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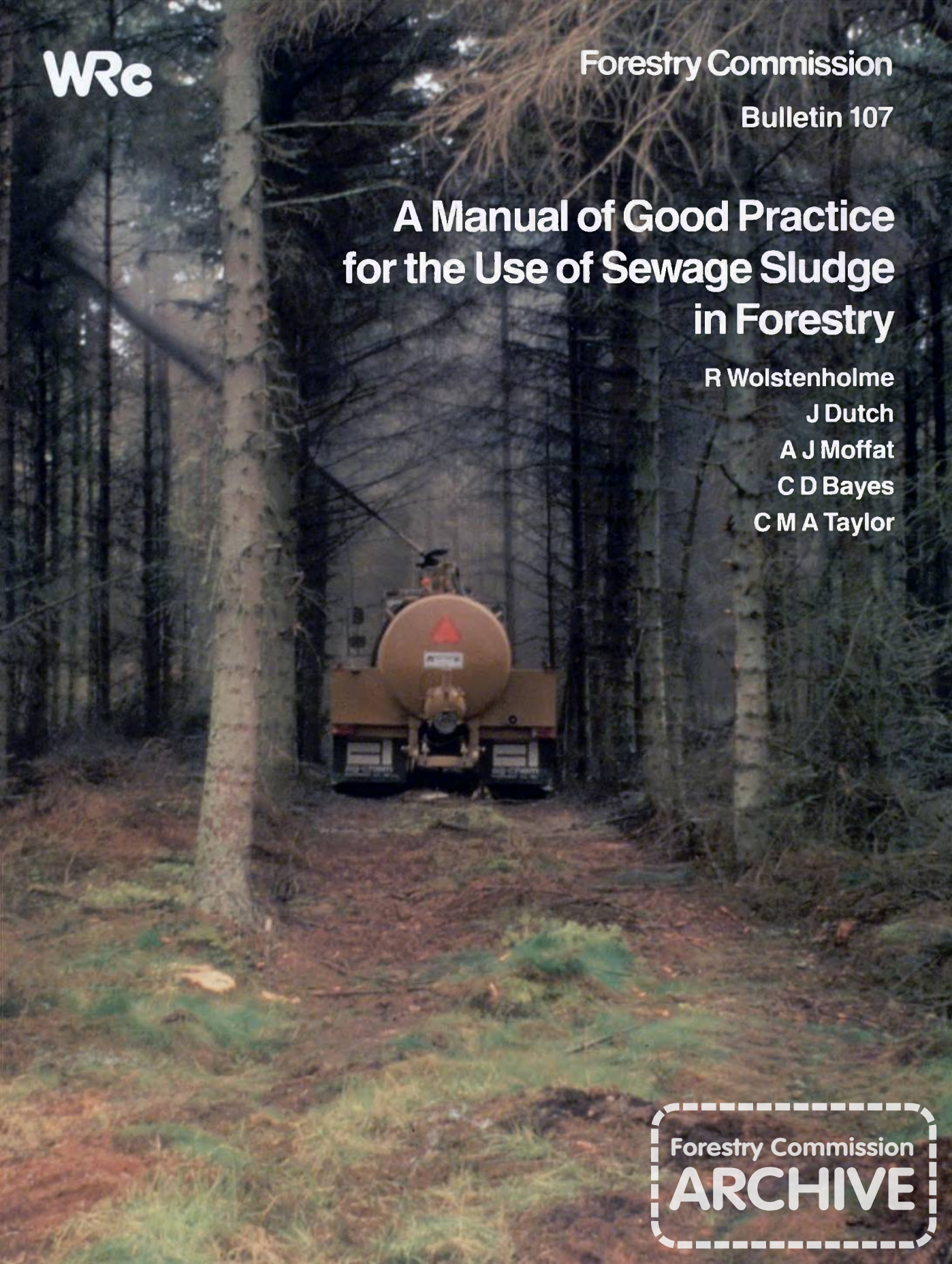

FORESTRY COMMISSION BULLETIN 107

A Manual of Good Practice for the Use of Sewage Sludge in Forestry

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Front cover: Specialised tanker with top-mounted cannon applying liquid sludge to a pole stage crop. (*J. E. Hall*)

Contents

Foreword

Sewage sludge contains valuable nutrients which can be recycled by its application to land as a fertiliser. Currently, however, over 30% of the UK's sludge production is disposed of at sea. With the phasing out of sea disposal by 1998, and with the increasing pressure to conserve natural resources, we anticipate that sludge will increasingly be seen as a useful product rather than as a disposal problem.

We are pleased that we can offer new outlets for sewage sludge which will help to increase the productivity of our forests and will contribute towards safeguarding our marine environment. However, care must be taken when using sewage sludge and this manual gives guidance on how to apply it safely and with wildlife conservation in mind.

Research by the Forestry Commission and WRc (formerly the Water Research Centre) provided the background for this manual, but more research still needs to be done. Agricultural uses for sludge have been available for decades, but its use in forestry is only very recent. As the forestry use expands monitoring will be required to be confident that it continues to be compatible with the wildlife conservation, recreation and timber value of our woodlands.

R. T. Bradley
Head of The Forestry Authority

A Manual of Good Practice for the Use of Sewage Sludge in Forestry

Introduction

Sewage sludge, a mixture of solids and water produced during the treatment of waste water, can be used as a valuable fertiliser and is currently widely used as such in agriculture.

Since 1981 a joint Forestry Commission/WRc research programme has evaluated the growth responses and environmental implications of sewage sludge applications to forests (Bayes *et al.*, 1991). This programme has shown that tree growth can be significantly enhanced following sludge application (Wolstenholme *et al.*, 1991; Dutch and Wolstenholme, in press). The experience gained from the various pilot trials and experiments has been used to develop the following guidelines for the use of sewage sludge in forestry. Research is continuing and future findings will be used to update the guidelines.

Part I of the manual addresses the subject of the silvicultural value of sewage sludge as a forest fertiliser. This will assist the forest manager in selecting suitable sites where a growth response can be expected.

Part II of the manual, the Code of Good Practice, deals with the practicalities of suitable application procedures and is aimed at those actively involved in these procedures, including forest managers and water industry staff.

Un Manuel des Règlements et Usages à observer dans l'utilisation de la boue des eaux d'égout en sylviculture

Introduction

La boue des eaux d'égout, mélange d'éléments solides et d'eau résultant du traitement des eaux usées, peut constituer une forme d'engrais très efficace et est actuellement souvent utilisée à cette fin en agriculture.

Depuis 1981, un programme de recherche réalisé conjointement par le Service des Eaux et Forêts (Forestry Commission) et le WRc a porté sur l'utilisation de la boue des eaux d'égout dans les forêts et les conséquences observées au niveau de la croissance des arbres et de l'environnement (Bayes *et al.*, 1991). Ce programme a révélé que la croissance des arbres est plus importante lorsque la boue des eaux d'égout est utilisée comme engrais (Wolstenholme *et al.*, 1991; Dutch et Wolstenholme, sous presse). Les conclusions tirées des différents essais et expériences pilotes ont permis de mettre au point les recommandations qui suivent pour l'utilisation de la boue des eaux d'égout en sylviculture.

La recherche continue et les découvertes réalisées à l'avenir seront utilisées pour mettre à jour ces recommandations.

La première section du manuel porte sur la valeur et l'utilité de la boue des eaux d'égout en tant qu'engrais de forêt. Cette section va aider les exploitants forestiers à sélectionner les endroits où une meilleure croissance des arbres peut être attendue.

