

# The *Soil* Code

Revised 1998



Countryside  
matters





# **Code of Good Agricultural Practice for the Protection of Soil**

MINISTRY OF AGRICULTURE,  
FISHERIES AND FOOD

WELSH OFFICE  
AGRICULTURE DEPARTMENT

OCTOBER 1998



## Summary

A summary of the key messages in this Code is set out below. You will be able to avoid causing long term damage to the soils on your farm and enhance their ability to support plant growth by adopting these practices. Read the Code for further guidance.

### Soil fertility

- Maintain or enhance the fertility of your soil. Applications of manure or changing the crop rotation can maintain or increase soil organic matter and biological activity. *Paragraphs 30-33 and 46-49.*
- Apply lime and fertilisers according to soil analysis and the needs of crops. Always allow for the nutrients in any organic manures that you have applied. *Paragraphs 34-45.*
- Apply all these materials with care avoiding uncropped areas, hedges, ditches, watercourses and wildlife sites. *Paragraph 43.*

### Soil compaction

- Soil compaction restricts the growth of crops and can lead to run-off and soil erosion. Avoid damaging soil structure during arable cropping and by grazing stock. If soil structure is damaged, take positive steps to correct the problem. *Paragraphs 51-54.*

### Soil erosion

- In the long term, loss of soil by erosion can reduce crop yields. In the short term, run-off and sediment can have serious offsite effects – particularly on roads and in rivers where it can cause flooding, pollution and harm to fisheries. *Paragraphs 58-62.*
- Reduce erosion by increasing the stability of soils, maximising crop cover and avoiding run-

off. Prepare a plan to highlight where erosion occurs and develop strategies to prevent further problems. *Paragraphs 63-75.*

- Livestock can cause erosion in both lowland and upland situations. Avoid poaching land, particularly where run-off may enter surface waters. Do not let livestock damage river banks. *Paragraphs 76-78.*
- Wind erosion can be damaging on sandy and peaty soils, particularly in a dry spring, before crop cover is established. Shelter belts or hedges and other in-field measures should be used to protect the crop. *Paragraphs 79-87.*

### Soil mixing

- Avoid deep cultivation or mixing of soil if this will reduce fertility by diluting organic matter and available nutrients. Ensure cultivations do not damage sites of archaeological interest. *Paragraphs 88-93.*

### Contamination

- Soils may be contaminated by atmospheric deposition and by the application of farm manures and slurries, sewage sludge and industrial wastes. Obtain a soil analysis if you have reason to believe your soil may be contaminated or if you regularly apply large quantities of pig or poultry manure. *Paragraphs 96-112.*
- Sewage sludge and industrial wastes can provide fertiliser nutrients and improve soil physical conditions. Ensure the relevant legislation is followed when wastes are applied, and that the wastes and your soils are monitored by analysis. *Paragraphs 113-126.*

### Restoring disturbed soils

- Whenever land disturbed by mineral working or laying pipelines is restored to agriculture, detailed plans should be prepared and any necessary approval obtained before work starts. Ensure these plans are followed during site operations. *Paragraphs 157-170.*
- Soils should be stripped, stored and replaced to the highest standards to ensure that they are reinstated in good condition.  
*Paragraphs 171-180.*
- During the aftercare period, plan drainage and fertiliser use and manage cropping and grazing to ensure that soil fertility and structure are protected and recover fully.  
*Paragraphs 181-201.*



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## Introduction



### About this Code

- 1 This *Soil Code* (the Code of Good Agricultural Practice for the Protection of Soil) is a practical guide to help all farmers and growers avoid causing long-term damage to the soils which they farm. Agriculture has an important role to play in protecting soils. It is in the farmers' interest to protect their soils by appropriate management as they are the basis of their future income. The Code also provides general guidance on practices which will **maintain and increase the ability of soil to support plant growth**. It complements advice given in the *Water Code* and the *Air Code* (the Codes of Good Agricultural Practice for the Protection of Water and of Air) and the *Code of Practice for the Safe Use of Pesticides on Farms and Holdings*. These Codes are available free of charge from MAFF Publications (telephone number 0645 556000). This *Soil Code* is a revised version of the one issued in 1993 and it is based on the best information available at the time of writing.

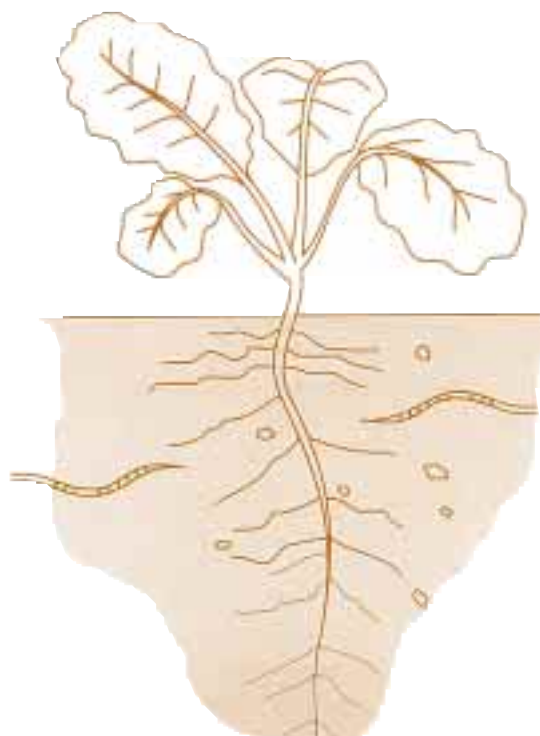
#### The importance of soil

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 one metre. The biological, physical and chemical characteristics of soil need to be protected for it to perform its important functions, including the production of food, raw materials and energy. Protecting soils *is the responsibility of all farmers* and this in turn helps to protect other parts of the environment. Soils provide a filtering and buffering action to protect water and the food chain from potential pollutants; they help to maintain gene pools and wildlife populations; and they often cover historic and archaeological sites and contain artefacts and historical indicators such as pollen. All soils should be managed sustainably in the long term.

- 2 The Council of Europe, of which the UK is a member, adopted the European Soil Charter in May 1972 and agreed to the Recommendation on Soil Protection in May 1992. These recommendations emphasise that soil is a limited natural resource which is easily destroyed and which needs to be protected against damaging farming practices, erosion, pollution and degradation caused by human settlement and civil engineering.
- 3 This Code describes the main risks of causing irreversible – or only slowly reversible – physical, chemical or biological changes to soils which would reduce their ability to grow plants for commercial, conservation or recreational purposes and to support living organisms. In each section of the Code, good agricultural practice is defined. It aims to reduce the possibility of such changes occurring.
- 4 This Code provides guidance on protecting and improving the current condition of the soil. It does not include methods of soil management such as land drainage, or methods which deal with short-term damage such as compaction which can be remedied in a year or two by natural processes or good management practices. However, farmers should avoid such short-term damage, especially if it may encourage other adverse effects, e.g. compaction can lead to increased run-off and erosion. The Code concentrates on maintaining soils in a condition suitable for a wide range of current and future uses. It is recognised that particular plants or certain uses of soil may justify specific conditions that do not keep to this general aim.
- 5 This Code is mainly concerned with preventative action to protect soil, including while it is not being used to grow plants. It also includes remedial actions to cope with contamination incidents such as sea flooding or

oil spillage, and following soil disturbance such as mineral workings or laying pipelines. It provides advice on avoiding the off-site effects which can result from poor soil management.

- 6 When applying the *Soil Code*, it is important to recognise the properties of a particular soil, to choose an appropriate use of the site and to carry out appropriate action. If you do not, you could make matters worse rather than better. The United Kingdom has a wide range of soils. Their physical, chemical and biological properties depend on the materials of which they are made up, the influence of climate and previous management. Details of soils, where they can be found and their properties are shown in the maps and reports published by the Soil Survey and Land Research Centre.
- 7 You should manage soils in a way that will maintain their long-term ability to perform their vital functions. You should find out the correct management requirement for the soils on your farm, as set out in this Code. For areas likely to suffer from erosion, you should draw up a plan of action for future management.





### Introduction

- 8 This is not a statutory code. Following it will not protect you from legal action, although it should reduce the chance of this happening. Causing pollution of soil is not a specific offence, but there are various laws on contamination and degradation of soils and some of these are outlined below. This is not a detailed description. If you are in any doubt about what the law requires, and how it affects you, you should obtain professional legal advice.

### Waste disposal

- 9 Waste disposal is controlled by the Waste Management Licensing Regulations 1994. They are made under the Environmental Protection Act 1990 and implement the EC Framework Directive on Waste (91/156/EEC and 91/692/EEC). Industrial, household and commercial wastes are defined in these Regulations as controlled wastes and are subject to a number of provisions, including waste management licensing controls and the duty of care obligation. The 1994 Regulations apply to the recovery or disposal of non-agricultural waste and include activities taking place on farms such as landspreading of industrial wastes, e.g. food and drink waste. The landspreading of the wastes listed in the tinted box does not have to be licensed where specific conditions are met. In particular, the operation must provide either benefit to agriculture or ecological improvement. It is necessary to notify the Environment Agency of the intention to apply such wastes to land. The Agency requires details of when, where and how the waste will be spread, together with information on the type, quantity, chemical composition, and pollution risks of the waste.

### Landspreading of wastes

The spreading of these materials on agricultural land is exempted from waste management licensing, subject to certain conditions. A key condition is that no more than 250 tonnes (or, in the case of dredgings from inland waters, 5,000 tonnes) of waste per hectare are spread on the land in any 12-month period.

- Waste soil or compost
- Waste wood, bark or other plant matter
- Waste food, drink or materials used 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 sludge
- Septic tank sludge
- Sludge from biological treatment plants
- Waste hair and effluent sludge from a tannery

Further information on the Waste Management Licensing Regulations 1994 is contained in the Department of the Environment (DOE) Circular 11/94, or you may contact the Environment Agency for advice.

### Special waste

- 10 Certain types of waste that are toxic, dangerous or particularly difficult to treat, keep or dispose of, are called special waste and are subject to strict controls. The Special Waste Regulations 1996 (which amended the Control of Pollution (Special Waste) Regulations 1980) are made under the Environmental Protection Act 1990. They implement the EC Hazardous Waste Directive (91/689/EEC). The controls are

generally the same as were in place under the 1980 Regulations, but they apply to additional materials covered by the Directive.

The Special Waste Regulations require a system of consignment notes which are used by those who produce, transfer for disposal, or dispose of, special waste. The Environment Agency enforces control procedures and should be notified in advance of the removal of waste from the place of production.

### Sewage sludge

- 11 Over half of the sewage sludge produced in England and Wales is recycled as an organic fertiliser on agricultural land. Applying sludge to agricultural land is regulated throughout the European Union by Council Directive 86/278, which is implemented in Great Britain by the Sludge (Use in Agriculture) Regulations 1989 (as amended). The Regulations contain provisions which are designed to prevent harm to humans, animals, plants or soil micro-organisms from heavy metals or pathogens that may be present in sludge and to maintain soil fertility and crop yields. The Regulations must be followed by anyone applying sewage sludge to any part of your land which is used for growing food crops (including animal feed) or grassland for livestock. The obligations which the Regulations place on land owners are explained in MAFF leaflet (PB 2568) *General Information on the Application of Sewage Sludge to Agricultural Land*.



12 The main provisions of the Regulations require that:

- all soils must be sampled and the results available before sludge is first applied and regularly thereafter;
- sewage sludge must not be applied to agricultural land when the concentrations of certain heavy metals in the soil (lead, cadmium, mercury, copper, zinc and nickel) are greater than specified limits according to soil pH (see Appendix III);
- the rate at which heavy metals in sewage sludge are added to soil is restricted;
- sewage sludge must not be applied to soil if the pH is below 5.0;
- the harvesting of forage crops or the grazing of animals on agricultural land to which treated sludge has been surface applied is prohibited for at least three weeks after application;
- untreated sludge must be injected or worked into the surface of the soil as soon as practicable after application;
- fruit or other crops which are in contact with the soil and normally eaten raw must not be harvested for at least ten months after sewage sludge has been applied;
- the sludge application rates must take into account the fertiliser needs of the next crop;
- the use of sludge must not impair soil quality or pollute ground or surface waters.

A complementary *Code of Practice for Agricultural Use of Sewage Sludge*, published by the Department of Environment Transport and the Regions (DETR), provides detailed

guidance on the application of sludge to land and also recommends a number of additional safeguards. These include maximum soil concentration limits for molybdenum, selenium, arsenic and fluoride (see Appendix III) and special requirements for grassland. The *Code of Practice for Agricultural Use of Sewage Sludge* was reissued in 1996 to include revised maximum soil concentration limits for certain metals. This Code has been adopted by the Water Service Companies.

