathogens are used on the land. A dual barrier approach has been adopted based on treatment of sludge to reduce the numbers and infectivity of pathogens combined with land management practices to be followed according to whether or not the sludge has been treated. There has been no recorded incident of disease transmission where these precautions have been followed. Untreated sludges have to be applied to the land by subsurface soil injection or otherwise worked into the soil so as not to cause nuisance. It should be noted that for these purposes septic tank sludge is untreated sludge and must therefore be injected or ploughed into the soil and must not be applied to the surface of grassland. Waste from cesspits (cesspools) is not exempted for landspreading (see Appendix D10). See also Section 9.10.

Operators need to be fully advised of the nature of wastes they are handling, made aware of precautions they should be taking, and equipped with the necessary protective clothing and facilities.

Diseased plant waste cannot be spread on agricultural land. The disposal of such waste is controlled by the Plant Health (Great Britain) Order 1993 which requires such material to be incinerated or disposed of to a landfill site. PQA should be sought if there is uncertainty (see Section 9.10 and Appendix D). A new publication entitled 'Code of Practice for the Safe Disposal of Agricultural and Horticultural Waste' is to be released shortly by MAFF.

Texture and handleability

Operational problems may arise from, for instance, wastes which are dusty or gelatinous or oily and greasy in texture. Dust may be hazardous to operators or cause nuisance when the waste is spread on the land. Gelatinous or greasy wastes may block spreading equipment and remain as an unsightly residue on the surface of the soil or cause anaerobicity in the soil if excessive amounts are ploughed in. Smothering of grass which has received surface applications may occur and can cause die-back due to light exclusion.

Waste containing oil is categorised as special waste and is not exempted for landspreading which is confined to specified controlled wastes.

High carbon/ nitrogen ratio

High carbon/nitrogen ratio. This is a problem likely to be associated with organic wastes from wood, paper or sugar production. The cells of soil bacteria have a C/N ratio of about 10/1. Nitrogen is the limiting factor to degradation by bacteria in the soil of wastes with a C/N of >10/1. As they degrade such wastes, the bacteria will draw on soil reserves of nitrogen which could otherwise be used by crop plants. In reality, this problem is unlikely to occur until the C/N ratio of the waste exceeds at least 20/1. Application of such wastes can immobilise soil nitrogen supplies thereby inducing nitrogen deficiency and reduced yields of crops. The C/N ratio of the waste can be adjusted to make it more favourable for landspreading by composting it or adding a source of nitrogen (see Section 9.7.3 and Appendix D7).

Biological oxygen demand (BOD)

Organic wastes are very likely to have a high BOD, often at the level of 1000s of mg l^{-1}. Such wastes will be highly polluting if they contaminate water and care must be taken, as set out in COGAP/W (1991), to prevent runoff or spillage into surface water in particular. Operational experience with sewage sludge has shown that soils can satisfactorily stabilise wastes high in BOD but there is some risk of anaerobicity if rates of application are excessive.

7.1.4 Management factors that influence agricultural benefit and disbenefit

Management can make all the difference between a successful and disastrous landspreading operation. Consequently, consideration should be given to authorising operators for landspreading, on the basis of suitable qualifications and experience, as an alternative to exempting individual operations. Management factors are discussed in more detail in Section 9 on best practice. Some factors to consider are:

Risk assessment

The need to do a risk assessment for the proposed operation. This should take the form of three phases:

1. Is the waste of a generic type (Schedule 3, WMLR 1994) capable of providing agricultural benefit or ecological improvement?

2. Bearing in mind the type of waste, what further information should be provided concerning chemical analysis etc. of the actual sample of waste to be spread on land in the proposed operation? In the light of this information, is the operation still permissible?

3. On the basis of inspection of the proposed landspreading site, what special precautions are required to ensure compliance with Article 4 of the Waste

Framework Directive 91/156/EEC concerning protection of human health and the environment?

This guidance document is intended to provide the necessary information to do step 1 and to interpret steps 2 and 3 following analysis and site inspection (see Section 9.4).

Land use and management

This must be taken into account for determining rates of application of wastes to the land on the basis of the MAFF fertiliser recommendations (Reference Book 209) and, for wastes containing pathogens, actions to prevent disease transmission (DoE Code of Practice for the Agricultural Use of Sludge, 1996).

Topography of the site

This would include type of soil, drainage, slope, occurrence of ditches and watercourses, and access for vehicles. This information is needed to follow precautions in the COGAP/W (1991). It is also necessary for planning to avoid damage and nuisance from vehicles to be used in the operation.

Time, method and rate of application

This needs to be considered to protect surface and groundwater quality (COGAP/W, 1991) and to avoid odour nuisance and pathogen transmission (DoE Code 1996). There will be times in the winter when waste cannot be spread due to the unacceptable risk of soil damage or leaching/runoff of nutrients. Farmers have had to install storage facilities for their slurry and other liquid wastes to avoid the need for landspreading at inappropriate times of the year; waste producers using the landspreading option should be prepared to do likewise. Failure to do so may lead to the operation being regarded as disposal.

Quality and consistency of waste product

Agricultural benefit depends largely on suitable rates of application of waste calculated to deliver to the land the right amount of plant nutrients or other beneficial components to meet crop and soil requirements. This can only be done if the waste in question is of consistent quality particularly in terms of its properties which may influence agricultural benefit or disbenefit. The onus should be on the waste producer to demonstrate by statistically based sampling and analysis that the waste product for landspreading will be of suitable quality to achieve the agricultural benefit for which it is intended (see Section 5.2.4).

Notification, consultation, monitoring and record keeping

The waste producer or spreader has to notify the Agency of proposed landspreading operations as set out in Schedule 3 Section 7 of the WMLR 1994. Other authorities such as Environmental Health Officers may be consulted so that they are aware of operations in the event of enquiries from the public. PQA should be considered to assist with deciding on suitable rates of application of waste and other operational matters. Appropriate monitoring and analysis of waste product (to check its quality) and soil from the receiving farmland will be needed. Suitable schemes for monitoring and record-keeping have been devised and successfully operated for the utilisation of sewage sludge on agricultural land and could serve as a basis for landspreading of other wastes (DoE Code 1996). The waste producer should bear the responsibility for these actions (see Section 4).

7.2 Ecological improvement

7.2.1 Where is it achieved?

Demonstrating potential for ecological improvement where wastes are to be spread on the land is very much associated with identifying those managed environments (beyond designated agricultural land) which will benefit from inputs of nutrients, organic matter or other beneficial component of the waste. Also central to identifying sites where landspreading of wastes could bring ecological improvement is Article 4 of the Waste Framework Directive 91/156/EEC with its concern for the protection of human health and the environment, and in particular the requirement that waste is to be recovered 'without adversely affecting the countryside or places of special interest.'

Ecological improvement is associated with the maintenance of habitats and their biodiversity where these would otherwise deteriorate, the provision of new habitats for wildlife and the development or restoration of existing habitats to give greater biodiversity and sustainability.

In terrestrial ecosystems, species-rich habitats of high ecological value tend to have a finely balanced nutrient budget on which their biodiversity depends. Examples of habitats of high ecological and nature conservation value include chalk grassland, flower-rich meadows and mixed woodland, but this is not an exclusive list. The addition of nutrients, organic matter and other constituents in applications of waste, albeit of benefit for agriculture, would upset this fragile balance and lead to reduced biodiversity and loss of ecological value.

Whilst agricultural benefit from landspreading of wastes can readily be demonstrated there will be comparatively few instances where landspreading of wastes can be justified on the basis of ecological improvement. In this sense at least, agricultural benefit is more important than ecological improvement as a justification for landspreading of wastes.

Ecological improvement in the context of landspreading is confined to managed environments associated with planned soil improvement. These will be sites where the application of fertiliser/soil conditioner is considered essential for the planned land use which would not be possible without it. For example, restoration of soil of poor structure and nutrient status on land destined for agricultural or amenity use, and on derelict land resulting from human activities, e.g. mining and mineral exploitation, for the purpose of landscaping, amenity development or agriculture(see WMLR 1994, Schedule 3(9). In these cases landspreading can meet the criterion of ecological improvement by providing new habitats or improving the status of existing ones. However, each case must be taken on its merits as, for example, some derelict land is of nature conservation value due to the specialised habitats that can be found in such sites and thus would not benefit from improvement.

Landspreading in commercial forest land managed for timber production can also be acceptable and associated with a combination of benefit to timber production, from increased tree growth, and ecological improvement of the biomass and species diversity of the ground cover. Soils under coniferous forest are often of low nutrient status which limits tree growth unless fertiliser can be applied with phosphate being particularly beneficial. Utilisation of sewage sludge on forest land is well -established and the experience gained provides a basis for using other wastes for this purpose. Guidance is given in 'A manual of good practice for the use of sewage sludge in forestry' (Forestry Commission Bulletin 107, 1992).Landspreading of wastes would not be acceptable in many areas of forest and woodland because of the sensitive ecosystem, recreational value and public access. Proposals would need to be considered on a site-by-site basis.

It has been widely demonstrated that the reclamation or improvement of land is greatly improved by the addition of bulky organic manures and wastes (e.g. Wolstenholme and Hall 1996). Soils on such sites are often very deficient in organic matter and nutrients, and the use of wastes can achieve ecological benefit through improving soil conditions, enhancing plant establishment and generally providing long-term mitigation of the environmental impacts of derelict land sites, at reasonable cost. To achieve these benefits, the wastes may need to be applied at higher rates than for agricultural soils, and this may for instance result in soil concentrations of contaminants in excess of the limit values for agricultural soils. There are no statutory PTE limit values for the use of exempted wastes on non-agricultural land or derelict land, except for sewage sludges on non-agricultural land (WMLR Schedule 3, paragraph 8).

PQA may be necessary to decide on whether the balance of such potential benefits and disbenefits of waste use constitutes ecological improvement on a site-by-site basis. Consideration would have to be given to other remediation options or the lack of them, and the continuing or likely adverse environmental, health or visual impacts if no remediation was carried out.

7.2.2 Where is landspreading unsuitable for ecological reasons?

Land can be identified as unsuitable for landspreading of wastes on the basis of established land designations. This would follow the principle in Article 4 of the Waste Framework Directive 91/156/EEC that waste should be recovered without adversely affecting the countryside or places of special interest.

The exclusion zones include the recognised lists of biological and heritage designated sites and are set out in Tables 7.1 and 7.2 respectively. The biological sites concentrate on habitats but it should be noted that, over and above this, certain species of plants and animals are protected, for example all bats (Wildlife and Countryside Act, 1981). This covers both the individual animal, and any sites used for resting and breeding. The Agency conservation personnel can provide PQA on protected species in particular areas.

Table 7.1 Designated sites - biological

Designation	Status	Agency	Legislation (where known)
1. Biosphere Reserves (Global ecosystems)	Statutory International	DoE	
2. Special Protection Areas (Birds)	Statutory International	DoE, EN, CCW	EC Directives - Wild Birds, Habitats
3. Special Areas for Conservation (all habitats/species)	Statutory International	DoE, EN, CCW	EC Directive - Habitats
4. Ramsar (Wetlands)	International	DoE, EN, CCW	Ramsar Convention
5. National Nature Reserves (all habitats/species)	Statutory National	EN, CCW	Wildlife and Countryside Act
6. Sites of Special Scientific Interest (all habitats/species)	Statutory National	EN, CCW	Wildlife and Countryside Act
7. Environmentally Sensitive Areas	Statutory National	MAFF	EC Directive
8. Local Nature Reserves	Statutory County	EN, LA	
9. County Wildlife Site	County	LA, CWT	
10. Nature Reserves	County	CWT, Woodland Trust, RSPB etc.	
11. National Trust Land	Statutory (Inalienable)	NT	Town and Country Planning Act (1948)

Notes to Table 7.1

Key to agencies: DoE = Department of the Environment
MAFF = Ministry of Agriculture, Fisheries and Food
EN = English Nature
CCW = Countryside Council for Wales
LA = Local Authority
CWT = County Wildlife Trust
RSPB = Royal Society for the Protection of Birds
NT = National Trust

A resumé of key ecological designations in England and Wales is as follows:

1. **Biosphere Reserve.** Globally important habitats and ecosystems, e.g. Braunton Burrows (Devon). This is a non-statutory designation arising from a UNESCO initiative at a time when the UK was still a member.
2. **Special Protection Areas (SPA).** Internationally important areas for birds, e.g. Exe estuary (Devon).
3. **Special Area for Conservation (SAC).** Internationally important habitats; together with SPAs these form the Natura 200 network of European sites, e.g. Wareham Heaths (Dorset).
4. **Ramsar Sites.** Internationally important wetlands; the convention also covers the 'wise-use' of wetlands, e.g. Norfolk Broads.
5. **National Nature Reserves (NNR).** Sites owned or managed by English Nature/countryside Council for Wales, or other approved bodies. Generally theses are the best examples of particular habitats, e.g. Lizard Heathland, Cornwall; Yarner Wood, Devon.
6. **Sites of Special Scientific Interest (SSSI).** A national network of sites covering approximately 7% of the land area in England. These are generally in private ownership under a management agreement with EN/CCW, e.g. Salisbury Plain, Wiltshire; Wye Valley, Welsh Borders. Includes designations 2-5 above.
7. **Environmentally Sensitive Areas (ESA).** Tracts of countryside designated by MAFF where landowners can receive payments to maintain/restore traditional management, e.g. Blackdown Hills, Somerset. The equivalent scheme in Wales is called Tir Cymen.
8. **Local Nature Reserves (LNR).** Sites which are important at a county level, designated by District Councils, generally with good public access.
9. **County Wildlife Sites.** Sites notified to Local Authorities by the County Wildlife Trust. They represent the best remaining habitats within the county, generally covering approximately 10% of the land area. Though not a statutory designation, the Environment Agency relies on information about these sites to safeguard conservation interests in the wider countryside. In practical terms these are the sites which will be most vulnerable to damage from landspreading of wastes, e.g. small wetlands, local woodlands, village ponds.
10. **Nature Reserves.** Sites owned/managed by conservation NGOs, the National Trust or sympathetic landowners. There is often overlap with statutory designations, thus the RSPB owns 70% of West Sedgemoor SSSI.

Table 7.2 Designated sites - heritage

Designation	Status	Agency
1. World Heritage Site	Statutory International	DoE, EH, LA, CADWO
2. Scheduled Ancient Monuments	Statutory National	DoE, EH, CADWO. LA
3. Regional Historic Parks and Gardens	Statutory National	DoE, EH, CADWO, LA
4. Historic Battlefields	Statutory National	DoE, EH, CADWO, LA
5. National Parks	Statutory National	DoE, EH, CADWO, LA
6. Areas of Outstanding Natural Beauty	Statutory National	DoE, EH, CADWO, LA
7. Heritage Coast	Statutory National	LA, Co Co, DoE, EH, CADWO
8. Areas of Great Historic Value	Statutory National	LA, DoE, EH, CADWO
9. Areas of Great Landscape Value	Statutory National	LA, DoE, EH, CADWO
10. Areas of Archaeological Importance	Statutory National	LA, DoE, EH, CADWO
11. Conservation (Built) Areas	Statutory District	LA, EH, CADWO

Key to agencies:
DoE = Department of the Environment
EH = English Heritage
CADWO = English Heritage equivalent in Wales
LA = Local Authority
Co Co = Countryside Commission

The advantages of this approach are that it is in accordance with sustainable development and the precautionary principle as regards environmental protection, and should help to minimise lengthy and contentious inquiries as to whether or not particular sites are suitable for landspreading on the grounds of ecological improvement. If complete exclusion from some of these classes of land is felt to be unacceptable, an option could remain there for allowing the waste producer to make a special case that the proposed landspreading operation would bring about ecological improvement or environmental benefit. The case would need to be supported by an ecological survey of the site in question for which the waste producer would be obliged to pay. Examples would be some mine spoil land within an Environmentally Sensitive Area or arable land or improved grassland of no particular nature conservation value within National Trust land. The same could apply to National Parks or Areas of Outstanding Natural Beauty. For other designations of land, such as SSSIs and NNRs, exclusion would be complete.

7.2.3 Sites where it may be difficult to decide

Despite avoiding landspreading of wastes in natural habitats and use of the exclusion zone approach, there will be sites where it will be difficult to decide whether landspreading should be permitted. Typically, these will be sites where on the one hand agricultural benefit would result, but on the other hand, this would be detrimental to the local ecology due to change to the habitat and loss of species diversity. The site is likely to be on marginal land with definite conservation value but of unprotected status. Landspreading on such sites should only be contemplated where it is demonstrably part of a 'planned/approved' scheme of development or rehabilitation and not as a means in itself, in which case it would be no more than a waste disposal operation not achieving ecological improvement. It would be incumbent on the waste producer to provide the necessary assurances, based on ecological survey, and make the case for landspreading.

7.3 Guidelines for decision-making

In practice, in almost all cases of landspreading of industrial waste, the criterion to be satisfied will be agricultural benefit rather than ecological improvement. Most landspreading will be confined to agricultural or commercial forest land. In addition to the points set out above in Sections 7.1 and 7.2, some guidelines to help in establishing whether or not application of waste would bring agricultural benefit when spread on the land are as follows:

- it should have at least one of the properties that can bring benefit (see Section 7.1.2);
- it should achieve agricultural benefit within a maximum application rate of 250 t ha^{-1} y^{-1} (5000 t for dredgings);
- it should not exceed crop requirements for nutrients, based on the estimated availability of nutrients from the waste;

- it should provide benefit to crop growth and/or improve soil conditions within the growing season of application;

- it should not require the addition of other materials to the waste or the soil in order to compensate for any disbenefits if the waste is applied on its own. Some forms of pre-treatment of waste to reduce disbenefits should be encouraged, such as composting to reduce odour and pathogen content. Mixing fertiliser, say, with a waste to increase its agricultural benefit should not be acceptable unless it is part of an integrated pre-treatment process or the waste can provide benefit without such addition;

- it should not supply in excess of 250 kg N ha^{-1} y^{-1} unless it is applied as a soil conditioner which contains a low concentration of nitrogen (<2% total N dry solids basis), or where the nitrogen is bound in very stable forms of organic matter (such as in composted wastes).

- it should not cause nuisance (odour, litter, visual), and should be applied in accordance with COGAP/W (1991) to avoid water pollution;

- it should not breach any environmental limits for contaminants, such as those for PTEs in the Sludge Regulations and DoE Code of Practice (1996);

- application rate should be limited by nutrients, and not by contaminants. If contaminant addition rates are limiting the rate of waste application before crop nutrient demand is satisfied or 250 kg N ha^{-1} y^{-1} is reached, then this should be regarded as not providing agricultural benefit; and

- it will not adversely affect places of special interest or the countryside. This is taken to mean visual quality and amenity and landscape value including from changes to roads, gates, walls and hedges to achieve access to landspreading areas.

For non-agricultural soils and for land reclamation, achieving ecological improvement is usually the more appropriate criterion for decision making than agricultural improvement. In such cases, the application rate of exempted wastes must be selected to achieve the former, and as a consequence, this may result in additions of nutrients and PTEs which may exceed those normally acceptable for agricultural benefit. Elevated rates of application may be acceptable provided that:

- there is an overall mitigation of the environmental, health and/or visual impact of the site (i.e. ecological improvement); and

- the use of the waste does not result in increased pollution from the site.

7.4 Deciding on whether a proposed landspreading operation will achieve agricultural benefit or ecological improvement.

This section discusses the basis for a sound but practical and straightforward factsheet for the purpose of deciding whether or not a proposed waste landspreading operation will achieve agricultural benefit or ecological improvement. It should be the responsibility of the waste producer to supply the necessary information for the factsheet and to ensure that it is correct, and this responsibility should remain with the waste producer even if a contractor is used to supply the information. The regulator (the Agency) would use the completed factsheet to decide whether the proposed operation will achieve agricultural benefit or ecological improvement (see also Appendices A and B).

The questions to be completed in providing the necessary information for the factsheet are set out below together with guidance notes of explanation.

1. Type of waste as listed in the categories in Table 2 of Schedule 3 of the WMLR 1994

The generic name of the type of waste for landspreading, e.g. Blood and gut contents from abattoirs.

2. Benefits intended from its application to land

One or more of the following should be confirmed.

- Crop yield and quality
  (*To demonstrate agricultural benefit a* *<u>yes</u>* *reply will almost always be required here)*
- Soil chemical properties
- Soil physical properties
- Soil biological properties
- Soil water content
- Land levelling

3. The properties of waste associated with benefit

These should be listed according to the benefit the landspreading operation is intended to bring. Section 8 and Appendix D will indicate to the Regulator which parameters to insist on for particular types of waste. Usually, only some of the parameters will be needed.

Analytical results are to be supplied as required for the determinands listed.

- Crop yield and quality - concentrations (dry matter basis) of plant nutrients in the waste: N, P, K, Mg, Ca, S and trace elements to be specified.
- Soil chemical properties - dry solids content and neutralising value (NV) of the waste
- Soil physical properties -organic matter and calcium sulphate content of the waste
- Soil biological properties - organic matter content of the waste
- Soil water content- water, conductivity and soluble salt content of the waste
- Land levelling- stability of the waste
  (*Likely to be confined to waste soil and compost, and dredgings from inland waters)*
- Quality - is the waste of consistent quality? If so, how was this checked and how frequently?
  (*Consistent quality of product is needed to achieve agricultural benefit or ecological improvement. The statistical basis for the stated waste quality should be described)*

4. The properties of waste associated with disbenefit

Details of only some of these determinands will be required for each waste according to the guidance in Section 8.

- Contaminants - concentrations (mg kg^{-1} ds basis) in the waste of potentially toxic elements and persistent organic compounds where the origin of the waste indicates their possible presence..
  (*See Section 8, Appendix D and the DoE Code of Practice for the Agricultural Use of Sewage Sludge (1996) for details of contaminants that should be determined for particular wastes)*
- pH value of the waste
- Conductivity and content of sodium and soluble salts
- C/N ratio of the waste, ds basis

- BOD
- Oil and fat content
- Microbiological quality
  (Does the waste contain human, animal or plant pathogens. If so, which and in what numbers?)
- Odour potential
  (Is the waste smelly or not?)
- Litter content
  (Has the waste been screened to remove litter or not?)

5. Site factors

The final source of information needed to make the assessment of whether or not agricultural benefit or ecological improvement will result from the proposed landspreading of waste operation.

- Location of site
- Landowner agreement
  (Obtained or not?)
- Does it include, or is it part of, a designated site (biological or heritage)?
  (If it does, landspreading will probably not achieve ecological improvement and not be acceptable)
- If so, what is the designation?
- Specify existing land use
  (Agriculture (arable or grassland), reclamation etc.)
- List details of soil texture, soil nutrient indices, pH value and lime requirement
- Proposed rate of application and how this is expected to achieve agricultural benefit or ecological improvement
  (Typically, this will have been derived for the crop to be grown according to MAFF Bulletin 209 on fertiliser recommendations and soil conditioning benefit, taking account of the limit for organic waste additions of 250 kg total N ha^{-1} y^{-1} and other guidelines in COGAP/W (1991))
- Has PQA been given, if so supply details including name and address of adviser?

- Time and method of application

- Will the operation adversely affect the countryside or places of special interest by damage to visual quality or amenity and landscape value?
(construction or widening of roads, destruction of walls or hedges or trees and destruction and widening of gateways may adversely affect the countryside)

- Arrangements for storage of waste

- What monitoring of the operation is to be done?

- What is the principal factor limiting the rate of application of waste to the land?
(If this is content of contaminants or other negative factor, then agricultural benefit or ecological improvement will not be achieved.)

- What additional steps will be taken to ensure that agricultural benefit or ecological improvement will be obtained without endangering human health and without using processes or methods which could harm the environment, and in particular:

  - without risk to water, air, soil and plants and animals,
  - without causing a nuisance through noise or odours,
  - without adversely affecting the countryside or places of special interest?

  (A reminder to the waste producer of statutory obligations)

8. PROPERTIES OF WASTES SPREAD ON LAND

8.1 General considerations

The purpose of this Section is to list the properties of the exempted wastes and other wastes which might be considered for landspreading. The properties described are those which will be associated with agricultural benefit or disbenefit when waste is spread on the land. This section is intended to be a general guide to the composition of wastes and the analytical information that should be obtained for deciding on the acceptability of landspreading of particular wastes. Detailed evaluations of individual wastes are given in Appendix D which includes analytical data on wastes taken from operational monitoring over the last 10 years carried out by ADAS on behalf of Transorganics Ltd (Organic Waste Recycling Specialists), whose assistance in supplying this information is gratefully acknowledged. Appendix E provides estimates of the quantities of some of the wastes spread on land.

Most industrial wastes currently landspread fall within the broad categories of waste in Schedule 3, Table 2 of the Waste Management Licensing Regulations. There are, however, a number of industrial wastes which have regularly been applied to land such as ammonia, bentonite and some pharmaceutical wastes. These wastes do not fall into any of the categories in Schedule 3, but could be considered either for classification as exempted wastes if the list is to be revised in the future, or for landspreading under licence.

Benefit from the landspreading of many wastes will depend on their content of plant nutrients. Accurate estimation of suitable rates of application of wastes to meet crop requirements for nutrients depends on knowledge of how much of the total content of nutrients in a particular waste is likely to be released for crop uptake, and over what period this will happen. This information has been developed for chemical fertilisers, and to a lesser extent for farm wastes and sewage sludge, over many years of field and pot trials. See, for example, Section 2 on organic manures in MAFF Reference Book RB 209 on fertiliser recommendations (MAFF 1994). Similar trials are needed to define the crop-available fraction of nutrients and, hence the fertiliser replacement value, of the various categories of exempted wastes. This information is essential to optimise the landspreading of exempted wastes to the benefit of farmers, the environment and waste producers.

Whilst there is a lack of authoritative technical information based on field trials in the UK, which would form the preferred basis for guidance, there is some information in the literature which has been drawn on as far as possible and supplemented with operational experience from the UK. Two general accounts of landspreading of industrial wastes, based on experience in the USA, are given by Parr *et al*, (1983), and by Karlen *et al*, (1995).

8.2 Categories of wastes

The general categories of exempt wastes are shown in Section 2.2. Other non-exempt wastes which may be suitable for landspreading are listed below:

- bentonite;
- fertiliser sludge;
- ammonia;
- ammonium sulphate;
- some pharmaceutical wastes;
- landfill leachate.

8.3 Waste treatment processes

Many wastes applied to land can be subjected to secondary treatment by the waste producer or their agents to achieve one or more of the following objectives:

- reduce/avoid potential environmental and health impacts;
- improve the consistency of product quality;
- reduce transport and disposal or landspreading costs;
- improve agronomic value; and
- improve 'marketability' through better handling, odour and visual qualities, and enhanced public perception of the wastes.

Treatment processes include dewatering, anaerobic and aerobic digestion, composting and heat treatment. The suitability of these methods is dependent on the chemical and physical nature of the waste and the economics of processing and disposal. All methods of processing incur additional costs but they can reduce overall costs by minimising the quantity of wastes requiring transport and spreading, making the product more attractive to the user of the land and securing long-term access to the landspreading outlet. For many wastes, the largest component applied to land is water.

There is a great deal of international literature available on waste treatment processes and their products, most of which is limited to specific types of wastes. Sewage sludge has received the most interest: for example, there was a Concerted Action (COST 68/681) run by the European Commission (DGXII) for 18 years (Hall *et al.* 1992) which established five research networks between Member States, published numerous proceedings and contributed to the drafting of the EC Directive 86/278. There is a need for similar development of the scientific basis and optimisation of the recycling of other wastes to land (Davis and Dalimier, 1994).

Composting of organic wastes has received a lot of research attention over many years, and the technology is well-understood, but it is not widely used for the treatment of waste in the UK. This is believed to be due to difficulty in establishing a market and selling the compost at a price which will recover the relatively high processing costs when more economic options are available. The situation is changing with the need to meet government recycling targets, the ability to source and mechanically separate components of wastes and increased landfill costs. A number of countries have well-developed waste composting industries (e.g. The Netherlands and Germany) which market branded quality controlled products, usually designed to compete with the conventional domestic peat-based growing media (ORCA 1992).

Many EU countries have legal or marketing standards for waste-derived compost (Hall 1993), but there are also European standards available through the Eco-label scheme, there is a CEN committee (CEN 223) which is considering soil improvers, and there is the likelihood of an EC Directive being proposed in the near future for composted wastes. The common feature of these standards is that they are product based, depending on the properties of the product and not directly on those of the raw materials or the type of industry from which they are derived. This approach facilitates the integration or co-treatment of different wastes by waste producers and independent companies, where the source of the waste is less important than ensuring the production of a quality-controlled product that can compete in the market place as a bulky organic manure or in the retail sector. Thus, by focusing on the quality of the product, the composter must ensure that the quality of the waste materials does not compromise the product quality standards.

8.4 Characterisation of exempted wastes

8.4.1 General

The general guidance provided in this section gives a framework for the evaluation and utilisation of all types of waste. At all times emphasis should be given to the need to protect the environment during the process of recovering waste by landspreading. A chemical analysis of the individual waste material will always be required to demonstrate and quantify beneficial characteristics and to ensure that the waste will not be polluting. In the majority of cases a waste need only be analysed for its major nutrient content to show an agricultural benefit, unless it is landspread for some other purpose. Exceptions include, for instance, gypsum wastes which should be analysed for calcium sulphate content and lime wastes for their neutralising value. A waste analysis would therefore, commonly include; N, P, K, Ca, Mg, pH, total solids content and volatile solids (organic matter) content. Other beneficial nutrients or chemical determinands including contaminants should be analysed if the waste is thought to contain them. This information must be obtained from the waste producer following an audit of the production process.