La deuxième section du manuel, le Code des Règlements et Usages, se concentre sur les détails pratiques des procédures d'application et elle est destinée à ceux qui sont directement impliqués dans ces procédures, par exemple les exploitants forestiers et le personnel du service des eaux.

Ein Verfahrenshandbuch zum Gebrauch von Klärschlamm in der Forstwirtschaft

Einleitung

Klärschlamm, eine Mischung von Feststoffen und Wasser die bei der Abwasseraufbereitung entsteht, ist ein wertvolles Düngemittel und wird als solches gegenwärtig im hohem Maße von der Landwirtschaft benutzt.

Seit 1981 hat ein Forschungsprogramm der Forstbehörde gemeinsam mit dem Wasser Forschungs Zentrum (WRc) die Wachstumsreaktionen und Umwelteinflüsse der Benutzung von Klärschlamm in Wäldern untersucht (Bayes *et al.*, 1991). Dieses Programm bewieß, daß Baumwuchs nach Klärschlammanwendung bedeutend anstieg (Wolstenholme *et al.*, 1991; Dutch and Wolstenholme, im Druck). Die gewonnene Erfahrung von verschiedenen Versuchsprojekten und -experimenten wurde benutzt um die folgenden Richtlinien für den Gebrauch von Klärschlamm in der Forstwirtschaft zu entwickeln.

Die Forschung wird fortgesetzt und zukünftige Ergebnisse werden benutzt werden um die Richtlinien auf den neuesten Stand zu bringen.

Teil I des Handbuches spricht den forstwirtschaftlichen Wert von Klärschlamm als Walddünger an. Dies wird dem Forstverwalter bei der Wahl geeigneter Standorte, in denen Wachstumssteigerungen zu erwarten sind, behilflich sein.

Teil II des Handbuches, der Verfahrenskodex, behandelt die Handhabung geeigneter Auftragungsverfahren und richtet sich an diejenigen die aktiv mit diesen Verfahren beschäftigt sind, inklusive Forstverwalter und Personal der Wasser-industrie.

Part I

The Silvicultural Value of Sewage Sludge

1. Potential for the Use of Sewage Sludge as a Forest Fertiliser

The potential for sewage sludge utilisation as a forest fertiliser is considerable. There is a gross area of over 2 million ha of productive woodland in the UK. Much of this area is situated on nutrient-poor soils where fertiliser applications are necessary for satisfactory tree growth (Taylor, 1991). Sludge can be used as a substitute for conventional fertilisers in some of these areas.

It has been estimated that 75 000 ha of forest land or land to be planted could benefit from sludge application, of which approximately 16 000 ha could be treated each year (Taylor and Moffat, 1991). Many of the new community forests include significant areas of infertile derelict land. This, together with the increasing restoration of mineral workings to forestry, will also provide additional opportunities for using sludge. It has been estimated that up to 11% of the total UK sludge production could potentially be applied to forest lands (Taylor and Moffat, 1991).

Fertiliser value of sewage sludge

Sewage sludge is a by-product of sewage treatment. It is a valuable organic manure containing nitrogen, phosphorus and organic matter. The availability of these nutrients and the amount of organic matter present is dependent on the treatment process used at the sewage works. Sludges are usually described as being either 'undigested' or 'digested' and are produced in either 'liquid' or 'cake' forms.

Liquid undigested sludge is produced by the sedimentation of screened sewage and typically has a dry solids content of 2 to 7%. Up to 75% of the solid fraction is organic matter which breaks down in the soil and acts as a slow release nitrogen fertiliser.

Liquid digested sludge is produced by the treatment of liquid sludge, usually in a digester, and has a dry solids content of 2 to 5%. This process reduces the amount of organic matter by about half and converts much of the nitrogen to ammonium ions, resulting in a quick acting nitrogen fertiliser with some slow release properties. Digested sludge is less odorous than undigested sludge.

Cake sludge is produced by pressing or centrifuging liquid sludge (either liquid digested or liquid undigested) after pretreatment with lime or other conditioning chemicals. This increases the dry solids content to 20–35% while stacking or air-drying can further increase this to over 50%. Most of the soluble nutrients are lost, making such sludges very slow acting fertilisers. They are, however, a good source of phosphate and organic matter.

Digested sludge is preferred to undigested sludge as it is less odorous and has a reduced pathogen content. It is especially important to use digested sludges at sites that are used by the public to any great extent. Undigested sludge is often produced at small rural sewage treatment works and could therefore be used in more remote forest sites that are unlikely to be frequently visited by the public. Either liquid sludge or cake sludge can be used beneficially depending on the site. Sludge can be ploughed in prior to planting. Cake sludge is especially valuable on sites being restored following mineral extraction as it provides a high input of organic matter. After tree planting it is feasible only to apply liquid sludge.

Biological stabilisation, e.g. composting, of

Table 1. Typical sludge nutrient analysis (total and available)

Sludge type		*Total*		*Available*[a]	
		N	*P*	*N*	*P*
Liquid undigested	(kg m^{-3})	1.8	0.6	0.6	0.3
Liquid digested	(kg m^{-3})	2.0	0.7	1.2	0.3
Undigested cake	(kg t^{-1})[b]	7.5	2.8	1.5	1.4
Digested cake	(kg t^{-1})[b]	7.5	3.9	1.1	1.9

[a] Available in first growing season.
[b] Wet tonnes.

sludge reduces odour and pathogen content and hence composted sludge is especially desirable for amenity planting.

Nutrient content varies considerably between sludges from different sources, but as a rough guide average figures are given in Table 1.

Research has shown that sludge application can produce growth responses at least as great as those from a combination of standard rates of conventional fertilisers (Plate 1) with or without control of heather by herbicide (Dutch and Wolstenholme, in press).

In some cases sludge has been found to eradicate heather from sites thus reducing or eliminating the need for herbicide use in pure spruce crops. However, sludge application will increase the growth of grassy and herbaceous vegetation which may necessitate additional weeding. The cost of such additional weeding is unlikely to outweigh the value of the sludge as a replacement for conventional fertilisers.

Sludge has been reported to act as a soil conditioner. As well as supplying nutrients (Byrom and Bradshaw, 1991), sludge addition may be used to improve water retention, root penetration and soil structure. This in turn can reduce run-off and erosion. All of these factors are particularly important in soil restoration.

2. *Site and crop selection*

Selection of appropriate sites for using sludge to achieve a growth response must be based on soil type, tree species, stage of crop development and topography.

Site selection

Suitable soil types should be selected on the basis of their nutrient status and draining characteristics. Heathland podzols and ironpans and freely draining sandy soils are suitable. Reference should be made to Taylor (1991) and Taylor and Tabbush (1990) for guidance on the nutritional requirements of crops at different sites. The principal recommended types are given in Table 2.

Table 2. The most suitable soil types for sludge utilisation

Soil type	*Forestry Commission Soil Classification Code (Pyatt, 1982)*
Podzols	3, 3m, 3p[a]
Ironpan soils	4z, 4, 4b, 4p[a]
Rendzina	12[b]
Littoral (freely drained)	15d, 15e, 15i
Disturbed and restored sites	2g[c], 2s[c]

[a] Upland soils (peaty podzols, peaty ironpan soils) with freely draining subsoils are acceptable provided that the cultivation method employed has, or will, expose the mineral soil.
[b] Rendzinas are typically shallow soils and, although usually dry, they have a limited absorption capacity. Application rates should therefore be reduced to no more than 100 m^3 ha^{-1} (see Application regime in Section 7).
[c] On disturbed and restored sites, an important requirement is to increase the nutrient status of the soil. Liquid sludge can only be applied where compaction has been relieved sufficiently to allow tree growth and infiltration of sludge.