The use of sewage sludge on non-agricultural land including forestry and land restoration is outside the scope of the Sludge (Use in Agriculture) Regulations 1989 and the *Code of Practice for Agricultural Use of Sewage Sludge*. However, these activities are controlled under the Waste Management Licensing Regulations 1994. They are exempt from waste licensing as long as the sludge provides ecological benefit and does not exceed the metal limits as set out in Schedule 2 of the 1989 Sludge Regulations but it is necessary to register with the Environment Agency. DETR circular 11/94 provides further guidance on these controls. Further guidance for forestry is given in a Forestry Commission bulletin *A manual of good practice for the use of sewage sludge in forestry*.

### Contaminated land

- 13 Contaminated land may be a statutory nuisance under Environmental Protection Act 1990. The local authority has to issue a notice on the person responsible for the nuisance or, in some circumstances, the owner or occupier of the premises, requiring the nuisance to be prevented or abated.

The Environment Act 1995 requires local authorities to identify contaminated land which poses a significant risk of harm to human health or the wider environment. They can make the polluter or landowner undertake any remediation that is necessary. Remediation may involve removing the contamination or avoiding whatever practice is causing the risk. If that person cannot be found, the cost will fall on the owner or occupier of the land, but a person who is only an owner or occupier of the land cannot be required to carry out any remediation which is intended to deal solely with water pollution. Local authorities will be able to pay for the work themselves where they consider that the person who would normally foot the bill cannot afford to do so. Guidance has been issued to local authorities on the identification of such contaminated land. If you require further information about the application of this legislation to your land, you should consult your local authority or the Environment Agency. Following good agricultural practice should prevent agricultural land being identified as contaminated under the Act.

As explained in Section 2, legislation which controls the application of sewage sludge to land sets limits for the concentration of certain potential contaminants in soil. Legislation does not prevent any particular soil being used for agriculture because of any contaminants in that soil. However, there are legal limits for

concentrations of lead and arsenic in food and for a variety of inorganic and organic substances in animal feed. You should take care not to exceed these limits if you produce food on soils with high concentrations of these contaminants.

### Contaminated food

- 14 There are powers under the Food and Environment Protection Act 1985 to prevent food contaminated with chemicals (such as lead or dioxins) entering the food chain. Separate controls are in place for food contaminated with pesticides.

### Minerals

- 15 The main law controlling the extraction of minerals and disposing of mineral wastes is the Town and Country Planning Act 1990. Virtually all developments to extract minerals for sale or which involve engineering operations need planning permission. Other conditions for dealing with old mineral permissions which were granted before the Town and Country Planning Act 1947 are contained in the Planning and Compensation Act 1991. The Environment Act 1995 provides for a review and updating of permissions granted from 1950-1980 and the periodic review of all minerals permissions thereafter.

### Removal of soil for sale

- 16 Removing large amounts of surface soil may be regarded as a development as defined by Section 55 of the Town and Country Planning Act 1990. If so, you will need planning permission to do this. If you do not get planning permission, it is an offence under the Agricultural Land (Removal of Surface Soil) Act 1953 to remove for sale, more than five



cubic yards of surface soil from agricultural land in any three-month period unless the removal is reasonably necessary for cutting turf or peat. If you are not sure, get advice from the local planning authority (usually the District Council or Unitary Authority).

### Water pollution

**17** The Water Resources Act 1991 contains provisions which are designed to prevent water pollution happening and allows people to be prosecuted if they pollute. The Environment Agency is responsible for most of the work.

**18** Under Section 85 of the Water Resources Act 1991 it is an offence to cause, or knowingly permit a discharge of noxious or polluting matter or solid waste matter into any controlled waters without the proper authority.

**19** Controlled waters include groundwater and all coastal or inland waters, including lakes, ponds, rivers, streams, canals and ditches. Temporarily dry watercourses are included. Proper authority is usually a consent to discharge from the Environment Agency under Section 86 of the Water Resources Act 1991.

**20** Farmers, employees and contractors may be prosecuted for causing pollution. You could be fined up to £20,000 in a Magistrates' Court or get an unlimited fine in the Crown Court. A person found guilty of causing pollution may also have to pay for any damage caused and for Environment Agency costs.

**21** Under section 161 of the Water Resources Act 1991, the Environment Agency can do work to prevent or clear up pollution and recover the cost from the person responsible. The Environment Act 1995 introduced a provision allowing farmers or landowners to be

prosecuted for not complying with the terms of a notice of works issued under Section 161. You could be fined up to £20,000 in a Magistrates' Court or face an unlimited fine in the Crown Court.

**22** Under section 202 of the Water Resources Act 1991, the Environment Agency can ask for information to help them prevent water pollution.

### Nitrate in water

**23** Section 94 and Schedule 12 of the Water Resources Act 1991 cover the designation of Nitrate Sensitive Areas where the Government considers it appropriate to control the amount of nitrate entering water from agricultural land.

**24** Under the EC Nitrate Directive (91/676), Member States are required to establish a code of practice which will operate on a voluntary basis as a means for providing all waters with a general level of protection against nitrate pollution. In addition, in designated Nitrate Vulnerable Zones, farmers will be required to comply with mandatory measures.

### Planning legislation

- 25 The Town and Country Planning (Assessment of Environmental Effects) Regulations 1988 (as amended) set out the requirements for the Environmental Assessment of certain major developments for which planning permission is needed. The local planning authority (or, if the matter is referred, the Secretary of State) will decide on the need for Environmental Assessment.

### Soil on roads

- 26 Highway authorities have powers under section 151 of the Highways Act 1980 (in England and Wales) to serve notices on the owner/occupier of adjoining land requiring them to take action to prevent soil from that land being washed onto the road. The Act enables the Courts to impose a fine if they do not comply.

### Contamination by radioactive substances

- 27 Radioactive waste is controlled by the Radioactive Substances Act 1960. Under this Act, no discharge may take place without permission from the Government.

### Ancient monuments and archaeological areas

- 28 Ancient monuments and archaeological areas are protected by the Ancient Monuments and Archaeological Areas Act 1979, which prevents any works being carried out on Scheduled Ancient Monuments without the permission of the Secretary of State for National Heritage. This is known as scheduled monument consent (SMC) and applies to specified allowable operations. However, under Section 3 of the Act, the Secretary of State has made provision, by way of the Ancient Monuments (Class Consents) Order 1994, for agricultural,

horticultural and forestry works to be carried out without the need to apply for SMC. The current order covers such works provided they are of the same kind as works previously executed in the same field or location during the period of six years immediately preceding the date on which works commence. This does not include subsoiling, drainage works, the planting or uprooting of trees, hedges or shrubs, or any other works likely to disturb the soil below the maximum depth affected by normal ploughing. There is provision for this permission to be rescinded in individual cases. Management agreements may also be offered to occupiers of farmland bearing ancient monuments, and these usually include small grants. For further information, you should contact your local English Heritage office. There are archaeological sites that are not regarded as Scheduled Ancient Monuments and are not protected legally. Advice on these sites may be obtained from the Archaeological Officer of your County or Unitary Authority or, in Wales, from the Archaeological Trusts.

### Introduction

- 29 This section deals with chemical and biological processes which affect fertility, including the acidification of soils, maintaining and improving the soil's nutrient reserves and its organic matter content. Loss of fertility due to physical degradation and chemical contamination is covered in Sections 4 and 5. Only those aspects which take several years to change are covered; short-term reversible changes can be dealt with by good soil management. A well planned rotation of crops can have many benefits for soil fertility. However, raising the fertility of soil in natural or semi-natural habitats or altering the pH may reduce the range of species living there. This should be avoided on all protected sites and, wherever possible, in other sensitive habitats.

### Biological activity

- 30 Soils contain very many living organisms ranging from microscopic bacteria and fungi to burrowing animals. All play a part in maintaining the natural soil processes which are vital for maintaining the chemical and physical fertility of the soil. Some organisms can play an important part in what happens to contaminants that may be in the soil while others are of value in the biological control of crop pests.
- 31 Earthworms are one of the most obvious organisms that benefit the soil. Along with other organisms, they are sensitive to certain





heavy metals, chemicals and contaminants which you may apply to the soil (see Section 5). These include some pesticides designed to control particular problems but which affect a wide range of organisms. Always choose pesticides carefully according to the purpose for which you need them. Follow the instructions on the label when you use them.

32 Excessive amounts of fertilisers or manures which contain a high proportion of their nitrogen in the form of ammonium, such as ammonium sulphate and certain animal manures or slurries, may reduce the number of earthworms in soil. You can reduce harmful effects on earthworms by not applying slurry on wet, poorly-drained soils. However, the long-term effect may be to increase numbers due to the extra food source provided. If you apply composted materials or well-rotted farmyard manure you will be more likely to increase the number of earthworms in the soil.

33 You can also increase earthworm numbers in soil by including grass in your crop rotation, or by regularly applying other bulky organic manures or crop residues. Shallow cultivation may cause less damage to worms than ploughing and may help to maintain their burrows which improves the drainage of the soil.

General biological activity in the soil will also be improved by following these actions to increase the number of earthworms. As a result, the nutrient supply to crops will be increased and the soil structure will be improved.

#### Soil acidity and liming

34 Acidification is a natural process which occurs in all soils, but which can be increased by man's activities. The extent to which it happens

depends on the composition of the soil, deposition from the atmosphere, cropping, nitrogen fertilisers and other management practices. Unless the soil is naturally well-supplied with calcium or magnesium carbonate or is regularly limed, the pH of the soil is reduced until a new balance point is reached. Very acid soils at a pH below 4 will only support a limited range of plant species and are not normally suitable for agricultural production. Water draining from acid soils may contain substances, particularly aluminium, which can have an adverse effect on the quality of surface and groundwaters. These can harm plants and animals especially fish, living in streams or lakes.

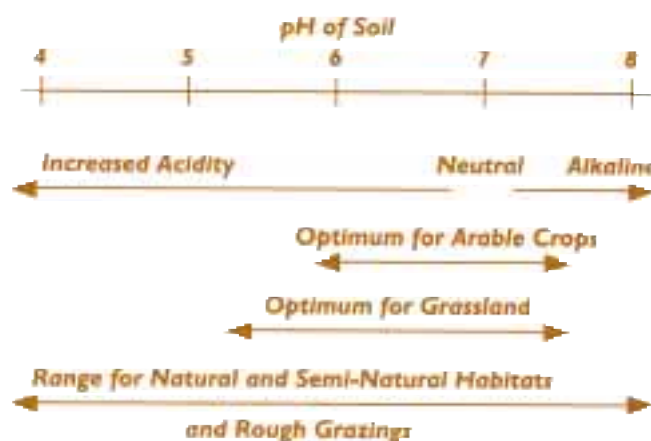
#### Definition of pH

The pH of a soil is a way of expressing how acidic or alkaline it is. It is usually measured using a water extract. A pH of 7 is neutral; soils with lower values are said to be acid and those above pH 7 are alkaline. Most agricultural soils (other than peats) are maintained at a pH of between 6.0 and 7.5. Although 5.5 is adequate for grass and some crops, clovers are more sensitive to acid conditions. If clover and other legumes are grown in pure or mixed swards, you should maintain a pH of at least 6.0. Peat soils may be maintained at a rather lower pH than the majority of soils. Determine the correct pH for your proposed cropping regime.

35 Have samples of soil analysed regularly to find out how much lime needs to be applied. The amounts you apply should take into account the neutralising value of the particular liming material used. You should make sure that it is applied evenly. Do not overlime soils. The uptake of most nutrients by plants will be decreased and plant growth may be reduced. If too much lime is applied, it can take several years for excess lime to be lost from the soil.

36 You can maintain or raise the pH value of the cultivated layer of a soil by using liming materials which contain calcium or magnesium. The pH of soil which has not been cultivated, or of the soil below the depth of cultivation, can only be changed very slowly by applying lime to the surface of the land. For this reason it is important that uncultivated soils, other than peats, which are to be used for growing agricultural crops should not fall below pH 5.5 unless you can use the soil at a lower value. If the pH is below this, it can take many years to raise it to an appropriate value. If it is necessary, you should always work lime into the soil before planting perennial crops that are sensitive to acidity (such as fruit trees), taking care to avoid mixing subsoil into the topsoil layer.

37 Not all soils can be maintained at pH 5.5 or above, particularly in the subsoil. Acid sulphate soils occur in limited areas of England and Wales, mainly in peat-covered river valleys or in marine alluvium. Unless these soils are already cultivated you should leave them in their natural state, as drainage and cultivation can cause extreme acidification. If this occurs, liming is often expensive and often fails to achieve a lasting increase in pH. However, very high rates of finely divided liming materials, e.g. sugarbeet factory lime, have been used successfully to improve the pH of subsoil. Drainage of acid sulphate soils permits oxidation of the naturally occurring sulphur-containing compounds. This can have a harmful effect on both the quality of the drainage water, by making it extremely acid, and the structure of the soil, which may make drainage systems ineffective. In any case of doubt, seek professional advice.



38 Some soils may be correctly maintained at a pH below 5.0 to grow and encourage particular species or plant communities in natural and semi-natural habitats. Take care to make sure that liming agricultural land does not raise the pH of any acid soils or aquatic habitats that are nearby as this would reduce their conservation value.