8.4.2 Waste evaluation

The evaluation of waste materials should include:

- The chemical and microbiological composition of all wastes considered to be suitable for landspreading must be established to ensure that the waste does not cause damage to the environment or harm to human health.

- All wastes should be submitted for laboratory analysis as recommended in Appendix D, Tables D1 - D16 before any waste is landspread. This analysis should include pH, % dry solids, and organic matter and major nutrient contents to confirm potential for agricultural benefit or ecological improvement.

- Laboratory analysis of a waste stream should be repeated at not less than six-monthly intervals to demonstrate product consistency, and more frequently (each time if results show that this is necessary) for waste streams which are thought to have highly variable compositions. Waste producers should aim to produce a product of consistent quality for landspreading. See also Section 5.2.4.

- Samples submitted for analysis should be representative of the material which is to be landspread. Great care should be taken in the abstraction of a uniform sample. Waste streams are commonly stored in tanks and lagoons where solids settle out. This separation of the solids can lead to a misrepresentation of the chemical and physical nature of a waste when analysed.

- A waste should be subjected to the analyses shown in Appendix D, Tables D1 - D16 for contaminants commonly found in the industrial process generating the waste. This will vary between wastes and may include other contaminants not indicated in this document.

- If there is uncertainty about crop response to nutrients or other components of the waste, then a suitable bioassay (plant growth test) can be carried out to provide more information. Additional procedures can be undertaken using PQA, ranging from laboratory and greenhouse bioassays to full-scale field experiments.

Appendix D describes the wastes within each exempt waste category in Table 2 of Schedule 3 in the WMLR 94, and other non-specified wastes spread on land. This includes an inventory for each waste type of:

- suggested chemical and microbiological analyses;
- anticipated agricultural benefit;
- potential for disbenefit; and
- a brief indication of best practice for the utilisation of the waste.

9. BEST PRACTICE

This Section deals with general aspects of best practice for landspreading of exempted wastes in accordance with the requirements of WMLR 1994. A description of best practice as it relates to individual wastes is given in Appendix D.

The success of landspreading of waste relies on effective management of the process by all parties involved - waste producer, waste recycling contractor, waste brokers and the Agency. Section 7.1.4 lists important factors to consider:

- risk assessment;
- land use and management;
- timing, method and rate of application;
- quality and consistency of waste product; and
- notification, consultation, monitoring and record keeping.

The exemption conferred in Schedule 3 of the WMLR 1994 for the landspreading of wastes relates to the activity and not to the waste directly. Therefore, appropriate consideration must be given to the potential adverse effects of landspreading of waste from the point of waste collection to the moment it is recovered by incorporation into the soil.

This Section outlines how to achieve maximum benefit from the process whilst safeguarding the environment.

9.1 Properly Qualified Advice (PQA)

DoE Circular 11/94 (DoE 1994) discusses the requirements in WMLR 1994 for landspreading of exempted wastes and states that in order to keep within the terms of the exemption, it will be essential to establish on the basis of properly qualified advice (PQA) what application rate is appropriate for each waste material, each soil and each site (para 5.74). Therefore PQA is likely to be needed to appraise the following:

- quality of the waste - beneficial qualities including content of nutrients and their likely availability to crops; presence of contaminants including pathogenic micro-organisms and their significance; other negative factors, such as odour potential; consistency of the waste - variability between batches;
- suitable rates of application to the land taking account of the qualities of the waste, crop requirements for nutrients, soil conditions and regulatory and advisory requirements; and

- site factors and management of the landspreading operation to ensure compliance with the environmental protection requirements of WMLR 1994.

Once landspreading for a particular waste stream has been established and shown to operate satisfactorily on a routine basis, then the experience gained will reduce the need for PQA.

Suitably qualified consultants can be found by contacting the Agency or the British Institute of Agricultural Consultants, which has a Farm Waste Division, or from the National Farm Waste Management Register (Tel: 01235 851515; Fax: 01235 851511).

9.2 Information requirements

9.2.1 General considerations

Although many activities involving the keeping, treatment and disposal of waste are exempted from waste management licensing under the Environmental Protection Act 1990 (EPA 1990), all exemptions are subject to qualifying criteria. In the case of exemptions relevant to the spreading of waste on land (Schedule 3, paragraphs 7, 8, 9 and 12 of the WMLR 1994) specific requirements are prescribed and are outlined in Section 3.2, above.

9.2.2 Advising the operator

The Agency may be in a position to advise the prospective operator **before** the commencement of the activity, either that his proposals will not satisfy certain requirements and could lead to a contravention of s33(1) of EPA 1990, once they commence (i.e. pollution of the environment or harm to human health) or that they require licensing.

'Properly Qualified Advice' (PQA), if copied to the Agency well beforehand, could provide the basis for the Agency to assess the risk. PQA may be provided in the form of a written report by a person who can demonstrate expertise in the appropriate disciplines. It will establish, within the terms of the exemption, what application rate is appropriate for each waste material, each soil, and each site under consideration (DoE Circular 11/94, paragraph. 5.74). Without PQA, few of the risks might be clear until the activities are well underway. In which case the environmental damage may have already occurred, resulting in a breach of the WMLR 1994.

The factors that the Agency will have to consider at the pre-operational stage and then to review subsequently during the operational phase are summarised below.

9.2.3 Pre-operational requirements

Ideally, before endorsing any of the 'landspreading' exemptions, the Agency would have an opportunity to check the following points. In reality, this does depend on early notification of the proposed landspreading operation, which will not always or necessarily be given.

- ensure the occupier of the land agrees to the proposal;
- ensure that none of the wastes dealt with are classified as special wastes as defined in the special waste Regulations 1996;
- evaluate whether or not the proposal is likely to endanger human health or cause harm to the environment and in particular any specified risks, nuisances or adverse effects;
- ensure that the waste type is appropriate and listed in Table 2 of Schedule 3 of WMLR 1994;
- ensure that the proposed quantities/loading rates are within the specified limits; and
- ensure that the location of any associated waste storage is as specified.

The Agency should also be satisfied that the following specific requirements will be met before endorsing the relevant land spreading exemption:

- the proposal will result in 'benefit to agriculture' or 'ecological improvement' (see Section 7);
- the associated waste storage is secure at all times;

  For the purposes of Schedule 3, a container, lagoon or place is secure in relation to waste kept in it if all reasonable precautions are taken to ensure that the waste cannot escape from it and members of the public are unable to gain access to the waste, and any reference to secure storage means storage in a secure container, lagoon or place(WMLR 1994 Regulation 17(5).

- the type of land to be used is appropriate;
- the specified detailed particulars are provided in advance (see Proforma at Appendix B);
- the activity is clearly not a disposal operation (landfill, no agricultural benefit or ecological improvement, rate of application limited by contaminants in the waste).

9.2.4 Subsequent considerations

Throughout the life of the exempted operation(s) the Agency will need to continue to be satisfied that the criteria for exemption remain valid. This means that the Agency will need to ensure that:

- the occupier of the land continues to give consent;
- the wastes remain non-special and appropriate to the exemptions (types, quantities, and/or loading rates);
- pollution of the environment or harm to human health is not occurring;
- any associated waste storage is meeting the requirements of the exemption;
- positive 'benefit to agriculture' or 'ecological improvement' is occurring (refer to Section 7);
- the specified detailed particulars are continuing to be submitted at the required frequency (WMLR 1994; Schedule 3, paragraph 7);
- 'ecological improvement' is occurring where sludge is being deposited on non-agricultural land, and that any heavy metal build-up in the soil remains within the levels listed in the Sludge (Use in Agriculture) Regulations 1989 and the DoE Code of Practice (1996); and
- the activity is not becoming landfill or disposal (WMLR 1994 Schedule 3, paragraph 9).

9.3 From waste producer to land

9.3.1 Waste collection

There is a risk of spillage occurring at the site of waste collection with consequent risk of water pollution. Spillage normally occurs on site roads or hard standing and can subsequently enter site drains. Where a collection point is not protected by a bund or underground collection tank, the waste disposal contractor should seek information from the waste producer on the fate of spillages and discharge points to watercourses.

The operator transferring the waste should be in possession of an adequate written procedure to contain accidental spillage of waste. Any liability for prosecution as a result of accidental spillage or deliberate discharge of waste to watercourse within the curtilage of the waste producer's premises should be agreed between the two parties.

9.3.2 Transport

The waste may be produced as large volumes of dilute liquid which would require many vehicle movements to transport to the landspreading site. The following factors should be taken into account:

- lack of storage may necessitate round-the-clock transport. Waste producers should consider installing at least 3 months storage capacity since there is unlikely to be suitable land available for spreading throughout the year. If this is impracticable due to lack of space on site, then treatment to minimise the volume of waste, such as dewatering, should be investigated;
- vehicle size must be matched to the requirements of narrow farm roads;
- vehicles should be suitable for the deposit of the waste at a farm, e.g. tipper wagons are unlikely to be suitable for use on non-metalled surfaces;
- damage to narrow rural roads and verges may need to be made good;
- warning traffic signs may be required for unloading the wastes;
- the operation may result in mud on the road; and
- Waste Transfer Notes (DCTN) should accompany all loads of waste.

9.3.3 In-field storage

The Agency requires that exempt liquid wastes are stored in a secure container or lagoon and dewatered sludge (solid wastes) in a secure place. Liquids, other than septic tank sludge may only be stored up to a maximum of 500 tonnes in any one container or lagoon (WMLR 1994 Schedule 3 paragraph 6).

Liquids

Where lagoons are constructed on permeable soils there is a risk of liquid waste leaching into ground or surface waters. This will require the following:

- consultation with the Agency;
- planning permission; and
- installation of an impermeable sub-surface barrier such as compacted clay or a butyl lining.

The most common method of transferring liquid waste from a road tanker to the field is by discharging into a portable waste transfer tank situated in a field. These tanks should be sited more than 10 m away from a watercourse or field drain that the waste could go into if it escaped. To reduce the risk of spillage causing groundwater pollution, storage tanks should be sited more than 50m away from any spring, well or borehole that supplies water for human consumption, or is to be used in farm dairies. Site inspection may indicate that these distances should be increased. Care should be taken to avoid spillages from accidental damage, failure of equipment and vandalism by ensuring that:

- all equipment is serviceable and fit for the purpose; and
- waste transfer tanks and equipment are secure and preferably empty overnight

Solids

Application of solid wastes is usually seasonal as it relies on the availability of bare land. Thus, field storage for long periods is often essential. The siting of storage facilities should take into account:

- leaching loss of nutrients and readily degradable organic matter in drainage water;
- storage sites should be placed more than 10 m away from any watercourse or field drain, and more than 50 m from any spring, well or borehole that supplies water for human consumption or is to be used in a farm dairies;
- wherever possible nutrient-rich wastes should be stored on a hard standing with efficient leachate collection facilities.

9.4 The site

Most industrial wastes which are landspread are produced all year round and storage at the production site is usually limited. This is not always compatible with seasonal and site requirements such as soil type, cropping systems, topography, climate and field drainage and access. In order to secure a sustainable landspreading operation into the future, waste producers may need to invest in storage facilities for their wastes or in minimisation treatment, such as dewatering.

9.4.1 Soil type

Soil type is a major factor influencing the suitability of land to receive wastes. The texture of soils is characterised by the relative proportions of sand, silt and clay which they contain. In light textured soils, sand is the most dominant constituent whereas in heavy textured soils clay predominates. Below are some of the characteristics of soil types which may influence the landspreading of wastes:

Heavy soils

During winter and spring heavy-textured soils are usually at field capacity, a condition when soils are fully wetted and more rain would cause water loss by drainage. Under these circumstances:

- surface spreading on waterlogged soils can result in surface run-off into water courses, even on shallow slopes and should be avoided;
- soil structural damage can be caused by the use of heavy machinery leading to rutting, compaction and poor drainage; and
- heavy soils may also be unsuitable for injection of wastes in dry conditions, particularly during summer when soil moisture deficits are highest. The soil can be extremely dry and hard and damage to grassland may be caused by:
  - the pruning of roots by subsurface injection of wastes. This is most damaging in droughty conditions; and
  - damaging the sward by pulling up large clods leaving the surface uneven and the sward difficult to cut with a mower.

Fields are commonly underdrained on heavy soils. In dry summers soils can be cracked to the depth of the drains. Also, permeable fill is often placed over drains to assist in the rapid removal of surface water to the underlying drainage system. These cracks and fissures can allow injected liquid waste rapid access to a watercourse. In addition, when soils are re-wetted in autumn, any waste deposited in the cracks and fissures earlier in the year by the injection of waste can be readily flushed from the system.

COGAP/W (1991) provides a simple guide to the method of risk assessment to minimise those risks outlined above.

Light soils

There is a tendency for waste operators to concentrate their activities onto light sandy soils in the winter. Light soils are preferred for this purpose because:

- vehicular access and waste application are possible all year round; and
- in arable areas spring cropping is more common leaving land bare for the application of wastes throughout the winter months.

However, despite the benefits indicated above, light sands are not always the most desirable for land spreading because:

- they are freely draining, providing rapid leaching of waste constituents into water courses and groundwater;
- sands are often found overlying important aquifers; and
- despite their light texture, sandy soils can suffer significant structural damage by the injection of large quantities of liquid wastes.

Dry soils

Research on spreading dirty water from animal manures has shown that on soils which do not readily crack when dry, large quantities of liquid can safely be applied in summer without polluting field drains. However, on dry cracked soils waste can quickly find its way to drains directly or through permeable back-fill. Where the waste is surface-applied to bare soil a light cultivation before spreading is an effective means of sealing cracks.

9.4.2 Soil analysis

pH and major nutrients

In order to match the input of beneficial nutrients to the requirements of the crop and the receiving soil it is advisable to analyse the soil for:

- Phosphorus, potassium, magnesium, pH value and lime requirement for acid soils.

This will enable estimation of indices of soil nutrient status and will also allow inorganic fertiliser use to be adjusted to take account of nutrients in the waste application. This is the first step in assisting the farmer in recognising and making use of the benefit from landspreading of waste.

Soil analysis is normally unhelpful in determining the crops need for nitrogen. This requirement is assessed from the knowledge of soil type and field history including cropping and organic manure use. MAFF Reference Book 209 (1994) provides a comprehensive inventory of fertiliser recommendations, which can be used to determine crop fertiliser needs.

Potentially Toxic Elements (PTEs)

The DoE Code of Practice for Agricultural Use of Sewage Sludge (1996) gives guidance on maximum permissible soil concentrations of potentially toxic elements where sewage sludge is applied to the land. Landspreading of industrial wastes known to contain significant quantities of heavy metals should use the same principles as apply in the Code in order to guard against accumulation of heavy metals in soil. The following should be analysed prior to the deposit of industrial wastes containing heavy metals:

- total copper, nickel, zinc, lead, cadmium, chromium, mercury; and
- some wastes for landspreading may contain additional PTEs. These elements will have been identified during the evaluation of the suitability of a waste for landspreading, e.g. boron, arsenic, selenium, molybdenum, fluoride or any other contaminant including persistent organic compounds (see Table 9.3, page 100). PQA should be sought to identify the environmental significance of these elements when added to soil and a monitoring programme designed specifically for that waste (see Sections 9.8 and 9.9).

9.4.3 Site Pollution Risk Assessment

Due account should be taken of the Agency policy on groundwater protection and its associated series of maps defining those areas of the country which are most vulnerable to groundwater contamination. The spreading of waste is not to be encouraged in areas of highest vulnerability. The Groundwater Regulations 1998 must also be considered (Section 2.3).

Having identified the general area of land on which wastes could be spread, a site survey should be undertaken, identifying hydrological features such as streams, springs, land drains, wells and boreholes. The survey should cover not only the areas intended for the reception of wastes but other adjacent areas which may be affected indirectly.

A field plan is required which should take account of the topography and geology of the area and highlight, using different colour shading, the areas of land where any spreading restriction must be adhered to. For the purpose of uniformity, the following table (Table 9.1) lists the recommended colour shading to categorise the land along with other relevant features.

A suitably qualified person should assess the pollution risk of sites intended for the landspreading of industrial waste. The assessment should take account of the guidance in this document and in the MAFF COGAP for Water, Air and Soil.

A field pollution risk assessment can change as soil and climatic changes occur on a day-to-day basis. Continuous assessment of pollution risk at sites used for the landspreading of waste is to be recommended.

The COGAP/W (1991) advises a maximum application of 250 kg ha^{-1} total organic nitrogen in any one year. Compliance with this limit will assist in preventing excessive applications and reduce the risk of nitrate leaching to aquifers and surface waters. Nevertheless, there may be case for higher rates of application of wastes with a low content of available N where the intention is to obtain agricultural benefit from the soil conditioning effect of the organic matter in the waste (see Section 7.3).

Table 9.1 Colour coding and features for the field plan

Item	Colour code
Land categories -	
Non-spreading areas (includes conservation areas)	Red
Very high risk areas	Orange
High risk areas	Yellow
Low risk areas	Green
Features -	
Watercourses, wells, ponds, boreholes, field drains, springs and private water supplies	Blue
Mineshafts and adits, bell pits, swallow holes	Purple
Down gradients	Arrowed
Houses (within a minimum distance of 400m) and any other features which have a bearing on the activity	Mark as appropriate

In order to control inputs of nutrients to the land a waste management plan may be required for the farm on which the waste is to be applied. The plan which is appropriate only for wastes containing significant amounts of nitrogen should be incorporated into a pollution risk assessment. Specific reference should be made to:

- Quantities of on- and off-farm wastes it is proposed to deal with, and their nutrient content;
- The cropping regime;
- Topography of the land;
- Soil and waste chemical and physical properties;

- Access to the site;
- Drainage properties of the site; and
- Occurrence of land drains, watercourses, wells and boreholes.

COGAP/W(1991) gives guidance on the production of a Waste Management Plan and MAFF have produced a leaflet showing how the assessment can be made.

A balance sheet can be used to ensure that the N applied satisfies the requirement of the crop to be grown and the need to limit total organic N applications to 250 kg ha^{-1} by taking into account:

- Crop requirement for N;
- the quantity of N applied in any other waste spread on the land on which the waste is to be spread;
- the quantity of organic N applied or to be applied by the land occupier; and
- the quantity of N to be applied by the land occupier in the form of inorganic fertiliser.

9.4.4 Cropping system

A factor limiting landspreading of wastes is the accessibility of suitable land within economic transport distance of the point of waste production. Treatment at the factory to reduce the volume of waste produced, for instance by dewatering, can extend the economic transport distance. Landspreading operations are restricted by cropping. In general, grassland may be accessible throughout most of the year, but access to arable land is usually restricted to the period between harvesting and sowing.

Grassland

Grass grown for silage, hay or grazing provides a wide window of opportunity for the application of waste for most of the year, either surface spread or injected. Factors which influence the location and choice of grassland for the landspreading of wastes are:

- Grass is more commonly grown on heavy soils in wetter areas in the West and North of England and Wales;
- a grass sward transpires soil water during the summer, drying out the soil. This can leave soils dry, hard, cracked and unsuitable for the injection of waste;

- solid waste applied to the surface of grassland can leave residues within the sward which can be picked up by mowing operations or by grazing animals. In this way there is a potential pathway for disease transmission and direct ingestion of contaminants by grazing animals. There is also a risk of odour nuisance from surface applications of waste. Application of wastes to grassland or forage crops is therefore a comparatively high-risk operation and particular care must be taken with quality control of the product (litter-free, contaminant levels, pathogen content and odour potential), rates of application and observance of 'no-grazing' periods following the deposit. PQA should be obtained if there is doubt about the suitability of wastes for application to grassland; and

- short term storage of solids at the place where it is to be spread may be required until herbage has been harvested or a field grazed.

Arable

In arable and vegetable rotations, waste application is not usually feasible once a crop has become established. Light textured soils offer an extended window for application since a large area of bare land can be available from harvest (July) through the winter months until the following spring planting (April).

On light soils the latest date for establishing a crop such as barley or linseed would normally be early April. Thus there is often a 'closed period' from mid-April to mid-July when land is not available or becomes difficult to find.

Set-aside

See Section 6.3.1

9.4.5 Topography

On waterlogged soils, surface flow of liquid wastes is likely even on shallow slopes. The contractor must take this risk into account and make a judgement as to the suitability of a landspreading operation on a daily basis, as weather conditions vary. This may mean ceasing the spreading operation if soils become too wet.

The risk of surface runoff is much reduced for solid wastes compared with liquids.

On heavy soil where watercourses are present, the pollution risk is influenced by the slope of the land and soil wetness, which is largely a function of the time of the year. The pollution risk and assessment recognises four categories of slope:

- slight;
- moderate;
- steep; and
- very steep.

COGAP/W(1991) describes how these slopes relate to the risk of pollution.

9.4.6 Climate

Rainfall tends to be higher in the North and West of England and Wales and this is reflected in the predominance of grassland in these areas. The growing seasons are also longer in Southern, low lying areas due to higher average daily temperatures and incident radiation. Altitude also has an influence on these two factors and soils are often at field capacity for most of the year in upland areas.

The location of waste producers is usually independent of these climatic considerations. This can result in wastes being transported long distances to suitable soils and crops when weather conditions are unfavourable for landspreading near to the point of production of the waste and again emphasises the need for adequate waste storage at the point of production and the possible advantages of dewatering the waste before landspreading.

9.5 The landspreading operation

Current practice normally involves the transfer from a road vehicle (liquid tanker or tipping lorry) into waste transfer tanks for liquids or into temporary storage mounds for solids at the place where the waste is to be spread.

A small number of liquid waste storage facilities is known to have been licensed in various areas of the country, where planning permission and Waste Transfer Station licences have been obtained. At these sites, several wastes are deposited into large balancing tanks and stored prior to landspreading of the mixed waste.

Wastes are handled at the place where the waste is to be spread by various means and choice of the method of application is determined by the solids content and physical nature of the waste and by site factors.

Solid wastes are commonly sludge cakes with a dry solids content of 20-60% and are loaded into specialised spreaders using mechanical shovels and grabs. Liquids and slurries are most effectively moved by pumping either into a trailed or mounted tanker or via an umbilical hose to tractor-mounted spreading equipment. Most wastes cease to act like a liquid above about 12% dry solids content.

9.5.1 Methods of waste spreading

The application of exempt wastes to land relies on the agreement and satisfaction of the land occupier, which must be retained if the operator wants to continue to use landspreading in subsequent years. Damage to soil structure is the most obvious and immediate cause of dispute between the two parties as it is readily visible. This can be avoided by selection of the most appropriate equipment and vehicles to store the waste and apply it to land and by not spreading when ground conditions are unsuitable.

Three methods of application are commonly adopted.

Surface applied solids

Solids are deposited into a mound in a field in preparation for application at the most appropriate time of the year and to suit the soil moisture conditions and stage of crop development. The choice of vehicles used to deposit and load the waste into spreaders should be selected to reduce the potential of soil damage by:

- Reducing the number of vehicle movements to a minimum;
- using low ground pressure tyres;
- using tracked vehicles for the loading of wastes into spreaders at the site where the waste is to be deposited;
- minimising the amount of double handling;
- using hard standings where available;
- agree a traffic management system with the farmer; and
- arranging sufficient alternative storage sites to allow spreading to be suspended when soil conditions are unsuitable.

Conventional muck spreaders are commonly used for spreading solid materials onto land, however, specialist solids spreaders have been developed to apply these materials more evenly. These machines are now used routinely by the larger contractors and are fitted with the following features:

- Moving floors or rams to discharge the waste evenly at the rear or side of the machine;
- vertical and horizontal choppers to condition the waste and break up a solid mass into a friable consistency;
- spinning discs similar to those found on a fertiliser spreaders; and
- re-engineered hydraulics and working parts to cope with demanding wastes.

The drawback with this type of machine is that:

- Odorous wastes can be thrown high into the air and create local nuisance; and

- accurate application of the solids can be difficult with wet wastes.

Surface applied liquids

For liquids, the choice between surface spreading and injection is largely governed by the risk of offensive odour production, disease transmission and sward contamination both by litter or chemical residues. Soil conditions and topography are also important in determining whether injection is feasible. The equipment conventionally used for surface application of liquids is based on equipment designed to apply farm wastes.

Vacuum tankers are used for some wastes, principally by farmer contractors who remove waste from a nearby factory to their own land. Surface application of odorous wastes or those which contain pathogens should be discouraged to avoid:

- Odour nuisance. High trajectory methods, such as rain guns, should be avoided.

- Microbiological contamination of land. Where blood products have been spread on the surface of a grass sward, grazing animals should be prevented from entering the field if blood is still present on the surface according to the Diseases of Animals (Waste Food) Order 1973. See Appendix D4. Subsurface injection is the preferred option for such products and should be followed by a three week no-grazing period to allow the injection slots to close and seal the waste from the sward. The DoE Code of Practice for Agricultural Use of Sewage Sludge (DoE 1996) includes guidance on surface applications of sludge to grassland.

Dribble bars are effective at reducing foul odour drift since the waste is applied at the soil surface through a series of trailing pipes thereby minimising the release of aerosols.

Injection of liquids

Soil injection, which is currently suitable only for liquids, can be carried out either on bare soil or into a grass sward. Benefits of using injection compared to surface application are:

- Major reduction in odour nuisance and potential for disease transmission and crop contamination;

- injection systems utilise umbilical hose or trailed tankers systems. Umbilical injection provides a low ground pressure system, reducing the risk of surface compaction of the soil;

- injection opens up the soil structure and can create a shattering effect in the topsoil similar to that of a shallow subsoiler;

- the loosening of the soil by the injector leg allows for the placement of liquid waste into a network of cracks and fissures. This reduces the risk of surface run-off compared with a surface application method; and

- shallow injection allows low rates of application of wastes which are high in plant nutrients.

There are several drawbacks to injection which must be set against the benefits shown above:

- Over-application of waste can occur as the soil can apparently absorb a large volume of liquid in a single pass;

- injection slots can channel waste down a slope and create ponding at the bottom of gradients. This can be avoided by injecting across a slope;

- injection into grass swards during prolonged dry weather can cause unacceptable crop damage by root pruning and disruption of the sward surface;

- low rates of application are difficult to achieve with deep injectors; and

- injection may place wastes close to land drains and increase the potential for water pollution.

9.6 Odour nuisance

Most organic wastes, and some inorganic sources, can create foul odours. Waste producers should consider treating wastes by a stabilisation process before landspreading to reduce the odour potential of their products. The Code of Good Agricultural Practice for the Protection of Air does not specifically address the landspreading of wastes other than livestock waste, but the advice it contains to avoid odour nuisance from animal manures is applicable to exempted wastes.

Good practice includes the following:

- Select a site carefully which is remote from residential development;

- take account of the direction of the prevailing wind;

- avoid spreading or storage of wastes near to footpaths or roads;

- stored wastes, particularly liquids, can generate many breakdown products capable of producing foul smells under anaerobic conditions. Foul odours are released when liquid wastes are disturbed. Therefore, the operator should create as little disturbance and spillage as possible when tanks are filled or emptied;

- weather conditions play an important role in the distribution of foul odours and the application of waste to land should be avoided on days when the air is still and humid or when the wind is blowing towards houses;

- avoid surface spreading, particularly from tankers throwing fine drops of liquid into the air. A downward trajectory with large droplets gives a substantial improvement;

- band spreading from dribble bars carried on a boom can reduce odour emissions compared with conventional splash plate spreaders;

- injection of wastes eliminates most odour emissions provided the injection slots are closed by rolling; and

- plan ahead and use a weather forecast to take account of changing conditions, e.g. a change in wind direction may cause a nuisance from another direction. Although the greatest potential for odour emissions occurs whilst spreading, a nuisance can persist for many hours following the application of a waste.

- it may be advisable to inform the local Environmental Health Officer of the proposed operation.

9.7 Crop nutrients

The chemical composition of individual industrial wastes varies enormously within named, exempt categories (see Appendix D). Most of the beneficial qualities of wastes spread on land relate to their plant nutrient contents and hence their ability to substitute for inorganic fertiliser. It is important to know the total content of nutrients in the waste and also as far as possible their availability; how much of the total nutrient content will become available for uptake by crop plants and over what period. Agricultural trials are needed to establish the availability to crops of nutrients in the wastes exempted for landspreading. This information is of fundamental importance and is inadequate at present.

9.7.1 Crop nutrient requirements

The ability of a waste to supply a beneficial quantity of plant nutrients is a function of:

- The concentration of nutrients in the waste;
- the availability of the nutrients for plant uptake - organic and inorganic nutrients may be present in the waste;
- the quantity of waste applied to a given area of land;
- the timing of application of a waste to coincide with crop demand for nutrients; and
- antagonistic effects caused by the combination of components in the waste. For example:
  - the application of excessive potassium can reduce the uptake of magnesium into grass resulting in hypomagnesaemia in livestock;
  - a high salt concentration can reduce the ability of nutrients to be taken up by a crop and certain crops such as potatoes are readily damaged by salt addition to soil;
  - the application of excessive available nitrogen - usually in the form of ammonium and nitrate nitrogen - may cause lodging in combinable crops such as cereals, oilseed rape and linseed giving rise to harvesting difficulties and subsequent loss of crop yield and quality;
  - the nitrogen content of malting barley grain may be raised to a level which interferes with the brewing process by the application of excessive N;
  - crops grown on sandy and peaty soils may suffer from trace element deficiency from the application of wastes containing excessive amounts of lime;
  - over-application of sulphur to crops, even those with a high requirement for this nutrient can lead to excessive uptake into plant tissues. The most obvious example is elevated glucosinolate content of rapeseed oil and consequent unsuitability for inclusion in animal feed; and
  - ingestion of large amounts of sulphur in grass herbage can give rise to copper deficiency in livestock while copper deficiency has been induced in cereals on rare occasions by large additions of sulphur.