Certain soils are unsuitable:

- Gley soils.
- Deep peats.
- Very shallow soils (e.g. rankers). These soils have a limited absorption capacity, especially when wet, and are likely to be associated with a high risk of surface or near surface run-off, and should therefore be avoided.

Crop selection

Trials to date have included application to Sitka spruce, Scots pine, Corsican pine and, recently, broadleaves (beech, alder, poplar). However, any crop where nutrient deficiencies may be limiting growth and where soil conditions are suitable could potentially be fertilised with sludge.

During the rotation of a forest stand, the period when the greatest demand for nutrients is made on the soil is from planting to canopy closure. It is during this period that the majority of conventional fertilisers are applied. On suitable

sites sludge can be used as a substitute for these. As in normal fertilising practice, foliar analysis can be used to determine whether a crop is nutrient deficient. Advice on foliar sampling can be obtained in Taylor (1991). Applications of liquid sludge made during this stage help to provide a reservoir of nutrients to support tree growth during late establishment and the thicket stage when stand density limits access.

Following canopy closure, recycling of nutrients both by litter decomposition and internal translocation reduces the crop demand for nutrients from the soil. Although conventional fertilisers are seldom applied to pole stage tree crops, growth during this stage can become nutrient limited. This is because at sites where litter decomposition is relatively slow, nutrients become immobilised in the developing litter layer (Miller, 1981).

Predicting fertiliser response in pole stage crops is, however, difficult. At present, this will restrict the use of sludge during the pole stage to pine crops. In these crops, low foliar nitrogen levels can be used to predict where a fertiliser response may be expected (McIntosh, 1984).

Nutrition is not normally limiting in the early stages of the second rotation (Taylor, 1990). However, there are exceptions to this, such as where pure Sitka spruce crops are planted on dry podzolic or ironpan sites (Taylor and Tabbush, 1990). As with all sludge applications, sludge should be applied to restock sites only where there is reason to believe that there will be a fertiliser response.

The density of the crop during the thicket stage, after canopy closure and before thinning, limits ground-based operations. This, together with the crop's nutritional requirements outlined above, gives four stages within the crop rotation where sewage sludge may be used as a forest fertiliser (Table 3).

Table 3. Suitable forestry stages for utilising sludge and the period over which sludge may be applied.

Number of years available	*Description*
2	Prior to new planting. The sludge application should precede cultivation if the site is to be ploughed.
5–8	Early forest establishment from 1–5 years (possibly extending to 8 or 10 years depending on growth rate).
25	Pole stage pine forests which have been thinned or brashed (typically 25 years or older). The timber extraction racks at 12–20 m intervals in thinned stands provide convenient access routes through the stands for sludge application operations.
≤2	Clearfelled areas awaiting replanting.

3. *Application regimes*

The application regime in terms of rate and frequency must take account of the forestry stage and nutrient requirements. Sludge should be applied to a crop only when there is a reasonable expectation that a fertiliser response will be achieved. Soil type, soil water conditions and effects upon wildlife conservation must also be considered, as detailed in Part II, Sections 6 and 7. This will avoid or minimise run-off, possible leaching to groundwater, the creation of anaerobic conditions in the rooting zone, and undesirable changes in plant and animal communities. These considerations are in addition to those already required for the protection of water during normal fertiliser operation as outlined in the *Forests & Water Guidelines* (Forestry Commission, 1991).

The main limitation on the total application rate is the amount of nitrogen applied. This should be calculated to provide no more than a total of 1000 kg N ha^{-1} over the course of the planting/establishment stage or up to a total of 1000 kg N ha^{-1} over the pole stage. The maximum application in any one year should be 200 m^3 ha^{-1} liquid sludge or 50 wet tonnes ha^{-1} cake sludge (both of which will supply approximately 400 kg total nitrogen: see Table 1). These limitations do not apply to land restoration sites (see Application to restored sites, p. 4).

Application prior to planting and to early establishment crops

Prior to afforestation and where appropriate on clearfelled sites, sludge applications should be

designed to supply nutrients to sustain tree growth through establishment, in place of conventional fertilisers. Before the site has been ploughed vehicle access will allow the application of either liquid or cake sludge. Top-dressings on establishment crops will, by necessity, be of liquid sludge.

The maximum volume that should be applied during any one year to newly planted/early establishment crops should be 200 m^3 ha^{-1} liquid sludge or 50 wet t ha^{-1} cake sludge.

Application to pole stage crops

In pole stage plantations it is practical to apply only liquid sludge. The number of applications to be made during this stage should be judged on a site-by-site basis, depending on the nutrient requirement of the crops as determined by foliar analysis. For pole stage crops liquid sludge should be applied at rates of 100–200 m^3 ha^{-1} with a return frequency of not less than 3 years.

Application to restored sites

Restored mineral workings or derelict sites often have a low organic matter content and nutrient status. On such sites the limits of nitrogen loading referred to above do not apply. Higher rates of up to 100 tonnes dry solids ha^{-1} of sludge during the course of establishment can improve soil structure and water-holding capacity.

However, the lack of ground vegetation and the ground compaction typical of such sites increases the potential for overland run-off should liquid sludge be used. Cake sludge application prior to planting can provide high levels of nutrients and organic matter without creating run-off (Plate 2).

Where cake sludge is applied before planting on reclamation sites the crop may require top-dressings with liquid sludge, as determined by visual deficiency symptoms or foliar analysis. Where there is an existing crop then sludge can feasibly be applied only in the liquid form (Plate 3). In such instances the initial applications should not exceed 100 m^3 ha^{-1}. However, once ground vegetation becomes established this can be increased to 200 m^3 ha^{-1} as necessary.

Part II

Code of Good Practice

4. *Introduction*

This Code of Good Practice explains how to maximise the fertilising effects of sewage sludge on tree growth while minimising any adverse environmental effects of application. The recommendations for the use of sewage sludge in forestry are based upon the best available current information.

A checklist of all stages to be included is given in Appendix 1. To facilitate information transfer between the sludge producer and forest manager, it is suggested that sewage sludge fertiliser records (examples of which are given in Appendix 2) should be drawn up before the commencement of any operation.

5. *Legislation*

For the purpose of this manual the term sludge producer is used to refer to the Water Companies in England and Wales and the Regional or Islands Councils departments responsible for sewage treatment.

Under the Collection and Disposal of Waste Regulations (1988) sewage sludge deposited on land in England and Wales for other than agricultural purposes is regarded as an industrial waste. Sewage sludge utilisation in forestry is, however, exempted from licensing under the Control of Pollution Act 1974, Part I, as it is for 'the purpose of fertilising or otherwise beneficial conditioning the land', providing the waste disposal authority receives notification. The waste disposal authorities are as follows:

- For any non-metropolitan county in England, the County Council.
- For metropolitan counties, the District Council or County Waste Disposal Authority.
- For any district in Wales, the District Council.
- For Scotland, an Islands or District Council.

In Scotland, the Control of Pollution (Licensing of Waste Disposal) (Scotland) Regulations 1977 exempt 'sewage sludge spread on land for agricultural purposes' from the description of industrial waste. However, as forestry does not come under the Agriculture (Scotland) Act 1948 a waste disposal licence is required from the local District Council if sewage sludge is to be applied to forestry land. The 1977 regulations will be revised and replaced as a result of the Environmental Protection Act 1990 and The Scottish Office should be consulted for the latest advice.