39 If you want to grow crops which prefer acid soils try and find a favourable site. It may be possible to reduce the pH of other soils by applying acid-forming materials such as flowers of sulphur. In practice, this is not suitable for large areas and the effect can be difficult to predict. Obtain professional advice if you are planning such treatment. If there is chalk or limestone in the soil, it is not a practical option because you would have to apply very large quantities of sulphur to obtain a lasting effect.

#### Soil nutrient content

40 To grow satisfactorily, plants need a balanced supply of the major nutrients: nitrogen, phosphorus, potassium, magnesium, calcium and sulphur. Sodium is also required by some crops. Smaller quantities of the trace elements: iron, manganese, copper, zinc, molybdenum,

boron and chlorine are required. Trace elements will generally be supplied by the soil, but the supply may need to be supplemented by inorganic fertilisers and organic manures.

Advice on fertiliser use is given in MAFF Reference Book 209 *Fertiliser*

*Recommendations.* If you receive professional advice on fertiliser use, make sure the person giving the advice is approved by FACTS (the Fertiliser Advisers Certification and Training Scheme.) You should have the soil analysed regularly (every four to five years) to set a correct fertiliser policy or whenever a major change in land use is proposed. The correct balance of available nutrients is necessary to promote satisfactory plant growth. Nutrients are also deposited from the atmosphere, particularly sulphur, nitrogen and some of the trace elements. Fertilisers or organic manures which contain sulphur are now needed in many areas of the UK as a direct result of the amount of sulphur deposits being reduced.



41 As long as the soil pH and organic matter content are maintained at appropriate values, most of the additional nutrient requirements of plants can be met from soil reserves or by applying fertilisers or manures each year, or once in the rotation. If an agricultural soil is very low in nutrients, you can raise reserves of phosphorus and potash in two or three years by using fertilisers or manure generously, if it is appropriate to do so. However, take care to maintain the balance of nutrients from all sources and avoid water pollution by nitrogen, phosphorus or organic matter (see the *Water Code*). In general you should match manure and fertilisers applications to the needs of the crop but you should not apply more than 250 kg/ha (kilograms per hectare) of total nitrogen in livestock manures or other organic wastes in any one year. As an alternative in catchments less sensitive to nitrate leaching, some non-livestock wastes such as sewage sludge cake or composted organic waste which contain very little plant available nitrogen may be applied up to 500 kg/ha of total nitrogen in one application every two years.

Nutrient uptake into herbage is important for livestock health. Plant analysis is often necessary, in addition to soil analysis, to identify and correct any mineral imbalance affecting livestock performance.

42 In soils which are naturally deficient, it can be difficult to raise available phosphorus reserves. In these situations, fertiliser phosphorus can bind strongly to the soil and is not available to plants. You may have to make many applications of organic or inorganic fertilisers to raise the available amount of phosphorus in the soil to a concentration suitable for general crop production. Once raised, you can maintain the available soil phosphorus content by regularly applying fertiliser.

- 43 You should not spread fertiliser into hedgerows or watercourses, including dry ditches, where it can have harmful effects and may also pollute water. Where necessary, make use of deflector plates or other techniques or consider conservation headlands or uncropped field margins.

Particular plants or sensitive natural habitats such as chalk grassland and flower-rich meadows may benefit from having low soil nitrogen and phosphorus contents, as this limits the growth of vigorous species such as ryegrass which compete with the natural species. Protect these habitats from direct application of fertiliser or run-off from nearby fertilised areas. Such principles have been introduced into the management regimes for some Environmentally Sensitive Areas.

- 44 Do not apply more phosphorus (in fertilisers or manures) than the crops in the rotation need. If soil particles with a high phosphorus content are eroded and deposited in rivers or lakes, the phosphorus content of the water will rise. This may cause eutrophication (making algae grow too fast), which uses up the oxygen in the water and can kill fish and other aquatic organisms. Algal blooms may be toxic to animals, including livestock. Leaching (washing out) of soluble phosphorus compounds in drainage water can occur if the available phosphorus content of soil is high. This is most likely to occur on sandy soils or after many years of applying very large amounts of fertiliser or animal manures.

#### Eutrophication

For the purpose of this Code, eutrophication is defined as the enrichment of water by nitrogen or phosphorus, causing algae and higher forms of plant life to grow too fast. This disturbs the balance of organisms present in the water and the quality of the water concerned.

- 45 Do not apply more nitrogen (in fertilisers and/or manures) than the crop needs, as this is a waste of money and can pollute the water with nitrate. Too much nitrate in surface water can cause aquatic plants to grow and contribute to other symptoms of eutrophication. Nitrate concentrations in water for public supply should not be more than 50 mg/litre. If they are above this value, they can trigger measures under the EC Nitrate Directive which affect agriculture, (see paragraph 24).

#### Organic matter

- 46 The amount and type of organic matter in the top layer of a soil influences its physical, chemical and biological properties. In particular, it affects its structural stability (and so the likelihood of erosion), how easy it is to cultivate, how much water it can retain and the nutrients available to plants. It also influences the behaviour of contaminants. Changes in management can result in increases or decreases in organic matter content. Do not over-cultivate soils. The repeated use of power-driven cultivation implements has been shown to hasten the loss of organic matter in soils, particularly under wet soil conditions.
- 47 A major aim should be to maintain the organic matter in a cultivated soil so that it can support plant growth. The amount that is needed will vary with the soil and farming system. The organic matter content of a soil under arable farming is lower than under permanent or

long-term grass, particularly if the amount of plant residue returned to the soil is low. Organic matter may also be reduced by erosion and by removing topsoil which both remove the organic rich layer. Deep ploughing dilutes the topsoil with subsoil, which is low in organic matter.

Long-term trials show that, in arable systems, the highest yields are only possible when you take positive steps to maintain the level of organic matter in the soil.

48 If you cannot apply regular quantities of bulky organic manures, such as farmyard manure or sewage sludge cake (see paragraph 41), you may only be able to increase the organic matter content in cultivated soil by changing the cropping. If you grow green manures or grass in previously cultivated land for a number of years, the soil organic matter may be increased. To maintain this higher level, your crop rotation may have to include grass. Returning crop residues to the land or applying bulky organic manures to land will gradually increase the organic matter content if you do this for several years. Following the ban on burning crop residues, ploughing straw into the soil has generally had a small beneficial effect upon organic matter content and the workability of the soil.

49 Significant increases in the organic matter content of arable soils will increase the amount of nitrogen available for crops. Adjust fertiliser rates or introduce other management practices to prevent an increase in leaching of nitrate (see MAFF Reference Book 209 *Fertiliser Recommendations*).



## Physical Degradation



### Introduction

50 Irreversible or only slowly reversible physical damage to soil is defined as physical degradation. This section of the Code describes how it can be reduced or avoided by appropriate techniques. By taking action to control short-term problems, you can control the more serious long-term degradation. This Code does not provide detailed guidance on land drainage and ditch maintenance. However on many soils it is important to ensure that these are working efficiently to help control the water content of the soils.

### Soil compaction

51 When choosing the crops to grow, you should take into account the ability to cultivate the land when necessary and undertake all other field operations without causing unacceptable compaction. Always take care on silty and clayey soils. Cultivations for autumn crops are likely to cause less damage than cultivations for crops that are sown in the spring. You should also consider if you might damage the soil during harvesting, in particular for root and vegetable crops. If winter harvesting is planned, take account of likely field conditions when deciding where to plant the crops. Advice on available work days for different soils is given in regional reports from the Soil Survey and Land Research Centre.

52 Compaction of topsoils, or more especially subsoils, may seriously damage soils and can only be reversed very slowly and at significant cost. Compaction restricts root growth and reduces infiltration of water into soil. It can increase run-off, which may lead to greater flooding, increased erosion and the transfer of potential pollutants (including nutrients and pesticides) to surface waters. As the air getting into the soil is also restricted, the biological

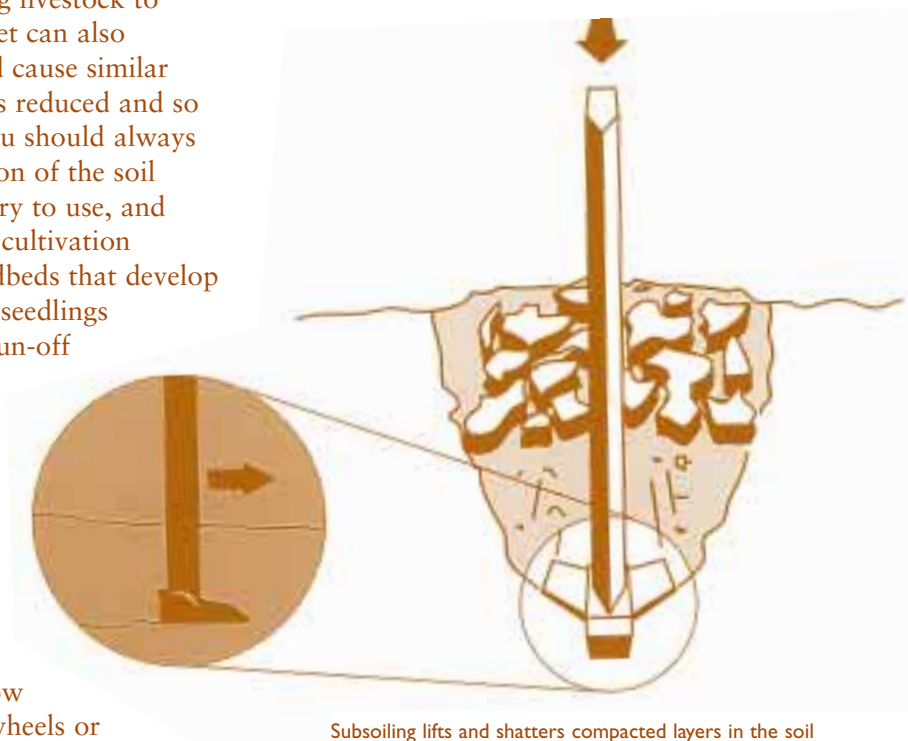
activity and root growth is affected. This reduces the fertility of the soil and, more specifically, the availability of plant nutrients. So it is important to minimise all forms of soil compaction.

53 Free-draining soils which are not regularly cultivated develop a soil structure which allows root growth, infiltration and drainage of water. Using agricultural or other machinery when the soil is too wet can seriously compact soil and restrict root growth. Allowing livestock to graze when the land is too wet can also damage the soil structure and cause similar problems. Water movement is reduced and so plant growth is restricted. You should always take into account the condition of the soil when deciding what machinery to use, and when to use it. Power-driven cultivation equipment can leave fine seedbeds that develop a surface cap. This may stop seedlings emerging or lead to surface run-off and erosion.

Large agricultural machinery is not necessarily a greater risk for normal work on undisturbed soils. This is because faster work rates allow the work to be completed under better soil moisture conditions. Using low ground-pressure tyres, dual wheels or tracked vehicles can be a great benefit. Axle load is an important factor and you should get professional advice to provide safe working guidelines for specific soil conditions, particularly on fine loamy, silty and clayey soils. However, when conditions are unsuitable, large machinery can cause deep compaction which is difficult and expensive to correct.

54 In England and Wales, severe soil compaction is not a widespread problem. In areas where

fine loamy or silty topsoils lie over clayey subsoils, plough pans and smearing can often be caused in wet conditions and the problems described in paragraph 52 can follow. When you have correctly identified these problems, they can usually be corrected by ploughing or by subsoiling. Pay particular attention to compaction caused by repeated driving on headlands, in tramlines or during harvesting. Take care to distinguish soils which are naturally slow to drain and which may need



Subsoiling lifts and shatters compacted layers in the soil

underdrainage and secondary treatment of moiling or subsoiling.

Regularly inspect vulnerable soils before cultivating to decide on any corrective measures that are necessary. However, if the structural damage is severe and is linked with low organic matter content, deep cultivation followed by several years in grass may be

necessary to regenerate the soil. Remember that set-aside payments may be available for such land. If damage is caused during soil restoration, the subsoil may become severely compacted. This can be very difficult, if not impossible, to correct (see Section 6). Whenever you are considering deep cultivation, take account of soil conditions and any work you will be carrying out later. Loosening the soil can make it more vulnerable to compaction by work that you do in the future.

#### Removing topsoil

55 The loss of topsoil, either by removal or indirectly by erosion, should be kept to a minimum. The formation of fertile, rich topsoil with a high organic matter content is a very slow natural process. Removal or erosion of topsoil reduces the productivity of the land by reducing the water and nutrients available to plants, and making the soil more likely to suffer from structural damage.

Shallow compact soils are less able to absorb rainfall and the risk of water erosion may be increased.

56 Stripping or removing topsoil for sale is an offence under the Agricultural Land (Removal of Surface Soil) Act 1953 unless you have planning permission to do so (see paragraph 16). If you do not need any of the soil that is part of an agreed development project, you should move it somewhere else on the farm where it can be used.