Plant nutrients, particularly the major nutrients, nitrogen, phosphate, potash, calcium, magnesium and sulphur are the elements which provide the principal benefit in wastes which are landspread. Increasing fertiliser prices have resulted in many farmers seeking alternative sources of plant nutrients. In addition, wastes can contain certain minor nutrients such as copper, manganese, zinc, cobalt, selenium, boron and molybdenum which are essential for plant growth or animal development (but are potentially toxic elements in excessive amounts).

Salty wastes containing sodium can increase the yield of sugar beet and some vegetable crops such as carrots and parsnips as well as providing sodium for uptake into herbage and livestock.

As is the case with farm wastes, most of the beneficial components of landspread wastes can also be detrimental to crops if utilised in an inappropriate way.

The most practical way to minimise potential detrimental effects of over-application of nutrients in wastes is to match inputs to soil, crop and livestock requirements. This is a complex process and the assessment of safe applications of nutrients is best left to PQA.

9.7.2 Phosphorus, potassium and magnesium

Phosphorus and potassium are usually expressed as oxides P_2O_5 (phosphate) and K_2O (potash) when equated to fertiliser equivalents.

Magnesium, phosphate and potash applications in wastes landspread should be based on knowledge of:

- existing soil nutrient reserves;
- crop requirements for the nutrients; and
- crop off-take of the nutrients.

It is advisable to maintain soil P and K nutrient levels at Index 2 (MAFF RB209, 1994) for arable and forage crops and P Index 3 for vegetables. Increasing levels further would be unlikely to achieve improvements in crop yield or quality for most crops and so would not equate to agricultural benefit.

Soil nutrient levels can be maintained by matching the input of nutrients to crop removal and examples of off-takes for P and K are given in Table 9.2.

The MAFF publication RB 209 "Fertiliser Recommendations" (1994) takes account of typical off-takes and recommendations at Index 2 closely match the data in the table.

Certain crops will provide an economic response to the application of applied nutrients above these soil indices, as is the case with P for potatoes. It is also common practice with grass and combinable crops, to apply sufficient phosphate or potash in a single application (MAFF 1985) to satisfy crop demands for up to three years of a rotation. In this case, no more P or K fertiliser would normally be applied during that period unless it is required to balance crop offtake.

Table 9.2 Typical phosphate and potash removal by commonly grown crops

Crop	Typical yield $t\ ha^{-1}$	Phosphate offtake $kg\ ha^{-1}$	Potash offtake $kg\ ha^{-1}$
Grass Silage	40	56	192
Cereal Grain	7.5	59	42
Cereal Straw	4.9	7	52
Oilseed Rape	3.5	56	39
Potatoes	50	50	290

9.7.3 Nitrogen

Nitrogen is an essential element of protein and it is the single most important nutrient governing crop yield and quality. The interaction of N contained in a waste applied to land, the soil biomass, crop off-take and other chemical and biochemical soil processes is complex and dependent on:

- Quantity and form of N in the waste - organic or inorganic;
- soil type - heavy clay, light sand, peat etc;
- soil N residues - related to previous cropping, the addition of organic manures and inorganic fertiliser application;
- soil moisture content - soil biomass activity (and hence nitrification) slows down in dry soils;
- climate - soil biomass activity slows down in the winter and increases as soil temperature rises;
- crop grown - legumes fix atmospheric N; and
- soil pH.

Nitrogen is the most common beneficial element found in wastes which are landspread. However, wastes vary from those such as lime and gypsum containing almost no N, to abattoir wastes containing undiluted blood with very high levels of N.

Carbon:nitrogen ratio

Waste such as certain paper sludges (Appendix D7) and timber residues have a high C:N ratio. This means that soil N is immobilised when the waste is degraded microbiologically in soil. The immobilisation process requires the addition of mineral nitrogen in the form of fertiliser, typically 30 to 50 kg N ha^{-1} for every 100 t ha^{-1} of waste (Aitken *et al*, 1995). This residual N will be released into the soil for crop uptake when all of the paper sludge has been broken down. Many wastes will contain a mixture of inorganic and organically-bound N (see Section 7.1.3).

Availability of N for crop uptake

Inorganic wastes from chemical manufacture will often contain nitrogen in the ammonium-N or nitrate-N form which is readily available for uptake by crops. In organic wastes most of the N is bound to organic matter, requiring mineralisation by microbial activity in soil to convert it to mineral nitrogen - ammonium-N and nitrate-N.

Both under-application and excessive supply of available nitrogen can have a potentially detrimental effect on crop performance. It is, therefore, important that the land user be provided with an indication of nitrogen availability resulting from the application of a waste to land in order to adjust the use of other sources of inorganic or organic N. Whilst rough estimates can be made of the availability of N in different wastes, this information needs to be based on authoritative agricultural trials, as mentioned above.

N losses

Gaseous - N applied to soil in a waste which is not taken up by a crop can be lost by denitrification to the atmosphere as nitrogen and nitrous oxide gas in heavy textured soils during wet conditions. Ammonia may also be volatilised if present in the waste, the extent of which depends on climatic and soil factors, and length of exposure before incorporation in the soil.

Leaching - N in the form of nitrate can be lost from the soil by leaching in drainage water, particularly on light soils. However, most organic wastes will not contain nitrate. Microbial processes in the soil, requiring a minimum soil temperature of about 4 °C, convert organic N to nitrate N which may be at risk of leaching if there is no crop to utilise the nitrogen. Grass and autumn sown crops such as winter wheat and winter oilseed rape are able to accumulate nitrogen in their foliage over the autumn, winter and early spring period. However, crop demand for N during this period is low. The peak demand for nitrogen in these crops is between late February to July when a shortage of N will limit yield potential.

The application of N in wastes containing a large amount of readily available N onto light soils in late summer and early autumn presents a significant risk of nitrate leaching and should be avoided so far as possible.

COGAP/W (1991) recommends that the maximum amount of 'total nitrogen' in organic wastes applied in any one year is 250 kg N ha^{-1}. This recommendation should generally be followed in landspreading of all exempted wastes to avoid potential problems associated with the application of excessive quantities of N. COGAP/W was produced principally as a guide for farmers to reduce the risk of pollution from farm wastes. An exception to this rule might be for fully stabilised solid wastes applied to the land as soil conditioners, because this kind of material has a low content of plant-available or readily mineralisable N. See also Section 7.3.

9.7.4 Eutrophication

Nitrogen and phosphorus are responsible for eutrophication; the enrichment of surface waters with N and P leading to the growth of aquatic weeds and algae.

N and P can enter surface waters in a number of ways:

- Surface run-off or leaching; and
- erosion of arable land with high soil phosphorus levels in the soil has been shown to be a major source of particulate P entering surface waters. Phosphorus is firmly retained within soil by absorption onto iron/aluminium oxide and hydroxide surfaces.

The process of eutrophication by the addition of P and N contained in wastes applied to land can be reduced by taking the following precautions:

- avoid direct entry of wastes to surface water by the use of good field practice as set out in COGAP/W;
- do not permit the application of wastes containing P on soils containing in excess of 60 mg l^{-1} 'available' phosphorus (Index 5 or higher);
- at soil P levels of between 45 and 60 mg l^{-1} no more than 150 kg ha^{-1} phosphate should be applied in any 12 month period; and
- care should be taken when applying P-rich wastes to soils to avoid surface run-off.

Recent investigations suggested that in soils with more than about 60 mg l^{-1} extractable P content, approximately mid Index 4, the soluble P content of soil water at depth increases markedly (Heckrath *et al.* 1995). These soils had a history of large applications of animal manures.

The same research also suggests that the solubility of phosphorus applied in sewage sludge to achieve 60 mg l^{-1} extractable P is far lower than that derived from animal manures. It is possible that the solubility and movement of phosphorus applied in industrial wastes will vary with the type of waste. Organic matter addition in wastes can help to stabilise soils and reduce erosion potential and P eutrophication of watercourses by soil particles. Furthermore, some wastes, notably gypsum have been shown to reduce the solubility of soil phosphorus. This again requires field testing and investigation

9.7.5 Irrigation

Watery wastes may be suitable for crop irrigation even if they contain only low levels of nutrients. Chemical properties of the waste should be analysed and checked against the criteria in ADAS Leaflet 776 (ADAS 1981) on water quality for crop irrigation. Irrigation should only be practised at times of the year when there is a soil moisture deficit which the operation will beneficially correct. This is likely to be in the period May- September inclusive. There will be additional benefit if the water serves to wash surface-applied fertilisers (for instance between grass cuts) down to the roots of the crop.

9.8 Potentially toxic inorganic elements

The MAFF Code of Good Agricultural Practice for the Protection of Soil (1993) lists zinc, copper, nickel, cadmium and arsenic as elements which can damage crops. Elements which are potentially harmful to animals or humans by entry into the food chain include lead, arsenic, cadmium, mercury, copper, fluorine, selenium and molybdenum.

The Sludge (Use in Agriculture) Regulations 1989 require analysis of the sludge and of the receiving soil for seven heavy metals, zinc, copper, nickel, lead, cadmium, mercury and chromium where sewage sludge is applied to land, and the latest guidance is given in the DoE Code (1996).

The vast majority of industrial wastes applied to land contain low levels of potentially toxic elements, typically less than those of animal manures. Certain wastes, however, (see Chapter 8 and Appendix D) can contain significant quantities of heavy metals depending on the manufacturing process. An evaluation of any waste production process will indicate those elements which may cause damage to the environment or harm to human health. A chemical analysis and risk assessment can then be made into the suitability of a waste for landspreading.

9.9 Organic compounds

9.9.1 Animal and vegetable fats and oils

Naturally occurring organic compounds such as oils and fats may be present in large concentrations in dairy, wool scouring, abattoir, meat processing, oil crushing, and rendering wastes. Above about 4% fat or oil content, in bioassays and in the field, ADAS have demonstrated detrimental effects on plant growth. The oil or fat appears to coat the soil particles, effectively producing a waterproof barrier. Plant roots are not then able to extract water and the result is stunting or die-back, these effects being similar to those caused by excessive salinity. Further additions of water do not result in any improvement as the water runs over the soil particles and very little is absorbed. Their presence can limit the application rate since microbial breakdown of oil or fat in the soil commonly leads to temporarily anaerobic conditions and subsequent crop damage. Pretreatment of these wastes is to be recommended to reduce oil and fat content to less than 4% by separation and alternative disposal of this component of the waste.

9.9.2 Organic contaminants

The significance of organic contaminants is due to:

- volatility - emissions to the atmosphere of solvents and fuel oil;
- water-solubility - leaching and contamination of aquifers and surface waters;
- persistency - build up in soil to potentially hazardous levels;
- toxicity to crops or animals and taint of product (lipophilic organic compounds in waste applied to the surface of grassland may be directly ingested by grazing farm animals and accumulate in meat and dairy products for human consumption); and
- toxicity to the soil biomass.

A large number of compounds could be associated with specific waste materials:

- waste soil or compost may contain persistent organics including residues of non-approved or prescribed compounds (Red List) such as DDT, lindane and other substances;
- antibiotics and other medicaments can be found in products derived from animal, fish and pharmaceutical waste;
- waste wood and paper may contain traces of persistent preservatives such as pentachlorophenol (PCP);
- bio-sludges and septic tank sludges can contain dichlorobenzene used in toilet disinfectants and alkyl benzenes used in detergents; and
- wastes derived from any process involving combustion could contain dioxins, furans and polynuclear aromatic hydrocarbons (PAHs).

Also, the presence of degradation products derived from the above must be considered.

Where a waste arises from a process such as those listed above it should be subjected to detailed evaluation and risk assessment.

Clues as to which organic contaminants to analyse for should come from knowledge of the process producing the waste. There are also various lists of priority pollutants one of which is the Red List.

The selection of Red List substances was made from the list of 129 potential List I substances published by the European Commission in 1982. The procedure for selection used by the Department of the Environment was based on four scenarios reflecting the significance of acute toxic effects (short term scenario), chronic toxic effects (long term scenario), bioaccumulation leading to toxicity to higher organisms (food chain scenario) and carcinogenic effects (carcinogenicity scenario). Each scenario involves a decision tree with defined branches indicating the combination of parameters (designated high, medium or low significance) which lead to a substance being selected for priority consideration. This selection procedure resulted, after consultation, in the publication of the agreed UK Red List (Table 9.3) (DoE 1989) (see Appendix D, especially D7).

9.10 Microbiological properties of wastes

If wastes which contain the agents of infectious diseases (pathogens), or the resting stages of parasites, are spread on agricultural land, hazards will arise to the health of susceptible species, such as:

- Humans - those applying the waste, farm workers and the general public coming into contact with the waste;

- farm animals housed or grazing on land to which waste has been applied;

- crops, where the wastes applied contain specific plant pathogens. Although untreated plant waste originating both on and off farm should not be spread on agricultural land, it may be returned to the field of origin if this would not present any plant health risk. Diseased plant waste cannot be spread on agricultural land. The disposal of such waste is controlled by the Plant Health (Great Britain) Order 1993 which requires the material to be incinerated or disposed of to a landfill site. It is understood that MAFF is preparing a publication on plant health protection, intended for release in 1997, entitled 'Code of Practice for the Safe Disposal of Agricultural and Horticultural Waste'. See also Appendix D2.

Table 9.3 The UK Red List Substances (DoE 1989)

	Substance	List I status[(1)]
	Mercury	+
	Cadmium	+
*	Gamma hexachlorocyclohexane (lindane)	+
*	DDT	+
*	Pentachlorophenol (PCP)	+
	Hexachlorobenzene (HCB)	+
	Hexachlorobutadiene (HCBD)	+
*	Aldrin	+
*	Dieldrin	+
*	Endrin	+
*	PCB (Polychlorinated biphenyls)	
*	Tributyltin compounds	
*	Triphenyltin compounds	
*	Dichlorvos	
*	Trifluralin	
	1,2 Dichloroethane	+
	Trichlorobenzene	+
*	Azinphos-methyl	
*	Fenitrothion	
*	Malathion	
*	Endosulfan	
*	Atrazine	
*	Simazine	

Notes:

1 Chloroform has List I status but is not included in the UK Red List
* Substances which enter the environment predominantly from diffuse sources

Whether or not a significant risk to health will occur can only be determined by a full assessment of all the factors involved, such as:

- The potential for pathogens to occur in the waste;
- the rates of decay of pathogens in the waste and in the soil after application;
- the existence of barriers to the transmission of infection, such as treatment or storage of the waste before application, the manner and rate of application and the adoption of restrictions on the use of the land after application. In general it is not good practice to recycle animal wastes directly onto land which is used for grazing or stocking farm animals or vegetable wastes onto arable land, without treatment and imposing adequate restrictions on use of the land;
- the susceptibility of those at risk. Many pathogens (e.g. plant pathogens and animal viruses) and parasites are host-specific, whereas others (e.g. many species of *Salmonella* and *Campylobacter*, and *E. coli* 0157) are freely transmissible between man and farm animals. The latter class of pathogen (zoonotic) presents major problems in the control of animal and public health.

An important consideration in connection with point 1 is that contamination of wastes by pathogens and parasites will only occur when subjects in the community producing the waste are ill or are carrying infection asymptomatically and thereby contaminate the waste. This applies to plant diseases, in the same manner as for human and animal infections. This means that the content of pathogens is likely to be extremely variable. For small communities and sources of waste, the wastes will normally be pathogen-free. The danger is that any occurrence of disease in the community will result in very heavy contamination of the wastes it produces. On the other hand, the wastes of a very large contributing community, if well-mixed, may regularly contain a background level of excreted pathogens, reduced in numbers by dilution. A well-known example of the former condition is that of septic tank wastes from single houses with a carrier of infection. One well-documented instance, resulting from contamination of grazing land with septic tank waste from a household with a carrier of *Salmonella. paratyphi* B, resulted in a massive infection of a dairy herd with *S.. paratyphi* B, infection of the farmer's household and transmission through the drinking water supply to a village (Harbourne 1977).

Some wastes, by reason of their origin or composition, are inherently free of pathogens.

It is not necessary or routinely possible to examine waste materials for presence and numbers of pathogens in order to assess whether or not a hazard exists. The occurrence of pathogens is normally sporadic, the methods of detection laborious or not available and success in detection is dependent upon the efficiency of sampling. Risk assessment therefore depends upon knowledge of the ways in which particular infections are spread, the likelihood that wastes are contaminated and upon which practices are known to be safe or hazardous from past experience.

The DoE Code of Practice for the Agricultural Use of Sewage Sludge (1996) provides information relevant to the management on the land of other wastes which may contain pathogens. The scientific basis for this code is described by Carrington *et al.* (1998) including full appraisal of the control of disease transmission and other wastes than sewage sludge which may contain pathogens. The greatest risk of disease transmission is from landspreading of untreated sludge so this has to be applied by subsurface injection or ploughed into the land as soon as possible after spreading. Sludges treated by specified processes to reduce numbers and infectivity of pathogens can be used on the land with less restriction. Nevertheless, even for those treated sludges, land management practices are specified to prevent disease transmission. These practices include the 'no grazing period' between applying sludge to the surface of grassland and the return of stock to the pasture, and restrictions on cropping practices. In the USA, the Environmental Protection Agency has identified in its Rule 503 for sludge management, 'processes to further reduce pathogens' (PFRP) which can produce a Class A sludge treated sufficiently to reduce the numbers of pathogens to those ambient in the soil. Class A sludge can then be used on the land without restriction.

Disease transmission can therefore be prevented by a dual barrier approach based on treatment of the sludge and suitable land management practice. The first stage is to define the microbiological characteristics of the waste. If it is likely to contain pathogens then suitable treatment and land management practices must be put into place to prevent disease transmission. Problems are prevented by managing the treatment process and land use restrictions effectively. Routine monitoring of wastes for pathogen content should be unnecessary.

Microbiological aspects of particular wastes are described in Appendix D and summarised below.

The exempted wastes can be divided into three categories of risk: those that will with a high degree of certainty contain pathogens; those that may contain pathogens; and those that are unlikely to contain pathogens.

The first category includes those wastes with a high content of faecal material: septic tank sludge and waste from abattoirs. These wastes should only be applied to land by subsurface injection or with immediate incorporation into the soil, followed by the land use restrictions specified in the sewage sludge Code (DoE 1996) for untreated sludge. These would be the minimum measures intended to prevent disease transmission.

A number of wastes may contain pathogens. These include: waste from food industries; compost and waste soil; water works sludge; dredgings from inland waters; and waste from tanneries. In most instances these wastes would not present any problems, but local knowledge of the source is important and should be considered before land application is approved.

The third category of wastes (those from beverage industries, vegetable processing, paper industry, textile waste, wood and green plant waste, and waste from lime and similar industries) arise from materials that by their nature will not harbour pathogens that will cause infections in man from contamination of food arising either from ill-health in domesticated animals or from contamination of vegetable crops. The exception is waste vegetation after harvest, such as potato haulms, which can be a potent means of spreading and perpetrating infection of sensitive crops, such as potato blight.

9.10.1 Septic tank sludge and cess pit waste

These wastes have a high potential for presenting a microbiological risk to man and animals. They serve very small communities, usually a single household in remote areas. Consequently they will consist almost, if not, entirely of human excreta and waste waters from ablutions and food preparation.

Septic tanks, by virtue of their limited retention period and operation at ambient temperatures, do not stabilise sludge. The lethal effect on pathogenic micro-organisms is at best small and is unpredictable. Cess pits serve similar populations but are simple watertight tanks and no treatment is involved. If there is infectious enteric disease in the family often most of the family will be infected and there will be a high concentration of those pathogens in the waste relative to that in sewage.

The Sludge (Use in Agriculture) Regulations (SI 1989) define 'septic tank sludge' as the residual sludge from septic tanks and similar installations. Only the sludge is an exempt waste and can be spread on land. The whole waste from septic tanks or the waste from cess pits is not exempt. The Code of Practice (DoE 1996) states that the contents of septic tanks cannot be considered as a treated waste and therefore as an untreated sludge may only be applied to land by subsurface injection or immediately worked into the soil.

9.10.2 Blood and gut contents from abattoirs

It is illegal to send diseased animals for slaughter for food and *ante-mortem* veterinary examination should eliminate such animals. However, the possibility of asymptomatic diseased animals, 'carriers', and the readiness with which bacterial pathogens can multiply in these wastes implies that such wastes should be used with caution. It is recommended that such materials should be immediately incorporated into arable land or applied to grassland by sub-surface injection. In the latter situation a 3-week period should elapse to allow for the injection slots to close before use of the grass for grazing or conservation. This recommendation is in line with those in the Code of Practice for the application of untreated sludge to agricultural land.

Wastes from slaughtered animals subsequently found to have been suffering from one of the notifiable diseases covered by the Animal Health Act 1981 must not be applied to land. The Veterinary Investigation Service should be notified and their advice on disposal obtained. Abattoirs dealing with clinically infected animals are not allowed to discharge waste water to sewers. The small risk of the BSE agent being present in material arising from the culling of healthy animals over 30 months of age is dealt with by the fitting of traps and screens which are required by The Specified Bovine Materials Orders (SI 1996).

9.10.3 Waste from food industries

Some raw materials of food production are inherently liable to contain enteric pathogens. Unless this is the main reason for material being discarded it can be assumed that the waste will be relatively pathogen-free, on the grounds that only high quality ingredients will be used for food and drink preparation. Cooked wastes will have been effectively disinfected. Re-infection by enteric pathogens, such as *Salmonella* and *Campylobacter* species is possible, if the wastes are allowed to be infested by rodents and scavenging animals.

9.10.4 Compost and waste soil

The processes used in the production of heated compost should normally disinfect the product. However, poor control during production, if the raw material contains large quantities of sewage or animal waste, may result in pathogens being present.

Waste soils will usually only contain pathogens at a level similar to the ambient levels of soils impacted by wildlife including birds. The possibility that the land from which the waste soil was derived had been used by infected animals cannot be discounted. Similarly plant pathogens such as *Rhizomania,* potato cyst nematode or white rot of onions may be present.

9.10.5 Water works sludge

Sludges from potable water treatment plants will reflect the microbiological content of the raw water. Water works are usually sited such that the source water is of best quality available in that locality. Groundwaters are usually of excellent quality, but surface waters are more vulnerable and liable to contamination. The number of pathogens in such sludges is likely to small and nature of the material presents a hostile environment to most organisms. However, those adapted for survival in the environment, e.g. *Cryptosporidium,* may persist and be concentrated in the sludge.

9.10.6 Dredgings from any inland waters

The mud of dredgings, which contain a high proportion of silts and clays are highly adsorptive of bacteria and viruses. Particular local care may need to be taken in the case of dredgings taken from downstream of discharges from sewage works, storm sewage overflows and the discharges from particular trades, such as compounders of organic fertilisers and abattoirs. Historically, particular problems suggest the need for caution in certain areas, in these cases local veterinary and public health knowledge would seem invaluable.

9.10.7 Waste hair and effluent treatment sludge from a tannery

The chemical and other treatments given to hides in tanneries effectively disinfect the waste, with the exception of the spores of the anthrax bacillus. The infection in the past was in workers handling these materials becoming infected by inhalation of spores in dust or by contact of infected hides with the skin. Sporadic cases in animals have been reported in the past, associated with pasture flooding downstream of tanneries. These problems have now disappeared as anthrax in farm animals is now rare in the UK. European Community requirements make the import of contaminated hides unlikely. Hairs and bristles are disinfected by means which destroy the infectivity of anthrax spores.

9.10.8 Waste from vegetable processing

There are unlikely to be any human infections arising from the disposal of soil and washings during vegetable processing.

These wastes may contain plant pathogens such as those causing Rhizomania or potato diseases (e.g. blight, blackleg and brown rot) or the potato cyst nematode (*Globodera pallida* and *Globodera rostochiensis*). A Code of Practice has been developed by MAFF whereby material leaving the processing plant should receive suitable treatment, or in the case of soil, be returned to the field of origin (MAFF 1994a).

9.10.9 Waste from beverage industries

Wastes from breweries can be considered to be pathogen-free by virtue of the nature of the production processes. Waste from soft-drink production will be acidic and therefore unlikely to contain pathogenic bacteria.

9.10.10 Wood and green plant material

With green plant material and rotted woods there is a possibility of plant pathogens, particularly fungi, being present but it is unlikely that animal or human pathogens will be present. On the other hand potato haulms are a recognised vehicle for the transmission of potato blight (*Phytophera infestans*) and should be destroyed by burning.

Wood waste arising from joinery and similar processes are unlikely to contain any harmful organisms.

9.10.11 Paper industry waste

These wastes are inherently composed of poorly biodegradable cellulose and lignins, which, even when wet, will support only limited growth of specialised micro-organisms. They can be regarded as pathogen- and parasite-free and present no risks to the health of plants or animals.

9.10.12 Textile waste

Cotton and synthetic fibre wastes present no hazards. The risk still exists in theory, of wastes from wool containing spores of the anthrax bacillus, *Bacillus anthracis*. Preventive industrial practices and the virtual elimination of human and animal anthrax from most developed countries imply that the hazard to farm animals or to man of using such wastes on land is now negligible.

9.10.13 Lime, cement and gypsum industries waste

These wastes, by virtue of their chemical nature and origin are inherently pathogen-free and present no problems from pathogens. Lime and lime sludges have pH values of 10-12+ and are therefore self-disinfecting, as long as they are not chemically neutralised. Gypsum is a mineral (hydrated calcium sulphate), used for preparing plaster and plaster-based building materials. Like lime, heat is used in preparing plaster, which disinfects the product.

9.11 Soil structure considerations

9.11.1 Lime

The benefit of a number of wastes will be derived from their lime content which should be quantified as neutralising value (NV) as a basis for calculating rates of application to soils with a lime requirement. See ADAS reference book 35 on lime and liming (MAFF 1981).

9.11.2 Organic matter

The organic matter content of organic wastes can, in the long term, improve the workability of heavy soils and increase drought resistance on light soils.

Organic matter makes both sands and clays lighter in character and stabilises poorly structured soils. Below are the important soil properties influenced by an increase in soil organic matter:

- ***nitrogen supply*** - Most of the soil nitrogen is present in the form of soil organic matter. As it degrades in the soil, the organic matter releases nitrogen in soluble forms, such as nitrate, available for crop uptake or which may be leached.

- ***stability of structure*** - Organic matter helps to prevent the breakdown of soil structure by water. This is important on soils with naturally unstable structures and on sandy soils subject to wind erosion.

- ***water-holding capacity*** - In general, the higher the organic matter content of soil the greater the water-holding capacity, and on very light soils this can reduce risk of drought appreciably.

- ***compaction*** - Soils with a high organic matter content will normally be more open and less easily compacted than a comparable soil with a lower organic matter content.

9.11.3 Gypsum

Gypsum has a well-established capability to improve heavy or saline soils and to supply the plant nutrient sulphur.

Non-saline soils

Research work carried out in a four year study for National Power and PowerGen has clearly demonstrated the benefits and low environmental risk of Flue Gas Desulphurisation Gypsum (FGD gypsum), when applied to agricultural land (Rimmer *et al.* 1995). Yield increases and soil structural improvements were both achieved by the application of FGD gypsum to heavy, non-saline, non-calcareous clays.

Saline soils

There is a small but significant area of land which could benefit from the application of waste gypsum in the salt marshes of East Anglia, Kent, Sussex and Humberside. Experiments on St Mary's Marsh, in North Kent in 1984 have demonstrated these benefits (Marks, 1987).

Land reclamation

Soils which have been stripped, stored and used in land reclamation schemes are often in poor structural condition. An experiment carried out for British Coal used FGD gypsum as a soil improver, showed that improvements in soil structure and plant growth are achievable using this material (Rimmer *et al,* 1995).

Sulphur for plant growth

In the UK a major source of S for crops has been industrially derived. In areas of intensive combustion of fossil fuels, total deposition of S can exceed 40 kg S ha^{-1} and may be as high as 70 kg S ha^{-1} (Gregson *et al,* 1985). The Clean Air Act and subsequently the Environmental Protection Act 1990 have ensured that atmospheric deposition of S has reduced rapidly since the 1950s and some soils in the UK are now deficient in S. The S content of waste gypsum can supply this demand for S on deficient soils.

9.12 Post-landspreading inspection.

It is good practice for the operator landspreading wastes to inspect the site as soon as is practicable after the deposit has been made.

Checks should be made to confirm compliance with the requirements of Codes of Good Agricultural Practice:

- sloping ground should be inspected for surface runoff;
- watercourses checked;
- spillage's and signs of leakage should be rectified; and
- sites of storage, lagoons and waste transfer tanks made good.

By this means, strict control can be exercised over the operation and a high level of environmental protection achieved.