The Sludge (Use in Agriculture) Regulations 1989 and the Sludge (Use in Agriculture) (Amendment) Regulations 1990, which enforce the provisions of EC Directive 86/278/EEC (Commission of the European Community, 1986), do not apply to sludge use in forestry. However, to ensure best practice, these regulations are adopted (where appropriate) in order to meet the objectives of this manual.

In addition, liaison is required between the sludge producer and the pollution control authority. The pollution control authority refers to the National Rivers Authority (NRA) in England and Wales or the River Purification Boards (RPBs) and Islands Councils in Scotland. However, it is considered that the use of sewage sludge in forestry in the Scottish islands will be very limited and hence for the purposes of this manual only the RPBs will be referred to for Scotland.

6. *Site selection*

Site criteria

The suitability of a forest site for the application

of sludge will depend on the capacity of the crop to use the sludge without detrimental environmental effects, on or off site. To ensure this, consideration should be given to physical, biological and environmental site factors and to public health.

The responsibility for suitable site selection outlined in Part I lies with the local forest manager. Further checking of the suitability of the site will be undertaken jointly by the forest manager and the sludge producer. The final selection is the responsibility of the forest manager.

All the following aspects should be considered when choosing a site:

- Threat of water pollution: as affected by terrain, geology, proximity to water resources (especially potable supplies), soil type, extent of vegetation cover, and type of cultivation.
- Threat to conservation value.
- Proximity to settlements/neighbours.
- Threat to recreational/sporting usage.
- Operational accessibility.
- Proximity to supply of sludge.

The principal sources of information for determining a potential site's characteristics and suitability for sludge application are topographic maps, soil maps, water resources maps, district road maps and forest conservation plans. The recommendations given in this Manual are in addition to those contained in the *Forests & Water Guidelines* (Forestry Commission, 1991).

Water pollution

The principal concerns are (a) surface run-off *during* the application of liquid sludge and (b) pollution from contaminated drainage water after the application of either liquid or cake sludge. Additionally the risk of groundwater contamination must be considered, especially in lowland situations.

Nutrient leaching is of concern in sensitive areas where there is a risk of eutrophication. In these areas, nutrient application is not permitted. Such areas should be identified during consultation with the NRA/RPB.

Under the Water Resources Act (1991) it is an offence to cause or knowingly permit a discharge of poisonous, noxious or polluting matter or solid waste matter into any 'controlled' waters without the proper authority. 'Controlled waters' include groundwater and all coastal or inland waters, including lakes, ponds, rivers, streams, canals and ditches. 'Proper authority' is usually a consent to discharge from the NRA (England and Wales), or the RPBs in Scotland.

The use of sewage sludge as a forest fertiliser may pose a potential risk to public and private water supplies, fisheries and water resources generally, and effective liaison is therefore required.

Liaison

- The NRA in England and Wales has a general duty with respect to the protection of all watercourses and must be consulted whenever sludge application to forestry is planned.
- In Scotland, the Regional Councils and District Councils should be consulted on the proximity of any private supplies. In addition the River Purification Boards must be consulted on the protection of watercourses and non-potable abstractions.

It is the responsibility of the sludge producer to carry out the above liaison and to keep the forest manager informed at all stages.

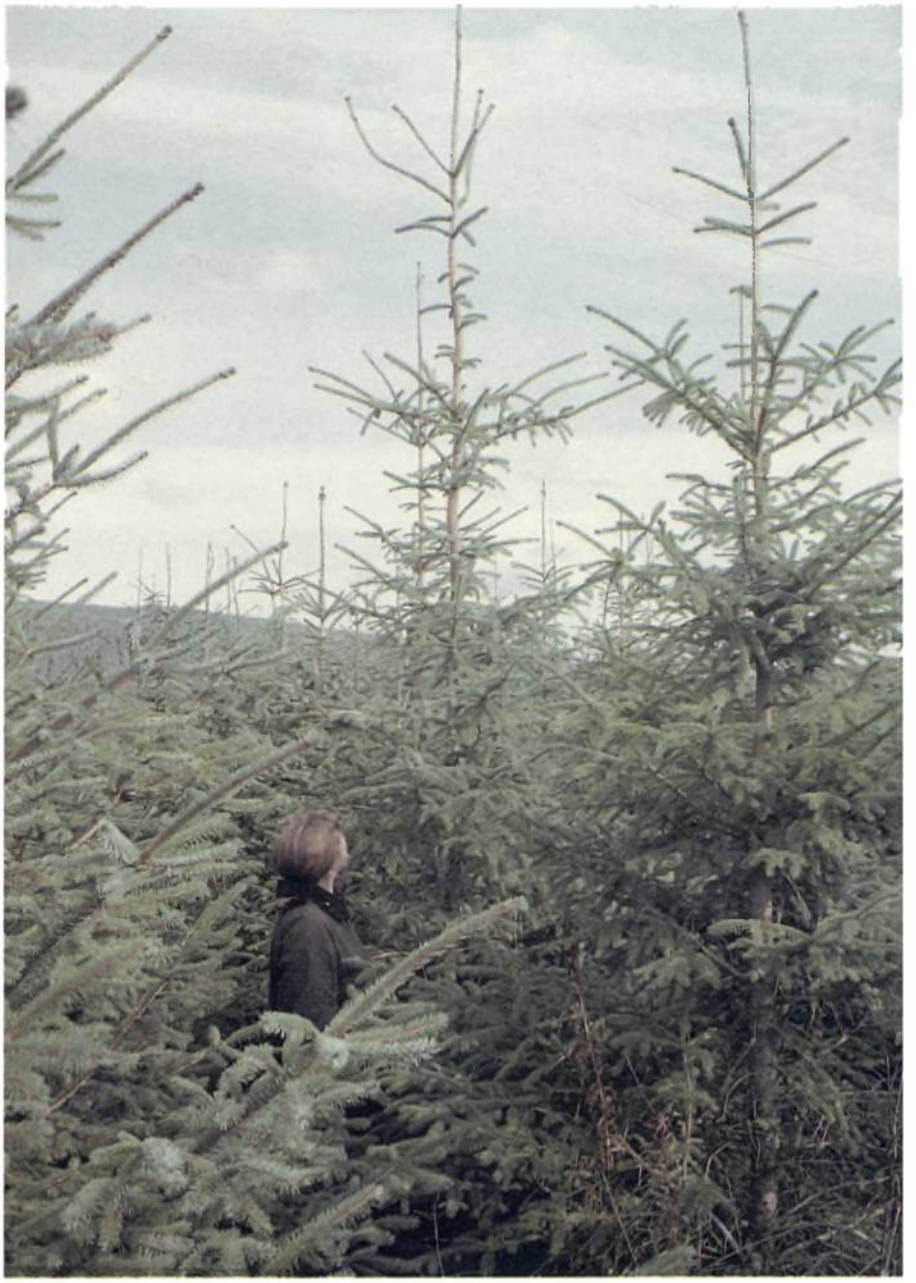
Site considerations

- *Slope.* The greater the slope, the greater the care required to prevent run-off of sludge into drainage courses. Ploughing may also exacerbate run-off problems. It is therefore recommended that no sludge be applied to slopes greater than 25°. Slopes greater than 15° which have been ploughed should also not receive sludge (see Section 7).
- *Groundwater.* The most important consideration here is to protect water abstraction sources (see Section 7).
- *Water resources.* Depth and quality of groundwater, location and size of streams, use and/or potential for use as a potable supply must be considered and advice obtained from the NRA/RPBs and the District Council Environmental Health Department.
- *Soil.* Soil types suitable for sludge application have already been discussed in Part I, Section 2.