57 Removing turf from agricultural land removes the surface layer of soil and its organic matter and plant nutrients. Although modern turfing techniques only remove a shallow layer of soil, you should avoid repeated cutting if this would restrict the future use of the land.

#### Soil erosion

58 Soil erosion is the loss of soil particles by the action of wind and water. The risk of erosion should be minimised by the appropriate management outlined below and given in the MAFF Booklet *Controlling Soil Erosion*.

Plants generally protect the soil against erosion but significant problems can occur on soils used for arable crops or grazing livestock, or after large areas of trees have been cut down. Risk of soil erosion is increased where soil organic matter content is low.

Repeated erosion results in a gradual loss of topsoil and reduces the fertility of the soil by selectively removing the fine soil particles which are rich in nutrients. Rooting depth and the quantity of soil water available for crops is reduced. The significance of losing soil from land which lies on top of hard rock at shallow depth is much greater than where the underlying material is already weathered.

59 Apart from soil loss, damage can be caused to agricultural crops by washing soil from the roots or blasting them with soil particles during wind erosion. Crops may have to be resown, which results in extra costs and possibly a loss in yield from late establishment. Extra cultivations may be needed to level out the soil. Removing sediment from ditches and drains can be costly.

60 Erosion can increase flooding by increasing run-off and blocking ditches and drains. Surface waters may be contaminated by sediment and by the nutrients and pesticides in the eroded soil. Fish spawning grounds can be seriously damaged by sediment deposited in the beds of gravel streams. Obvious cases of erosion, as detailed below, occur in lowland England and Wales, but significant problems

can also occur in upland areas where over-grazing and/or recreational activities have affected the vegetation cover.

- 61 Erosion may cause inconvenience and damage to your neighbours and to the general public, e.g. by flooding or by sediment being deposited on roads or on adjoining property. You should take all appropriate measures to prevent soil erosion, as detailed below, but if it occurs take immediate action to clean up any soil.

Highway authorities have powers under section 151 of the Highways Act 1980 (in England and Wales) to serve notices on the owner/occupier of adjoining land requiring them to take action to prevent soil from that land being washed onto the road and enabling the Courts to impose a fine if they do not comply.

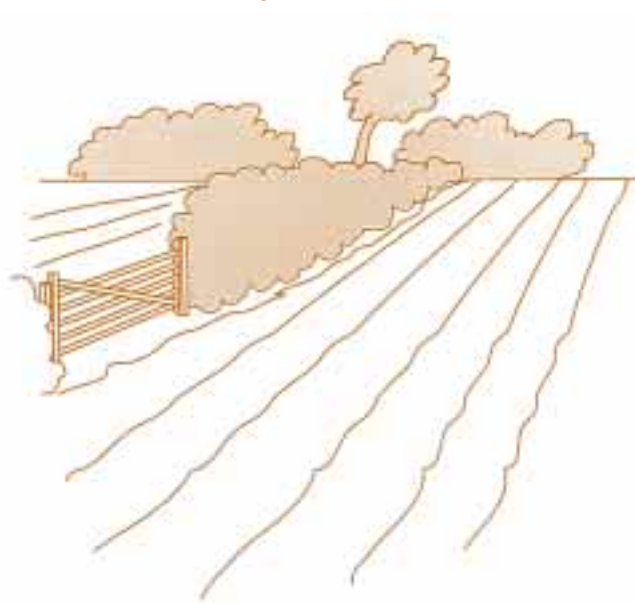
- 62 It is not just erosion that causes gullies that is important. Even run-off that looks clear can pollute water by nutrients and pesticides in solution or attached to very small particles. Muddy run-off from land poached by livestock can have similar effects.

#### Erosion by water

- 63 Water erosion causes soil to be lost to some extent from all sloping arable land and all sloping land that is alternated between grass and arable crops. It may occur when the rate of rainfall is greater than the rate at which water soaks into the surface of the soil, resulting in run-off. Rainfall events that cause run-off are not as rare as many people think. There is a significant risk of rill and gully erosion occurring on susceptible sites when more than 15 millimetres of rain falls in a day or when more than four millimetres falls in an hour. Severe erosion is uncommon in the UK but moderate erosion can occur on sands and light loams where heavy rainfall, slope and reduced infiltration combine to cause surface water to

run off. Erosion may be confined to run-off which contains fine soil particles, or it may be more serious and cut channels called rills or gullies.

- 64 Water erosion in England and Wales has increased due to the increased area of winter cereal cropping, the use of tramlines for spraying crops, the need for fine seed beds and the removal of hedges and other linear features.



Water erosion can occur on sloping arable fields

Consider the possibility of soil erosion before you carry out any of these operations, particularly ploughing or reseeded pasture that is on sloping land or the floodplain of a river. In some areas, growing silage maize and keeping pigs outdoors has increased erosion. Damage to river banks by livestock can also be an important source of sediment.

Sandy soils in Southwest and Southeast England, East Anglia, the Midlands and South Wales are most at risk. Chalky soils in the South of England, the Wolds and in East Anglia also suffer from erosion.

65 Careful planning to prevent erosion should include the whole farm, pinpointing situations where there is a high risk of run-off and taking measures to reduce the risk in these areas. Headlands and steep or long slopes are particularly vulnerable as are valley bottoms and gateways where run-off can accumulate. Fields with complex slope patterns can channel run-off into these areas. Reduce run-off from farm roads and tracks and from concreted areas by having adequate drains, ditches and soak-aways. Control drainage water from fields by maintaining land drains, pipe outlets and ditches. Pay particular attention to removing sediment that has been deposited in ditches and drains and whenever possible return it to where it was eroded.

66 Appropriate management can greatly reduce the risk of erosion. Avoid unnecessarily deep or numerous cultivations and working on the land when it is too wet. Compaction reduces the ability of soil to absorb water and this leads to ponding and run-off. You should correct this before you sow the next crop (see paragraphs 51 and 197-198). Avoid fine seedbeds that will run together and seal the soil surface (see paragraph 53). You may need to increase the organic matter content of the soil to prevent this happening (see paragraphs 46-49).

67 Plant cover is an important way of protecting the surface of land. Early planting of winter crops and grass re-seeds is very important where the risk of erosion is high. Aim to achieve at least 25% ground cover by early winter. In such situations, drill winter cereals early and if possible without gaps for tramlines. Set up paths for spraying after the crops have emerged. If tramlines are left when you drill the crops do not use them until the spring. If this is not practical, due to your method of crop management, a shallow tine

behind the wheel can break up any compacted soil and, on some soils, can reduce run-off.

68 Cultivating and planting crops in fields on the contour is recommended for controlling erosion in many parts of the world. For mechanised agriculture, it is only likely to be effective for crops grown in gently sloping fields with simple slope patterns. These conditions are not present in many arable fields in England and Wales. For steeper sloping fields with complex slope patterns, it is not practical to follow the contours accurately. In these fields, attempts at cultivations across the slope often lead to channelling of run-off water, particularly in tramlines or wheelings, which can cause severe erosion. On steeper slopes, the risk of accidents from using machinery across fields is high. For row crops such as potatoes and sugarbeet, harvesters only work effectively up and down the slope. Arable crops, particularly root crops and vegetables, may be unsuitable for sites that are particularly vulnerable to water erosion.

When using a reversible plough across the slope, always throw the soil up the hill to reduce the effect of erosion and soil creep.

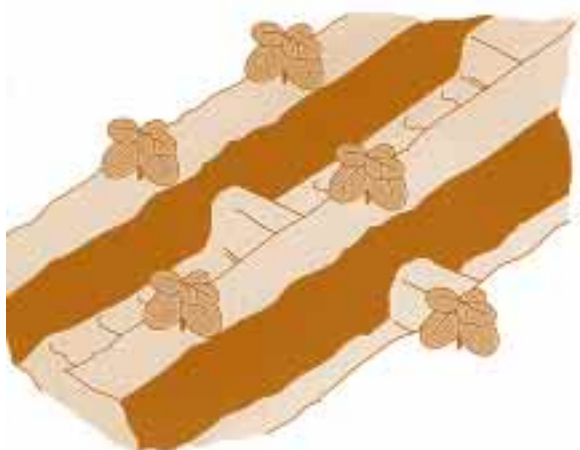
69 You can protect bare ground after harvest by making sure that some chopped straw or other residues are left at the surface during cultivations. You can do this by using tines, discs or shallow one-pass systems (sometimes known as conservation tillage) in place of ploughing. Such practices have the added advantage of increasing organic matter in the surface layer of the soil. Rough seedbeds are more stable than fine tilths. Avoid rolling after autumn drilling on vulnerable sites (particularly when soils are wet) to help maintain the rate at which water is absorbed by the soil.



70 Undersown cover crops or crops such as rye or mustard, sown in late summer or early autumn and ploughed in or killed off before drilling in spring, give good control of both water and wind erosion on sensitive soils. They may also reduce nitrate leaching. Leaving stubbles uncultivated is often preferable to leaving ploughed ground bare over winter. However maize stubble may not provide sufficient protection.

71 Land which is ridged to grow potatoes, and bed systems for vegetables in general, are particularly at risk of increasing water erosion. Using soil walls to bridge furrows across the slope (tied ridges) and small pits (dikes) along furrow bottoms help to improve the soil's ability to absorb water, reduce run-off and so prevent erosion. These techniques are particularly valuable for irrigated crops.

72 Always apply irrigation water in a way that avoids run-off and erosion. Assess the needs of the crops and do not apply too much water at too high a rate or with too great a droplet size. Large droplets are more likely to cause sealing



Tied ridges reduce run-off between potato rows

of the surface. Stop irrigating if run-off occurs. Avoid pipework leaking and carefully drain water from disconnected equipment.

73 If water erosion is a frequent or serious problem you may need to

- create permanent grass strips as buffer areas within fields at strategic places on slopes or in valley bottoms;
- change the crops that you grow or introduce grass into your crop rotation;
- develop stable topsoils by applying bulky animal manures or other suitable organic materials where these are available (but see paragraph 41 and the *Water Code*);
- plant hedges or build new ditches to restrict run-off;
- direct run-off water away from areas prone to erosion.

74 Buffer strips are uncropped areas of grass or natural vegetation adjacent to watercourses. In some circumstances they have the potential to prevent surface run-off and sediment entering watercourses. However, they are unlikely to be a long-term solution to reduce nutrient or sediment pollution of water. Where there is severe soil erosion or excessive run-off, they may become overwhelmed and by-passed by channelled flow.

Buffer strips are most likely to be effective where they are targeted within fields to intercept and slow down run-off and prevent excessive channelling of water. However, targeting may not be feasible for a number of reasons, e.g. where land is in rotational set-aside. Better results may be obtained by planting hedgerows.

Buffer strips are effective at removing nitrate when water movement is within the soil at shallow depth. This is rarely the case but the anaerobic conditions in wetland (water-logged) buffer areas can remove nitrate by denitrification. Further details on buffer strips are available in an Environment Agency booklet – *Understanding Buffer Strips*.

Where buffer strips are likely to be effective, their optimum width will depend on function, soil type, climate and topography, and this could vary between two and fifty metres. The set-aside rules are a constraint in this respect since they require a minimum width of twenty metres for buffer strips sited on set-aside land. This is one of the reasons why the Government has asked the European Commission to reduce the minimum width requirement. The Countryside Stewardship Scheme encourages the establishment of field margins of permanent grass which are two to six metres wide.

**Rather than rely on buffer strips, run-off and erosion should be prevented from happening in the first place.**

**75** In appropriate circumstances, consider introducing grass into arable rotations, or even having areas of permanent grassland or woodland. In many cases, Government schemes such as Environmentally Sensitive Areas, Nitrate Sensitive Areas, Countryside Stewardship and the Habitat Scheme, encourage the conversion of arable land to permanent grassland.

Set-aside arrangements may allow the most vulnerable areas of the field or farm to be protected by grass cover. If you have land which is eligible for Arable Area Payments but is subject to erosion problems you may be able to switch it on a one-to-one basis for ineligible land elsewhere on your holding. You should consult your MAFF Regional Service Centre or

WOAD office about this possibility.

Agricultural land may be converted to woodland with Government payments such as the Farm Woodland Premium Scheme and Woodland Premium Scheme. When you are establishing or harvesting any woodland or forestry areas, take precautions to avoid soil erosion. Keep a cover of plants or trash where possible and avoid causing compaction by planting equipment, particularly on slopes, shallow soils and in upland peaty areas. Take care when installing ditches, roadways and stream crossings. (see *Forests and Soil Conservation Guidelines*, Forestry Commission).

**76** Livestock can also increase the risk of water erosion. You should avoid practices which result in the soil being poached so that run-off and erosion increase. Problems can occur from:

- gateways;
- high stocking rates in wet weather;
- strip grazing and around winter feeding areas;
- tracks for livestock or machinery particularly if they cross streams or natural wet areas;
- overgrazing near the banks of a stream or river;
- uncontrolled access to the watercourse causing bank erosion.