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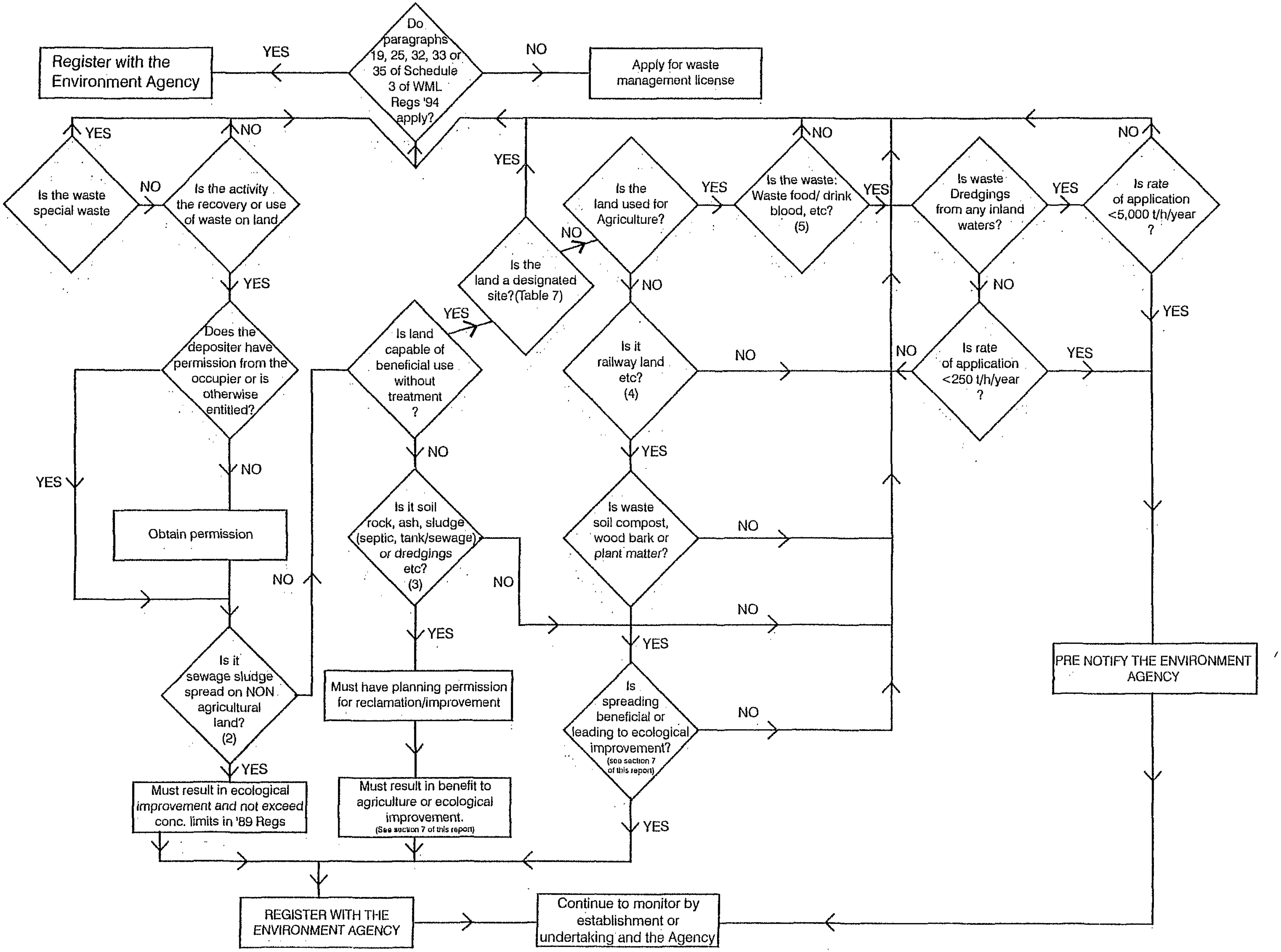
APPENDIX A PROCESS MAP TO AID DECISION MAKING FOR THE SPREADING OF WASTE ON LAND

Based on a map originally developed by the NAWRO/NRA liaison group (1996).

The 1989 Regulations referred to in the process map are the Sludge (Use in Agriculture) Regulations 1989. In addition, the 'WML Regs. '94' are the Waste Management Licensing Regulations 1994.

FLOW CHART TO AID DECISION MAKING FOR THE SPREADING OF WASTE OF LAND



APPENDIX B PROFORMA FOR THE SPREADING OF WASTES ON LAND

Guidance and prenotification proforma used by the Environment Agency, South West Region.

Agency Ref. No:	Site Name:

THE ENVIRONMENT AGENCY

SOUTH WEST REGION

THE SPREADING OF CONTROLLED WASTE ON LAND WHICH IS USED FOR AGRICULTURE

PRENOTIFICATION OF DEPOSIT

The Waste Management Licensing Regulations 1994

Please read the attached guidance note before completing this form

[ONLY ONE WASTE PER FORM]

** Delete as appropriate*

SECTION 1 - REGISTRATION PARTICULARS

The particulars in this Section must be furnished to the Local Environment Agency Office, in whose area the spreading is to take place, in accordance with paragraph 7(3)(c) of Schedule 3 to the Waste Management Regulations 1994.

1.1 FREQUENCY OF SPREADING [Tick box]

Single spreading [ ]

[date]..................................

Frequent or regular spreading [ ]

For the six month period from [date]..................................

to [date]..................................

1.2 DETAILS OF SPREADER [Establishment or undertaking]

Name:

Address:

Post Code:

Telephone Number: Fax Number:

1.3 STORAGE

Where will the waste be stored prior to spreading?

[If storage is located at the site to be spread show its location on Field Plan]

1.4 DETAILS OF WASTE [ONLY ONE WASTE PER FORM]

Indicate which type of waste is to be spread	**[Tick box]**
Part 1	
Waste soil or compost	[ ]
Waste wood, bark or other plant matter	[ ]
Part 2	
Waste food, drink or materials used in or resulting from the preparation of food or drink	[ ]
Blood and gut contents from abattoirs	[ ]
Waste lime	[ ]
Lime sludge from cement manufacture or gas processing	[ ]
Waste gypsum	[ ]
Paper waste sludge, waste paper and de-inked paper pulp	[ ]
Dredgings from any inland water	[ ]
Textile waste	[ ]
Septic tank sludge	[ ]
Sludge from biological treatment plants	[ ]
Waste hair and effluent sludge from a tannery	[ ]

1.5 PROCESS FROM WHICH WASTE ARISES [Except in the case of septic tank sludge]

Process from which waste originated:

Producer:

General description and physical nature of the waste:

1.6 QUANTITY

Quantity to be spread **[Single spreading]**: **tonnes**

or

Quantity to be spread **[Six month period]**: **tonnes**

1.7 LOCATION OF SPREADING

[Show the location(s) where waste is to be spread on Field Plan]

SECTION 2 - ADDITIONAL PROVISIONS AND TERMS OF EXEMPTION

The following information will be necessary in order to establish that the activity is carried out in accordance with the provisions of Regulation 17 and the conditions and limitations contained in paragraph 7 of Schedule 3 to the Waste Management Licensing Regulations 1994. In order to discharge these functions a Waste Regulation Authority may, under Section 71 of the Environmental Protection Act 1990, require such information to be furnished to it.

2.1 DETAILS OF SITE

Occupier:

Address:

Telephone number: OS Grid Reference [**Six figure**]:

Location Plan attached: **Yes / No / Previously supplied***

2.2 BENEFIT TO AGRICULTURE OR ECOLOGICAL IMPROVEMENT AND POLLUTION RISK ASSESSMENT

Has benefit to agriculture or ecological improvement and pollution risk been determined on the basis of Properly Qualified Advice (PQA)? **Yes / No***

Determination of benefit to agriculture or ecological improvement and pollution risk assessment attached: **Yes / No / Previously supplied***

Does a Farm Waste Management Plan exist for the site? **Yes / No***

Farm Waste Management Plan attached: **Yes / No / Previously supplied***

Appropriate chemical analysis based on PQA attached [**Except septic tank sludge**]: **Yes / No / Previously supplied***

Microbiological analysis based on PQA attached [**Where appropriate**]: **Yes / No / Previously supplied***

[Complete Parts A to E if the information has not been otherwise supplied]

PART A FIELD PLAN

Field Plan attached: **Yes / No / Previously supplied***

Mark position on Field Plan of the following features on and within the vicinity of the spreading area:

- Watercourses, wells, ponds, boreholes, field drains, springs, private water supplies **(Blue)**
- Mineshafts and adits, bell pits, swallow holes, etc. **(Purple)**
- Down gradients **(Arrowed)**
- Houses (within a minimum distance of 400m)

Mark spreading areas by dividing and colouring Field Plan into the following categories:

Non Spreading Areas:	**RED**	High Risk Areas:	**YELLOW**
Very High Risk Areas:	**ORANGE**	Low Risk Areas:	**GREEN**

PART B FIELD INFORMATION

OS Field No	Total area [ha]	Area available for spreading [ha]	Previous crop	Next crop	Special requirements
Total areas	[ha]	[ha]			

PART C SOIL INFORMATION

OS Field No	Topsoil type	Topsoil depth	Subsoil type	Subsoil depth	Soil analysis attached?
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*
					Yes / No / Previously supplied*

PART D APPLICATION METHOD

Surface spreader: **Yes / No*** Direct injection: **Yes / No***

Rain gun: **Yes / No*** Fixed irrigation: **Yes / No***

Theoretical maximum application rate: **tonnes per hectare**

Frequency of spreading: **Daily / Weekly / Monthly***

PART E OTHER WASTES APPLIED WITHIN THE LAST 12 MONTHS [OR TO BE APPLIED]

Description:

Quantities: **tonnes per hectare**

2.3 DECLARATIONS

Person who is to undertake the waste spreading

I declare that the information provided is true to the best of my knowledge. The application of wastes are in accordance with current Codes of Practice and the types and quantities of wastes submitted to this activity, and the methods of waste recovery, are consistent with the need to attain the objectives mentioned in paragraph 4(1)(a) of Schedule 4 to the Waste Management Licensing Regulations 1994.

Full name:.. Position:...

Signature:.. Date:..

Person who occupies the land

I declare that I consent to the spreading of the above waste on land which I occupy.

Full name:.. Position:...

Signature:.. Date:..

Activity of benefit to agriculture - Properly Qualified Person

I declare that on the basis of the information provided, and subject to adherence to all Codes of Good Agricultural Practice, that the exempt activity concerned will result in Benefit to Agriculture or Ecological Improvement, and the methods of waste recovery are consistent with the need to attain the objectives mentioned in paragraph 4(1)(a) of Schedule 4 to the Waste Management Licensing Regulations 1994

Full name:.. Qualifications:...

Signature:.. Tel:.................................... Date:...............................

WASTE RETURN FORM

Complete and return this form to your Local Environment Agency Office:

i)	**In the case of a single spreading:**	Within 28 days of spreading
ii)	**In the case of regular or frequent spreading:**	Within 28 days of the end of the six month period **or** at the time of the renewal of any exemption **whichever is the sooner**

DETAILS OF SPREADER/ DATE OR SIX MONTH PERIOD OF SPREADING ACTIVITY

Name:

Address:

Telephone No: Fax No:

Single spreading: .... [Date] Six month period: From .... [Date] To .... [Date]

DETAILS OF SITE

Agency Ref. No: Site Name:

Landowner/occupier:

Address:

Telephone No: OS Grid Reference [**Six figure**]:

OS Field No	**Spreading area (ha)**	**Total tonnage spread**	**Waste type(s)**
			Continue over if necessary

DECLARATION

I declare that the information provided is true to the best of my knowledge. The application of waste was undertaken in accordance with the current Codes of Practice and the types and quantities of waste submitted to the activity, and the methods of recovery, were consistent with the need to attain the objectives mentioned in paragraph 4(1)(a) of Schedule 4 to the Waste Management Licensing Regulations 1994.

Signed:... **Date:**..

OS Field No	Spreading area (ha)	Total tonnage spread	Waste type(s)

DECLARATION

I declare that the information provided is true to the best of my knowledge. The application of waste was undertaken in accordance with the current Codes of Practice and the types and quantities of waste submitted to the activity, and the methods of recovery, were consistent with the need to attain the objectives mentioned in paragraph 4(1)(a) of Schedule 4 to the Waste Management Licensing Regulations 1994.

Signed:... Date:..

LANDSPREADING OF CONTROLLED WASTE

PLEASE READ THIS GUIDANCE NOTE BEFORE COMPLETING THE LANDSPREADING PROFORMA

Under Regulation 17 of the Waste Management Licensing Regulations 1994 the spreading of specific wastes listed in the regulations, on land used for agriculture is exempt from the licensing requirements of the Environmental Protection Act 1990, subject to the following conditions.

a) No more than 250 tonnes or, in the case of dredgings from inland waters, 5000 tonnes of waste per hectare are spread on the land in any period of 12 months (*These limits are reserve ceilings. On most land and for most of these wastes quantities approaching these figures are most unlikely to be within the other constraints of the exemption*);
b) the activity results in benefit to agriculture or ecological improvement; and
c) the establishment or undertaking spreading the waste furnishes to the Waste Regulation Authority in whose area the land is situated, the following particulars, in a case where there is to be a single spreading, in advance of carrying out the spreading; and in a case where there is to be regular or frequent spreading of waste of a similar composition, every six months or, where the waste is of a description different from that last notified, in advance of carrying out the spreading.

The particulars referred to are:-

i) the establishment or undertakings name and address, and telephone or fax number;
ii) a description of the waste, including the process from which it arises;
iii) where the waste is being or will be stored pending spreading;
iv) an estimate of the quantity of the waste or for multiple deposits, an estimate of the total quantity of waste to be spread during the next six months; and
v) the location, and intended date, or in the case of multiple deposits, the frequency, of the spreading of the waste.

Waste may be stored on the land on which it is to be spread provided that the waste is stored in a secure container or lagoon (or in the case of dewatered sludge, in a secure place, and for other than septic tank sludge or dewatered sludge, no more than 500 tonnes is stored in any one lagoon or container. A secure lagoon, container or place is one which is secure in relation to waste kept in it if all reasonable precautions are taken to ensure that the waste cannot escape from it and members of the public are unable to gain access to the waste. Any container used should be maintained so as to prevent leakage and any lagoon designed and constructed to meet the requirements of the Code of Good Agricultural Practice for the Protection of Water.

Any spreading or storage of waste must be undertaken without endangering human health and without using processes or methods which could harm the environment and in particular without:-

i) risk to water, air, soil, plants or animals; or
ii) causing nuisance through noise or odours; or
iii) adversely affecting the countryside or places of special interest.

The activity must be carried on by or with the consent of the occupier of the land where the activity is carried on; or the person carrying out the exempt activity is otherwise entitled to do so on that land.

The activity must result in benefit to agriculture or ecological improvement. Guidance from the Department of the Environment (Circular 11/94, para. 5.74) and the Welsh Office (Circular 26/94, para. 5.74) states that all application of waste materials to soil should be in quantities and at frequencies which convey a positive benefit. In order to keep within the terms of the exemption it will be **essential** to establish on the basis of **Properly Qualified Advice (PQA)** what application rate is appropriate for each **waste material**, each **soil** and each **site.**

To ensure that the conditions and limitations of exemption have been satisfied the Agency require information to be furnished in order to demonstrate that benefit to agriculture or ecological improvement has been determined and that a pollution risk assessment has been undertaken prior to the commencement of the spreading activity by a **Properly Qualified Person.** The information required includes, amongst others, an appropriate and representative chemical analysis of the waste to be spread and the receiving soil, a location plan and a field plan. An appropriate and representative chemical analysis for septic tank sludge will not be required where the sludge is spread at a rate no greater than $120m^3$/ha in any period of twelve months. However, quantities of septic tank sludge approaching that figure may not be within the other constraints of the exemption and proper qualified advice should be sought

Details of Agricultural Agencies and other Advisory bodies properly qualified to give advice on these matters may be obtained from your MAFF Regional Service Centre. If a Farm Waste Management Plan already exists for the recovery of farm produced wastes this should be modified to incorporate and assess the effects of any controlled wastes being spread onto the same land.

You should retain sufficient copies of the completed landspreading proforma, analysis, sample reports, location and field plans, to ensure that the relevant information contained in them is available at any time to yourself, your employees on site, the occupier of the land and Agency Officers.

The completed landspreading proforma will be subject to an internal consultation programme. A copy will also be forwarded externally to the District Council Environmental Health Department and English Nature (Countryside Council for Wales), where appropriate. External consultees may comment directly on aspects of the proposed spreading.. It is in your interests to give sufficient time for any comments to be made by the Agency or either of the other bodies before spreading the waste as you may commit an offence by failing to ensure that the activity is conducted in a manner without risk to the environment or without endangering human health. However, the failure of either the Agency or other bodies to respond should not be taken as approval of the method of the proposal and the completion of the landspreading proforma does not remove any obligation under other legislation to consult with or notify the Agency or any other body. If you are in any doubt of the suitability of the land then you should contact the appropriate body.

The spreading of liquid and other organic wastes onto agricultural land can cause serious water pollution if due consideration is not given to the location and method of application. The MAFF Code of Good Agricultural Practice for the Protection of Water describes the methods of application, circumstances under which waste must not be spread and the various steps to take to avoid the risk of water pollution. You MUST read this Code of Practice before applying any waste to land. Copies of the Code of Practice together with those for the protection of Soil and Air, may be obtained free of charge from MAFF Publications London SE99 7TP or telephone 081 697 8862.

The Sludge (Use in Agriculture) Regulations 1989 apply to the spreading of sewage sludge (the residual sludge from a sewage treatment works) onto agricultural land. They aim to prevent substances that could be potentially toxic from building up in the soil and to prevent possible spread of disease and are again supported by a Code of Practice. Sewage sludge is available in both raw and digested forms. Raw sludge must be incorporated into the land as soon as practical after application. The regulations also control the grazing of animals and the harvesting of crops on land on which sludge has been spread.

Many domestic and commercial premises in isolated areas are not connected to the mains drainage but are served by the means of septic tanks and cesspits. Although the residual sludge from a septic tank may be spread on land, often these tanks are incorrectly installed or poorly maintained so that they operate as a cesspit in that waste contained in them is untreated and should be treated as raw sewage. Raw sewage cannot be spread onto agricultural land under the terms of the exemption and it is recommended that such waste is disposed of at a sewage treatment works. Even when suitable for land spreading, septic tank sludge must be screened to remove plastic and rubber debris prior to spreading and the waste incorporated into the soil. The restrictions on grazing and harvesting of crops apply.

As well as pollution to water the disposal of organic wastes to land can cause offensive smells. Waste should be applied in such a way as to minimise any smell problem.

Controlled wastes spread onto agricultural land under this exemption are subject to the Duty of Care imposed by Section 34 of the Environmental Protection Act 1990, and Waste Transfer Notes should therefore be completed and retained in respect of controlled wastes recovered through these activities onto agricultural land.

The Agency require a return of the actual amounts of waste spread per hectare of land during the six month notification period, or in the case of a single deposit, the amount deposited. The information is required to ensure that in any period of twelve months the established theoretical maximum application rate, based on **Proper Qualified Advice (PQA),** for each **waste material**, each **soil** and **site** has not been exceeded.

If the waste is being spread on land not being used for agriculture then this may require PLANNING PERMISSION and a WASTE MANAGEMENT LICENCE. Further information on this can be obtained from the Local Planning Authority and the Agency.

The spreading or storage of waste in contravention of the Environmental Protection Act 1990 may constitute an offence which on summary conviction may result in a fine of up to £20,000.

Other Legislation and Guidance Affecting the Spreading of Waste on Agricultural Land

Environmental Protection Act 1990

Section 33(1)c
This section prohibits the deposit of Directive Waste in such a manner that it is likely to cause pollution of the environment or harm to human health.
Section 34
This section places a duty on anyone who produces, stores, transports, handles or disposes of Directive Wastes to ensure that all reasonable steps are taken by them and anyone to whom they pass waste, to ensure Section 33(1) is not breached.

Water Resources Act 1991
Requires consent from the National Rivers Authority for discharge into or onto land from fixed plant.

The Sludge (Use in Agriculture) Regulations 1989

The Sludge (Use in Agriculture) (Amendment) Regulations 1990
These regulations govern the spreading of sewage and sewage sludge on agricultural land and require regular analysis of sludge and soil and the maintenance of records.

Control of Pollution (Silage, Slurry and Fuel Oil) Regulations 1991
These regulations govern the storage of silage liquor, slurry, other farm wastes and fuel on farms.

Controlled Waste Regulations 1992
Defines controlled waste for the purpose of Environmental Protection Act 1990.

In addition the following documents should be acquired.

Code of Practice for Agricultural Use of Sewage Sludge (DoE) 1989
ADAS Booklet 2200 Advice on Avoiding Pollution from Manures and Other Slurry Wastes (MAFF) 1983
Code of Good Agricultural Practice for the Protection of Water (MAFF) 1991
Code of Good Agricultural Practice for the Protection of Air (MAFF) 1992
Code of Good Agricultural Practice for the Protection of Soil (MAFF) 1993
Policy and Practice for the Protection of Groundwater (NRA) 1992
Fertiliser Recommendations for Agriculture and Horticultural Crops, Sixth Edition (MAFF) 1994

APPENDIX C ON-LINE DATABASE SEARCH OF WASTE CATEGORIES LISTED IN THE WASTE MANAGEMENT LICENSING REGULATIONS

C1 SEARCH RATIONALE

A search rationale was developed which specified the various types of waste of interest and the application to land for agricultural use or in reclamation or remediation. Information relating to the possible use of certain waste by-products as animal or fish feeds was excluded. Radionuclide wastes were also excluded from the search strategy because an initial assessment had shown that a number of citations concerning radioactivity were being abstracted under the general description of 'waste'. Individual searches were formulated for each of the specified wastes as follows:

- Blood, guts or abattoir
- Meat, food or drink
- Cement or gas
- Lime
- Gypsum
- Paper or pulp
- Dredgings
- Textiles
- Septic tank sludge or septage
- Hair or tannery

Although pharmaceutical and biotechnology wastes are not included in Part II of the 1994 Waste management Licensing Regulations, it is possible that certain types of waste from these industries may have potential for beneficial use *via* land application. Consequently, it was considered worthwhile also to obtain information concerning these waste products as an additional feature of the search strategy.

Part II of Table 2 of the regulations also specify sludges from biological treatment plants. There is a vast literature available on sludge in the abstracting databases. Consequently, it was necessary to adopt a search strategy which excluded information relating to sewage sludge, compost and the other waste categories listed above.

The final search looked at the possible classification and suitability of land for receiving different types of waste.

C2 DESCRIPTION OF DATABASES IN ON-LINE LITERATURE SEARCH

The world-wide scientific literature compiled within seven of the major international abstracting databases were scrutinised by an 'on-line' computer search using the search strategies described in the next section. The selected databases held information on agriculture, environment, engineering and water which were considered likely to be relevant to land application of industrial and other wastes. The following descriptions give a brief outline of each database and the nature of the information they contain. The various databases were linked together allowing the abstracted information to be screened simultaneously during the 'on-line' search procedure.

AGRICOLA

The AGRICOLA database of the US National Agricultural Library provides comprehensive coverage of world-wide journal literature and monographs on agriculture and related subjects from 1979 onwards. Related subjects include: animal studies, botany, chemistry, fertilisers, forestry, hydroponics and soils etc.

AGRIS International

The AGRIS International database serves as a comprehensive inventory of world-wide literature of published research results on food production and rural development. The file corresponds in part to *AgrIndex*, published by the Food and Agriculture Organisation. Subjects covered include: general agriculture; geography; education, extension and advisory work; legislation; economics, development and rural sociology; plant production; forestry; animal production; natural resources; food sciences; human nutrition and pollution. The coverage is from 1975 to the present.

BIOSIS Previews

BIOSIS Previews contains over 8.3 million citations from 1969 to the present from *Biological Abstracts* and *BioResearch Index*. Together, these constitute the major English-language service providing comprehensive world-wide coverage of research in the biological and biomedical sciences. *Biological Abstracts* includes approximately 280 000 accounts or original research per year from nearly 7600 primary journal and monograph titles. *Biological Abstract/RRM* includes an additional 260 000 citations a year from meeting abstracts, reviews, books, notes, letters, selected institutional and government reports, and research communications.

CAB ABSTRACTS

CAB ABSTRACTS is a comprehensive file of agricultural and biological information and contains all records in the 26 main abstract journal published by CAB International covering 1972 to the present. Over 8500 journals in 37 different languages are scanned for inclusion, as well as books, reports, theses, conference proceedings, patents, annual reports and guides. The journals included in CAB cover all aspects of agriculture and animal science.

Ei Compendex* Plus

The Ei Compendex* Plus database is taken from *The Engineering Index*, which provides abstracted information from the world's significant literature of engineering and technology. The database provides world-wide coverage of approximately 2600 journals and selected government reports and books from 1970 to the present. Relevant subjects include environmental and biological engineering.

Enviroline

This database covers more than 5000 international primary and secondary source publications reported on all aspects of the environment from 1971 to the present. Included are such fields as management, technology, planning, law, geology, biology and chemistry as they relate to environmental issues. Literature coverage includes periodicals, government documents, industry reports, proceedings of meetings and monographs.

Pollution Abstracts

Pollution Abstracts is a leading resource for references to environment-related literature on pollution, its source, and its control covering 1970 to the present. Among the subjects included in the database are: air pollution, environmental quality, solid wastes and water pollution.

Wasteinfo

This database is produced by the Waste Management Information Bureau, Harwell Laboratory and contains references from 1973 on all aspects of non-nuclear waste management with extensive coverage in the areas of waste treatment and disposal, waste recycling, environmental hazards of wastes, waste management policy, guidelines, legislation and economics.

APPENDIX D EVALUATIONS OF EXEMPTED AND OTHER WASTES

Introduction

D1 Waste soil or compost

D2 Waste wood, bark or other plant matter

D3 Waste food, drink or materials used in or resulting from the preparation of food or drink

D4 Blood and gut contents from abattoirs

D5 Waste lime and lime sludge from cement manufacturing or gas processing

D6 Waste gypsum

D7 Paper waste sludge, waste paper and de-inked paper sludge

D8 Dredgings from any inland waters

D9 Textile wastes

D10 Septic tank sludge

D11 Sludge from biological treatment plants

D12 Waste hair and effluent treatment sludge from a tannery

D13 Other wastes

INTRODUCTION

Analytical data

Analytical data in Appendix D was obtained from the analysis of waste materials carried out by ADAS for the waste recycling contractor, Transorganics Ltd, over a period of ten years. Since these data are derived from only a limited number of the total number of potential sources of these wastes in the UK, they may not be entirely representative but should provide a broad indication of the composition of the wastes.

Units are kg m^{-3} wet volume for nutrients, mg l^{-1} wet volume for BOD and mg kg^{-1} dry solids (ds) for potentially toxic elements. Other units are as indicated in the Tables.

The number of waste samples analysed each year is shown below:

Year	**Number of samples analysed**
1986	4
1987	43
1988	31
1989	63
1990	85
1991	94
1992	134
1993	126
1994	130
1995	136
1996	100
Total	**946**

The data has been presented in the following way:

- Tables of data show the analyses of wastes falling within the categories of the exemptions in the WMLR 1994 and other wastes which are landspread but are not exempt. Where possible, exempt wastes have been further sub-divided into categories as appropriate.

- The general suite of analysis presented has remained relatively consistent since 1986. However, not all waste materials were analysed for all of the elements on each occasion, hence the differences in the numbers of samples represented for each determinand in the tables. Also some of the determinands identified in the report as being necessary to determining benefit or disbenefit have not been analysed.

- The minimum **(Min)** value in the tables is the lowest value in the range for each determinand. For N, NH_4-N, P_2O_5, K_2O and Mg, a value of 0 indicates <0.1 kg m^{-3} in the wet waste. For Cu, Zn, Ni, Cd, Pb, Cr and Hg, the following values were the lowest measured detection limits in the wet waste (mg kg^{-1} ds):

Cu	<1.0
Zn	<1.0
Ni	<1.0
Cd	<0.25
Pb	<1.0
Cr	<1.0
Hg	<0.01

For this reason, no statistics were possible on the datasets with significant numbers of < values.

- The **Median,** or 50 percentile, is the middle number (or average of the two middle numbers) in an ordered sequence of the dataset for each determinand. Since data from the analysis of wastes is generally skewed to high values, the median value characterises such data better than the arithmetic mean. When analysing wastes, there will tend to be a few high values which results in the arithmetic mean often being much higher than the median.

- The arithmetic **Mean**

- The maximum **(Max)** value in the tables is the highest value in the range for each determinand. The skewedness of data may also be shown by presenting the 90 percentiles.

- The **Standard Deviation** is a measure of how widely the values are dispersed from the mean for the dataset.

Analysis

Two categories are used to indicate whether analysis is recommended (Y) or may not be necessary (N). Wastes have to be assessed according to origin and there may be samples that do need to be analysed, for instance for Red List compounds, although in most cases for that generic type of waste this would be unnecessary. Because of the nature of waste materials, there is no definite, objective basis for deciding what determinands should or should not be analysed for any particular waste stream. PQA may be needed to remove uncertainty in the initial assessment of the suitability of a waste for landspreading. The assessment of the suitability of a waste for landspreading will require frequent sampling and analysis to begin with, to establish the quality and consistency of the waste. These results will provide a statistical basis for setting the subsequent monitoring and analysis routine for the waste to ensure that it is effectively monitored.

Principles of evaluation

The waste cited in each proposed exemption needs to be evaluated in terms of its benefits and disbenefits (Section 7) including compliance with Article 4 of Directive 91/156/EEC (Section 2.1), and this assessment combined with that of the proposed operation (Sections 7 and 9) as a basis for deciding whether the proposal complies with the need to demonstrate agricultural benefit or ecological improvement and therefore qualifies for exemption.

The description of each waste category begins with an outline of its potential benefits, disbenefits and best practice for landspreading. This is followed by a general discussion of its properties relevant to landspreading. The evaluator should always be aware that within each category of waste there is potential for substantial variability between and within streams and batches of waste.

D1 WASTE SOIL OR COMPOST

Potential benefits: The long term benefits from adding waste soil or compost to agricultural land result from the high organic matter in the compost with its benefits as a soil conditioner and use of waste soil as a soil-making material or substitute, for instance in land reclamation or levelling (see Section 7.1.1).

Potential disbenefits: The potential for other contaminants arising in waste soil and compost depends on the origin of the compost feed material, type of production process for compost, and the origin of waste soil. Vigilance is needed to detect soil from contaminated land which might be included in landspreading proposals because of the landfill tax and restrictions on what landfills will accept.

Best practice: Rate of application should take account of nutrient and contaminant content of the waste soil or compost, crop requirements for nutrients, and benefit as a soil conditioner.