(a)

Plate 1. *Response of Sitka spruce 7 years after planting.*
(a) *Herbicide, no fertiliser.*
(b) *Rock phosphate, no herbicide.*
(c) Overleaf
(G. Brearley)

(b)



(c) *Liquid sludge prior to planting.*

(a)

(b)

Plate 2. *Response of Sitka spruce 2 years after planting on former opencast coal site.*
(a) *No fertiliser.*
(b) *Cake sludge applied before planting.*
(c) Overleaf
(R. Wolstenholme)

(c) 

Cake sludge applied before planting and top dressing of liquid sludge.

(a)

(b)

Plate 3. *Response of Sitka spruce 5 years old on former opencast coal site.*
(a) *No fertiliser.*
(b) *Two years after liquid sludge top dressing.*
(G. L. Gate)

(a)

(b)

Plate 4. *Ground vegetation 3 years after planting a restock site.*
(a) *No fertiliser.*
(b) *Liquid sludge applied before planting.*
(G. Brearley)

(a)

Plate 5. *Methods of sludge application.*

(a) *Agricultural tractor and muck-spreader applying cake sludge before cultivation and planting.* (C. D. Bayes)

(b) *Application of liquid sludge to pole stage Scots pine, Speyside.* (G. Brearley)

(c) Overleaf

(b)

(c) 

Modified irrigation gun applying liquid sludge to early establishment crop. (C. M. A. Taylor)

- *Soil drainage characteristics and wetness.* Sludge must not be applied to otherwise suitable soil types when the water table is near the surface or when the soil is saturated. Application under these conditions will lead to surface run-off and probable pollution of water courses. Areas which have a plough and drainage pattern encouraging rapid run-off are not suitable.
- *Ground vegetation.* Sparse vegetation will increase the likelihood of surface run-off. This is especially important on (a) sloping ground and (b) reclamation sites (see Sections 7 and 3 respectively)..

Conservation features

Nature conservation

Sewage sludge may alter plant communities and the associated animal communities. This is true also of conventional fertilisers, but the effects of sewage sludge may be more substantial, particularly where repeated applications approaching the maximum levels of 1000 kg N ha^{-1} are made.

The high nitrogen levels in sewage sludge will favour the growth of grasses and common 'weed' species at the expense of ericaceous plants and other species which are less competitive and often of conservation value (Plate 4).

Whenever sludge application to a Site of Special Scientific Interest (SSSI) is under consideration then there must be consultation with Scottish Natural Heritage, English Nature or the Countryside Council for Wales as sludge application may be a potentially damaging operation. Other areas of special conservation value should be identified by survey if not already recorded on the forest conservation plans, and advice should be sought on how the areas may be affected by sludge application. Conservation plans should be amended to describe management practice requirements for sludge application where there is an expectation of its use. These must highlight the opportunities to maintain the conservation value of forest habitats in relation to sludge use.

When planning the use of sewage sludge the possible effects on wildlife should be borne in mind and steps taken to minimise undesirable changes. The possible leaching or run-off of nutrients from sewage sludge into wetland areas should be considered so as to avoid any changes in these wetland communities. The use of cake sludge, as opposed to liquid sludge, before cultivation is likely to minimise these problems.

Application should be avoided on areas of conservation value including:

- areas to be retained as open habitats, for example rides;
- semi-natural woodland;
- stands of trees where the understorey vegetation is of current or potential conservation value;
- riparian and wetland habitats.

The conservation organisations listed above should also be informed about operations affecting Regionally Important Geological Sites (RIGS). More extensive advice is necessary before applying sludge than conventional fertilisers to a conservation site as the impact through vegetation change is likely to be greater. The responsibility for any liaison or consultation lies with the forest manager.

Archaeological sites

Because sludge application can frequently result in vigorous growth of herbaceous and woody plants, which may obscure or damage archaeological sites, all such sites that are recorded on forest conservation plans should be excluded. In cases of doubt information should be obtained from:

England: County Archaeologists
Wales: Welsh Archaeological Trusts
Scotland: Regional Archaeologists (for Lothian, Tayside and Western Isles consult Historic Scotland)

Neighbours

A compromise will exist between selecting a site sufficiently far from centres of population to minimise any public complaints concerning odour or aesthetics and a site sufficiently close to the sewage treatment works to make the transport of sludge economic.

Undigested sludge, either liquid or cake, has a strong odour which diminishes fairly quickly

over time. Forest areas are usually more remote than agricultural ones and the potential or perceived nuisance to neighbours can be avoided by considering the proximity of dwellings and the prevailing wind direction in relation to site selection and spreading operations.

Digested sludges do not have an offensive odour and are recommended for forest areas which are near to settlements or near to areas identified in the next section.

Local communities or neighbours should be informed of the plans for sludge application. Responsibility for this should be agreed between the forest manager and the sludge producer.

Public and sporting access

It is the responsibility of the forest manager to assess the importance of the site for public usage and recreation. Where public usage is very high the required public exclusion period referred to in the Introduction, Section 8 may make the site unsuitable.

The area within the forest to receive sludge should be located away from high public usage and recreation areas. The use of public information notices will help to avoid any conflicts with low intensity recreational use (see Section 8). Consultation should take place between the forest manager and any shooting tenants.

Accessibility

Forest road systems are constructed to a high standard for timber extraction and provide ready access for sludge transportation vehicles. However, off road the terrain is rougher than that encountered in agriculture. Site cultivation can exacerbate this, although ripped or scarified sites are easier to treat than ploughed sites.

Poor road access may limit the suitability of certain sites for sludge application. Upgrading of substandard roads may overcome the problem and this possibility should be discussed by the forest manager and the sludge producer.

7. *Application guidelines*

Application regime

Once a suitable site has been selected the appropriate application regime should be calculated, taking account of the following factors:

1. *Sludge nutrient content.* The dry solids and nutrient content of the sludge should be determined (see Section 9). Sludge should be applied to crops only where a fertiliser response can be expected (see Sections 2 and 3, and Taylor (1991) for guidance). The amount of sludge applied during the forest rotation should be calculated such that it provides no more than 1000 kg N ha^{-1} over the course of the planting/establishment stage, or 1000 kg N ha^{-1} over the pole stage.

The maximum application in any one year should be 200 m^3 ha^{-1} liquid sludge or 50 wet tonnes ha^{-1} cake sludge. This limitation does not apply to land that has been restored, where application can be increased to provide up to 100 tonnes dry solids (tds) ha^{-1} during the course of establishment.

2. *Sludge consistency.* This influences the potential for pollution. Sludges with a high dry solids content are less prone to cause run-off during or shortly after application and hence are more desirable. However, if the sludge is too thick or if the soil too wet then the sludge does not dry readily and in the event of rainfall could be washed into watercourses.

3. *Screenings content.* In order to avoid the aesthetically unacceptable problem of debris on the tree foliage, sludges must be from well-screened or macerated sewage (screen size of 5–6 mm) or receive separate sludge screening.

4. *Ground conditions.* For liquid sludge each application should be limited to a maximum of 200 m^3 ha^{-1}. However, a number of site factors may further constrain the application rate that can be employed when using liquid sludge. These factors include ground vegetation, slope and soil moisture condition.