Fencing may be necessary to control the access of livestock to watercourses. It is encouraged under the Countryside Stewardship Scheme. Further details on river bank erosion are available in an Environment Agency booklet – *Understanding River Bank Erosion*.

**77** Keeping large numbers of pigs outdoors can cause run-off and erosion and lead to increased nitrate leaching. Select and lay out sites for

outdoor pigs that minimise the risk of erosion. Take account of location, slope, soil type and rainfall. Manage the site to maintain grass cover or move to another site when this is necessary to prevent run-off. Plan vehicle access so as not to cause wheelings that will lead to run-off.

78 Erosion in upland areas can increase sediment in streams and damage spawning gravels for trout and salmon. Soils in upland areas with high rainfall are frequently shallow, often with a peaty topsoil that is not very fertile. When the plant cover is disturbed (by bracken clearance, livestock, unsealed tracks, drainage ditches or recreational activities) these soils are particularly prone to water erosion.

When over-grazing has caused, or is likely to cause a problem, you should –

- reduce your stocking rates in the vulnerable areas;
- locate supplementary feeding areas well away from watercourses;
- wherever practical regularly move these feeding areas to avoid poaching;
- take care to limit the other activities mentioned in vulnerable areas that are under your control;
- protect eroding areas by encouraging the regeneration of plants to cover the soil. This may need some means of protecting the soil, possibly by fencing, until the plants are established. [See also the MAFF publications *Code of Good Upland Management* and *Your Livestock and Your Landscape*].

Livestock subsidies can be reduced if you are found to be overgrazing your land or are carrying out supplementary feeding practices which leads to excessive trampling or poaching by the animals or excessive rutting by vehicles

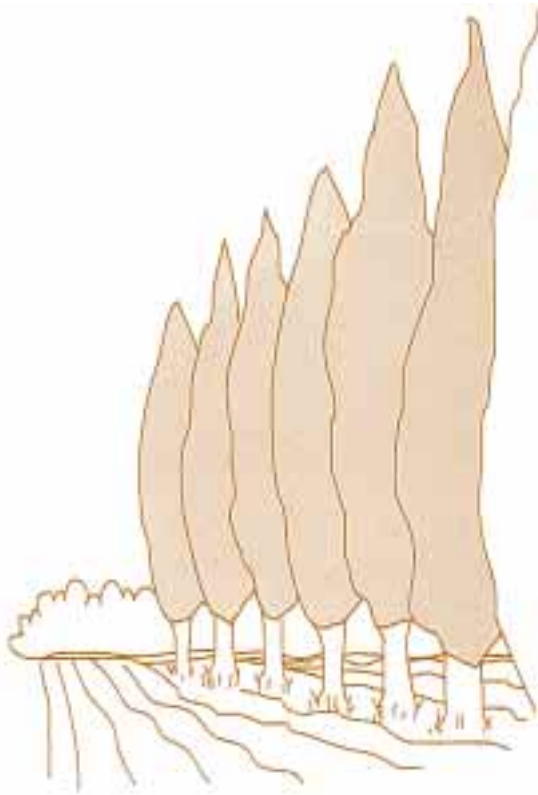
used to transport feed. See *Your Livestock and your Landscape*.

#### Erosion by wind

79 Wind erosion normally only affects bare sandy and peaty soils in exposed areas, especially between March and June. Arable soils that are planted in spring are commonly bare and dry during this period. The areas of highest risk are in parts of the East Midlands, Yorkshire and East Anglia. Wind erosion of exposed peaty soils can also occur in upland areas.

80 If your farming system and soil type together result in wind erosion, you should use control measures. It may be appropriate to avoid some crops on the most exposed fields. You can control wind erosion by reducing wind speed at ground level, making the soil surface stable and trapping any soil particles which are already moving. Individual methods for control are described in the following paragraphs.

81 You can grow rows of trees or hedgerows to trap airborne particles and to provide protection for soil and for crops grown on the sheltered side. Shelters should allow 30-50% of the wind to pass through. Protection from the shelter reduces with distance and does not extend more than 20 times the height of the shelter. The benefit depends on the actual direction of any damaging winds. You can get information on the likely frequency and direction of damaging winds from meteorological records and you can use this information to help you decide where to put shelter belts. Shelters can also have important value for wildlife and should be planted accordingly.



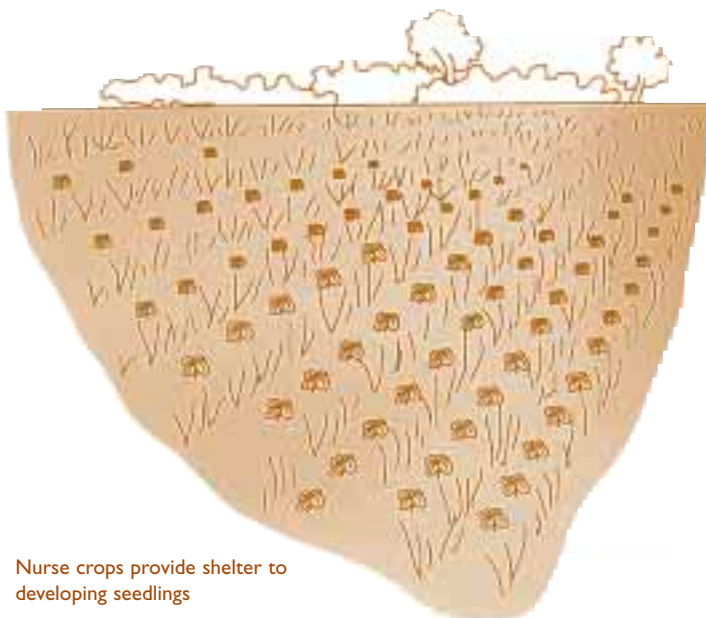
- 82 Crops such as winter rye, winter barley or mustard can be grown as cover or nurse crops to provide protection for both soil and for

spring-sown crops. You can kill off cover crops before the spring crop is drilled, by cultivation or spraying, and nurse crops may be sprayed out during the early life of the crop. These methods are effective for peaty soils and for irrigated sandy soils.

- 83 On peaty soils, mechanised straw planting in rows may provide shelter for vegetable crops that you sow very early.

- 84 The traditional practice of marling to increase the clay content of peats and sands may provide a long-term solution to wind erosion. This technique is unlikely to be practical or economic unless suitable material is available close-by. You need to apply 300-1000 tonnes/ha of suitable marling material to stabilise the surface of the soil. To be successful, the clay content of sandy topsoils should be increased to 8-10%. The marl should be left on the soil surface long enough for the lumps to break down by frost action before you cultivate it into the soil. After marling, you can lose the benefit if you plough the soil too deeply.

- 85 Applying mulches to the surface of seed-beds on sandy soils at 5-15 t/ha after drilling is an effective control measure. Organic manures, sugar beet factory lime and sewage sludge are suitable materials for mulches. Waste cellulose from paper production may be available locally and may be suitable for stabilising the surface. When you use sewage sludge you must comply with the Regulations (see paragraphs 11-12) and any local restrictions to protect groundwater. Other wastes must comply with the Waste Management Licensing Regulations 1994 (paragraph 9). If you disturb the mulch by cultivating the land, the benefit is lost. Always take full account of the nutrients, including lime, that may be present in the mulch (see paragraph 41).



Nurse crops provide shelter to developing seedlings



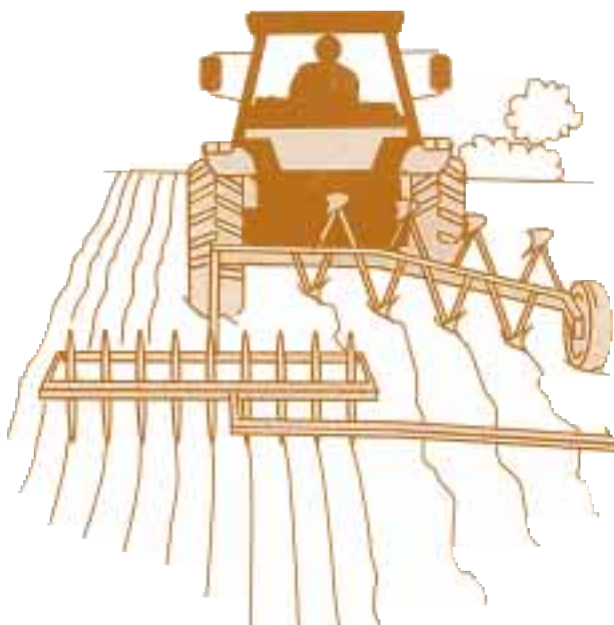
86 Synthetic stabilisers such as PVA (polyvinylacetate) emulsions or PAM (polyacrylamides) sprayed onto the soil surface of sands after drilling can provide temporary protection for high value crops. This method is unsuitable on peat soils. Appropriate professional advice should be obtained before you use these methods to control erosion.

87 Choosing cultivation practices carefully can provide effective erosion control for sandy soils. You can form an erosion-resistant surface by ploughing if there is enough silt and clay in the topsoil. Plough and press the soil at the same time before you sow the crop and drill it at right angles to the direction of pressing without cultivating the seedbed any further. Adequate moisture is needed if pressing is to provide a stable surface. Uncultivated crop stubble also provides protection against wind erosion and a spring-sown crop can sometimes be drilled directly into the soil surface. However, you must take care as a compacted surface may increase run-off and cause water erosion. To ensure satisfactory crop growth, remove any compaction by loosening where necessary.

#### Deep cultivation and mixing of soil

88 In certain situations, mixing the topsoil and subsoil may improve the physical characteristics of the soil by introducing clay into sandy soils or mineral matter into shallow and degraded peats. Usually, however, you should avoid diluting topsoil with subsoil brought to the surface as it will reduce fertility and cause physical degradation.

89 Do not plough deeper than 30 centimetres in silty and fine sandy topsoils with a low organic matter content, especially if the subsoil has an even lower organic matter content. If subsoils are ploughed, the stability of the topsoil will be



reduced even more. Crop establishment may be affected or wind and water erosion may be increased.

90 Deep ploughing will dilute plant nutrients, result in coarser seedbeds and slow down soil warming in spring. Increase the rooting depth by subsoiling rather than by ploughing. In particular, avoid deep-ploughing shallow soils which lie over loose or weathered materials such as chalk. By contrast, shallow cultivations, including conservation tillage (see paragraph 69), may help to improve structure and will conserve nutrients in the surface layer of soils.

91 Many heavy textured, poorly drained grassland soils only have a well-developed structure of small aggregates in the top few centimetres. They should only be reseeded in exceptional circumstances. Ploughing these soils can dilute organic matter, destroy natural soil drainage and so increase the risk of damage by machinery and animals. The management of

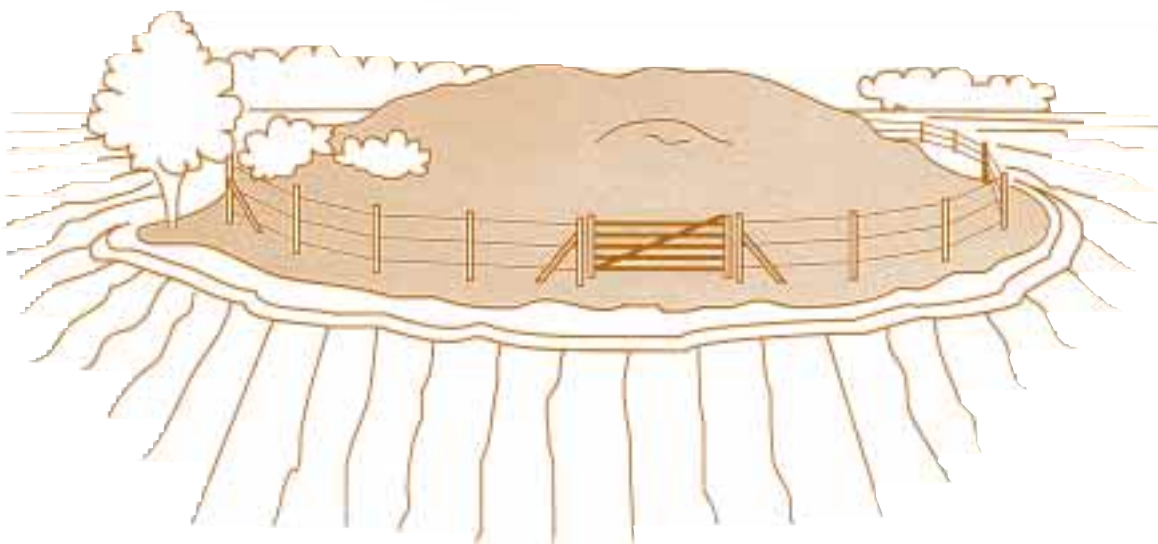
these soils will then be difficult for many years. If you need to reseed such swards, use surface seeding or shallow cultivation techniques.