Waste soil or compost, and waste wood, bark or other plant matter can be spread on certain categories of land without registering with the Agency. These are:

- Operational land of a railway, light railway, internal drainage board or the National Rivers Authority; and
- land which is forest, woodland, park, garden, verge, landscaped area, sports ground, recreation ground, churchyard or cemetery.

This exemption is provided so long as benefit to agriculture or ecological improvement results and no more than 250 t ha^{-1} of waste are spread on the land in any period of 12 months. It is understood that this is to enable the management of such land to continue without unnecessary controls since the wastes concerned can be expected to be produced or used in the routine maintenance of such sites.

Table D1 indicates a suggested evaluation programme for waste soil or compost prior to landspreading. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D1 Waste soil or compost

ANALYSIS	**Soil**	**Compost**
Major nutrients	Y	Y
pH + solids	Y	Y
BOD	N	N
Microbiological	N	N
Electrical conductivity and sodium	Y	Y
Calcium carbonate (%)	Y	Y
Oil/fat	N	N
Red List	N	N
PTEs	Y	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Soil is the medium in which plant roots live and grow and from which they absorb water and mineral nutrients (Agricultural Advisory Council 1970). Soil may also be defined as a mixture of mineral matter, organic matter, water and air (Foth and Turk 1972). The volume occupied by each of these in a soil in ideal condition for plant growth will be approximately as follows: mineral matter 45%; organic matter 5%; water 25%; and air 25% (Foth and Turk 1972). The number of different soils is very large, a point which the Agricultural Advisory Council (1970) illustrated as follows: Soils differ from each other in many ways that are important to farming. They can differ in altitude, aspect, slope, parent material, amount of stone, amount of chalk, organic matter, depth, texture, structure, permeability, consistence, drainage, weather and treatment they receive. If there were only two variants of each of these fifteen factors, 2^{15} = 32 768 different soils would be possible, and if there were three variants, 3^{15} = 14 348 000 different soils would be possible. Thus soil is very variable within the broad definition of a medium in which plants can survive and which includes a mixture of mineral matter, organic matter, water and air.

Topsoil is defined as the 'Upper layer of an in situ soil profile, usually darker in colour and more fertile than that below (subsoil) and which is a product of natural biological and environmental processes'(BS 3882:1994). It can usually be clearly defined from a less organic, lighter coloured subsoil. BS 3882:1994 provides a sampling and analytical procedure to provide a 'Specification for Topsoil'. This includes:

- sampling techniques;
- analytical methods and interpretation for pH, Extractable P, K, Mg, Total N, calcium carbonate content, electrical conductivity and exchangeable Na percentage as well as soil structure, stone content and textural classification; and
- recommendations for use and handling of topsoil.

The Organic Reclamation and Composting Association (ORCA) produced an informative report on composting in December 1992. This was ORCA Technical Publication Number 2, ' A review of compost standards in Europe'. The report observed that definitions of compost and composting vary widely in the legislation and the non-legislative standards that have been established. The basic process of composting is decomposition of organic residues by micro-organisms. Usually, this is achieved by aerobic conditions at an elevated temperature in such techniques as aerated static piles, turned windrows and in-vessel reactor systems. Properly stabilised compost should be odour-free and suitable for use as a soil conditioner. It does not contain much plant-available nitrogen. Total content of nitrogen is likely to be about 2% ds basis. For materials of this kind there are grounds for rates of application to exceed 250 kg N ha^{-1} y^{-1} (the MAFF recommended limit for organic fertilisers, COGAP/W 1991) in order to achieve agricultural benefit from the soil conditioning effect.

Composting of wastes is likely to increase substantially because of recycling targets, the landfill tax and probable restrictions on the placement of biodegradable materials in landfills. The current situation is reviewed by Walker (1997) (see Section 8.3).

Waste soil and compost can originate from a variety of sources and locations. The source of the soil can range from green belt agricultural land to land development projects in urban areas. The soil can, therefore, vary between high quality to grossly contaminated. It is difficult to differentiate between these two extremes by a visual assessment. Also, it is often difficult to tell the difference between topsoil and subsoil.

Soils from an uncertain origin may need to be analysed for contaminants indicated in the 'Guidance on the Assessment and Redevelopment of Contaminated Land' (ICRCL 1987).

Compost can be derived from a wide range of materials such as:

- Green waste;
- municipal solid waste;
- organic industrial wastes;

- horticultural wastes;
- agricultural wastes; and
- sewage sludge.

Various quality standards for contaminants are relevant to the landspreading of waste soil or compost. The ORCA (1992) report referred to above includes a review of compost standards in Europe. The CEC (1994) has set out eco-labelling criteria for soil improvers. Some of these standards are compared in Table D2. The DoE Code of Practice (1996) provides suitable guidance for landspreading of waste soil and compost.

Inherently, any pathogenic agents and distributive stages of parasites should be at background levels normal for soil impacted by wildlife, including birds. No health problems should result from applying these wastes to agricultural land, with the following exceptions:

- Soil from land which has been occupied by livestock suffering from an outbreak of a notifiable infectious disease. The following infectious animal diseases are covered by the Animal Health Act 1981:

  - Foot and mouth disease;
  - swine vesicular disease;
  - fowl plague;
  - Newcastle disease;
  - swine fever;
  - African swine fever;
  - anthrax;
  - tuberculosis;
  - brucellosis;
  - equine infectious anaemia;
  - Dourine;
  - rabies;
  - Teschen disease (encephalomyelitis of pigs);
  - bovine spongiform encephalopathy (BSE);
  - Aujesky's disease;

- seed potatoes and nursery stock of potatoes and of bulbs for export must be grown in soil certified to be free of infection by the potato cyst nematodes, *Globodera* species. These parasites are widely distributed in most soils, particularly where potatoes have been grown. It follows that waste soil or compost should not be applied to land used for raising seed potatoes and bulbs, or to land where transplanted crops are being grown in rotation with seed potatoes;

- other plant diseases that should be considered in assessing waste soil are white rot of onions and the presence of honey fungus (*Armillaria*); and

- weed seeds may occur in waste soil or poorly stabilised compost.

Table D2 Some examples of quality standards for PTEs (mg kg^{-1} DM)

Standard	Zn	Cu	Ni	Cd	Pb	Hg	Cr
Eco-label soil improvers (CEC 1994)	300	75	50	1.5	140	1	140
USEPA clean sludge* (USEPA 1993)	2800	1500	420	39	300	17	1200
EC Directive - soil (CEC 1986)	150 - 300	50 - 140	30 - 75	1 - 3	50 - 300	1.0 - 1.5	-
EC Directive - sludge (CEC 1986)	2500 - 4000	1000 - 1750	300-400	20 - 40	750 - 1200	16 - 25	-
DoE Code of Practice - soil (DoE 1996)	200-300**	80 - 200**	50 - 110**	3	300	1	400
Background soil (Ure and Berrow 1982)	60	26	34	0.6	29	0.1	84

* Considered suitable for cumulative loadings of at least 1000 t ha^{-1} ds
** Variable according to soil pH level

D2 WASTE WOOD, BARK OR OTHER PLANT MATTER

Potential benefits: The long-term benefits from adding waste wood, bark or other plant matter to agricultural land results from the high organic matter content of the wastes. Immediate benefit can be obtained by using chipped wood or bark as a mulch to discourage weed growth and conserve soil moisture.

Potential disbenefits: The potential for other contaminants arising in waste wood, bark or other plant matter depends on the nature of the production process. Sawdust can contain wood preservatives and pesticides such as pentachlorophenol and lindane and a precautionary analysis for organic contaminants should be undertaken unless the waste producer can give an assurance that the waste is free of preservatives. Other chemicals such as copper chrome arsenate have been used in the past for wood preservation.

Best practice: The presence of contaminants should be investigated and PQA should be sought where there is uncertainty as to the quality of the product. Application to land of wood products with a high C/N ratio can temporarily remove plant-available nitrogen from the soil. Additional inorganic nitrogen should be applied to the soil to compensate for this and avoid crop yield and quality loss. The principal agricultural benefit will be as a soil conditioner.

Waste wood, bark or other plant matter can be spread on certain categories of land without registering with the Agency. These are described in Appendix D1, above.

Table D3 indicates a suggested evaluation programme for waste wood, bark or other plant matter prior to landspreading. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested. Some operational analyses are given in Table D4.

Table D3 Waste wood, bark or other plant matter

ANALYSIS	Waste wood, bark or other plant matter
Major nutrients	Y
pH + solids	Y
BOD	N
Microbiological	N
Electrical conductivity and sodium	N
Calcium carbonate (%)	N
Oil/fat	N
Red List	N (Y if preservatives likely)
PTEs	N (Y if preservatives likely)

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

The same criteria should be adopted for this category of waste as for waste soil or compost. Waste can originate from the following sources:

- Timber yards - sawdust and shavings;
- municipal parks and gardens;
- any processing of vegetable matter such as sugar beet, vegetables, green waste;
- chipboard, fibreboard and MDF processing;
- pallets; and
- reclaimed timber from building sites and packing crates.

Table D4 Waste wood bark or other matter

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	3	1.0	38.7	31.5	54.9	27.7
pH	3	4.1	5.0	5.8	8.4	2.3
N (kg m^{-3})	3	0.0	2.5	4.0	9.5	4.9
NH_4N (kg m^{-3})	3	0.0	0.0	0.8	2.5	1.4
P_2O_5 (kg m^{-3})	3	0.0	0.0	0.2	0.5	0.3
K_2O (kg m^{-3})	3	0.0	0.2	0.6	1.5	0.8
Mg (kg m^{-3})	3	0.0	0.0	0.3	1.0	0.6
Cu (mg kg^{-1})	2	3.1	4.8	4.8	6.4	2.3
Zn (mg kg^{-1})	2	14.6	18.5	18.5	22.3	5.4
Ni (mg kg^{-1})	3	<1	<1	0.3	<1	
Cd (mg kg^{-1})	2	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	3	<1	3.6	2.4	3.7	
Cr (mg kg^{-1})	3	<1	<1	3.3	9.9	
Hg (mg kg^{-1})	3	<0.01	<0.01	<0.01	<0.01	
BOD (mg l^{-1})	2	3000	5500	5500	8000	3536

Waste wood and bark are inherently free from animal pathogens and those likely to be of concern to food crops.

The nature and origin of waste plant matter needs to be considered, in case diseased material is present that could act as a source of infection for succeeding crops. Two particular examples are:

- Haulms and tubers of potatoes infected with the potato blight fungus, *Phytophthora infestans*. These must be burnt or disposed to landfill; and

- vegetable wastes, washing-waters and soil from farm and industrial washing, grading, packing and processing of imported vegetables should not be spread on agricultural land. This is to prevent the introduction and spread of the notifiable Rhizomania disease of sugar beet and other beetroot and fodder beet crops. Provisions for the safe treatment and disposal of such wastes from imported vegetables are given in a voluntary code of practice (MAFF 1985). It is understood that this Code is being revised. The new Code will cover the safe disposal of waste arising from imported and domestic plant material. Under this Code it is recommended that, as a precautionary measure, all waste should be treated if it is intended to spread it on agricultural land except where it is being returned to the field of origin. These precautionary measures are recommended in order to prevent the spread of a number of pests and diseases such as potato brown rot and Colorado beetle as well as Rhizomania. The Code was issued for public consultation in June 1995. It is understood that the title is to be 'Code of Practice for the Safe Disposal of Agricultural and Horticultural Waste' and is to be released by MAFF in 1997. See also reference to the Plant Health (Great Britain) Order 1993 above (Section 9.10).

D3 WASTE FOOD, DRINK OR MATERIALS USED IN OR RESULTING FROM THE PREPARATION OF FOOD OR DRINK

A recent review of composting food processing waste in the EU (de Bertoldi, 1995) estimated that more than 200 million t y^{-1} of food processing wastes are produced in the EU and these volumes are expected to increase in the future. Production of wastes at food processing factories may vary from 10 to 70% of the raw materials.

Wastes derived from the food and drink industry are by their very nature both relatively contaminant free and contain many potential plant nutrients. The levels of nutrients they contain, however, can cause harm if used inappropriately. Some of these wastes will have a high BOD with potential to cause water pollution or anaerobic conditions in soil.

It is important to consider the origin and processing of such wastes in assessing environmental risks when they are spread on land. For example:

- Some raw materials used for preparing food are inherently liable to contain enteric pathogenic bacteria, such as *Salmonella, E. coli O 157* and *Campylobacter* spp., or have been incriminated in the past for outbreaks of bacterial gastro-enteritis, e.g. dried egg, coconut and milk powder, animal and fish meals, waste offcuts of meat and "drip" from carcasses. Wastes deriving from such materials may also be prone to contamination;

- waste food, which has been cooked, can be assumed to be pathogen-free immediately after production. However, the potential for re-contamination by enteric pathogens, such as *Salmonella* and *Campylobacter* species is possible if the wastes are allowed to be browsed by rodents and scavenging birds;

- wastes from breweries and distilleries (e.g. spent barley, hops and yeast) can be considered pathogen-free by virtue of the processes to which they have been subjected and those from preparation of fruit juices (waste fruit pulp) and soft drinks by reason of their acidity.

There is a wide range of different industries associated with food production, examples of the main types of wastes they produce are discussed below.

D3.1 General food processing wastes

Table D5 indicates a suggested evaluation programme for general food wastes prior to landspreading. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific waste characteristics to be tested.

Table D5 Food processing wastes

ANALYSIS	Bio-sludge	Salty	Lime	Vegetable matter/soil	Oily	General
Major nutrients	Y	Y	Y	Y	Y	Y
pH + solids	Y	Y	Y	Y	Y	Y
BOD	Y	Y	Y	Y	Y	Y
Microbiological	N	N	N	N	N	N
Electrical conductivity and sodium	N	Y	N	N	Y	Y
Neutralising value (lime)	N	N	Y	N	N	N
Oil/fat	Y	Y	N	Y	Y	Y
Red List	N	N	N	N	N	N
PTEs	N	N	N	N	N	N

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Some typical analyses are given in Table D6.

Table D6 **Waste food, drink or materials used in or resulting from the preparation of food or drink - *general***

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	365	0.1	4.6	8.2	90.7	11.3
pH	364	2.8	5.6	5.8	12.8	1.7
N ($kg\ m^{-3}$)	365	0.0	1.6	3.5	31.2	4.8
NH_4N ($kg\ m^{-3}$)	316	0.0	0.1	0.5	7.6	1.0
P_2O_5 ($kg\ m^{-3}$)	349	0.0	0.7	1.2	13.8	1.8
K_2O ($kg\ m^{-3}$)	365	0.0	0.2	1.1	157.2	8.4
Mg ($kg\ m^{-3}$)	356	0.0	0.0	0.1	5.6	0.4
Cu ($mg\ kg^{-1}$)	261	<1.0	1.2	3.8	78.4	2.3
Zn ($mg\ kg^{-1}$)	262	<1.0	5.05	1.4	336	5.4
Ni ($mg\ kg^{-1}$)	362	<1.0	0.005	0.9	57.0	
Cd ($mg\ kg^{-1}$)	362	<0.25	<0.25	0.1	10.3	
Pb ($mg\ kg^{-1}$)	329	<1.0	<1.0	0.7	30.8	
Cr ($mg\ kg^{-1}$)	280	<1.0	<1.0	1.4	57.0	
Hg ($mg\ kg^{-1}$)	269	<0.01	<0.01	0.06	8.0	
BOD ($mg\ l^{-1}$)	339	1	11 700	23 000	260 000	33 753

D3.2 Dairy wastes

Table D7 indicates a suggested evaluation programme for dairy wastes which are to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested. Some operational analyses are given in Table D8.

Table D7 Dairy wastes

ANALYSIS	Whey/salty water	Bio-sludge
Major nutrients	Y	Y
pH + solids	Y	Y
BOD	Y	Y
Microbiological	N	N
Electrical conductivity and sodium	Y	N
Neutralising value (lime)	N	N
Oil/fat	Y	Y
Red List	N	N
PTEs	N	N

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Table D8 **Food, drink or materials used in or resulting from the preparation of food or drink - *dairy wastes***

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	54	0.2	3.7	5.3	23.7	5.5
pH	54	3.0	5.6	5.6	10.9	1.4
N ($kg\ m^{-3}$)	54	0.0	1.0	2.1	26.0	3.8
NH_4N ($kg\ m^{-3}$)	46	0.0	0.1	0.3	3.8	0.7
P_2O_5 ($kg\ m^{-3}$)	54	0.0	0.8	0.9	3.1	0.7
K_2O ($kg\ m^{-3}$)	54	0.0	0.2	0.5	6.6	1.0
Mg ($kg\ m^{-3}$)	54	0.0	0.0	0.05	0.4	0.1
Cu ($mg\ kg^{-1}$)	32	0.0	1.4	2.4	15.8	3.4
Zn ($mg\ kg^{-1}$)	44	0.1	3.7	1.7	209.0	39.8
Ni ($mg\ kg^{-1}$)	53	<1.0	<1.0	0.3	3.7	
Cd ($mg\ kg^{-1}$)	53	<0.25	<0.25	<0.25	0.5	
Pb ($mg\ kg^{-1}$)	48	<1.01	<1.0	5.8	250	
Cr ($mg\ kg^{-1}$)	44	<1.0	<1.0	0.4	8.9	
Hg ($mg\ kg^{-1}$)	40	<0.01	<0.01	<0.0106	0.14	
BOD ($mg\ l^{-1}$)	48	250	11 250	31 000	260 000	51 213

Below are characteristics of food wastes which should also be considered:

Sludge from biological treatment plants for food wastes

There is specific exemption in the WMLR 1994 for 'Sludge from biological treatment plants'. The food industry is investing increasingly in biological treatment of wastes to reduce the costs of discharges to sewers. This section addresses the components of food wastes which have an impact on landspreading of waste.

Potential benefits: The biological treatment of food wastes results in the partial conversion of plant nutrients, particularly N, from an organic into an inorganic form with much of the remaining N occurring in readily degradable bacterial floc so much of the N should be readily plant-available. Nitrogen, and ammonium nitrogen, are usually present in low to moderate amounts (>0.5 $kg\ m^{-3}$), whilst potassium and phosphorus contents are highly variable. The solids content is usually low, and the material is commonly applied as a liquid sludge. Waste that has received biological treatment can be more stable (less odorous) and will have a reduced (less potentially polluting) BOD.

Potential disbenefits: Some wastes can have a high nutrient and BOD content. Over application of these types of waste may cause anoxic soil conditions leading to crop growth problems and may potentially contaminate water. Assurance should be sought that the rate of application will be in accordance with crop requirements for nutrients.

Best practice: Since these wastes often contain a large quantity of nutrients a waste management plan for each site would be desirable. These types of waste are often applied as liquid sludges, and therefore the relevant Best Practice outlined in Sections 9.3 and 9.5 should be followed.

Salty wastes

This category of wastes can include yeast cell debris with a high protein content and salty whey from cheese manufacture and other processes using salt as a preservative. The salt content is usually in the from sodium and potassium chlorides but other compounds such as nitrate and sulphate can add to the electrical conductivity of a waste.

Potential benefits: Large concentrations of N, P and K (>1 kg m^{-3}) are often found. Sodium in particular can be present in moderate to high amounts. Both potassium and sodium can be used as plant nutrients by specific crops and PQA should be sought before application.

Potential disbenefits: Salty wastes can present specific soil and crop problems, if applied to soils under the wrong conditions. Salts added to soils can lead to soil structural damage, reduce the availability of soil water for plant uptake (induce artificial drought conditions) and can be toxic to plant growth. A limited number of crops require sodium (MAFF Ref Book 209). The most common problem arising through applications of salty wastes is the high soil electrical conductivity resulting from application in dry conditions. The highest risk period is in the dry summer months when grass swards are often injected with wastes.

Best practice: The application of salt should be limited to 600 kg ha^{-1}. On sandy soil where an arable or vegetable crop is to be grown the waste should not be applied less than six weeks before drilling.

Lime sludge (Sugar)

This type of waste originates from the processing of sugar cane and sugar beet. It usually contains large quantities of lime and is therefore highly beneficial on acidic soils. Other nutrients can be present, but usually in small amounts. The pH is usually in excess of 7.5 and the waste consists predominantly of calcium and magnesium carbonate with a proportion of calcium hydroxide also. The 'Neutralising Value' (NV - a measure of the agronomic liming value, where ground limestone and chalk have NVs of 50%) is in the range of 10-20% in the solids, varying with moisture content, and these wastes are a valuable replacement for agricultural lime. See Section 9.11.1.

Potential benefits: This value is recognised by the industry and the material can be sold as a 'product' to farmers to correct decline in soil pH value.

Potential disbenefits: The use of these wastes is little different from using agricultural lime. Over-application of lime applied to certain soils and crops can result in trace element deficiencies in crops and soils.

Best practice: These wastes should be applied at rates suitable to meet the lime requirement of acid soils. Soil analysis should be undertaken in order to confirm that the subsequent pH rise will be beneficial and advice should be sought on what types of soil are suitable for application and which are not. Lime sludges which contain other nutrients must only be applied at rates commensurate with the lime requirement of the soil.

Vegetable matter / soil

These wastes originate from the washing and preparation of vegetables. Nutrient contents are highly variable due to the many potential sources of such waste. Wastes are often dilute with solids contents of approximately 1%.

Potential benefits: Vegetable matter contains moderately high proportions of all three major nutrients; nitrogen, phosphate and potash, usually greater than 0.5 kg m^{-3}, in a non readily-available, organic form. Some materials may be stored for a period of time which allows the nutrients to breakdown as they are effectively digested or composted. This may increase nutrient availability slightly.

Potential disbenefits: Wastes from the processing of imported and home grown vegetables may contain a range of pests and diseases such as:

- purple root rot of carrot, parsnip or potatoes
- potato cyst nematode
- rhizomania

PQA should always be sought where there is potential risk of the spread of pests and diseases to land spread with waste. Diseased plant waste cannot be spread on agricultural land. The disposal of such waste is controlled by the Plant Health (Great Britain) Order 1993 which requires such material to be incinerated or disposed of to a landfill site. A guidance code is being prepared - see Section 9.10.

Best practice: With the potential for disease being high, the advice of a competent plant health consultant should be sought where there is doubt. To minimise the risk of spreading infectious diseases and pests, due account should be taken of the origin of the waste and the use of the land onto which the waste is to be applied.

Oily wastes

Oily wastes result from secondary treatment processes that segregate part of the oil/fat content of waste materials. Typical examples are wastes produced from chocolate manufacture, dairy processing, meat processing, rendering and oilseed crushers. This is usually achieved through a 'trap' where oils and other matter are 'skimmed' from the surface of the waste. Non-food oily wastes are classified as special wastes and are not exempted for landspreading.

Potential benefits: The solids content is highly variable depending on the industry resulting in a variable plant nutrient content according to origin. Some oily wastes, such as those produced from fish processing, can have a relatively high protein content and hence a high nitrogen content in excess of 1 kg m^{-3}.

Potential disbenefits: Oily wastes can have a similar effect in soils to that caused by high salt content. Above about 4% fat or oil content, in bioassays and in the field, detrimental effects have been demonstrated on plant growth. The oil or fat appears to coat the soil particles, effectively producing a waterproof barrier. Plant roots are not then able to extract water and stunting or die back results. Further additions of water do not result in any improvement as the water runs over the soil particles and very little is absorbed.

Best practice: Not enough is known about the type of fat or oil (vegetable or mineral) to quantify its effect on the soil and a simple analysis of fat or oil content is not sufficient to predict this. The oil or fat content should be measured in order to determine an acceptable application rate. Fatty or oily wastes should not be applied to land unless testing shows that the material does not cause harm.

Experience has shown that wastes containing more than 4% oil can cause adverse effects on plant growth. This will depend in particular on soil type, time of year and microbial activity.

General wastes

Potential benefits: These wastes can be highly variable, but agricultural benefit is gained due to their nitrogen content. This is found in dilute solutions of proteins and cell debris, but may also be derived from other biological wastes which are produced on site and mixed into the final waste. The low solids content (<2%) reflects the predominance of wash waters in this category, and therefore nutrients, other than nitrogen, are usually only present in small amounts, and benefit can be questionable.

Potential disbenefits: The potential for disbenefit is relatively low compared to some of the proceeding categories, mainly because of the predominance of wash waters in this category. There may, however, be moderate levels of salts and high nutrient components, such as blood, which if applied at rates exceeding crop requirements for nutrients could cause crop damage or water pollution.

Best practice: Analysis of nutrient content and then adjusting the rate of application to meet a particular crop requirement is essential as variations in waste composition may lead to patchy application and areas of poor crop growth. Such wastes should be well mixed to ensure a consistent product and applied on the basis of nitrogen content to meet the requirements of the crop, taking account of the need to avoid potential water pollution from hydraulic overloading of the soil. Conductivity and sodium content of the waste should be checked if the waste is from a process using salts, and the proposed rate of application adjusted accordingly.

D3.3 Brewery and soft drinks wastes

This category of the food industry produces large volumes of liquid wastes as a result of washing, or other processes that generate weak effluent. Although weak in an agricultural sense they are usually very high in BOD (10-40 000 mg l^{-1}) and are therefore expensive to discharge to sewer. BOD, unless extremely high, has little direct effect on soil.

The brewing and soft drinks industry produce large quantities of water which contain either carbohydrates or alcohol residues. Alcohol is a product of the fermentation of carbohydrates and is readily oxidised to weak organic acids. If left for any length of time both solutions of carbohydrates (sweet water) and alcohols will degrade to produce weak organic acids. The acids are weak in sense that they are poorly buffered and easily neutralised, but they can have a dramatic effect on the pH of the solution. Solutions at pH 7, if left for 24 hours, can easily degrade to a pH as low as 2.0. If material of such low pH is added to soil, it can have a severe stunting effect on crop growth. This is usually a short term effect as most soils will have a buffering capacity capable of dealing with such weakly buffered acid waste. However, to avoid any potential problems, waste producers should neutralise their wastes prior to collection.

Table D9 indicates a suggested evaluation programme for brewery and soft drinks wastes which are to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D9 Brewery and soft drinks wastes

ANALYSIS	Kieselguhr	Brewery	Trub/ yeast	Distillery	Bio-sludge	Soft drink
Major nutrients	Y	Y	Y	Y	Y	Y
pH + solids	Y	Y	Y	Y	Y	Y
BOD	Y	Y	Y	Y	Y	Y
Microbiological	N	N	N	N	N	N
Electrical conductivity and sodium	N	Y	N	N	Y	Y
Neutralising value (lime)	N	N	Y	N	N	N
Oil/fat	N	N	N	N	N	N
Red List	N	N	N	N	N	N
PTEs	N	N	N	N	N	N

Y = Analysis or evaluation is recommended N = Analysis or evaluation may be necessary

Some typical analyses are given in tables D10 and D11.

Table D10 Waste food, drink or materials used in or resulting from the preparation of food or drink - *brewing wastes*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	80	0.0	6.6	9.2	49.2	9.1
pH	80	2.3	5.0	5.8	-	4.5
N (kg m^{-3})	80	0.0	2.1	3.9	45.5	6.4
NH_4N (kg m^{-3})	78	0.0	0.0	0.2	1.9	0.3
P_2O_5 (kg m^{-3})	80	0.0	0.8	1.7	22.0	3.3
K_2O (kg m^{-3})	80	0.0	0.2	0.6	4.6	1.0
Mg (kg m^{-3})	80	0.0	0.0	0.2	7.0	1.0
Cu (mg kg^{-1})	45	0.2	3.7	3.1	314.0	78.1
Zn (mg kg^{-1})	64	0.2	3.8	9.9	163.0	22.4
Ni (mg kg^{-1})	80	<1.0	<1.0	2.4	154	
Cd (mg kg^{-1})	80	<0.25	<0.25	0.03	1.1	
Pb (mg kg^{-1})	78	<1.0	<1.0	1.3	63	
Cr (mg kg^{-1})	78	<1.0	<1.0	3.2	78	
Hg (mg kg^{-1})	78	<0.01	<0.01	<0.02	0.65	
BOD (mg l^{-1})	74	1000	11 750	18 000	92 100	19 539

Potential disbenefits: A watery waste may be unable to supply sufficient nutrients to achieve agricultural benefit except where use for irrigation (but not of growing crops or grassland) can be justified. It cannot be assumed that wash water is free of pathogens. The general comments on pathogens in D4 above apply.. Wash water can also contain caustic soda used as a cleaning agent in which case sodium content should be determined.

Best Practice: The same precautions as for blood and gut contents should apply to the use of wash water on the land. Application rates must be tailored very closely to crop requirements and the strength of the waste in question. Sodium content should be taken into account as necessary. It should not be used for crop irrigation or surface application to grassland. Rates of application should be moderate (50 m^3 ha^{-1}) and should not exceed the hydraulic loading capacity of the soil.

Table D15 Blood and gut contents from abattoirs - *wash water*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	14	0.1	6.4	7.8	21.9	6.8
pH	14	3.7	6.1	6.1	7.6	1.0
N (kg m^{-3})	14	0.2	2.4	3.2	9.0	2.7
NH_4N (kg m^{-3})	14	0.0	0.4	0.6	1.8	0.5
P_2O_5 (kg m^{-3})	14	0.0	1.2	1.3	2.9	1.0
K_2O (kg m^{-3})	14	0.0	0.3	0.4	1.2	0.4
Mg (kg m^{-3})	14	0.0	0.0	0.04	0.3	0.1
Cu (mg kg^{-1})	12	1.0	1.7	2.1	5.5	1.4
Zn (mg kg^{-1})	13	1.8	9.5	18.4	115.0	29.7
Ni (mg kg^{-1})	14	<1.0	<1.0	<1.0	4.35	
Cd (mg kg^{-1})	14	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	14	<1.0	<1.0	<1.0	1.5	
Cr (mg kg^{-1})	14	<1.0	<1.0	1.1	10.5	
Hg (mg kg^{-1})	14	<0.01	<0.01	<0.01	0.04	
BOD (mg l^{-1})	14	899	12 650	23 000	86 900	27 121

easily. The resulting mixture of wastes is probably one of the most agronomically beneficial examples of waste from the food industry.