Where the soil is shallow (e.g. rendzinas), or where soil drainage is imperfect, e.g. certain reclaimed sites, individual applications should be restricted to no more than 100 m^3 ha^{-1}.

Sludge should not be applied to slopes greater than 25°. Slopes greater than 15° which have been ploughed should also not receive sludge. Slopes which have not been ploughed but have

a gradient of 15–25° should receive sludge at a lower rate of no more than 100 m^3 ha^{-1}. Where ground vegetation is sparse this should be reduced to 50 m^3 ha^{-1}.

An even application of sludge should help to avoid problems of run-off. Applications should cease immediately if surface ponding or run-off is observed.

5. *Potentially toxic elements*. Heavy metals are present in sludge arising from domestic sewage and from controlled trade effluent discharges to the sewerage system. The use of sewage sludge in forestry does not significantly affect the human food chain and trees are less susceptible to heavy metal toxicity than agricultural crops. Background levels of heavy metals in forest soils are usually low. However, forest soils are generally acidic, typically around pH 4, making many of the metals potentially more mobile and, therefore, available.

It is recommended that to provide an adequate safety tolerance the metal additions and the subsequent soil concentrations should not exceed levels prescribed in the Sludge (Use in Agriculture) Regulations 1989. These levels should also safeguard forest wildlife. The recommended limits are given in Table 4. It should be noted, however, that these values are subject to review and the prevailing position should be checked with the Department of the Environment or The Scottish Office.

Table 4. Recommended heavy metal limits for forestry

Element	*Average rate of addition* [a] *(kg ha $^{-1}$ per annum)*	*Limit value for soil* [b] *(mg kg $^{-1}$ of dry matter)*
Cadmium	0.15	3
Chromium	15.0 (provisional)	400 (provisional)
Copper	7.5	80
Lead	15	300
Mercury	0.1	1
Nickel	3	50
Zinc	15	200

[a] The annual rate of application to any site shall be determined by averaging over the 10-year period ending with the year of calculation.

[b] Soil samples taken to a depth of 15 cm including litter layer.

The heavy metal content of the sludge and soil should be determined as outlined in Sludge sampling and Soil sampling in Section 9.

For the majority of sludges these constraints will not be restrictive under the application regimes recommended for forestry. Soil samples should be taken prior to sludge application as outlined in Section 9.

The following is a summary of factors to be considered when planning sludge application:

- Maximum total nitrogen application during pre-planting and early establishment is 1000 kg N ha^{-1}.
- Maximum total nitrogen application during the pole stage is 1000 kg N ha^{-1} with a minimum period of 3 years between individual applications of up to 200 m^3 ha^{-1}.
- There should be an annual limit of 200 m^3 ha^{-1} of liquid sludge or 50 wet t ha^{-1} cake sludge.
- Maximum application to restored soils is 100 tds ha^{-1} during pre-planting and early establishment.
- Application of liquid sludge to wet soils or soils with little ground vegetation should be limited to a maximum of 100 m^3 ha^{-1}.
- Sludge should not be applied to slopes in excess of 25°, or to ploughed slopes greater than 15°.
- Liquid sludge application to slopes of 15–25° should be restricted to 100 m^3 ha^{-1}.
- Liquid sludge application to slopes of 15–25° with sparse ground vegetation should be limited to 50 m^3 ha^{-1}.
- Application of sludge should not result in levels of metals exceeding those in Table 4.
- Sludge should not be applied in sensitive areas where there is a risk of groundwater contamination.

Pre-application planning

Once a suitable regime has been determined and agreed between the sludge producer and forest manager a number of practical details should be considered.

Sludge supply and storage

On-site storage may be required in order to maintain operational flexibility especially where sludge is from small sewage treatment works

with limited storage capacity. On-site storage also allows for application to be made at the appropriate times, for example when soil moisture status is satisfactory.

Planning permission will be required if sludge is to be stored for any considerable time and advice should be sought from the local District Council.

Buffer zones

Buffer zones must be identified for sensitive areas, e.g. stream channels, riparian zones and sensitive wildlife habitats. The extent of the buffer zone should be determined individually for each site but a minimum value of 20 m is recommended.

As most public access to forests is via the forest roads an untreated 20 m wide buffer strip must be left adjacent to all forest roads. This also ensures that any drifting or dripping of sludge near the road does not result in sludge movement into road drainage ditches and then into streams.

Sludge should not be applied within 50 m of a spring, well or borehole that supplies water for human consumption (MAFF, 1991).

Timing of application

- *Time of year.* Sludge application to establishment crop before bud break will prevent damage although sludge can be applied all year round. For preference, sludge should be applied during the growing season.
- *Soil temperatures.* Sludge must never be applied to snow-covered or frozen ground.
- *Rainfall.* Sludge must not be applied in rainy weather or if heavy rain is forecast for the next day.
- *Soil moisture content.* Sludge must not be applied if soil is saturated or near to saturation. Sludge should not be applied where there is any conspicuous surface water run-off.
- *Wind conditions.* Sludge should not be applied during strong winds as this could result in uneven application and possible run-off, or spray drift.
- *New planting sites.* Where sludge is to be applied to afforestation sites, this should be done *prior* to cultivation to minimise run-off and odour problems. A drying time of 1 week (or greater if the sludge has not dried) is recommended after sludge application and prior to cultivation.

Application methodology

Information on appropriate equipment is given in Hall (1988). Tractor-drawn slurry tankers will be suitable on a limited range of sites prior to ploughing or after clearfelling. Conventional manure spreaders may be suitable for applying cake sludge on restored soils prior to site cultivation (Plate 5a). Retracting reel irrigators can be used to apply sludge on even terrain prior to cultivation and in pole stage stands they can be operated from the parallel extraction racks created during thinning. Extending the legs of the applicator also allows this method to be used during the early establishment stage but again only on even terrain.

A more flexible system is the use of static irrigation guns fed by lightweight temporary pipelines, either directly from tankers on the road system or from site storage facilities (Plates 5b and c). More robust equipment, e.g. pipe couplings, may be required on rough terrain. There is scope for the use of specialist off-road vehicles prior to planting or restocking and in thinned mature forests, e.g. irrigation guns mounted on the top of mobile tankers (front cover). However, these may generate more aerosols and wind conditions would require consideration.

Injection of sludge has been found to offer no advantages and is likely to incur greater expense than other means of sludge application.

As with all forest operations which involve the use of heavy equipment off-road, the possibility of site damage should be considered. This is particularly important on wet sites or in pole stage crops where rutting may cause root damage. However, by definition, the sites suitable for sludge application are generally freely draining and so are less prone to damage.

Operational supervision

Each operation will require close supervision. It is the responsibility of both the forest manager

and the sludge producer to ensure that regular site visits are made by designated members of staff from both bodies, and that the guidelines and agreed application regime are observed.

Post-application considerations

Pipework, rain-guns and any other equipment should be washed before leaving the site. Where necessary, vehicles should also be washed down, avoiding run-off of dirty water into drains and watercourses. Marker tape and public information signs (see Public information notices in Section 8) should be removed by the forest manager at the end of the 'restricted access' period.

Records should be kept of sludge application (time, weather conditions, quantities and location of application) by the sludge producer and copies passed to the forest manager.

8. Health and safety

Introduction

By nature of its origin sewage and hence sewage sludge will contain pathogenic bacteria and viruses. The levels of infectious organisms will depend upon the extent of infection in the community and the degree and type of sewage and sewage sludge treatment. The risk to health due to such organisms will be low or very low and can be virtually eliminated by good working practices and good hygiene. Digestion of sludge reduces the risk of disease transmission and the use of digested sludge is recommended for sites that are commonly used by the public.