**92** Keep soil disturbance to a minimum when you remove trees from land by grubbing orchards, harvesting standard nursery stock trees or clearing farm woodlands (including coppiced stands), according to any tree-felling licensing conditions. Mixing subsoil can cause problems similar to those described in paragraph 88. Carry out all mechanised work when there is no risk of compacting the soil. Soil removed on the roots should be kept to a minimum. Under certain conditions, rapid breakdown of stumps and coppice stools can be encouraged by heavy discing and leaving them in the soil to rot down. You should seek professional advice as to the most appropriate technique for your situation.

**93** A large part of our archaeological heritage is in the countryside, protected beneath the soil. These remains are easily disturbed and can be damaged or lost by ploughing, under drainage,

subsoiling or other soil disturbance, including planting or uprooting of trees, shrubs or hedges. Such sites may be legally protected (see paragraph 28). You should make careful plans and obtain the necessary consent before undertaking any new work. The MAFF and English Heritage booklet *Farming Historic Landscapes and People* and English Heritage's publication *Ancient Monuments in the Countryside* provide additional information. A management agreement, including a small grant, may be available to help you to protect the site.

Not all ancient monuments are legally protected but they may still be of historic importance. All important archaeological remains should be preserved, if possible. If you have such sites on your land or you uncover remains or objects, you should contact the Archaeological Officer of your County or Unitary Authority or in Wales, from the Archaeological Trusts (details from English Heritage or Welsh Historical Monuments (CADW) in Wales).



Protect archaeological features from livestock and cultivation



### Loss of lowland peat

94 Some lowland parts of England and Wales (such as Humberside, the East Anglian Fens, Somerset Levels, and Lancashire and Cumbria Mosses) have areas of peat deposits. In their original state, these deposits formed raised mires (domes of peat) or fen (sedge) peats. Areas of undrained, lowland peat-bogs with natural vegetation have become increasingly rare in England and Wales and many of these habitats are protected as Sites of Special Scientific Interest (SSSIs). Such wetlands also preserve important archaeological interests including evidence of past environmental conditions. You can receive grants under various conservation schemes including Countryside Stewardship to manage nearby land so as to reduce effects upon SSSIs. These grants may also be available to help you preserve other undisturbed soil site types and habitats.

**You should leave all undrained or virtually unaltered sites as natural or semi-natural areas, or as traditionally-managed pasture.**

95 In the past, large areas of original peatland have been drained to form agricultural land. When drained and fertilised, these areas have formed very productive soil which is capable of producing high yields of root crops and vegetables. For effective drainage, the water table needs to be lowered and the Environment Agency and the Internal Drainage Board should be consulted. Lowering the water table causes shrinkage of the land through the peat drying out and, together with repeated cultivation, it stimulates breakdown (oxidation) which leads to a reduction in the depth of peat. These soils are a resource which have a limited life. Several metres of peat have been already lost by these processes. To reduce the rate of loss, keep the water table as close to the surface for as long

as possible consistent with the need to manage this land for food production. In some areas, care will be needed not to expose acid sulphate soils which lie below the peat (see paragraph 37). The processes of peat wastage can be prevented only by reinstating natural peat mire conditions. This action would drastically reduce the value of the soils for growing crops. Land set-aside for periods of one year will have little effect on the rate of wastage if water tables stay at low levels in surrounding fields.

### Introduction

- 96 Contamination can affect the fertility of the soil as well as affecting livestock and the human food chain. This section describes the risks associated with the chemical contamination of soils and the measures that you need to take to avoid this happening. Risks associated with the burial of carcasses are covered in the *Water Code* (Section 13, paragraphs 275-279).

Man's activities may contaminate soil; either directly through applying materials such as industrial wastes, animal manures, sewage sludge, pesticides, fertilisers or contaminated irrigation water; or indirectly by atmospheric deposition such as from factories or lead from car exhausts. Such activities usually result in contaminants building up slowly over many years and the time-scale involved may mean that their significance is not easily recognised. Contamination may also occur quickly by more obvious and damaging events such as spillages, leaking pipelines, uncontrolled land spreading or dumping of wastes.

- 97 Soil may also become contaminated by natural processes which result in eroded materials that contain potentially harmful elements being deposited in the soil. Flooding by water from waste tips or mining sites can be a direct source of contamination. In such cases you may need to use short-term and long-term management techniques to protect the soil and the safety of livestock and humans who eat the crops grown there.

- 98 Land may already have been contaminated by natural processes or by man's activities. If large areas of soil are seriously polluted, appropriate remedial measures may be too expensive for agricultural land. However, you may be able to improve crop growth or reduce metal uptake by the crop by taking appropriate management

measures such as liming the soil to raise its pH. For smaller areas, removal of contaminated soil to an appropriately licensed disposal site or covering it with a clean material may be appropriate. You should take professional advice on the best way of dealing with individual problems and if necessary consider an alternative use of the land. Clean-up techniques available for contaminated sites frequently involve high-cost treatment and have been reviewed in a DETR report *Review of Innovative Contaminated Soil Clean-Up Processes* which is included in the list of further reading.

99 Contaminants can be considered under two headings:

- *Inorganic materials*: – such as zinc, copper, nickel, lead, cadmium and arsenic; these tend to remain in soil indefinitely, although their chemical or physical state may change with time.

- *Organic materials*: usually man-made chemicals such as pesticides or industrial solvents; – they are broken down to a greater or lesser extent by micro-organisms in the soil. In some cases the result of the breakdown can be chemicals which are themselves contaminants. Even though the materials or their breakdown products are broken down, repeated applications may mean that a high concentration is present in the soil.

100 As inorganic and some organic contaminants occur naturally in soils, you need to analyse and assess the local background concentrations as well as the nature and origin of the various added contaminants. If background concentrations are low, deposits of trace elements such as zinc and copper, which are essential for the growth of plants and animals, may increase the fertility of soils.



Soils can be contaminated from many sources

**101** To protect soil in the long-term for a wide range of users, you must recognise the many potential sources of contamination in order to assess their significance and then to take the necessary steps to prevent, limit or overcome their effects. Pay attention to surrounding natural habitats as well as to agricultural land.

A guide to acceptable concentrations and recommended management techniques is given in this section and in Appendix II. You should protect soils from all avoidable contamination. Contaminants which were having no harmful effects may be taken up by the crop or leached from the soil if the soil becomes acid.

**102** The risk associated with a particular contaminant in soil can be assessed by considering the contaminant's effects on the following:

- soil biological, chemical and physical status;
- crop growth;
- concentration in human and animal diets;
- exposure of humans and animals through breathing in dust or vapours, or through skin contact;
- surface water and groundwater quality.

General guidance is available in the DETR *Guide to Risk Assessment and Risk Management for Environmental Protection*.

**103** Whenever contamination is suspected, or you want to dispose of waste, professional advice should be obtained, based on analysis of the soil and of the waste materials.

### Heavy metals and other inorganic contaminants

**104** Although soils may be affected by a wide range of contaminants, problems usually arise from a relatively small number of elements. Elements which can kill plants or reduce yields if they are present in high concentrations include zinc, copper, nickel, cadmium and arsenic. Elements which can be particularly harmful to animals or man include lead, arsenic, cadmium, mercury, copper, fluorine, selenium and molybdenum. Crops that are growing satisfactorily may still affect animals and man. In lower concentrations some of these elements may be essential trace elements for either plants or animals. With the exception of molybdenum and selenium, plants take up more of these substances from acid soils. Individual contaminants are discussed in Appendix II.

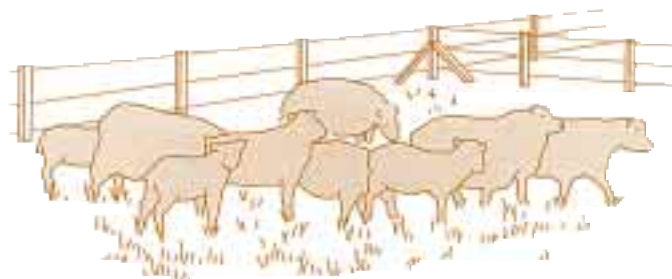
### Effects on Livestock

For most contaminants, but not molybdenum and selenium, the risk of poisoning livestock which graze on a contaminated soil depends almost entirely on the amount of soil swallowed and the concentration of the contaminant in that soil rather than the concentration in the grass. This concentration factor is more important than the fact that the contaminant may be released more easily from grass than from the soil once it is in the digestive system of the animal. The amount of soil contamination on grass will vary with the type of sward, its thickness, the time of year, weather conditions, stocking density and how grazing is managed. In a thick sward, or where there is a surface mat of grass, soil contamination of the diet may be less than 3% of the dry matter. In reseeded pastures, with an incomplete plant cover, soil contamination is often as high as 10% or more. Make sure that hay and silage are not contaminated with soil during harvesting. This means making sure that cutting equipment and pick-up reels are not set so low that they touch the soil.

#### The risk to livestock depends on:

- levels and type of contamination in the soil, and of soil contamination on the grass;
- levels of contaminants accumulated in the grass;
- variations in dietary intake over the year;
- differences in the uptake of the contaminant by livestock from their diet;
- the type, species, age and health of the animals;
- the length of time they are grazing; and
- supplementary food they are given.

There is a limited amount of reliable information on livestock tolerance to metals and other contaminants, particularly possible interactions between them. So it is only possible to give general guidelines on critical soil concentrations. It is based on expected metal concentration in or on the grass and the animals intake, assuming that a specified proportion of soil is eaten as part of the diet. It is essential that you receive appropriate veterinary advice when you suspect that contamination is the cause of either acute (rapid) or chronic (long-term) deterioration of the health of your livestock.



### Organic contaminants

**105** Although they can supply valuable nutrients and organic matter, some composted town refuse industrial wastes and sewage sludge may contain organic chemicals which pose a threat to the environment. A large number of compounds could be involved and it is not possible to identify or monitor all of them while they are being applied to the land. Before you apply any wastes to land, they should have been analysed to see if any contaminants are likely to be present in large amounts. Without knowledge of specific contaminants, indicator compounds should be used to assess the likely overall concentration of contaminants. Take specialist advice on these. More research is needed before it is possible to give general recommendations on maximum concentrations of organic contaminants.

**106** Some organic compounds are lost from soil by volatilisation into the air and many are broken down in the soil, but at different rates. The breakdown products may also be harmful. You must take precautions when you apply wastes or pesticides (see paragraph 131) to soil to make sure that there is no risk to water or the food chain. To protect soil over the long-term, applications should not affect soil organisms as this could damage soil fertility. The amount or frequency of application should not cause contaminants to build up in the soil. This is particularly important for compounds such as polychlorinated biphenyls (PCBs) and the more

persistent pesticides which break down slowly in soils.

**107** The following compounds give an indication of those which may be encountered. The group produced from benzene includes dichlorobenzene used in toilet disinfectants, and alkyl benzenes used in detergents. Polychlorinated biphenyls (PCBs) were used as electrical insulating agents but are no longer made or used in the United Kingdom. Polycyclic aromatic hydrocarbons (PAHs) are produced by various processes including burning of waste materials. They occur at moderate levels in industrial wastes. Dioxins and furans may be present but usually only at very low concentrations.

**108** Contamination of soil by mineral oils reduces plant growth by blocking soil pores and reducing the amount of oxygen available. Some oils are also directly poisonous to plants (see paragraphs 147-153 on dealing with an oil spillage).

#### Industrial contamination

**109** It is important to identify any contamination of land previously used for industrial purposes including mining for metals, particularly where such sites are being returned to agriculture. Information on contaminants associated with specific industries can be found in DETR Industry Profiles. Take care to prevent contaminants being spread on clean sites or from entering ground or surface waters.

Seek professional advice before you take any action to reclaim contaminated land. Recommended threshold values have been provided by the DETR for possible uses of such land and your advisers should consider these in relation to the specific risks of the site.

**110** Treatment processes to clean up contaminated land are based on a range of physical, chemical and biological treatments which either remove the contaminants or make them harmless. The costs of these treatments are commonly greater than the value of land for agricultural purposes. They may also cause severe damage to the structure and fertility of the soil.

**111** It is unlikely that industrial sites, other than some closed landfill sites or some in old mining areas, will be returned to agriculture. Industrial sites of archaeological interest should not be disturbed. However, if the land is returned to agriculture, professional guidance must be sought as described above. In the case of grazing on old metal-mining sites separate guidelines have been prepared. (see ICRCL Guidance Note 70/90).

#### Atmospheric deposition

**112** Atmospheric deposition is the term used to describe how contaminants and other substances in the air reach the soil as gases or dust or are washed down in rain. These contaminants may arise from natural sources such as wind erosion or volcanic activity. In the United Kingdom, deposits of contaminants from natural sources have little effect. Contaminants which arise from human activities such as an industrial complex may cause large deposits near to a source. They may be dispersed more thinly over a wide area from activities such as coal burning.