Potential disbenefits: As kieselguhr wastes are often added to other waste liquors from the brewing process the resulting mixture may have a low pH value which should be adjusted back to pH 6-7 before landspreading.

Best practice: As these are generally high-nutrient wastes, a waste management plan for the site should be prepared.

Waste beer and wash water

Potential benefits: Due to the low solids content, this material is usually weak in nutrients (<0.1 kg m^{-3}), although some wash waters can have yeast present which provides a moderate nitrogen content. If applied in large quantities (i.e. in excess of 110 m^3 ha^{-1}) they can be beneficial.

Potential disbenefits: Waste beer and wash waters contain carbohydrates in solution. As a result they can become acidic unless neutralised.

Best practice: Nutrient content is usually low. This material should be not be applied to land of pH less than 5.5 unless the acidity of the waste has been neutralised by the addition of caustic soda or similar alkali material.

Trub and yeast waste

These types of waste contain the primary brewing materials and can be rich in brewers grains, malt and yeast debris.

Potential benefits: They can contain a large quantity of all the major plant nutrients and are highly beneficial. However, they are often either mixed with other wastes and landspread, or sold separately as animal feed.

Best practice: The nutrient content can be moderately high in these wastes. Where analysis shows this is the case a waste management plan should be prepared.

Distillery wastes

Distilleries produce large quantities of weak wash water without the addition of yeast or kieselguhr waste.

Potential benefits: Effluents are often very weak in nutrients. If applied in large quantities (i.e. in excess of 110 m^3 ha^{-1}) they can be beneficial.

Potential disbenefits: The distillery industry has traditionally used copper vessels in the brewing process and, as a result, copper is often found in this waste. Sludges can therefore have significant levels of copper.

Best practice: The heavy metal content of these wastes must be checked. The metal content of the soil where waste is to be deposited should be determined before the waste is spread, and attention paid to the statutory limits in the Sludge Regulations 1989. The pH of this waste is normally low, and it should not be applied to land of pH less than 5.5 unless the acidity of the waste has been neutralised by the addition of caustic soda or similar alkali material.

Soft drinks water

Soft drinks manufactures produce large volumes of low solid wastes with very low nutrient contents, but which contain very high levels of soluble sugars. Treatment of the waste by aerobic or anaerobic digestion to reduce the BOD produces a biological sludge with an N content of potential agricultural benefit.

Potential benefits: As sugars do not contain plant nutrients the application of these wastes to land can be difficult to justify unless it has undergone some form of processing, resulting in the addition of plant nutrients. Without this they are not beneficial in terms of nutrient status, but may be considered valuable for irrigation purposes.

Potential disbenefits: These wastes can become very acidic and should be adjusted to pH 6-7 before landspreading.

Best practice: This material normally has a low nutrient content. The pH of this waste is also normally low. It should be not be applied to soils with a pH of less than 5.5 unless the acidity of the waste has been neutralised by the addition of caustic soda or similar alkali material.

D4 BLOOD AND GUT CONTENTS FROM ABATTOIRS

Wastes from abattoirs include blood, gut contents, wash waters and sludge from dissolved air flotation treatment (DAF) where this process has been used to separate solids from any of the liquid waste materials of the abattoir, or some admixture of them. Of these, the exempted wastes are blood and gut contents. Other wastes from abattoirs are also discussed below in case they are to be considered for exemption or for landspreading under licence. Landspreading of abattoir wastes was probably likely to be the BPEO for small local abattoirs but is likely to be much less appropriate for the modern, large-scale abattoir operations.

Landspreading of blood and gut contents from abattoirs is liable to cause public nuisance due to odours and environmental concerns. If spread on the soil surface it is unsightly and there is potential for disease transmission. The material should be dealt with as for untreated sewage sludge and applied to the land by subsurface soil injection or else incorporated as soon as possible after spreading on the surface of arable land. The land-use restrictions as for untreated sewage sludge should apply (DoE 1996). The rate of application of the waste should be in accordance with crop requirements for nutrients.

In general, slaughterhouse wastes are a recognised source of environmental contamination by salmonellae and other zoonotic pathogens (Wray and Sojka 1977, Edel *et al.* 1978). *Cryptosporidium* may occur in gut contents although not necessarily in infective form. Veterinary ante-mortem inspection at slaughterhouses ensures that no animal suffering from notifiable disease or any other disease likely to affect the fitness of meat is slaughtered for human consumption. However, slaughtered animals may be symptomless carriers of pathogenic bacteria and therefore slaughterhouse wastes should be used with caution and with restrictions on use of land for rearing livestock or grazing after application. *E. coli* 0157 may be comparatively persistent in the soil environment (Maule 1997). Cases of notifiable diseases identified at ante-mortem will result in restrictions being served ensuring that the waste is disposed of safely.

The Spongiform Encephalopathy Advisory Committee (SEAC) has considered the acceptability of landspreading of blood and gut contents in relation to concern about possible transmission of BSE resulting from the practice. The Committee felt that given the fact that no BSE infectivity had ever been detected in blood and that there was no evidence of horizontal transmission of disease which would suggest that cattle wastes were directly infective to cattle, there was no reason to recommend that this practice should be prohibited or thought to be inadvisable (MAFF News Release 198/96 7.6.1996). Strict procedures are now enforced at abattoirs and renderers with the intention of removing, for separate disposal, components of cattle carcasses which might contain BSE prions. The term Specified Bovine Material (SBM), now called Specified Risk Material (SRM), is used to refer to these parts of the carcass. An example of these statutory procedures is The Specified Bovine Material (No. 2) Order 1996 (SI 1996 No. 1192) which came into effect on 1 May 1996. Further legislation (Article 2e SBM (No. 3) Order 1996) includes the need to ensure that trapped abattoir waste (i.e. caught in screens and drain traps in areas handling SBM) is dealt with separately as SBM and is not discharged onto land.

Abattoir wastes can be expected to contain potentially beneficial levels of nutrients, especially nitrogen, and may also have a high conductivity and fat content. These wastes are potentially odorous.

D4.1 Waste evaluation of blood and gut contents from abattoirs

Table D12 indicates a suggested evaluation programme for blood and gut contents from abattoirs which are to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D12 Blood and gut contents waste from abattoirs

ANALYSIS	Blood	Stomach contents	Wash water
Major nutrients	Y	Y	Y
pH + solids	Y	Y	Y
BOD	Y	Y	Y
Microbiological	N	N	N
Electrical conductivity and sodium	Y	N	N
Neutralising value (lime)	N	N	N
Additional analysis	N	N	Sodium
Oil/fat	N	N	Y
Red List	N	N	N
PTEs	N	N	N

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Blood

Waste blood is produced in large quantities from abattoirs and has various uses including landspreading as a source of nutrients especially nitrogen.

Potential benefits: The high fertiliser value of waste blood has been known for a long time, and it is one of the more traditional materials applied to land. Nitrogen content is extremely high, in excess of 15 kg m-

^{3} total nitrogen and 2 kg m^{-3} of ammonium nitrogen being typical. With potassium and phosphorus contents of 1-2 kg m^{-3} it is a good source of plant nutrients in comparatively available form compared with most organic wastes.

Potential disbenefits: The potential of high salt concentrations leading to increases in soil electrical conductivity has already been discussed in the previous food processing section, and the high levels of nitrogen and potassium in blood wastes can have an identical effect. In addition, over application can rapidly result in anaerobic soil conditions due to the high BOD of the waste which is readily degradable by soil micro-organisms. See also general comments about pathogens in D4 above.

Best practice:

- The nitrogen content is high and in a readily available form.
- Great care must be taken at all times to prevent blood from entering watercourses.
- A waste management plan should be prepared for a site receiving blood.
- These wastes normally have an offensive odour and precautions should be taken to minimise this.
- These wastes should be applied by subsurface injection into grassland or immediately incorporated into arable land. In the case of grassland, a minimum three week period should elapse, to allow the injector slots to close, before use of the grass for grazing or conservation.

Some analytical results of operational sampling are given in Table D13

Stomach contents

Waste stomach contents produced by the abattoir industry consist predominantly of partially digested feed or vegetable matter. Table D14 gives some results of operational monitoring

Potential benefits: A balanced mixture of nutrients is usually present. Levels of nitrogen, potassium and phosphorus are high, in the order of; N 5 kg m^{-3}; K 1 kg m^{-3}; and P 1 kg m^{-3} with a moderately high ammonium nitrogen content being an added benefit.

Potential disbenefits: Stomach contents can cause foul odour depending on the storage period. See also general comments about pathogens in D4 above.

Best practice: As a general rule all abattoir wastes should be injected into the soil to reduce odour and avoid any potential pathogen transmission, and should not be surface spread on pasture land or forage crops. If these materials are surface spread on arable land, they should be incorporated immediately by ploughing. Injection into grassland should be followed by a minimum interval of three weeks before the grass is used for grazing or conservation.

Table D13 Blood and gut contents from abattoirs - *blood*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	84	0.0	10.9	11.0	37.9	6.9
pH	84	5.3	6.6	6.6	10.3	0.7
N (kg m^{-3})	84	0.7	11.7	13.4	38.0	9.5
NH_4N (kg m^{-3})	82	0.0	1.0	1.7	8.0	2.0
P_2O_5 (kg m^{-3})	84	0.0	0.8	1.3	11.9	1.6
K_2O (kg m^{-3})	84	0.0	0.7	1.0	6.4	1.4
Mg (kg m^{-3})	84	0.0	0.0	0.03	0.3	0.1
Cu (mg kg^{-1})	54	0.3	1.6	3.2	34.1	5.9
Zn (mg kg^{-1})	73	1.0	6.1	12.8	87.2	19.0
Ni (mg kg^{-1})	83	<1.0	<1.0	0.4	5.7	
Cd (mg kg^{-1})	82	<0.25	<0.25	<0.25	0.68	
Pb (mg kg^{-1})	83	<0.1	<0.1	0.3	10.0	
Cr (mg kg^{-1})	80	<1.0	<1.0	0.3	3.2	
Hg (mg kg^{-1})	79	<0.01	<0.01	<0.01	10.24	
BOD (mg l^{-1})	78	88	28 650	33 100	122 000	25 608

Table D14 Blood and gut contents from abattoirs - *stomach contents*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	6	2.4	10.1	8.6	14.2	4.7
pH	6	5.2	6.5	6.3	7.6	0.9
N (kg m^{-3})	6	0.2	3.1	8.2	22.7	9.8
NH_4N (kg m^{-3})	5	0.0	0.3	0.3	0.5	0.2
P_2O_5 (kg m^{-3})	6	0.0	1.5	1.5	2.9	0.9
K_2O (kg m^{-3})	6	0.0	0.6	0.6	0.9	0.4
Mg (kg m^{-3})	6	0.0	0.0	0.03	0.1	0.1
Cu (mg kg^{-1})	5	0.8	1.2	2.4	7.5	2.9
Zn (mg kg^{-1})	6	2.4	4.1	9.0	34.1	12.4
Ni (mg kg^{-1})	6	<1.0	<1.0	0.8	4.6	
Cd (mg kg^{-1})	6	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	6	<1.0	<1.0	0.4	2.1	
Cr (mg kg^{-1})	5	<1.0	0.15	0.2	<1.0	
Hg (mg kg^{-1})	5	<0.01	<0.01	0.03	0.14	
BOD (mg l^{-1})	6	6000	12 500	18 000	41 000	13 622

Wash water

As with many other food processing industries, large volumes of wash waters are produced, and the term is often used to describe a wide range of low solid waste materials. This category can contain dung and urine from animal holding areas and washings from distribution vehicles. Some typical analyses are given in Table D15.

Potential benefits: As for other abattoir wastes, a mixture of nitrogen, potassium and phosphorus is usually present. Levels of major nutrients are somewhat lower, usually in the order of; N 1 kg m^{-3}; P 0.5 kg m^{-3} and K 0.5 kg m^{-3} with a moderate ammonium nitrogen content of 0.25 kg m^{-3}.

Potential disbenefits: A watery waste may be unable to supply sufficient nutrients to achieve agricultural benefit except where use for irrigation (but not of growing crops or grassland) can be justified. It cannot be assumed that wash water is free of pathogens. The general comments on pathogens in D4 above apply.. Wash water can also contain caustic soda used as a cleaning agent in which case sodium content should be determined.

Best Practice: The same precautions as for blood and gut contents should apply to the use of wash water on the land. Application rates must be tailored very closely to crop requirements and the strength of the waste in question. Sodium content should be taken into account as necessary. It should not be used for crop irrigation or surface application to grassland. Rates of application should be moderate (50 m^3 ha^{-1}) and should not exceed the hydraulic loading capacity of the soil.

Table D15 Blood and gut contents from abattoirs - *wash water*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	14	0.1	6.4	7.8	21.9	6.8
pH	14	3.7	6.1	6.1	7.6	1.0
N (kg m^{-3})	14	0.2	2.4	3.2	9.0	2.7
NH_4N (kg m^{-3})	14	0.0	0.4	0.6	1.8	0.5
P_2O_5 (kg m^{-3})	14	0.0	1.2	1.3	2.9	1.0
K_2O (kg m^{-3})	14	0.0	0.3	0.4	1.2	0.4
Mg (kg m^{-3})	14	0.0	0.0	0.04	0.3	0.1
Cu (mg kg^{-1})	12	1.0	1.7	2.1	5.5	1.4
Zn (mg kg^{-1})	13	1.8	9.5	18.4	115.0	29.7
Ni (mg kg^{-1})	14	<1.0	<1.0	<1.0	4.35	
Cd (mg kg^{-1})	14	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	14	<1.0	<1.0	<1.0	1.5	
Cr (mg kg^{-1})	14	<1.0	<1.0	1.1	10.5	
Hg (mg kg^{-1})	14	<0.01	<0.01	<0.01	0.04	
BOD (mg l^{-1})	14	899	12 650	23 000	86 900	27 121

Other wastes and wastes from biological treatment plants at abattoirs

Potential benefits: Due to the predominance of blood in the wastes for treatment and disposal, nitrogen levels can be very high, usually in excess of 8 kg m^{-3} with ammonium nitrogen usually present in excess of 1 kg m^{-3}. Potassium, phosphorus and magnesium can all be present in excess of 1-2 kg m^{-3}. As with pure blood wastes, these materials are likely to be a beneficial source of readily-available plant nutrients.

Potential disbenefits: The effect of animal fat on soil has already been covered in the previous section. Different types of abattoir will produce different types and percentages of fat, but chicken processing plants are potential sources of high fat materials. Deleterious effects on crop growth from additions of animal fat are usually observed at relatively low fat percentages compared to wastes containing other fats and oils. Wastes containing animal fat should be incorporated into the soil. The general comments in D4 above concerning pathogens apply.

Best practice: Rates of application should be based on content of plant nutrients but take account also of the fat content of the waste. Fatty waste is unsuitable for surface application to growing crops. Cultivations should proceed as soon as possible after the waste is injected or applied so that fatty material is thoroughly mixed through the soil profile. There should be an interval of at least three weeks between injection into grassland and use of the grass for grazing or conservation.

D5 WASTE LIME AND LIME SLUDGE FROM CEMENT MANUFACTURE OR GAS PROCESSING

These two waste descriptions are separated into two different categories in WMLR 1994 but are sufficiently similar to consider collectively. The categories cover all sources of lime other than that produced in the food processing industry. The two biggest producers are cement manufacture and gas processing, although the salt industry produces significant quantities of waste lime and gypsum.

These wastes, by virtue of their chemical nature and origin are inherently pathogen-free. Lime and lime sludges have pH values of 10 -12+ and are therefore self-disinfecting, as long as this high pH value is maintained.

D5.1 Evaluation of waste lime and lime sludge from cement manufacture or gas processing

Table D16 indicates a suggested evaluation programme for waste lime sludge from cement manufacture or gas processing which is intended for landspreading. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D16 Waste lime and lime sludge from cement manufacturing or gas processing

ANALYSIS	Cement manufacture	Gas processing
Major nutrients	Y	Y
pH + solids	Y	Y
BOD	Y	Y
Microbiological	N	N
Electrical conductivity and sodium	Y	Y
Neutralising value (lime)	Y	Y
Oil/fat	N	N
Red List	Y	Y
PTEs	Y	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Some operational analyses are given in Tables D17 and D18

Table D17 Waste lime

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	21	0.0	31.6	33.0	76.8	23.0
pH	21	4.6	8.2	9.2	13.1	2.9
N (kg m^{-3})	21	0.0	0.6	1.6	15.0	3.2
NH_4N (kg m^{-3})	21	0.0	0.0	0.2	1.5	0.5
P_2O_5 (kg m^{-3})	21	0.0	0.4	1.7	12.0	3.3
K_2O (kg m^{-3})	21	0.0	0.3	2.2	21.0	4.8
Mg (kg m^{-3})	21	0.0	1.1	4.4	55.0	11.8
Cu (mg kg^{-1})	16	0.4	6.7	9.9	26.2	8.8
Zn (mg kg^{-1})	17	2.1	14.4	35.9	270.0	65.7
Ni (mg kg^{-1})	10	0.7	2.3	3.0	8.5	2.4
Cd (mg kg^{-1})	20	<0.25	<0.25	<0.25	2.47	
Pb (mg kg^{-1})	20	<1.0	<1.0	1.2	6.97	
Cr (mg kg^{-1})	17	<1.0	2.5	38.5	614	
Hg (mg kg^{-1})	20	<0.01	<0.01	<0.01	0.02	
BOD (mg l^{-1})	19	5	3000	9700	59 700	15 824

Table D18 Lime sludge from cement manufacture or gas processing

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	9	2.9	15.3	36.2	100.0	38.1
pH	9	6.5	12.0	11.1	12.5	2.1
N (kg m^{-3})	9	0.0	0.0	0.4	2.5	0.9
NH_4N (kg m^{-3})	8	0.0	0.0	0.2	1.3	0.5
P_2O_5 (kg m^{-3})	9	0.0	0.3	0.4	1.5	0.5
K_2O (kg m^{-3})	9	0.0	0.7	2.6	16.9	5.5
Mg (kg m^{-3})	9	0.0	0.8	3.9	18.0	6.2
Cu (mg kg^{-1})	9	0.3	2.0	12.7	46.0	16.8
Zn (mg kg^{-1})	8	0.2	38.9	44.4	153.0	50.1
Ni (mg kg^{-1})	8	0.1	4.1	5.8	25.0	8.0
Cd (mg kg^{-1})	9	<0.25	<0.25	1.0	8.0	
Pb (mg kg^{-1})	7	0.0	2.0	145	1000.0	377.0
Cr (mg kg^{-1})	7	0.5	8.8	10.7	31.5	10.1
Hg (mg kg^{-1})	8	0.5	8.8	0.5	3.5	
BOD (mg l^{-1})	4	95	1400	1224	2000	868

Cement manufacture

The waste material, some of which may be special waste and therefore not exempted, usually consists of cement kiln dust, which is a mixture of calcium carbonate and calcium oxide. Other wastes may be produced from the cement process, but volumes are usually low.

Potential benefits: The benefit of these materials is derived from their liming value. Neutralising Values can vary depending on the moisture content of the material, but are usually in the range 20-40%. Some wastes may also contain moderate amounts of potash in the region of 0.5 kg m^{-3}, but as the material is traditionally applied to the land at low rates the benefit from potash addition is negligible.

Potential disbenefits: Cement kiln dusts usually contain residues from the combustion of materials used to generate the high temperature requirements for the process. Some manufacturers have recently started using waste organic solvents as sources of fuel for these processes (e.g. Chemfuel) and therefore organic residues may occur in kiln dusts. Over-liming should be avoided as trace element deficiencies can be induced when soils are limed above their optimum for specific crops.

Best practice:

- Products for landspreading should be accompanied by a full analysis of potentially toxic elements including Cu, Ni, Zn, Cd, Cr, Hg, Pb, B, As, Se, Mo and F. Assurance must be given by the waste producer, based on analysis, that the product is free from organic contaminants.

- Subject to a satisfactory analysis for contaminants, the rate of application should be based on the NV of the waste and the lime requirement of the receiving soil. The pH of the receiving soil should be determined prior to landspreading, because agricultural benefit will not be achieved if the soil has no lime requirement.

Gas processing

Waste lime is produced from the production of acetylene gas.

Potential benefits: The lime consists of a large percentage of calcium hydroxide and therefore is of high quality in an agricultural context, because it has a high Neutralising Value. Other nutrients, and indeed contaminants, may be present in varying amounts, and these may have an agronomic effect, but this depends to a large degree on the nature of the production process. Munoz *et al*, (1994) described laboratory studies in which calcium hydroxide, produced as a slurry (20% dry solids) from the acetylene generation process, compared favourably with calcium carbonate in liming trials.

Potential disbenefits: The production of acetylene gas involves the reaction of calcium carbide with water, producing lime as a by-product. Other constituents are also produced, e.g. thiourea, for which the consequences of land application may be uncertain. PQA should be sought for such wastes before land application is undertaken.

Best practice:

- The PTE content (as for cement lime) of the waste should be determined before landspreading.
- The Agency should be consulted to determine the need to consider organic residues from the combustion process.
- The soil pH value of receiving sites should be checked to confirm the need for lime and the rate of application based on NV accordingly.

D6 WASTE GYPSUM

Mined gypsum is a widely occurring mineral that has been used for many years in agriculture as a soil conditioner for clay and saline soils and as a source of the plant nutrients, calcium and sulphur. A detailed review of the use of gypsum (mined and industrial) in agriculture has been described by Sumner (1993).

Industrial gypsum is derived as a by-product from the manufacture of phosphoric acid (phosphogypsum), from the capture of sulphur dioxide in the flue gases of fossil-fuel powered generators (flue gas desulphurisation gypsum), from the neutralisation of sulphuric acid in many chemical processing industries (waste acid neutralisation gypsum) and from salt extraction.

Experiments carried out for the CEGB (now National Power and PowerGen) by Rimmer *et al.* (1995) on flue gas desulphurisation gypsum (FGD) demonstrated the ability of FGD gypsum to increase crop yield and improve soil structure.

These wastes, by virtue of their chemical nature and origin are inherently pathogen-free and present no problems from pathogens. Gypsum is a mineral (hydrated calcium sulphate), used for preparing plaster and plaster-based building materials. As in the production of lime, heat is used in preparing plaster, which disinfects the product.

D6.1 Evaluation of waste gypsum

Table D19 indicates a suggested evaluation programme for waste gypsum which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific waste characteristics to be tested.

Table D19 Waste gypsum

ANALYSIS	Acid neutralisation	Flue gas desulphurisation	Salt extraction
Major nutrients	Y	Y	Y
pH + solids	Y	Y	Y
BOD	Y	Y	Y
Microbiological	N	N	N
Electrical conductivity and sodium	Y	Y	Y
Neutralising value (lime)	Y	Y	Y
Oil/fat	N	N	N
Red List	Y	Y	N
PTEs	Y	Y	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Some operational analyses are given in Table D20.

Table D20 Waste gypsum

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	12	8.7	52.7	47.6	78.3	21.7
pH	12	5.5	9.4	9.4	12.4	2.6
N (kg m^{-3})	12	0.0	0.0	2.3	27.5	7.9
NH_4N (kg m^{-3})	12	0.0	0.0	0.0	0.0	0.0
P_2O_5 (kg m^{-3})	12	0.0	0.0	0.4	2.2	0.7
K_2O (kg m^{-3})	12	0.0	0.0	0.4	2.0	0.7
Mg (kg m^{-3})	12	0.0	0.4	1.0	6.0	1.7
Cu (mg kg^{-1})	9	1.2	9.2	12.0	31.8	10.8
Zn (mg kg^{-1})	12	2.4	7.5	124.0	1075.0	310.3
Ni (mg kg^{-1})	10	1.0	1.9	32.5	144.0	52.4
Cd (mg kg^{-1})	4	0.1	0.1	1.4	5.0	2.5
Pb (mg kg^{-1})	10	1.3	10.2	53.0	404.0	124.5
Cr (mg kg^{-1})	11	1.6	3.1	51.0	466.0	138.5
Hg (mg kg^{-1})	2	0.0	0.1	0.1	0.2	0.9
BOD (mg l^{-1})	10	2	300	770	2000	904

Acid neutralisation gypsum

Large volumes of waste sulphuric acid are produced from a wide range of industrial processes. The acid is used as an extractant for a variety of chemical compounds, but especially for the extraction of mineral ores. Consequently the acid contains many different contaminants derived from the primary raw materials. The contaminants can be carried over in the neutralisation process and incorporated into the gypsum produced.

Potential benefits: The use of gypsum as a soil conditioner is well known. One application is on saline sodic soils, especially those affected by flooding from sea water, where the gypsum is used to restore soil structure. Use of gypsum is also beneficial in less extreme cases, where poorly structured clays can be improved in the long -term by additions of gypsum at rates in excess of 5 t ha^{-1}. There is little, if any, structural benefit from adding gypsum to very light soils, i.e. sands and loamy sands.

Gypsum also contains very large quantities of sulphur, which can in theory be as high as 20%, depending on the purity of the product. With the reduction in atmospheric depositions of sulphur in acid rain, many agricultural soils are becoming sulphur deficient and sulphur -containing fertilisers are increasingly being used. In recent years, applications of gypsum have sometimes produced unexpected improvements in crop yields which have been attributed to correction of sulphur deficiency not previously diagnosed. The presence of other plant nutrients depends on the process from which the material is derived, but such gypsum wastes can contain quantities of phosphate which also have an agronomic value.

Potential disbenefits: Due to the wide range of different industries, it is not possible to give a detailed description of potential contaminants that may occur in gypsum. However, contamination from metals is very common, as the strong acids used in the mineral based industries will lead to the extraction of metals. PQA should be sought before these materials are considered as suitable for landspreading.

Best practice: Details of the relevant process and any IPC information are necessary before considering landspreading this material. The waste should be analysed for content of calcium, sulphur and PTEs. If these results are satisfactory, applications as a soil conditioner can be made to heavy land at a rate of 5-20 t ha^{-1}, or to sulphur deficient land in accordance with crop requirements for this nutrient.

Flue Gas Desulphurisation gypsum

Potential benefits: The soil conditioning benefits gained from FGD gypsum are identical to other sources of high purity gypsum, but gypsum from this source will not usually contain other beneficial nutrients.

Potential disbenefits: FGD gypsum is produced primarily to remove sulphur dioxide in flue gases. It will, therefore, absorb other contaminants in the flue gases. The nature of the contaminants will depend on the fuel used in the combustion process. The majority of FGD gypsum is produced from coal-fired power stations and therefore contains a range of metals as well as combustion products. Gypsum derived from the burning of other materials may contain complex organic compounds.

Best practice: PQA should be sought to fully evaluate the suitability of this material before it is spread to land. The same analytical requirements as for cement kiln dust apply. PTE content of the waste and the receiving soil should be determined. Analysis for persistent organic compounds may be required depending on the process of production.

Below are characteristics of waste gypsum from acid neutralisation processes and flue gas desulphurisation, which should also be considered:

- Since the sulphur content is a large beneficial component the waste should be applied to a responsive crop;
- it should not be applied immediately before oilseed rape unless the quantity of sulphur applied can be limited to that required for crop off-take. Large additions of sulphur can raise the glucosinolate content of the oil to an unacceptable level;
- large additions of sulphur can induce copper deficiency in livestock; and
- the Agency should be consulted to determine the need to consider organic residues from the combustion process.

D7 PAPER WASTE SLUDGE, WASTE PAPER AND DE-INKED PAPER SLUDGE

Potential benefits: The long term benefits from adding paper sludge to agricultural land results from its high organic matter and lime content. With the depletion in organic matter status of many UK soils, the addition of organic matter is seen as essential for the continued production capability of some soils. Paper sludges contain in the region of 30% organic carbon. Most sludges also contain between 1-6 kg t^{-1} of total nitrogen, much of which is not immediately available for crop uptake, but which becomes available in the long term.

Depending on the nature of the de-inking process from which the sludge is derived, the sludge also contains lime. This can be up to one fifth as effective as ground limestone for liming purposes (equates to a total NV of about 10%).

Potential disbenefits: **Nitrogen immobilisation.** These materials have a comparatively high C/N ratio which will deprive crops of N or immobilise N when they are applied to the soil. Trials by Aitken *et al* (1995) showed that an application of N fertiliser of 40 kg N ha^{-1} y^{-1} was needed with each 100 t ha^{-1} paper waste to minimise yield loss. N must, therefore, be added to the waste or applied to the soil to overcome this N immobilisation effect.

Other contaminants. The potential for other contaminants arising in waste paper sludges depends on the nature of the manufacturing process and raw materials used. De-ink sludges contain the ink and colour residues from waste paper. As inks and colours are derived from metal constituents they contain varying quantities of metals. For newsprint (the most common source of recycled waste paper) zinc is the main constituent of the sludge. Some sludges can contain 150 mg Zn kg^{-1}. As mentioned above, organic contaminants may also be present. PQA should be obtained to evaluate the implications of these contaminants for landspreading of the waste.

Best practice: Additional inorganic nitrogen should be added to the soil to avoid temporary N immobilisation. A dressing of 30 to 50 kg N ha^{-1} should be applied, above the normal N requirement of the crop for N, per 100 t ha^{-1} waste applied.

Sludge should be regularly analysed for liming value (NV) and rates of application adjusted accordingly taking account of the lime requirement of the soil.