The greatest risk exists during sludge application and shortly afterwards. Once the sludge has dried the risk of infection is greatly reduced. Hence the greatest precautions should be taken during application. However, to minimise any risk of infection it is advisable to restrict the public from entering the areas of the forest where sludge has been applied for 3 months following application of digested sludge and 6 months following application of undigested sludge. The public therefore needs to be informed that sludge spreading is taking place and public notices to this effect should be erected before application commences.

Public information notices

Two types of information notice are required at the forest site:

1. A short explanatory note should be placed at all known entrances to the forest to inform the public of the operation and the rationale behind it. An example is:

> **Sewage sludge is being used as an organic fertiliser in this forest, and the areas treated are shown on the map. Visitors are requested not to enter the fertilised areas at present. We are sorry for any inconvenience caused and thank you for your co-operation.**
>
> **Date** **Forest manager**

2. The actual area fertilised should be clearly signed with public information notices. These should remain in place until the restricted access period of either 3 or 6 months has expired, but must be removed after this time. The signs should state:

Organic Fertilising with Sewage Sludge.
You are advised not to enter the fertilised areas.

Ideally areas treated should also be identified by plastic warning tape. Responsibility for the erection of these notices lies with the forest manager.

Precautions during application

COSHH (Control of Substances Hazardous to Health) risk assessments should be carried out by the employer responsible for sludge application and by persons responsible for the management of areas to which sludge has been applied. Hazard data will need to be supplied by the sludge producer as to the chemical content of the sludge and likely microbial content. If the sludge producer carries out the application, then they will also need to perform the assessment. It should be borne in mind that the assessment of risk could vary depending upon the application method chosen and the COSHH assessment should reflect local conditions.

The key points to be addressed by the assessment are outlined below.

1. The risk of infection can be minimised by

keeping material away from the mouth by not allowing eating, drinking or smoking during sludge application.
2. Protective clothing in the form of waterproof gloves, stout boots and outer clothing, e.g. a boiler suit or waterproof garments, should be worn.
3. Protective clothing should be removed and hands and forearms washed with clean water and soap before leaving the site, eating, drinking or smoking.
4. Unbroken skin is a very effective barrier against micro-organisms. The risk to health is through material entering the body through cuts and abrasions. Cuts and grazes must be covered with waterproof dressings.
5. Full face shields should be available for use if necessary during sludge application.
6. Employees who handle sludge should be immunised against tetanus and poliomyelitis.
7. All workers should carry a Leptospirosis (Weil's disease) card (to be supplied by the sludge producer) to indicate that they have been in contact with sludge.
8. If the application method produces any type of splashing or aerosol, then it will be necessary for workers to be upwind of the application process and if this is not possible or practicable then a suitable form of respiratory protection equipment must be worn.

Spillages

Should any large spillages occur on roadsides then the following actions should be taken:

- prevent entry of sludge to any watercourse;
- inform the forest manager of the spill if he is not on site;
- consult the RPB/NRA on clean-up technique;
- gather up the spill with only limited washing down.

Precautions following application

Investigations using undigested sludge on open heathland revealed a rapid die-off of faecal indicator organisms down to background levels in 3 weeks (McPhail and Bayes, 1984). Bacterial numbers have been found to return to near background levels within 3 months of undigested sludge application under a pole stage forest canopy (Wolstenholme *et al.*, 1991).

However, precautions should be taken by forestry personnel engaged in any activity such as tree planting after sludge application. In the 3 months following digested sludge application (6 months following undigested sludge application) the following precautions should be exercised:

- stout boots and gloves should be worn;
- all cuts and grazes should be covered by a waterproof dressing;
- eating, drinking or smoking should not be allowed while in contact with the soil/sludge;
- hands and forearms should be washed down before leaving the site, eating, drinking or smoking.

9. *Monitoring programme*

The monitoring programme recommended is based on the Code of Practice for Agricultural Use of Sewage Sludge (Department of the Environment, 1989).

Sludge sampling

It is the requirement of the sludge producer to analyse the sludge to be applied to land and to give the results to the forest manager. Representative sludge analysis must be made available for determining application rates. This analysis should include:

Dry matter (%)
Organic matter (% dry solids)
pH
Nitrogen: total and ammoniacal (% dry solids)
Phosphorus (% dry solids)
Heavy metals: zinc, copper, nickel, cadmium, lead, mercury and chromium (mg kg^{-1} dry solids)

It is the practice of the sludge producer to sample sludges at regular periods and to bulk several of these samples for analysis. *Sludges from any particular source should be analysed at least once in each 6-month period*, unless the results do not vary significantly when the frequency of analysis may be reduced to not less than once a year.

Watercourse sampling

Any adjacent watercourse should be sampled before and after application to help to identify the effect of sludge application from the pollution control point of view. The responsibility with this lies with the sludge producer to contact the NRA/RPBs.

Soil sampling

It is the responsibility of the sludge producer to sample the soil to which sludge is applied. The soil must be sampled and analysed for its pH value and the heavy metals content before the first use of sludge within a forest area and every tenth year of subsequent sludge application. More frequent sampling is required if application rates or metal additions are high and soil metal levels are likely to approach those in the Sludge (Use in Agriculture) Regulations 1989.

Soil samples should be taken to a depth of 15 cm including the litter layer. Standard soil sampling practices should be employed with one bulked sample of 25 sub-samples per compartment or per 5 ha area, whichever is the smaller. Sampling should take account of soil differences as identified on a soil map if available.

Records of the soil and sludge analysis should be maintained by the sludge producer along with the location and size of areas treated, rates of applications and dates of treatment. Copies of these records should be supplied to the forest manager.

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REFERENCES

AGRICULTURE (SCOTLAND) ACT (1948). HMSO, London.

BAYES, C. D., TAYLOR, C. M. A. and MOFFAT, A. J. (1991). Sewage sludge utilisation in forestry: the UK research programme. In: *Alternative uses for sewage sludge*, ed. J. E. Hall. Pergamon Press, Oxford, 115–138.

BYROM, K. L. and BRADSHAW, A. D. (1991). The potential value of sewage sludge in land reclamation. In: *Alternative uses for sewage sludge*, ed. J. E. Hall. Pergamon Press, Oxford, 1–20.

COMMISSION OF THE EUROPEAN COMMUNITY (1986). Council Directive of 12 June, 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (86/278/EEC). *Official Journal of the European Communities*, 4.7.86.

CONTROL OF POLLUTION ACT (1974). HMSO, London.

CONTROL OF POLLUTION (LICENSING OF WASTE DISPOSAL) (SCOTLAND) REGULATIONS (1977). HMSO, London.

COLLECTION AND DISPOSAL OF WASTE REGULATIONS (1988). HMSO, London.

DEPARTMENT OF THE ENVIRONMENT (1989). *Code of practice for agricultural use of sewage sludge*. HMSO, London.

DUTCH, J. and WOLSTENHOLME, R. (IN PRESS). The effects of sewage sludge appli-

cation to a heathland site prior to planting with Sitka spruce. *Forest Ecology and Management.*

ENVIRONMENTAL PROTECTION ACT (1990). HMSO, London.

FORESTRY COMMISSION (1991). *Forests & Water Guidelines*. HMSO, London.

HALL, J. E. (1988). *Application of sewage sludge to agriculture — a directory of equipment*. Water Research Centre Report PRU 1857.