Controls over industrial emissions to the atmosphere have increased in recent years. Although long-term deposition is less likely in future, continuing care is necessary, particularly to control organic contaminants. Care needs to be taken near industrial sites and you should ensure that any necessary precautions under



your control are taken to protect the environment and the food chain if an accidental emission occurs. You should seek professional guidance on what to do in any particular situation. Radioactive fall-out from a nuclear accident is dealt with by Government action according to the particular circumstances. General advice is not given in this Code.

### Sewage sludge

**113** It is a positive environmental benefit to recycle to agricultural land the organic matter and plant nutrients that are in sewage sludge. Sludge has a similar nitrogen and phosphate fertiliser value to animal manures and slurries and the nutrients it contains should be built into an overall fertiliser policy for your land. The total quantity of nitrogen you apply in the form of sludge, animal manure or other wastes should not exceed 250 kg/ha per year as recommended in the *Water Code*. This limit may be relaxed when sludge cake is applied for soil conditioning in catchments that are not sensitive to nitrate leaching (see paragraph 41).

#### WHAT IS SEWAGE SLUDGE?

Sewage sludge, sometimes known as biosolids, is a by-product arising from the treatment of sewage. Untreated sludge is produced by either the primary (settlement) or secondary (biological) stages of sewage treatment. Further processing or storage may be undertaken to improve its stability (i.e. to reduce health hazards and odour problems) to produce treated sludge. Both untreated and treated sludge may be supplied as a liquid with a consistency similar to animal slurry, or as a dewatered sludge cake. You may also be offered composted, thermally dried or lime-treated sludge. All of these materials are suitable for application to land.

**114** Applying sludge to agricultural land is controlled by the Sludge (Use in Agriculture) Regulations 1989 (as amended) (see paragraph 11) which implement EC Council Directive 86/278 (see paragraph 12). Further guidance is given in the supporting DETR *Code of Practice for Agricultural Use of Sewage Sludge* which was amended in 1996. The Regulations are designed to protect the environment in general, human and animal health, and the soil, when sewage sludge is used in agriculture (paragraph 12). The Environment Agency is responsible for enforcing the Regulations in England and Wales. The controls are kept under review and may need to be further amended as a result of current research. Many other materials contain one or more of the contaminants present in sewage sludge and may cause similar problems.

**115** The producers of the sludge are responsible for keeping to the legal requirements on concentrations of metal contaminants in the sludge itself and the soil to which it is applied. It is an offence to cause or knowingly allow sludge to be used on agricultural land when such use does not meet the requirements of the Regulations. If sludge is used on your land, you should make sure that you know about your responsibilities; these are summarised in MAFF leaflet (PB 2568) *General Information on the Application of Sewage Sludge to Agricultural Land*. (Information packs are available from many of the sludge producers regarding their agricultural operations).

**116** The metals in sludge are from industrial discharges and domestic sources. They remain in soils virtually forever and their adverse effects may increase as the associated organic matter is broken down by natural soil processes. If uncontrolled, these effects would include reductions of crop growth, increased intake of metals by animals and man through food, and reductions in the activity of microbes in the soil.

**117** The Regulations restrict the amount of zinc, copper, nickel, cadmium, lead, mercury and chromium applied and the ultimate concentration of these metals in the soil (in samples taken to a depth of 25 cm, or the depth of topsoil if less). The *Code of Practice for Agricultural Use of Sewage Sludge* also recommends that the concentrations of these metals should not be exceeded in soil samples taken to a depth of only 15 cm in arable land or to the depth at which sludge may be injected. The *Code of Practice for Agricultural Use of Sewage Sludge* also gives recommended limits (not legally-set ones) for applying molybdenum, selenium, arsenic and fluoride and precautionary limits for zinc which are lower than the legally set values. Any other contaminants present in sludge should not be a problem, as long as you keep within the limits set for these major contaminants. However, the concentration of contaminants in sewage sludge, in particular of heavy metals, has been greatly reduced in the last two decades, mainly because of controls on industrial discharges. As a result, the nutrients needed by your crops should usually determine the application rates. The limits for soil metals are given in Appendix III.

**118** The *Code of Practice for Agricultural Use of Sewage Sludge* also provides recommendations for the maximum concentration of contaminants in the top 7.5 centimetres of soil under grass. These are intended to limit the risk to grazing animals and to reduce the damage to plants whose roots may concentrate in this surface layer. If these concentrations are exceeded at 7.5 centimetres, cultivate the soil to disperse the metals before further applications are made.

**119** Different metal limits apply according to the acidity (pH) of the soil. It is important that you keep the pH of the soil at the appropriate level

both during and after applying sludge. Most metals become more available in acid soils and any adverse effects will then increase. The availability of selenium and molybdenum to plants increases in alkaline soils. When sludge is applied up to the allowed limits, you will need to maintain the pH for an indefinite period. Sludge must not be applied to agricultural land with a pH below 5.0.

**120** The Regulations and the *Code of Practice for Agricultural Use of Sewage Sludge* only relate to agricultural land which is used for growing food crops (including for animal feed) or grassland for livestock. They do not apply to forests, reclaimed land, amenity or service areas. A separate Code of Practice has been issued by the Forestry Commission for sludge use in forests. This recommends that the metal concentration limits in Appendix III of this *Soil Code* relating to pH 5.0-5.5 should apply. This allows for the acidic nature of many forest soils. For other types of land, the metal concentration limits in Appendix III for the appropriate pH should apply. Under the set-aside rules, sludge may not be applied to land set-aside unless it is being used to grow non- food crops. When sludge is used on land growing non-food crops you should see that the same care is taken as if the land were growing food crops, as it may be returned to food-crop production in the future.

#### Other industrial and domestic wastes

**121** The disposal of non-agricultural wastes is controlled by the Waste Management Licensing Regulations 1994. Paragraph 9 of this Code explains that the landspreading of some wastes is exempt from licensing when certain conditions are met. Other wastes can be spread if specific site licences are obtained. The application of wastes must be registered with the Environment Agency who will supply advice on the Regulations and their interpretation. One of

the requirements for landspreading of non-agricultural wastes is that the operation must achieve agricultural benefit or ecological improvement. Detailed guidance on what constitutes such improvement is being prepared and will be issued shortly. The following paragraphs provide interim advice on agricultural benefit.

#### What to check with your sludge provider

*Before agreeing to accept sewage sludge or other domestic and industrial wastes you are advised to ask the sludge provider for the following information:*

- How much nitrogen, phosphate and potash the material contains and what guidance on its fertiliser value will be given?
- What is the content of heavy metals or other contaminants, and how will the company monitor the metal content of your soils?
- Does the company provide a soil analysis service and will you be charged for this?
- Has the material been treated and if so how?
- Will the material be supplied in solid or liquid form?
- Has the material been screened to remove non-biodegradable solids?
- What machinery will be used to apply the material?
- How and when can the material be used safely in your farm system according to the crops grown?
- What measures will the company take to minimise the risks of water pollution and odour nuisance arising from applying the material?
- Will you be charged for taking the material?

**122** Agricultural benefit should be regarded as providing necessary quantities of plant nutrients or as a long-term physical improvement. Nutrient benefit can be obtained if the waste contains lime, available plant nutrients or trace elements needed for crop growth on a particular site, (See Section [2] of this Code). Apart from consideration of

whether a waste contains plant nutrients, the amount applied should not exceed the lime or nutrient requirement of the crop, or rotation of crops, being grown. Applications must not pollute water-courses or have other harmful effects on the environment during or after handling and spreading. This includes not causing a smell nuisance.

**123** Benefit may also be obtained by improving the physical status of the soil. This can be done by adding significant quantities of organic materials to soils low in organic matter, or by materials such as gypsum which can help to reclaim saline and alkaline soils. Spreading of material to change the land profile and liquid wastes for irrigation may be considered as a benefit by the Environment Agency in certain circumstances.

**124** Even if a waste can be said to provide agricultural benefit, it should not be applied to land if it contains unacceptable quantities of potential contaminants. Nor if it poses a microbiological or other risk to the health of plants, livestock or to the food chain. Contaminants applied to soil may also subsequently affect water quality if they are leached or eroded into groundwaters or surface waters. Application of wastes containing contaminants should be undertaken so that the risk to water quality is minimised by avoiding losses to the aquatic environment.

**125** When wastes are known, or suspected, to contain elements not specifically covered in this Code, all relevant information should be assessed, professional guidance sought and the Environment Agency informed to decide if land application is desirable and allowable and if so at what rate.

**126** Wastes from the handling or processing of imported plant material carry a risk that

serious pests and diseases will be introduced or spread in agricultural or horticultural systems. All surplus soil, liquid waste and plant debris, which can carry harmful organisms must be disposed of safely. Further guidance is given in the *Plant Health Code of Practice for the Safe Disposal of Agricultural and Horticultural Waste*.



### Animal manures

**127** The main contaminants in animal manures are copper and zinc. They are present naturally in feedstuffs but their concentrations are increased by additions either as growth promoters, for medicinal purposes, or to increase the supply of trace elements. Metal accumulation in soils from manure applications can be as great as from the regular use of sewage sludge. On fields which receive regular applications, you should check the content of these metals in pig and poultry manures and slurries and in the soil. Take samples to a depth of 15 centimetres for arable land and 7.5 centimetres for permanent grassland. If soil values approach the limits in Appendix III, get professional advice about applying manure to this land in future.

**128** Animal manures contain relatively high quantities of plant nutrients. When you apply manures according to the *Water Code*, the amount of contaminants added to the soil will be limited and damaging concentrations are unlikely. However, you should take precautionary samples as outlined in paragraph 127. The *Water Code* includes a maximum guide figure for total nitrogen in animal manures of 250 kg/ha per year which you should keep to, but you should also consider the phosphorus and potassium need of the crops (see also paragraph 40). Always adjust the

amount of inorganic fertiliser you apply to take account of any manures you have applied.

### Inorganic fertilisers

**129** Base the amount of inorganic fertilisers you use on soil analysis and follow the principles of the detailed fertiliser recommendations given in MAFF/ADAS Reference Book 209 *Fertiliser Recommendations*. Avoid potentially harmful build-ups of nutrients, and also avoid applying too much lime.

**130** Materials you use as inorganic fertilisers (such as rock phosphate) may be applied in a relatively unprocessed form or after chemical and physical treatment. These treatments may affect the quantity or availability to plants of any contaminating materials which are present. Manufacturers should monitor the concentration in fertilisers of any contaminants so that the soil will be protected from any unacceptable contamination. Cadmium and, to a lesser extent, fluorides and uranium in phosphate fertilisers are of continuing concern, although cadmium contents are lower now than in the 1980s.

### Pesticides

**131** Pesticides in England and Wales are controlled under Part III of the Food and Environment

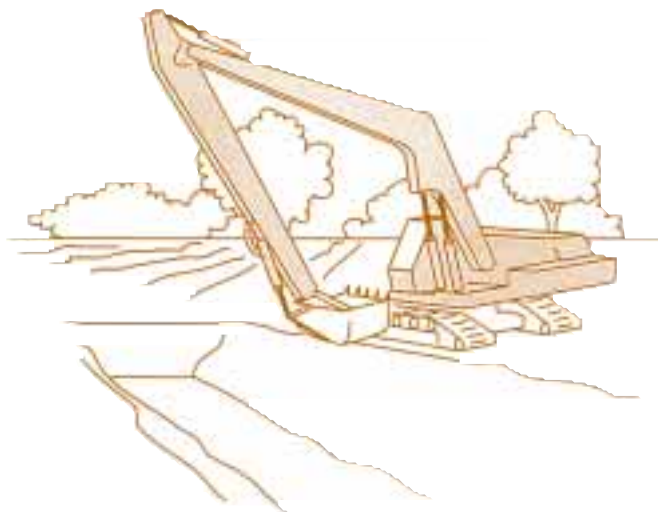
Protection Act 1985 (FEPA). The Control of Pesticides Regulations 1986 (COPR) provide legal controls over advertising, selling, supplying, storing and using pesticides in England, Scotland and Wales. The MAFF/HSC statutory *Code of Practice for the Safe Use of Pesticides on Farms and Holdings* (1998) provides guidance on all aspects of using pesticides, including disposing of wastes and washings, containers, packaging and other contaminated materials. Practical guidelines to avoid pesticides polluting water are given in the *Water Code* and in the *DETR Guidance for Control of Weeds on Non-Agricultural Land*. Guidance on avoiding pollution of water is directly relevant to avoiding pollution of soil. Read both of these Codes when you are finding out about protecting soil.

132 Most pesticides are organic compounds which are broken down in the soil by physical and chemical processes and by micro-organisms. By law, these compounds must only be applied at a rate and in the way specified in their authorisation. This is granted on the basis that, when correctly used, the chemical will have no unacceptable long-term effect upon the environment. Regularly using certain pesticides (such as some soil-acting herbicides) may leave residues which take several years to break down.

133 Some pesticides that are currently approved contain copper. Although these are no longer widely used, repeated applications over many years may raise the copper concentration in soils. In these rare situations, particularly where hops are grown, you should have your soils analysed and compare the copper content with the figures given in Appendix III to find out if you should continue to use the pesticide.