Growth in the paper industry has resulted in increased production of waste paper sludges. Paper sludges are produced from primary paper production using virgin wood fibre, but much of this waste is used within the industry to produce lower quality paper or cardboard. The majority of waste sludges produced by the industry are in the form of 'de-ink' paper sludges.

These wastes are inherently composed of poorly biodegradable cellulose and lignins, which, even when wet, will support only limited microbial growth of specialised micro-organisms. They can be regarded as pathogen and parasite-free and present no microbiological risks to the health of plants or animals.

Table D21 indicates a suggested evaluation programme for paper waste sludge, waste paper and de-inked paper pulp which are to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D21 Paper waste sludge, waste paper and de-inked paper pulp

ANALYSIS	De-inked paper pulp	Virgin fibre sludge	Cotton fibre sludge
Major nutrients	Y	Y	Y
pH + solids	Y	Y	Y
BOD	N	N	N
Microbiological	N	N	N
Electrical conductivity and sodium	N	N	N
Neutralising value (lime)	Y	Y	Y
Oil/fat	N	N	N
Red List	Y	Y	Y
PTEs	Y	Y	Y

Y = Analysis or evaluation is recommended   N = Analysis or evaluation may not be necessary

Some operational analyses are given in Table D22.

Table D22 Paper waste sludge, waste paper and de-inked paper pulp

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	25	1.7	21.6	21.4	65.1	16.2
pH	25	4.9	7.2	6.9	9.4	1.0
N (kg m^{-3})	25	0.0	0.3	0.9	4.5	1.1
NH_4N (kg m^{-3})	24	0.0	0.0	0.02	0.3	0.1
P_2O_5 (kg m^{-3})	25	0.0	0.1	0.4	2.0	0.5
K_2O (kg m^{-3})	25	0.0	0.1	0.2	1.5	0.3
Mg (kg m^{-3})	25	0.0	0.0	0.1	0.6	0.2
Cu (mg kg^{-1})	23	2.0	12.7	32.8	349.0	72.2
Zn (mg kg^{-1})	24	1.3	13.8	29.4	157.0	38.2
Ni (mg kg^{-1})	25	<1.0	1.02	1.3	8.7	
Cd (mg kg^{-1})	25	<0.25	<0.25	0.02	0.5	
Pb (mg kg^{-1})	24	<1.0	0.45	1.7	14.8	
Cr (mg kg^{-1})	24	<1.0	1.50	2.4	16.07	
Hg (mg kg^{-1})	24	<0.01	<0.01	<0.01	0.03	
BOD (mg l^{-1})	19	18	1100	1800	1600	2020

De-inked paper sludge

De-ink paper sludge is produced from the paper recycling industry. Waste paper is re-pulped, generating in the process short fibres which cannot be re-used containing inks and colour from the original print. Substantial growth in this industry in the past few years has seen a corresponding growth in de-ink waste paper sludges. As landfill costs have risen so alternative disposal routes have been found of which the most important is agricultural land spreading. Aitken *et al.* (1995) have given an account of effects on soil fertility from applying paper mill sludge to agricultural land based on field experiments established in North Wales in 1991. The sludge used was de-ink paper sludge (DPMS), the production of which is expected to increase in the UK from 370 000 wet tonnes in 1994 to 1 million tonnes by the year 2000. It is estimated that 520 000 tonnes of paper sludge (dry solids basis), or in excess of 1 x 10^6 tonnes as produced, were spread on land in 1995 in England and Wales.

Paper sludge such as DPMS is largely cellulose and ash (clay and calcium carbonate) with high C/N ratio. This can cause immobilisation of soil N when it is incorporated into the soil and hence crop N deficiency. The findings of Aitken *et al* (1995) showed that losses in yield due to DPMS could be minimised in the first year by applying 40 kg N ha^{-1} of fertiliser N per 100 t ha^{-1} DPMS. Results indicated that DPMS immobilised very little or no N in the second year after application. Visual studies of the soil profile two years after application indicated that DPMS had degraded satisfactorily in the soil even at a rate of application of 300 t DPMS ha^{-1}. Phillips et al. (1997) described the results of field trials at Silsoe with wheat and grass plots which received 5 to 20 t dm ha^{-1} of paper mill sludge in each of three successive years. All plots received normal fertiliser dressings throughout the trial. In most cases , topsoil condition, as assessed by the percentage content of organic carbon, was significantly improved (by about 0.5%) as a result of paper mill sludge application over 3 years. Other measures of soil physical conditions suggested the benefit would be greater on clay soils than sandy soils. It was thought that the case for landspreading of paper mill sludge rested mainly on potential improvements in soil condition from which increases in crop yield might perhaps follow from successive applications over a number of years. Such a benefit ought in due course to be particularly evident in very dry seasons.

N immobilisation can be avoided by treating paper sludge by a process such as composting to improve its C/N ratio before landspreading. Accounts of successful composting operations are given by Cardwell (1994) and by Campbell *et al,* (1995). Depressed yield can be avoided also where secondary sludge from biological treatment of paper mill effluent is mixed with DPMS before landspreading (Cabral and Vasconcelos, 1993).

Waste from mills using peroxides to make paper are preferred for landspreading because of concerns about toxic residues such as dioxins in wastes from mills using chlorine (Cardwell, 1995). Organic contaminants in pulp and paper sludges have been reviewed by Webber (1996) in a report which includes reference to various compounds. Analysis of eight primary pulp and paper sludges from Quebec (Canada) mills involving de-inking processes, found that PCDD/Fs (dioxins and furan) concentrations were low and international 2,3,7,8-tetrachlorobenzodioxin toxicity equivalents (I-TEQ) for them ranged from 1.3-13.6 ng kg^{-1} dw (ppt). PCDD/Fs concentrations in several analyses of combined primary and secondary pulp and paper sludge from a plant in Canada were $\leq$12 ng I-TEQ kg^{-1} dw when chlorine was used in the process but <3.5 ng I-TEQ kg^{-1} dw when it was no longer used. Other analyses of wastes from paper mills using chlorine-based bleaching found that PCDD/Fs concentrations were generally <14 ng I-TEQ kg^{-1} dw, with two of 24 samples containing 22 and 48 ng I-TEQ kg^{-1} dw respectively. Both sludges were being successfully used in agriculture and as constituents of media for container nursery culture. It was observed that most bleached pulp mills in Canada have successfully implemented process modifications to decrease chlorinated dioxins and furans and their precursors in mill operations and products. A recent comparison is cited which showed that there were orders of magnitude more dioxin in every day materials such as plastic packaging and vacuum cleaner dust than in Canadian pulp and paper. The Ontario Ministry of the Environment and Energy has set maximum allowable dioxin concentrations of 100 ng I-TEQ kg^{-1} dw for solid residues applied to land and a maximum soil concentration of <10 ng I-TEQ kg^{-1} dw after land application of materials. Further review evidence is cited which concluded that the risks to the ecosystem and human population from organic contaminants are likely to be only slightly elevated through the use of municipal, septic, pulp and paper, and de-inking sludges in agriculture and forestry. There are reasonable grounds for expecting that this would apply in the UK also. In an updated inventory of potential PCDD and PCDF emission sources in the UK the paper production process was not included, presumably making only a negligible contribution (Eduljee and Dyke, 1996).

Levels of AOX (adsorbable organic halogens) in paper sludges often reach or exceed 500 mg kg^{-1} dw according to a review cited by Welker and Schmitt (1997). The main sources of AOX in waste paper sludges were chlorinated wood polymers (lignin and cellulose) and printing inks, especially yellow pigments. Generally, AOX compounds were found to be very insoluble in water so it was considered that effects on the environment (such as transfer into groundwater) would not be significant if the sludge was spread on agricultural land. Nevertheless, Welker and Schmitt (1997) recommend that AOX levels in paper sludges should be reduced and this could be achieved by phasing out traditional bleaching processes using chlorine.

Aitken *et al.* (1995) recommended that because of the variable nature of paper sludge from different mills, each product should be subject to investigation before being recycled to agricultural land.

D8 DREDGINGS FROM ANY INLAND WATERS

Potential benefits: Dredgings can supply organic matter and nutrients in the form of phosphate and organically bound nitrogen. Sandy material, low in organic matter content, has potential value for land levelling purposes.

Potential disbenefits: Many inland waterways, canals in particular, run through urban and industrial areas and sediments may have become polluted with various contaminants following industrial and other discharges to the waterway made before these were adequately regulated. Tributyltin residues may be present in dredgings from boating centres.

Best practice: Dredgings should be analysed for content of organic matter, nitrogen, total and extractable phosphate, PTEs listed in the DoE Code of Practice for Agricultural Use of Sewage Sludge and organic contaminants if these are thought likely to be present. An appropriate rate of application can then be estimated. The permitted maximum of 5000 t ha^{-1} y^{-1} is far in excess of agricultural benefit associated with supplying nutrients or organic matter but could conceivably be compatible with benefit from land levelling to prevent flooding if the dredgings are inert, or land reclamation. CIRIA Report 157 discusses the possible classification of dredged material as inert waste and the achievement of agricultural benefit (p95) and ecological improvement (p100).

Table D23 indicates a suggested evaluation programme for dredgings from inland waterways which are to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D23 Dredgings from inland waterways

ANALYSIS	Dredgings from inland waterways
Major nutrients	Y
pH + solids	Y
BOD	N
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	N
Oil/fat	N
Red List	Y
PTEs	Y

Y = Analysis or evaluation is recommended   N = Analysis or evaluation may not be necessary

The main disadvantage of this material lies in the presence of undegradable plastic litter and metal scrap items, which impede cultivation and are hazardous to farm animals which may eat them. The muds of dredgings, which contain a high proportion of silts and clays are highly adsorptive of metals and persistent organic residues and also bacteria and viruses. Care will need to be taken on a local basis in the case of dredgings taken from downstream of discharges from sewage works, storm sewage overflows and the discharges from particular trades, such as compounders of organic fertilisers, abattoirs and tanneries. Historically, particular problems suggest the need for caution in certain cases, where local veterinary and public health knowledge would seem invaluable:

- Sporadic cases of anthrax in farm animals grazing on pastures after flooding (e.g. in the Nene valley) which have been thought to be attributable to spores originating from tanneries treating hides from areas where anthrax was endemic;

- the relatively high frequency of isolation and of numbers of exotic *Salmonella* species in estuaries (e.g. the Hull area) downstream of fertiliser compounders (McCoy 1971); and

- sediments may have become contaminated in the past before modern effluent discharge consents were put into place. The sediment may reflect historic pollution from potentially toxic elements and persistent organics and is likely to be rich in phosphate.

Some analysis of dredgings from a 100 km length of canal are given in Table D24.

Table D24 Analysis of dredgings from a 100 km length of canal

Parameter	Mean	Minimum	Maximum
Solids air dried (%)	23.2	7.8	63.2
Loss on ignition (%)	24.5	6	44
pH	6.7	5.4	7.6
(total) antimony (mg kg^{-1})	10.0	0	146
(total) arsenic (mg kg^{-1})	47.4	9	873
(total) cyanide (mg kg^{-1})	0.6	0	2.6
(total) lead (mg kg^{-1})	408.9	22	8275
(total) mercury (mg kg^{-1})	83.0	0.1	1570.7
(total) molybdenum (mg kg^{-1})	1.6	0	7.1
(total) nickel (mg kg^{-1})	79.3	34	204
(total) PAH (mg kg^{-1})	16.1	0	203
(total) phenols (mg kg^{-1})	23.4	2.11	292
(total) phosphorus (%)	0.5	0.17	2.51
(total) barium (mg kg^{-1})	243.8	38.6	731
(total) beryllium (mg kg^{-1})	1.8	0.8	9.7
(total) boron (mg kg^{-1})	45.0	9.9	172
(avail) boron (mg kg^{-1})	9.2	1.16	37.4
(total) cadmium (mg kg^{-1})	2.2	0	21
(total) chromium (mg kg^{-1})	159.7	25	4011
(total) cobalt (mg kg^{-1})	36.4	15	94
(total) copper (mg kg^{-1})	136.8	26	1357
(total) selenium (mg kg^{-1})	3.7	0.1	23.1
(total) silver (mg kg^{-1})	0.1	0	23.1
(total) sulphide (mg kg^{-1})	1805.1	0	6330
(total) tin (mg kg^{-1})	33.2	9.7	278
(total) thallium (mg kg^{-1})	0.1	0	5.2
(total) tungsten (mg kg^{-1})	0.0	0	0
(total) vanadium (mg kg^{-1})	68.7	37.8	104
(total) zinc (mg kg^{-1})	958.1	154	6671

(the median values were not available)

Sediment has to be dredged periodically from the beds of rivers and canals to maintain navigability and water quality. Sediments may have built up over many years and in some cases the canals pass through industrial areas. Most contaminants typical of industrial activities can be found in these sediments. The dredgings are usually deposited into an area near to the canal and left to de-water and the solids, if suitable, used as soil making material on surrounding land. Those sediments which are heavily contaminated are removed and disposed of to a suitable disposal site. A CIRIA technical paper has been produced relating to this activity (CIRIA Report 157, 1996).

D9 TEXTILE WASTES

Table D25 indicates a suggested evaluation programme for textile waste which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D25 Textile waste

ANALYSIS	Dyers and bleachers	Wool scourers	Fellmongers and hide processors
Major nutrients	Y	Y	Y
pH + solids	Y	Y	Y
BOD	Y	Y	Y
Microbiological	N	N	N
Electrical conductivity and sodium	N	Y	Y
Neutralising value (lime)	N	N	N
Oil/fat	N	Y	Y
Red List	Y	Y	Y
PTEs	Y	Y	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Dye and bleach effluent

The textile industry includes 'finishing processes' where the textiles are dyed. Large quantities of sludges and other process effluents are produced, often mixed with bleaching agents such as ammonia. Some operational analyses are given in Table D26.

Potential benefits: The nutrient content of these wastes is highly variable and depends on the constituents of the dyeing process. The nitrogen content is usually very high, in the order of 5 kg m^{-3}, due to the ammonia content and the wastes often contain 1-2 kg m^{-3} of phosphate and potash. The pH is frequently in excess of 7.0, due to the presence of ammonia, but this does not have a significant liming effect.

Table D26 Textile waste - *Dyers and bleachers*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	37	0.7	3.8	6.4	43.7	7.7
pH	37	4.6	6.7	6.9	12.1	1.4
N ($kg\ m^{-3}$)	37	0.0	1.9	7.3	171.0	27.8
NH_4N ($kg\ m^{-3}$)	32	0.0	0.2	5.3	164.0	29.0
P_2O_5 ($kg\ m^{-3}$)	33	0.0	0.7	1.2	6.2	1.5
K_2O ($kg\ m^{-3}$)	37	0.0	0.1	0.3	2.8	0.5
Mg ($kg\ m^{-3}$)	37	0.0	0.1	0.7	14.6	2.5
Cu ($mg\ kg^{-1}$)	32	0.5	9.6	27.5	243.0	53.7
Zn ($mg\ kg^{-1}$)	35	1.4	10.5	17.2	80.0	19.2
Ni ($mg\ kg^{-1}$)	36	<1.0	0.12	0.8	4.7	
Cd ($mg\ kg^{-1}$)	36	<0.25	<0.25	<0.25	0.5	
Pb ($mg\ kg^{-1}$)	32	<1.0	0.51	2.5	20.3	
Cr ($mg\ kg^{-1}$)	28	<1.0	0.30	10.7	123	
Hg ($mg\ kg^{-1}$)	28	<0.01	<0.01	0.08	0.94	
BOD ($mg\ l^{-1}$)	34	500	3500	10 000	94 000	19 617

Potential disbenefits: Dyes used in the textile industry may contain various metals or organic compounds which contribute to the colouring effect. Although the dyes are not manufactured in the textile process, the washing process takes dye residues through into effluent treatment plants, where the residues are concentrated into the sludge for disposal. Levels of metals of the order of several 100 $mg\ kg^{-1}$ can result.

Best practice: Details of the process, dyes used and possible residues in the sludge should be established and PQA sought if there is uncertainty about the suitability of the sludge for landspreading. If heavy metals are found in the sludge applications should only be made according to the Sludge Regulations Use in Agriculture Regulations.

Hide processing and fellmonger sludges (see also D12)

These sludges are produced from the primary processing and curing of animal hides. Fellmongers sludge can contain high levels of chromium and salt.

Potential benefits: Major nutrients from the animal products and dirt remaining in the effluent. This can be highly variable depending on the water content of the waste.

Potential disbenefits: Various different contaminants may be present depending on the exact nature of the process. Main concerns arise from the use of dyes, the presence of organophosphorus pesticide residues originating from animal hides or wool and high levels of sulphide.

Best practice: Rates of application should be based on nutrient content but taking account of any contaminants that may be present and the recommendations of PQA.

Wool scouring sludge

The primary textile industries generate large quantities of waste from washing. The wash water also often contains large quantities of waste wool, 'dags' containing animal excrement, grease and suint (potash-rich animal residue). For results of operational analyses see Table D27.

Potential benefits: The nutrient content is highly variable and depends on the proportions of fibres and animal excreta in the sludge. The nitrogen content is usually high, 2-5 kg m^{-3}, and may also contain moderate amounts of phosphate and potash (approximately 1 kg m^{-3}).

Potential disbenefits: The various washing processes carried out on fleeces result in the final waste containing pesticide residues and grease. Organophosphorus and organochlorine compounds are often found in association with the grease fraction of the sludge. Most of these compounds are approved pesticide products but imported wool can be found to contain Red List compounds such as gamma-HCH (lindane) and DDT. Analysis can now detect very low levels of these materials in scouring sludge. PQA should be obtained before these materials are landspread.

The risk still exists in theory, of wastes from wool containing spores of the anthrax bacillus, *Bacillus anthracis*. Preventive industrial practices and the virtual elimination of human and animal anthrax from most developed countries imply that the risk of using such wastes on land to man and to farm animals is negligible.

Best Practice: Rates of application should be based on nutrient content and crop requirements and should take account of any contaminants that may be present.

Table D27 Textile waste - *Wool scourers*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	3	7.7	54.8	45.1	72.8	33.6
pH	3	2.8	6.8	5.5	6.9	2.3
N (kg m^{-3})	3	1.9	2.4	2.6	3.4	0.8
NH_4N (kg m^{-3})	3	0.0	0.0	0.03	0.1	0.1
P_2O_5 (kg m^{-3})	3	0.0	0.2	0.5	1.2	0.6
K_2O (kg m^{-3})	3	0.6	3.6	-	4.0	1.9
Mg (kg m^{-3})	3	0.1	0.2	0.5	1.2	0.6
Cu (mg kg^{-1})	3	1.7	9.6	7.5	11.3	5.1
Zn (mg kg^{-1})	3	12.0	13.2	29.1	62.0	28.5
Ni (mg kg^{-1})	3	0.5	5.2	-	5.6	2.9
Cd (mg kg^{-1})	3	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	3	1.3	1.3	3.3	7.2	33.6
Cr (mg kg^{-1})	2	1.5	8.6	8.6	15.7	10.0
Hg (mg kg^{-1})	2	<0.01	<0.01	<0.01	<0.01	
BOD (mg l^{-1})	3	284	11 000	9400	17 000	8468

D10 SEPTIC TANK SLUDGE

Potential benefits:

The benefits from such wastes will therefore be from their nitrogen, phosphorus and potassium content, which may vary widely according to dry solids content. Carlton-Smith and Coker (1985) have investigated the manurial value of septic tank sludge in field trials over several years with ryegrass and barley. They concluded that septic tank sludge can supply to grassland useful amounts of N (40% available) and P (70% available) and, unlike other forms of sewage sludge, significant quantities of K (100% available). They suggested that estimates of the nutrient value should be based on analysis for dry solids and total N, P and K content. They noted that septic tank sludge is usually low in metal content and no metal contamination problems should arise when it is applied to the land.

Potential disbenefits:

- Landspreading of septic tank sludge is likely to cause public nuisance and environmental concerns.
- Odour and potential pathogen transmission problems are no different from those associated with untreated sewage sludge and can be overcome by subsoil injection of the material, or where surface-spread, through immediate cultivation.
- Litter items in septic tank sludge can include plastics; chiefly condoms and backings of sanitary towels; which will cause visual offence when left on the surface or ploughed up in subsequent seasons. This nuisance can be avoided by screening the sludge before land application. Unlike sewage sludge, septic tank sludge is likely to be comparatively free of potentially toxic elements except for contaminants originating from domestic products.
- The Royal Commission on Environmental Pollution (RCEP 1996) has suggested that recycling of untreated sewage sludge (which includes septic tank sludge) to agricultural land ought to be phased out on precautionary grounds.

Best practice:

The DoE Code of Practice for the Agricultural Use of Sewage Sludge (1996) states that the contents of septic tanks cannot be considered to be biologically treated. As an untreated sludge, septic tank sludge should be applied to the land by subsurface injection into the soil or otherwise worked into the soil so as not to cause nuisance. Surface application to grassland is therefore not recommended because of potential problems from pathogen transmission and nuisance (odour and litter). The rate of application should take account of the N, P and K content of the septic tank sludge and the requirements of the receiving crop for these nutrients.

Table D28 indicates a suggested evaluation programme for septic tank sludge which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific waste characteristics to be tested.

Table D28 Septic tank sludge

ANALYSIS	**Septic tank sludge**
Major nutrients	Y
pH + solids and inspect for screenings	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	N
Neutralising value (lime)	N
Oil/fat	N
Red List	N
PTEs	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

The technical details of septic tanks and small sewage treatment works have been described by Payne and Butler (1993). In The Sludge (Use in Agriculture) Regulations SI 1263 HMSO, London (1989), it is stated that 'septic tank sludge' means residual sludge from septic tanks and other similar installations for the treatment of sewage. Only the residual sludge can be spread on the land; the whole waste is not exempted.

Septic tank sludge presents a well-defined microbiological risk to the health of man and farm animals, particularly if it originates from facilities serving individual households or small communities with active cases or carriers of infectious enteric diseases, such as paratyphoid fever. Septic tanks, by virtue of their limited retention capacity and operation at ambient temperature, do not significantly stabilise their sludge and consequently give little or no reduction in the infectivity of enteric pathogens or parasites discharged to them. This is why the use of septic tank wastes on land should be subject to the same restrictions on use as untreated sewage sludge. In the rare case where a septic tank is known to have served a case or a carrier of a notifiable infectious disease, the contents must not be placed on agricultural land and public health advice should be sought for their disposal.

Septic tanks provide a static environment for the settlement of sludge and the development of anaerobic conditions for the partial decomposition of organic matter. Raw sewage is fed to the tank and after passing through at least one settling chamber, supernatant liquid is discharged to a soakaway. Sludge which accumulates at the bottom of the tank is removed periodically. A cesspool (cesspit) is a watertight tank, installed underground, for the storage of sewage with no treatment involved (Payne and Butler, 1993). Cesspool liquors are strong, usually septic and with a low solids content. Cesspool wastes are not exempted for landspreading.

D11 SLUDGE FROM BIOLOGICAL TREATMENT PLANTS

The definition in Table 2 of para 7(2), Schedule 3 of WMLR 1994 which lists the exempted wastes includes the category, 'Sludge from biological treatment plants'. A more precise definition would be helpful describing the type and origin of the wastes it includes and the biological treatment processes that are acceptable. Biological treatment plants are essentially smaller versions of full-scale sewage treatment plants but are located at industrial premises to treat effluents high in COD before discharge to sewer.

Potential benefits: The organic content of these sludges consists largely of bacterial cells, it is quite usual to find high levels of N, P, and K at pHs around neutral.

Potential disbenefits: Bio-sludges from the food industry are usually low in contaminants and need only be monitored for their nutrient content in relation to crop requirements. Bio-sludges from other industries may contain inorganic or organic contaminants. Bio-sludges are likely to be highly putrescible with the potential to cause odour problems.

Best practice: Information concerning the type of industry, the raw materials used and the type of processes employed is vital to identify any potential disbenefits. This information should be followed up by appropriate chemical analysis to check the quality of sludges. PQA may be required to evaluate the chemical analysis and suitability of the sludge for landspreading. The DoE Code of Practice for Agricultural Use of Sewage Sludge (1996) provides suitable guidance for the landspreading of bio-sludges although the restrictions on land use could be relaxed for a bio-sludge which is free of pathogens.

Wastewater is usually fed into a tank in which a population of micro-organisms in the presence of air is able to breakdown the organic components of the waste. The bio-plant (as they are commonly known) is usually operated continuously and the treated water is settled out, producing a quantity of settled solids commonly known as bio-sludge and consisting largely of bacterial cells. Individual bio-sludges can vary enormously depending on the type of industry producing the waste water. Bio-sludges from the treatment of industrial wastewater will not necessarily contain any human or animal pathogens. This is in contrast to sewage sludge and septic tank sludge.

Table D29 indicates a suggested evaluation programme for sludge from biological treatment plants which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D29 Sludge from biological treatment plants

ANALYSIS	Sludge from biological treatment plants
Major nutrients	Y
pH + solids	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	N
Oil/fat	N
Red List	N
PTEs	Y

Y = Analysis or evaluation is recommended   N = Analysis or evaluation may not be necessary

Some results from operational analysis are shown in Table D30.

Table D30 Sludge from biological treatment plants

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	126	0.0	3.7	8.4	91.7	13.8
pH	126	3.7	6.6	6.5	12.7	1.3
N (kg m^{-3})	126	0.0	1.7	2.6	26.5	3.3
NH_4N (kg m^{-3})	122	0.0	0.2	0.4	3.5	0.6
P_2O_5 (kg m^{-3})	126	0.0	0.9	2.2	51.5	5.6
K_2O (kg m^{-3})	126	0.0	0.2	0.4	7.0	0.8
Mg (kg m^{-3})	125	0.0	0.1	0.2	2.5	0.4
Cu (mg kg^{-1})	92	0.0	3.8	15.9	207.0	36.6
Zn (mg kg^{-1})	115	0.1	12.8	33.0	900.0	89.5
Ni (mg kg^{-1})	115	<1.0	<1.0	1.8	106	
Cd (mg kg^{-1})	115	<0.25	<0.25	<0.25	1.34	
Pb (mg kg^{-1})	115	<1.0	<1.0	3.5	84.5	
Cr (mg kg^{-1})	115	<1.0	<1.0	5.6	165	
Hg (mg kg^{-1})	115	<0.01	<0.01	0.07	3.20	
BOD (mg l^{-1})	120	44	5000	9600	82 000	13 281

Due to their varied nature, it is not possible to fully describe the range of different bio-sludges, without describing individual industries.

For completeness, sludges produced by sewage treatment plants will be mentioned in this category. The sludges will be either raw and untreated, being derived from primary sedimentation, or from biological processes (secondary sludges from activated-sludge plants or biological filtration). Usually, sewage sludge will have been treated to stabilise it and to reduce the number of pathogens significantly, by a effective process (DoE 1989, Bruce *et al*, 1990).

Sludge is effectively the concentrated stream of suspended solids removed during sewage treatment and is largely comprised of faecal matter, moribund microbial cells from faeces and from growth of the microbes responsible for purification of the sewage. Bacterial pathogens and viruses are largely destroyed during sewage treatment, but residual pathogens and parasitic resting stages are concentrated in the sludge. Pathogens of concern to the health of farm animals and the workers handling the sludge include *Salmonella* species and the eggs of the human beef tapeworm, *Taenia saginata*. Tapeworm infections in man are now extremely rare and the disease in beef cattle (bovine cysticercosis) is now of minor concern. Since the introduction of the national Code of Practice for the Agricultural Use of Sewage Sludge (DoE 1989) and operational guidelines by the UK's water industry, outbreaks of both diseases attributable to use of sludge have not occurred. The Code of Practice should be consulted for details, but the essential strategies for control of disease are to impose several barriers to the transmission of infection, thus:

- Sludge must be treated to reduce pathogens before application to land. Restrictions are then placed on the use of the land, depending on the type of agricultural activity, to allow residual pathogens to decay further; and
- raw sludge can only be used if it is injected below the soil surface, or immediately ploughed in, to eliminate contamination of the surface. Appropriate restrictions are then applied before the land can be re-used.

The adoption of the Code of Practice followed much national research, summarised by Pike and Carrington (1986) and Bruce *et al.* (1990). This has been paralleled by international co-ordination of research information between Member States of the European Union in the programmes of the Concerted Actions on Treatment and Use of Sewage Sludge and Liquid Agricultural Wastes (COST 68 and COST 681) and the development of the USEPA (1993) sludge regulations. The success of the Code of Practice has been that outbreaks of infectious disease or cysticercosis, attributable to use of sludge on animal grazing land, have not occurred in the UK since its introduction.

D12 WASTE HAIR AND EFFLUENT TREATMENT SLUDGE FROM A TANNERY

Wastes falling into this category are similar to the textile wastes described in Section D9. Tanneries are a process within the textile industry (see D9), but tannery wastes can contain particular contaminants.

A detailed account of leather manufacturing wastes is given by Chaney (pp 285-291 in Parr *et al*, 1983). Hides are transformed into leather by two major methods; chrome tanning and vegetable (polyphenol) tanning. Where chrome tanning is used, much of the chromium is recycled within the plant. In a review of the effects of metals in sewage sludge on crops, Webber (1981) observed that chromium, especially when used in the hexavalent (Cr^{6+}) form, has been found to produce toxic effects on crops in pot experiments. There was is no evidence that Cr is harmful to crop growth when added to the soil in sewage sludge, where it occurs as the Cr^{3+} form and is only slightly soluble in extractants normally used for measuring 'availability' to crops. He cites evidence from a field trial in which no toxic effects on crops followed an application of 125 t ha^{-1} sludge containing 8600 mg Cr kg^{-1}. It was considered unnecessary to include any restriction on chromium in the Sludge Directive 86/278 or the Sludge Regulation SI 1263. The issue was the subject of debate and a provisional limit for soils of 400 mg Cr kg^{-1} (loading rate 15 kg ha^{-1} y^{-1}) is included in the DoE Code of Practice (1996). This would be appropriate for chromium in tannery waste applied to land.