McINTOSH, R. (1984). *Fertiliser experiments in established conifer stands*. Forestry Commission Forest Record 127. HMSO, London.

McPHAIL, C. D. and BAYES, C. D. (1984). *Use of sewage sludge as a forest fertiliser. Ardross forest experiment — application of sludge to heathland prior to establishment of Sitka spruce*. Water Research Centre Report ER 712-M.

MAFF (1991). *Code of good agricultural practice for the protection of water*. MAFF publications, London.

MILLER, H. G. (1981). Forest fertilisation: some guiding concepts. *Forestry* **54**, 157–167.

PYATT, D. G. (1982). *Soil classification*. Research Information Note 68/82/SSN. Forestry Commission, Edinburgh.

SLUDGE (USE IN AGRICULTURE) REGULATIONS (1989). No. 880. HMSO, London.

SLUDGE (USE IN AGRICULTURE) (AMENDMENT) REGULATIONS (1990). HMSO, London.

TAYLOR, C. M. A. (1990). *The nutrition of Sitka spruce on upland restock sites*. Research Information Note 164. Forestry Commission, Edinburgh.

TAYLOR, C. M. A. (1991). *Forest fertilisers in Britain*. Forestry Commission Bulletin 95. HMSO, London.

TAYLOR, C. M. A. and MOFFAT, A. J. (1991). The potential for utilising sewage sludge in forestry in Great Britain. In: *Alternative uses for sewage sludge*, ed. J. E. Hall. Pergamon Press, Oxford, 103–114.

TAYLOR, C. M. A. and TABBUSH, P. M. (1990). *Nitrogen deficiency in Sitka spruce plantations*. Forestry Commission Bulletin 89. HMSO, London.

WATER RESOURCES ACT (1991). HMSO, London.

WOLSTENHOLME, R., DUTCH, J. and RIDDELL-BLACK, D. (1991). *The use of sewage sludge in forestry — final report to SOEnD*. WRc Report DoE 2824.

Appendix 1

Checklist of stages in the use of sewage sludge as a forest fertiliser

Forest Manager		*Sludge Producer (Water Company/Regional Council)*
Initiation		
1. Decide if sludge is suitable for use as a forest fertiliser and contact sludge producer.	*or*	1. Decide that sludge is suitable for use in the forest and contact forest manager. 2. Inform forest manager of nature of sludge, i.e. digested/undigested, cake/liquid.
Site identification		
3. Identify suitable soil types.		
4. Identify suitable crop type.		
5. Check suitability of road.		5. Check suitability of road.
6. Check other constraints, e.g. recreation and public acceptance.		6. Check other constraints, e.g. operational accessibilty and proximity to supply of sludge.
Consultation		
7. Consult conservation and archaeological organisations to establish whether any relevant interests are present. *Nature conservation* English Nature Countryside Council for Wales Scottish Natural Heritage *Archaeology* England: County Archaeologists Wales: Welsh Archaeological Trusts Scotland: Regional Archaeologist (Lothian, Tayside and Western Isles consult Historic Scotland)		
		8. Consult Regional Councils[a] and District Councils (Scotland) over water supplies and any threat of contamination.
		9. Obtain site licence in Scotland.

Note that some stages apply to both forest manager and sludge producer.

	10. Consult River Purification[a] Boards (Scotland) and National Rivers Authority (England and Wales) to discuss any threat of contamination of water resources. Provide the RPBs and NRA with maps and information on the application methodology.
	11. Inform forest manager of results of above consultation with regulatory organisations.
12. Consult neighbours.	12. Consult neighbours.
13. Consult shooting tenants.	
14. Agree provisional programme with sludge producer	14. Agree provisional programme with forest manager
Pre-application monitoring	
	15. Conduct soil sampling and analysis[a] on the area to be treated prior to application of sludge.
	16. Analyse sludge.[a]
Planning	
17. Ensure that roads are sound and able to withstand heavy sludge tanker movement.	17. Ensure that roads are sound and access satisfactory.
18. Discussion with sludge producer on: • Method of application, rate of application and period over which the designated area will be treated. • Preferred itinerary of tankers on public and forest roads.	18. Discussion with forest manager on: • Method of application, rate of application and period over which the designated area will be treated. • Preferred itinerary of tankers on public and forest roads.
19. Map buffer strips along roadsides and watercourses (20 m) and from water abstraction points (50 m). Give maps to sludge producer.	
20. Erect public information notices around the designated area before application.	
21. Mark buffer strips before application.	
	22. Produce a COSHH assessment.
Operational	
23. Designate person responsible for on-site supervisory visits to ensure adherence to guidelines.	
	24. Inform forest manager of intended application time.
	25. Arrange delivery and storage of sludge on site.
	26. Check weather forecast and do not apply if heavy rainfall imminent.

27. Guard against on-site spillage of sludge.

28. Do not allow run-off into drains.

29. Ensure that agreed application rates are adhered to.

30. Ensure even application over designated areas.

31. Supervise contractors if employed for sludge application.

32. Ensure COSHH is adhered to.

33. Provide washing facilities.

34. Do not wash out equipment near drains or public access roads.

35. Check that guidelines are being adhered to.

Post-application

36. Keep records detailing sludge application.[a]

37. Conduct soil sampling at periodic intervals following application.[a]

38. Produce a COSHH assessment for persons working in areas to which sludge has been applied (for 3 months following application of digested sludge and 6 months following application of undigested sludge).

39. Remove notices at the end of the exclusion period.

[a] Indicates that outcome/information should be given to the forest manager.

Appendix 2

Sewage sludge fertiliser record

Forest industry

Forest .....Site name .....NGR.....

Forest Manager .....Designated Forest Supervisor .....

Regional Council/Water Company Project Officer .....

	Details	*Date*
Consultation		
Neighbours		
Shooting tenants		
Conservation Bodies		
Details received from sludge producer of consultation on water quality		
Pre-application Site Planning		
Soil and sludge analysis received from sludge producer		
Buffer zones identified and marked		
Maps showing buffer zones sent to sludge producer		
Public information notices erected		
Application regime agreed with sludge producer		
Method to be employed		
Rate of application		
Nature of sludge		
Timing of application		
Period over which area will be treated		
Access route/suitability of roads		
Contractor		
Operational		
Operational details received from sludge producer (date applied, problems encountered, any differences from agreed application regime)		
Post-operational		
Public information notices removed after 3/6 months		

Sludge producer

Forest .....Site name .....NGR.....

Forest Manager .....Designated Forest Supervisor .....

Regional Council/Water Company Project Officer.....

	Details	*Date*
Consultation		
Water supplies: Scotland (Regional and District Councils)		
Watercourses: Scotland (RPBs)		
Water resources: England and Wales		
Neighbours' details of above sent to forest manager		
Details received from forest manager of neighbours, shooting tenants and conservation bodies		
Pre-application Planning		
Soil sampled		
Sludge analysed		
Results referred to forest manager		
Detailed maps received from forest manager indicating where sludge to be applied and buffer zones		
Application regime agreed with forest manager		
Method to be employed		
Rate of application		
Period over which the area will be treated		
Access route/suitability of roads		
Contractor/supervisor		
Forest manager informed of intended timing of application		
NRA/RPB informed of agreed details, including map		
Operational		
Date applied		
Problems encountered		
On-site spillages		
Run-off into drains		
Above information reported to forest manager		
Any differences from agreed application regime reported to the forest manager		
Source of sludge		
Nature of sludge		
Timing of application	.....	

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