Table D31 indicates a suggested evaluation programme for sludge from biological treatment plants treating tannery effluent, which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

The chemical and other treatments given to hides in tanneries effectively disinfect the waste, with the exception of the spores of the anthrax bacillus, *Bacillus anthracis*. Occupational anthrax traditionally occurred in workers handling these materials who became infected by inhalation of spores in dust or by contact of infected hides with the skin. There were also, in the past, sporadic cases in farm animals, which had grazed on pastures prone to flooding, where the spores were thought to have originated from the effluents of tanneries upstream. These problems have now disappeared as anthrax in farm animals and man is extremely rare, with the possible exception of hides and animal materials imported from the few areas of the world where anthrax is still endemic. Hairs and bristles are disinfected by means which destroy the infectivity of anthrax spores. Tannery wastes may contain pesticide residues.

Table D31 Waste hair and effluent treatment sludge from a tannery

ANALYSIS	Waste hair and effluent treatment sludge from a tannery
Major nutrients	Y
pH + solids	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	N
Oil/fat	N
Red List	Y (pesticide residues)
PTEs	Y (especially Cr)

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Results of operational analyses are given in Table D32

Potential benefits: High levels of N can be found in this waste.

Potential disbenefits: High levels of Cr and salts can be found in these wastes. A high sulphide content may cause them to be odorous. They may contain pesticide residues.

Best practice:

- Check the waste and the receiving soils for Cr content. The rate of application should be based on the N content of the waste, taking into account of the Cr content also.
- Wastes should be analysed for residual pesticides as a precautionary measure. If they are not found, further analysis can be undertaken occasionally rather than on a routine basis.

Table D32 Waste hair and effluent treatment sludge from a tannery

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	3	0.9	2.2	6.1	15.0	7.8
pH	3	6.5	6.6	6.7	7.0	0.3
N (kg m^{-3})	3	2.2	3.6	-	3.7	0.8
NH_4N (kg m^{-3})	2	0.2	0.2	0.2	0.2	0.0
P_2O_5 (kg m^{-3})	3	0.0	0.4	-	0.6	0.3
K_2O (kg m^{-3})	3	0.0	0.7	-	1.0	0.5
Mg (kg m^{-3})	2	0.0	0.0	0.0	0.0	0.0
Cu (mg kg^{-1})	3	<1.0	<1.0	<1.0	1.6	
Zn (mg kg^{-1})	3	2.8	9.2	-	10.2	4.0
Ni (mg kg^{-1})	3	<1.0	<1.0	<1.0	0.84	
Cd (mg kg^{-1})	3	<0.25	<0.25	<0.25	0.04	
Pb (mg kg^{-1})	3	<1.0	<1.0	<1.0	2.1	
Cr (mg kg^{-1})	2	169.0	237.0	-	305.0	
Hg (mg kg^{-1})	2	<0.01	<0.01	<0.01	<0.01	
BOD (mg l^{-1})	3	560	2000	6000	15 500	8241

D13 OTHER WASTES

Most wastes spread on land are in the exempted categories shown above, but there are materials which have been spread on the land in the past and could be considered for exemption or for landspreading under licence. In some cases there is a question mark over whether such materials should even be classified as wastes, as they are effectively sold as fertilisers. The following are examples of wastes which are already used on the land or are potentially suitable for landspreading but do not fall into the categories of Schedule 3 paragraph 7 of the 1994 Regulations. This list is not exhaustive. These wastes should be considered for exemption but in the interim can be spread on the land under licence or if of suitable quality may be classed as fertilisers.

D13.1 Bentonite

Table D33 indicates a suggested evaluation programme for bentonite which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested.

Table D33 Bentonite

ANALYSIS	Bentonite
Major nutrients	Y
pH + solids	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	Y
Oil/fat	Y
Red List	N
PTEs	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Bentonite is a clay mineral that is used extensively for drilling, tunnelling and piling. It is used as a major constituent of drilling and tunnelling muds, mainly because of its high swelling characteristic which causes it to occupy 10 to 15 times its dry volume when hydrated. This helps to lubricate the cutting edge, seals the wall of the hole and provides viscosity to carry cuttings away from the cutting edge.

Because of the high cost of bentonite, it is recycled as often as possible but ultimately the mud is discarded when significantly contaminated with fine particles of the penetrated, discarded strata. Bentonite has no organic or biological content and cannot be defined as waste soil (D1 above). Some results of operational sampling are given in Table D34.

Table D34 Non-exempt wastes - *Bentonite*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	5	10.9	14.1	-	14.9	1.6
pH	5	7.7	9.6	-	11.0	1.3
N (kg m^{-3})	5	0.0	0.0	3.0	15.1	6.8
NH_4N (kg m^{-3})	5	0.0	0.0	0.02	0.1	0.0
P_2O_5 (kg m^{-3})	4	0.0	0.3	0.3	0.6	0.3
K_2O (kg m^{-3})	5	0.4	0.8	0.8	1.0	0.2
Mg (kg m^{-3})	5	0.0	0.7	0.9	2.8	1.1
Cu (mg kg^{-1})	4	1.1	2.0	2.0	2.7	0.7
Zn (mg kg^{-1})	5	1.7	7.5	-	10.3	4.2
Ni (mg kg^{-1})	3	2.6	5.0	-	5.1	1.4
Cd (mg kg^{-1})	5	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	5	<1.0	<1.0	0.5	1.3	
Cr (mg kg^{-1})	5	<1.0	1.6	1.9	4.3	
Hg (mg kg^{-1})	5	<0.01	<0.01	<0.01	0.02	
BOD (mg l^{-1})	5	18	2000	4000	14 000	5698

Bentonite

Potential benefits: Bentonite, is a useful material to act as a marling agent in agriculture. This process involves the addition of large quantities of clay to light textured soils in order to stabilise them and reduce soil erosion. Marling is not now a commercially viable activity, as the logistics of purchasing and spreading clay materials are not economic. Waste bentonite is an acceptable substitute and can perform the same function as a soil conditioner.

Waste industrial bentonite can improve resistance to wind erosion risk on sandy and peaty soils. It can also increase crop yields on sandy soils by improving available water holding capacity.

Research has shown benefits when clay was applied in 1967 to a sandy soil containing approximately 85% sand and 5% clay (Simpson and Alvey, 1991). The material used was Keuper Marl applied at 375 and 750 t ha^{-1}. Over the following 14 years the yields of cereals, potatoes and sugar beet were measured. The two clay treatments gave mean increases in yield over this extended period of 9% and 22% respectively.

This substantial improvement in crop performance was attributed to significant increases in measured soil water content. In addition it was observed that the plots receiving clay were less susceptible to wind erosion.

Potential disbenefits: Lubrication oils can occasionally be found in with the waste due to accidental spillage's and all wastes should be screened for this contaminant. Excessive applications or applications to unsuitable soil may impede drainage and cause waterlogging.

Best practice:

- The bentonite should be analysed regularly for potential contaminants
- The site to be landspread should be assessed for its suitability to receive the waste
- Where the waste contains a significant lime content, the land should be tested for pH and lime requirement.
- Light, sandy soils are likely to be the most responsive to the application of bentonite waste

D13.2 Ammonia

Table D35 indicates a suggested evaluation programme for waste ammonia which is to be landspread.

Table D35 Ammonia

ANALYSIS	Ammonia
Major nutrients	Y
pH + solids	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	N
Oil/fat	N
Red List depends on process	Y/N
PTEs	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Ammonia

Large volumes of waste ammonia are produced by the chemical industry. Some analyses are given in Table D36.

Potential benefits: Agricultural benefit accrues from the high nitrogen content, ranging from 5-60 kg m^{-3}, the majority of which is immediately available for crop uptake.

Potential disbenefits: Solutions of ammonia are, unless diluted substantially, extremely high in nitrogen. Applications should only be made at very low rates and strictly according to crop requirements. Surface applications to crops and grass can cause damage by scorching.

Best practice: All of the N is in an available form and should be matched to crop requirements and fertiliser use. The waste can also contain other contaminants from the chemical process and PQA should be sought before applying this material to land. Surface applications should be avoided as the ammonia may scorch crops.

Table D36 Non-exempt wastes - *Ammonia*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	9	0.0	1.8	8.1	38.3	13.6
pH	9	1.5	8.4	8.6	12.2	3.4
N (kg m^{-3})	9	0.7	21.0	25.2	64.3	20.7
NH_4N (kg m^{-3})	9	0.0	21.0	22.2	46.1	16.7
P_2O_5 (kg m^{-3})	9	0.0	0.0	4.3	37.8	12.6
K_2O (kg m^{-3})	9	0.0	0.0	0.12	0.7	0.2
Mg (kg m^{-3})	9	0.0	0.0	0.04	0.2	0.1
Cu (mg kg^{-1})	9	<1.0	2.5	3.8	18.4	
Zn (mg kg^{-1})	9	<1.0	3.1	4.8	17.7	
Ni (mg kg^{-1})	9	<1.0	<1.0	0.3	1.7	
Cd (mg kg^{-1})	9	<0.25	<0.25	0.2	0.98	
Pb (mg kg^{-1})	9	<1.0	<1.0	2.2	19.3	
Cr (mg kg^{-1})	9	<1.0	<1.0	2.8	25.3	
Hg (mg kg^{-1})	8	<0.01	<0.01	<0.01	<0.01	
BOD (mg l^{-1})	6	11	33 225	7200	28 000	10 437

D13.3 Ammonium sulphate

Table D37 indicates a suggested evaluation programme for waste ammonium sulphate which is to be landspread.

Table D37 Ammonium sulphate

ANALYSIS	Ammonium sulphate
Major nutrients	Y
pH + solids	Y
BOD	Y
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	N
Oil/fat	N
Red List	N
PTEs	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Ammonium sulphate

Large volumes of waste acidic ammonium sulphate are produced by the chemical industry. This ammonium sulphate is neutralised with ammonia into a concentrated (>8% N) form and sold as an agricultural fertiliser. Some analyses are given in Table D38.

Potential benefits: Agricultural benefit accrues from the high nitrogen content, ranging from 5-60 kg m^{-3}, the majority of which is immediately available for crop uptake.

Ammonium sulphate also contains a significant quantity of sulphur which is an essential nutrient for crop growth

Potential disbenefits: Solutions of ammonia are, unless diluted substantially, extremely high in nitrogen. Applications should only be made at very low rates and strictly according to crop requirements. Surface applications to crops and grass can cause damage by scorching. Applications can lead to a reduction in soil pH value.

Best practice:

- All of the N is in an available form and should be matched to crop requirements and fertiliser use..

- The waste can also contain other contaminants from the chemical process and PQA should be sought before applying this material to land.

- Since the sulphur content is a large beneficial component the waste should be applied to a responsive crop.

- It should not be applied immediately before an oilseed rape crop unless the quantity of sulphur applied can be limited to that required for crop off-take. Large additions of sulphur can raise glucosinolate content of the oil to an unacceptable level.

- Large additions of sulphur can induce copper deficiency in livestock.

- Soil pH value should be monitored and adjusted by liming as necessary.

Table D38 Non-exempt wastes - *Ammonium sulphate*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	6	2.3	32.7	-	49.9	21.5
pH	6	4.3	7.7	-	9.1	1.7
N (kg m^{-3})	6	6.3	56.7	57.2	107.0	45.5
NH_4N (kg m^{-3})	6	1.5	46.4	46.7	98.8	43.2
P_2O_5 (kg m^{-3})	6	0.0	0.0	0.03	0.1	0.1
K_2O (kg m^{-3})	6	0.0	0.0	0.1	0.6	0.2
Mg (kg m^{-3})	6	0.0	0.1	0.1	0.3	0.1
Cu (mg kg^{-1})	6	<1.0	0.24	0.61	2.2	
Zn (mg kg^{-1})	6	<1.0	0.5	0.86	2.8	
Ni (mg kg^{-1})	6	<1.0	<1.0	<1.0	1.0	
Cd (mg kg^{-1})	6	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	6	<1.0	<1.0	<1.0	<1.0	
Cr (mg kg^{-1})	6	<1.0	<1.0	<1.0	<1.0	
Hg (mg kg^{-1})	6	<0.01	<0.01	0.10	0.62	
BOD (mg l^{-1})	5	5	200	11 000	33 000	15 517

D13.4 Pharmaceutical waste from antibiotic production

The manufacture of antibiotics results in the production of biomass consisting largely of fungal mycelia. When broken down in soil, this material can provide essential nutrients for plant growth and substitute for inorganic fertiliser.

Most of the antibiotics are removed in the extraction process, however, it is very difficult to remove the last trace of product. Antibiotics remaining in the waste may adversely affect the soil microbiological population but this is likely to be a short-term effect. Exposure of soil micro-organisms to antibiotics could result in dissemination of resistance to antibiotics through natural populations. Some research is needed to resolve this question.

Before considering the landspreading of such a material, an assessment must be made with PQA as to its safety and any environmental risk associated with the process, including:

- the quantity of antibiotic and cells/colonies remaining in the waste;
- the major plant nutrients in the waste and other contaminants; and
- the effect that residual antibiotic or cells/colonies may have on the soil microbiological population.

Some analyses are given in Table D39 which shows that these materials can contain beneficial amounts of plant nutrients.

Table D39 Non-exempt wastes - *Pharmaceutical*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	24	0.9	4.6	9.0	52.1	11.6
pH	24	3.7	6.4	-	10.5	1.5
N (kg m^{-3})	24	0.0	3.7	4.6	17.5	4.3
NH_4N (kg m^{-3})	24	0.0	0.3	1.5	16.9	3.5
P_2O_5 (kg m^{-3})	23	0.0	0.6	0.7	2.9	0.7
K_2O (kg m^{-3})	24	0.0	0.2	0.3	1.7	0.4
Mg (kg m^{-3})	24	0.0	0.0	0.1	1.6	0.3
Cu (mg kg^{-1})	12	0.0	2.3	3.5	12.7	3.8
Zn (mg kg^{-1})	23	0.5	5.2	6.3	19.5	4.4
Ni (mg kg^{-1})	24	<1.0	<1.0	0.5	3.4	
Cd (mg kg^{-1})	24	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	24	<1.0	<1.0	<1.0	2.6	
Cr (mg kg^{-1})	24	<1.0	<1.0	<1.0	7.6	
Hg (mg kg^{-1})	24	<0.01	<0.01	<0.01	0.09	
BOD (mg l^{-1})	23	400	12 200	17 000	88 800	19 480

D13.5 Basic slag

This material is a by-product of steel making and is used on the land principally as a source of P; it usually contains about 10 - 22% P_2O_5 (Cooke 1976). The value of slags for crops also depends on the quality of the phosphate present and this is tested by the percentage solubility of the P in citric acid. Basic slags are also effective liming materials containing 25 - 30% calcium and some magnesium. They contain trace elements (which can be potentially toxic in excess) such as copper, cobalt, boron, zinc and molybdenum.

Table D40 indicates a suggested evaluation programme for basic slag which is to be landspread.

Table D40 Basic slag

ANALYSIS	Basic slag
Major nutrients	Y
pH + solids	Y
BOD	N
Microbiological	N
Electrical conductivity and sodium	Y
Neutralising value (lime)	Y
Oil/fat	N
Red List	N
PTEs	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary

Potential benefits: This lies in the content of phosphate and calcium. The magnesium and trace elements may also be of benefit.

Potential disbenefits: May contain various PTEs.

Best practice: Apply as a phosphate fertiliser taking account of the soil P index and crop requirement for P. Neutralising value and soil lime requirement must be considered. PTEs must be taken into account if present in excessive concentrations.

D13.6 Landfill leachate

Landfill management practice leads to the production of leachate which has to be treated or otherwise safely dealt with. The leachate produced is highly variable and can contain various different contaminants from within the site. Some leachates are treated biologically or 'recycled' back onto the site, but others require disposal of some kind. As many leachates are high in ammonia and potassium compounds, they are potentially suitable for agricultural use, provided they do not contain excessive concentrations of contaminants. Detailed analysis is advisable followed by PQA.

Landfill leachate has a high COD and applications to the land would need to be carefully managed to avoid water pollution.

Some results of operational analysis are given in Table D41.

Table D41 Non-exempt wastes - *Landfill leachate*

Analyses	No. of samples	Min	Median	Mean	Max	Standard Deviation
Total solids (%)	2	1.4	2.4	2.4	3.3	1.3
pH	2	7.3	7.9	7.9	8.4	0.8
N (kg m^{-3})	2	10	3.2	3.2	5.3	3.0
NH_4N (kg m^{-3})	2	0.9	3.1	3.1	5.3	3.1
P_2O_5 (kg m^{-3})	2	0.0	0.1	0.1	0.2	0.1
K_2O (kg m^{-3})	2	1.1	2.5	2.5	3.8	1.9
Mg (kg m^{-3})	2	0.0	0.2	0.2	0.3	0.2
Cu (mg kg^{-1})	2	<1.0	<1.0	<1.0	<1.0	
Zn (mg kg^{-1})	2	<1.0	5.2	5.2	10.4	
Ni (mg kg^{-1})	2	<1.0	<1.0	<1.0	<1.0	
Cd (mg kg^{-1})	2	<0.25	<0.25	<0.25	<0.25	
Pb (mg kg^{-1})	2	<1.0	<1.0	<1.0	<1.0	
Cr (mg kg^{-1})	2	<1.0	<1.0	<1.0	<1.0	
Hg (mg kg^{-1})	2	<0.01	<0.01	<0.01	<0.01	
BOD (mg l^{-1})	2	500	4500	4500	8500	5657

D13.7 Water treatment sludge

Potential benefits: These materials are not high in content of major nutrients but will contain some N and P in the form of bacterial cell debris, which will be greatest in natural sludges (see below), and precipitated phosphate. Their main benefit is as a source of the secondary plant nutrient, sulphur. They may also contain trace elements such as Mn. A significant amount of organic matter can be found in sludges derived from peat run-off in upland areas. Sludges can vary widely depending on the geology of the area of sludge production. This can lead to other benefits if they contain lime and organic matter.

Potential disbenefits: The main concern with this type of waste sludge is its high aluminium content. Although aluminium is a major component of soils, it can be toxic at low soil pH values when it cause induced phosphate deficiency in crops. Effects of aluminium toxicity would not be expected to occur above a soil pH value of about 5.0. As a precautionary measure, it is advisable to restrict applications of alum water treatment sludges to soils of pH value not less than 6. Again as a precautionary measure, it is advisable to monitor and prevent excessive build-up of Al and Fe levels in the surface layer of pasture grass receiving repeated top dressings of alum or iron rich sludges. This is to avoid possible effects on ruminant animals following direct ingestion of sludge or soil and may require PQA.

The microbiological quality of water treatment sludge will reflect that of the raw water. It is possible that the sludge may contain pathogens such as *Cryptosporidium.*

Best practice: Below are characteristics of water treatment sludge which should also be considered:

- Analysis for iron, aluminium, sulphur and manganese should be carried out on these wastes.
- The sulphur content of this waste can be the main beneficial component. It should, therefore be applied to a responsive crop such as grass, cereals or oilseed rape. Soils of pH below 6 are unsuitable because of potential phosphate deficiency or aluminium toxicity.
- Where aluminium content is high great care should be taken to prevent the waste from entering a watercourse since this can harm aquatic life.

The types and characteristics of waterworks sludge produced depend on the water treatment process and raw water quality. In the UK, the following are the main types:

Coagulant sludges - produced from the treatment of raw waters (usually surface waters) with a coagulant (usually aluminium sulphate or ferric sulphate) and are composed of aluminium/iron hydroxide flocs together with impurities (colour and turbidity) removed from the raw water.

Natural sludges - produced as a result of filtration of raw waters through slow sand filters (usually without additional chemicals) and are composed of impurities removed from the raw water together with biological growth from the filter, sometimes known as the 'Schmutzdecke'.

Groundwater sludges - produced as a result of the oxidation of dissolved metals (usually iron and manganese) in groundwaters and comprising of metal hydroxide/dioxide floc.

Softening sludges - produced as a result of softening of hard waters and largely composed of calcium carbonate which would have a lime value in agriculture.

Table D42 indicates a suggested evaluation programme for water treatment sludge which is to be landspread. Each waste should be compared with the broad categories shown in Table 2 of Schedule 3 and consideration given to any specific characteristics of the waste to be tested. Some operational analyses are given in Table D43.

Table D42 Water treatment sludges

ANALYSIS	Aluminium sulphate	Ferric sulphate
Major nutrients	Y	Y
pH + solids	Y	Y
BOD	Y	Y
Microbiological	N	N
Electrical conductivity and sodium	N	N
Neutralising value (lime)	Y	Y
Oil/fat	N	N
Additional analysis	Aluminium/sulphur	Iron/sulphur
Red List	N	N
PTEs*	Y	Y

Y = Analysis or evaluation is recommended N = Analysis or evaluation may not be necessary
* Al and Fe content to be determined as appropriate

Table D43 Non-exempt wastes- *water treatment sludge*

Analyses	**No. of samples**	**Min**	**Median**	**Mean**	**Max**	**Standard Deviation**
Total solids (%)	8	2.4	8.5	20.8	55.7	21.8
pH	8	4.4	5.0	5.4	7.0	1.0
N (kg m^{-3})	8	0.8	2.0	2.3	9.0	2.7
NH_4N (kg m^{-3})	7	0.0	0.0	0.01	0.1	0.0
P_2O_5 (kg m^{-3})	8	0.0	1.1	1.5	5.5	1.8
K_2O (kg m^{-3})	8	0.0	0.8	0.9	2.3	0.9
Mg (kg m^{-3})	8	0.0	0.2	0.6	2.0	0.8
Cu (mg kg^{-1})	8	3.1	11.0	13.3	34.7	10.1
Zn (mg kg^{-1})	8	3.8	21.3	29.3	78.7	28.3
Ni (mg kg^{-1})	8	0.5	3.5	6.1	17.1	6.2
Cd (mg kg^{-1})	7	0.1	0.3	0.2	0.4	0.1
Pb (mg kg^{-1})	7	2.8	8.1	17.4	50.1	19.4
Cr (mg kg^{-1})	6	0.1	5.2	9.9	27.9	11.5
Hg (mg kg^{-1})	6	<0.01	0.02	0.03	0.09	
BOD (mg l^{-1})	5	100	3000	6020	19 000	7563

APPENDIX E QUANTITIES OF WASTES SPREAD ON LAND

Information on types and quantities of wastes going to land is scarce and the figures in Table E1, which have been derived from ADAS (1994, 1996), Davis and Dalimier (1994), Hall and Dalimier (1994) and Hobbs and Archer (1994), are in most cases no more than rough estimates. The exceptions are sewage sludge, which is quite accurately measured, and paper wastes which are also thought to be reasonably reliable. The figure for farm animal wastes provides a perspective on the quantities of other wastes spread on land. It has not been possible to estimate a figure for some exempted wastes, although for some of these, such as dredgings and waste lime materials, the quantities spread on land are probably substantial and in excess of 500 000 tonnes wet weight per annum. Butterworth (1997) has estimated that about 650 000 tonnes of material classed as 'compost' is sold in the UK annually.

Table E1 Estimated quantities of wastes spread annually on land in the UK

Waste	Quantity(1)
Farm animal waste	21 000 (140 000)
Sewage sludge	430 (2900)
Paper industry waste	520 (1750)
Food industry waste	(600)
Sugar industry waste	200
Vegetable and fruit processing waste	70
Textile industry waste	22
Water treatment sludge	17
Meat processing waste (blood etc. from abattoirs)	15
Beverage production waste (breweries, soft drinks)	11
Dairy waste	7
Leather tannery waste	1

(1) Expressed as thousands of tonnes dry weight, figures in brackets refer to wet weight

APPENDIX F OPERATIONS LIKELY TO DAMAGE THE FEATURES OF SPECIAL INTEREST (see Section 2.8.1)

Standard Ref. No.	Type of operation
1.	Cultivation, including ploughing, rotovating, harrowing and re-seeding.
2.	Grazing, the introduction of grazing (where applicable) and alterations to the grazing regime (including type of stock, intensity or seasonal pattern of grazing).
3.	Stock feeding (where already damaging), the introduction of stock feeding (where applicable) and alterations to stock feeding practice.
4.	Mowing or cutting vegetation (where already damaging), the introduction of mowing etc. (where applicable) and alterations to the mowing or cutting regime (such as from haymaking to silage).
5.	Application of manure, slurry, silage liquor, fertilisers and lime.
6.	Application of pesticides, including herbicides (weedkillers) whether terrestrial or aquatic, and veterinary products.
7.	Dumping, spreading or discharging of any materials.
8.	Burning and alterations to the pattern or frequency of burning (where applicable).
9.	Release into the site of any wild, feral, captive-bred or domestic animal*, plant, seed or micro-organism (including genetically modified organisms).
10.	Killing, injuring, taking or removal of any wild animal* (including dead animals or parts thereof), or their eggs and nests, including/excluding pest control, and disturbing them in their places of shelter.
11.	Destruction, displacement, removal or cutting of any plant or plant remains, including (specify as appropriate - e.g. tree, shrub, herb, hedge, dead or decaying wood, moss, lichen, fungus, leaf-mould, turf, peat, etc.).

* "animal" includes any mammal, reptile, amphibian, bird, fish or invertebrate (including honey bees).

12. Tree and/or woodland management (where already damaging), the introduction of tree and/or woodland management (where applicable) and alterations to tree and/or woodland management (including, planting, felling, pruning and tree surgery, thinning, coppicing, changes in species composition, removal of fallen timber).

13a. Drainage (including moor-gripping, the use of mole, tile, tunnel or other artificial drains).

13b. Modifications to the structure of water courses (e.g. rivers, streams, springs, ditches, dykes, drains), including their banks and beds, as by re-alignment, regrading, damming or dredging (specify where possible).

13c. Management of aquatic and bank vegetation for drainage purposes.

14. Alterations to water levels and tables and water utilisation (including irrigation, storage and abstraction from existing water bodies and through boreholes). Also the modification of current drainage operations (e.g. through the installation of new pumps).

15. Infilling or digging of ditches, dykes, drains, ponds, pools, marshes or pits (specify).

16a. Freshwater fishery production and/or management, including sporting fishing and angling (where already damaging), the introduction of freshwater production and/or management (where applicable) and alterations to freshwater fishery production and/or management.

16b. Coastal fishing, fisheries management and seafood or marine life collection, including the use of traps or fish cages (where already damaging), the introduction of coastal fishing (where applicable), alterations to coastal fishing practice or fisheries management and seafood or marine life collection.

17 Reclamation of land from sea, estuary or marsh.

18. Bait digging in intertidal areas (England and Wales only).

19. Erection and repair of sea defences or coast protection works, including cliff or landslip drainage or stabilisation measures.

20. Extraction of minerals including peat, shingle, hard rock, sand and gravel, topsoil, subsoil, chalk, lime, limestone pavement, shells and spoil (specify where possible).

21. Destruction, construction, removal, rerouting or regrading of roads, tracks, walls, fences, hardstands, banks, ditches or other earthworks, including soil and soft rock exposures or the laying, maintenance or removal of pipelines and cables, above or below ground.

22. Storage of materials (specify features, e.g. geological where possible).

23. Erection of permanent or temporary structures or the undertaking of engineering works, including drilling.

24a. Modification of natural or man-made features (including cave entrances) and clearance of boulders, large stones, loose rock or scree.

24b. Battering, buttressing or grading of geological exposures and cuttings (rock and soil) and infilling of pits and quarries. (Modern-day quarrying practice may involve ongoing restoration/backfilling whilst extraction continues on other parts of the site. It may be necessary therefore, on some occasions, to use 24 in its entirety and not split it into 2 parts).

25. Removal of geological specimens, including rock samples, minerals and fossils.

26. Use of vehicles or craft.

27. Recreational or other activities (specify).

28a. Game and waterfowl management and hunting practices (where already damaging), introduction of game and waterfowl management and hunting practice.

28b Use of lead shot. (Only to be applied where species will be harmed).

THE ENVIRONMENT AGENCY

Complete and return this form to the Environment Agency:

A copy of the completed landspreading proforma will be forwarded to the Environment Agency, the Environmental Health Department and English Nature (Countryside Council for Wales), all of whom may comment directly on aspects of the proposed spreading. It is in your interests to give sufficient time for any comments to be made by either of these bodies before spreading the waste as you may commit an offence by failing to ensure that the activity is conducted in a manner without risk to the environment or without endangering human health. However, the failure of either the Agency or other bodies to respond should not be taken as approval of the method of the proposal and the completion of the landspreading proforma does not remove any obligation under other legislation to consult with or notify the Agency or any other authority. If you are in any doubt of the suitability of the land then you should contact the appropriate authority.

The spreading of liquid and other organic wastes onto agricultural land can cause serious water pollution if due consideration is not given to the location and method of application. The MAFF Code of Good Agricultural Practice for the Protection of Water describes the methods of application, circumstances under which waste must not be spread and the various steps to take to avoid the risk of water pollution. You MUST read this Code of Practice before applying any waste to land. Copies of the Code of Practice together with those for the protection of Soil and Air, may be obtained free of charge from MAFF Publications London SE99 7TP or telephone 0181 697 8862.

The Agency requires a return of the actual amounts of waste spread per hectare of land during the six month notification period, or in the case of a single deposit, the amount deposited. The information is required to ensure that in any period of twelve months the established theoretical maximum application rate, based on **Proper Qualified Advice (PQA)**, for each **waste material**, each **soil** and **site** has not been exceeded.

Agency.

Water Resources Act 1991 (as amended by the Environment Act 1995)
Requires consent from the Environment Agency for discharge into or onto land from fixed plant.

(new edition 1996)