### Dredging materials

134 The spreading of materials dredged from settlement ponds or natural waters such as ponds, lakes, rivers, canals, etc. is controlled by the Waste Management Licensing Regulations and may be exempt from the licensing provisions (see paragraph 9). They should not be spread on agricultural land until any contaminants have been identified, professional advice sought, a satisfactory programme of land application and subsequent management established and the Environment Agency informed. Local enquiries should be made on potential contaminants and identification should be confirmed by analysis of the material. The source of the contaminants, e.g. geological or industrial wastes, will determine their likely affect on crops or livestock. Appropriate action will vary accordingly. Contaminated dredging material may also be subject to Special Waste legislation (see paragraph 10). If that is the case, then use cannot be made of the exemption provided from waste licensing. Further guidance can be obtained by reading DoE circular 6/96, Construction Industry Research and Information Association, (CIRIA) Report 157 or by contacting the Environment Agency.





### Remedial treatment

**135** Take all possible steps to avoid contaminating soil. When accidental or natural events cause contamination, obtain professional advice and put action programmes in place to limit the damage. Where possible you should treat the soil to improve its condition. Two situations where problems can be solved by relatively straightforward management practices are in the cases of sea water flooding and oil spillages.

### Seawater flooding

**136** When sea flooding occurs, it is important that the water on the soil surface drains back to the sea or river as quickly as possible in order to minimise residues of sodium and chloride in the soil. High residues can restrict crop growth and damage soil structure. When possible, dig surface channels by hand to help remove the water from low-lying areas. If large areas have been flooded it might be more practical to use mechanical diggers with low ground-pressure tyres. You can also remove seawater by pumping. The sooner surplus water is removed, the sooner the recovery process can start.

**137** In freely draining soils, average winter rainfall in England and Wales can remove most of the chloride left in the soil in one winter. If flooding occurs in late winter or spring, the chloride will not be removed until the end of the next winter. This process may be quicker if you do not plant a crop in the soil for the first summer after flooding. You should also prevent the growth of any weeds.

**138** On soils that are not so well drained, washing out the excess chloride may take two or three winters. If the soil is very poorly drained, with little or no water moving through the soil, the soil may remain contaminated. This is a particular problem if the soil is very dry at the

time of flooding, so that salt water penetrates deep into the soil. However, the soil is usually already wet when it is flooded and in this condition the salt water will not penetrate deep down into the soil.

**139** Soils with pipe drainage will recover naturally as long as the system is working properly. The number of winters needed to leach the excess chloride will depend on rainfall, the structure of the soil and the effectiveness of the leaching process.

**140** If soils contain more than 1200 mg/litre of water-soluble chloride in the top 20 centimetres, grow tolerant plants such as barley or ryegrass rather than more sensitive species such as legumes or brassicas.

**141** As water moves through the soil, the soil sodium concentration will be reduced by leaching. If sodium taken up by the clay particles is not immediately replaced by calcium or magnesium, the clay particles will disperse and the soil will become very difficult to cultivate. Soils with a high silt or clay content are most at risk of deterioration. Peaty and coarse sandy soils are less prone to damage.

**142** To maintain a satisfactory structure, the soil must contain a supply of calcium or magnesium. This may come from a high natural content of calcium carbonate or from added gypsum. Gypsum is calcium sulphate which is more soluble in water than lime (calcium carbonate). On cultivated soils which are susceptible to structural deterioration and have been flooded with seawater, you should apply finely ground gypsum at 5 tonne/ha as soon as possible after the soil has dried out. This is likely to improve the soil even if it already contains some calcium carbonate. Gypsum is most effective if it is left on the soil surface and not ploughed in. You may need to



make another application on clay soils which do not contain lime and which have been flooded for a long time.

**143** Soils in grassland should only be treated with gypsum if they have a weak structure and contain no lime. Do not treat peaty and coarse sandy soils as you will get very little benefit.

**144** Use of waste gypsum in this way is subject to the Waste Management Licensing Regulations 1994. These controls are described in more detail in paragraph 9.

**145** For rapid recovery from flooding damage, do not carry out cultivations in wet conditions. Avoid sowing crops in the spring until the soil structure is fully restored.

**146** Apply adequate fertiliser because any nutrient shortage will increase the problem. If there is a drought, irrigate the land with non-salty water where possible.

#### Oil spillage

**147** When there is a significant oil spillage, the main concern is to reduce the fire hazard and prevent the oil from entering sewers, watercourses or groundwater. Tell the Environment Agency about the spillage immediately so that they may assess any risks to surface waters or groundwaters. The next step is to remove as much of the spillage as possible and dispose of it safely, so reducing the amount left to be broken down by micro-organisms in the soil or to be lost by evaporation. Only dispose of the contaminated soil to a site licensed to receive special waste.

**148** If light oil such as diesel or heating oil penetrates the topsoil but is held up by the subsoil or the water table, it may be possible to dig holes, allow the oil to drain into them and

then pump it out. If you are in any doubt regarding the watertable and the nature of the subsoil, you should seek professional advice before any excavation work is undertaken. The hole should not penetrate the layer that is holding up the oil. Do not apply water or detergents to try and flush the oil from the soil and do not try to burn oil on the soil surface.

**149** Crude and heavy oils will stay on the soil surface. Scrape them up, taking as little topsoil as possible, and remove them to a site licensed to receive such wastes. This may be easier if you let the oil solidify first. It will also reduce the risk of machinery damaging the soil during the clean-up operation.

**150** The next stage in restoring the soil is to make sure that the conditions for the remaining oil to be broken down by micro-organisms are as favourable as possible. All soils contain micro-organisms that can break down oils. The soil needs to have a pH of about 7, be at an adequate temperature, and contain water, oxygen and nutrients. If the soil is in a suitable state, cultivate the surface to improve the oxygen supply to the micro-organisms. Mixing the soil and oil will increase the rate of breakdown.

**151** For heavily contaminated soils, apply inorganic nitrogen and phosphorus fertiliser before cultivating so the micro-organisms have an adequate nutrient supply. Do not add organic manures to oil contaminated land as these increase the micro-organisms need for oxygen, and plants could be damaged.

**152** The time it takes for the soil to completely recover depends on the type and quantity of oil contamination, the soil conditions and the method of remediation employed. Spillages of light oil will generally affect the soil for one to two years. After this period, plant growth is



not likely to be affected. Spillages of crude and heavy oil may take five years or longer before the soil can be used to grow a wide range of plants again.

153 Commercial companies offer services for cleaning up soil contaminated with oil and other organic contaminants, using microbiological and other appropriate techniques. Get professional advice on the correct course of action for the particular contaminant which has to be treated. Detailed guidance is given in a *Code of Practice for the Investigation and Mitigation of Possible Petroleum-Based Land Contamination*, published by The Institute of Petroleum.



## Restoring Disturbed Soils

### Introduction

**154** This section of the Code gives advice on measures to reduce the effect of soil disturbance by extraction of minerals, landfill, laying pipelines and other civil engineering works. It provides information on safeguards that need to be taken to make sure that the long-term quality of the soil is protected. The main responsibility for applying most of the measures and safeguards described will rest with the developers, contractors and site operators as well as with planning authorities and the Environment Agency.

**155** This Code does not provide comprehensive guidance on detailed planning or operational practices. It aims to provide you, the farmer, or your advisers with an outline of operational standards and conditions that are likely to be placed upon operators. It also advises you on measures you may take to make sure that appropriate controls are applied and on the aftercare which is necessary to make sure that disturbed soils are restored to satisfactory standards for farming.

**156** The overall aim is to make sure that if land is going to be restored for agricultural use:

- soil damage is minimised;
- land is restored wherever practical to its original quality (the MAFF Agricultural Land Classification (ALC) grading is normally used);
- restored land is not damaged by inappropriate farming practices.

If planning permission has been given for restoring land for use other than agriculture, other measures for restoring the soil may be appropriate. However, the measures described here may be relevant to some other uses.

## LEGISLATION

### Extracting minerals and landfilling

**157** Virtually all development to extract minerals or to landfill waste needs planning permission, a process that includes provision for full public participation and comment. The Town and Country Planning Act 1990 (as amended by the Planning and Compensation Act 1991) controls the use of land for mineral extraction. When an application is made, the landowner and any tenant of the land involved will be notified. If you have any questions about the application, or you want to make any comments, you should contact the Mineral Planning Authority within 21 days of receiving the notification.

If consent is given, it is normally subject to planning conditions which control working of the site, how it must be restored and aftercare. These conditions are applied to make sure that land is restored to an appropriate standard. Detailed guidance on these aspects is given in the DoE Mineral Planning Guidance, Note 7 *The Reclamation of Mineral Workings* and in the DoE *Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture*.

As well as planning permission, landfill sites which take controlled wastes also need waste management licences from the Environment Agency under the Environmental Protection Act 1990.

**158** The site operator is responsible for making sure that the planning conditions are met. The Minerals Planning Authority is responsible for enforcing the conditions. Landfill sites containing non-inert waste will also need to be monitored for several decades after they have been closed, under the Waste Management Licensing system. The Environment Agency, as the waste regulation authority, is responsible

for enforcing the licence conditions and for determining when the surrender of a waste management licence should be accepted for the site.

**159** If you are the landowner, you should be aware that, although such cases are rare, if a site operator fails to meet their commitments in any way, and the authority concerned cannot take enforcement action against that operator because the management licence has been surrendered, then any necessary enforcement action might be taken against you as the landowner.

So you should ask the operator to provide evidence of how they have managed, restored and cared for a similar site; whether the operator follows any best practice guidance or codes issued by the relevant trade associations; and whether these associations have any restoration guarantee fund.

If appropriate, landowners can try to negotiate legally binding agreements to make sure that practices meet your personal requirements, including provisions to protect you against default by the operator or any third party involved in the working of the site. However, these are private contractual arrangements between you and operators, and entirely separate from any planning permission or conditions.

## Pipelines

**160** Legislation is contained in several Acts which are often specific both to the material being carried (oil, gas, water) and the status of the promoting organisation (private or public agency). The main laws are the Pipelines Act 1962, Gas Act 1986, Water Industry Act 1991, Water Resources Act 1991 and the Town and Country Planning Act 1990.

**161** Detailed operational requirements are given in BS 8010, the *British Standard Code of Practice for Pipelines*.

**162** Codes of practice have been prepared by individual water companies and approved by the DETR. The BS 8010 gives detailed recommendations for stripping, storing and reinstating soil. The BS Code is not a legal document and it is important to make sure that you observe all legal obligations which may mean more than just following the BS 8010.

**163** Engineering and restoration works are carried out by contractors for a pipeline operator who

has got exclusive rights for the temporary use of the land, possibly having used compulsory powers to buy land or get licences to carry out the work. So you usually have little or no control over the work being done. As the landowner or occupier you should make a note of all activities to help make sure that restoration is a success. Contractors may offer you private agreements for offices, soil storage facilities or for the disposal of surplus soil materials. If you accept these, take care to make sure that any land affected is properly restored.

## Planning the work

**164** For all sites, good planning requires attention to detail. No shortcuts should be attempted. If soil is seriously damaged it may not be possible to restore it at reasonable cost. All reasonable steps should be taken to avoid damage, as without due care restored land may be unsuitable for profitable agriculture.



**165** All work should be planned and carried out without staff or equipment having to go onto surrounding farmland. This is important to minimise soil disturbance and also to prevent any plant and animal diseases in the soil from being spread. Further guidance is given in the MAFF booklet *Preventing the Spread of Plant and Animal Diseases – A Practical Guide*.

**166** Before work starts, the developer or pipeline operator should carry out a survey of the site to provide a detailed inventory of the soils and potential soil-forming materials (including topsoil and subsoil depths) to provide an assessment of the quality of the land. It is important that this information is accurately prepared, as it will highlight potential problems with future working and provide the basis of the operators proposals for handling the soil in the site working and restoration scheme that they will send to the Minerals Planning Authority for approval.

**167** When preparing schemes, consideration should be given to:

- intended soil stripping depths and using available soils and soil-forming materials to get the best possible reclamation;
- ways of keeping different soils apart;
- methods of handling the soil, including proposals to minimise dust nuisance at all stages of the work;
- the location and height of soil mounds and how long they will be present;
- proposals for reinstating soils including the location, depth and composition of reinstated soil profiles, and the contours of the restored land;

- installing or restoring the necessary infrastructure such as appropriate pipe drainage, ditches, fences and hedges or shelterbelts;
- commitments for undertaking necessary restoration works according to an assessment of soil conditions made after reinstatement e.g. soil loosening or de-stoning operations.

**168** There may also be a risk of off-site flooding where slopes or drainage patterns have been altered or disrupted. Flooding can cause considerable damage to soils in surrounding areas, and surface run-off may cause pollution. If this may occur, the proposals should also include plans to deal with any disruption of watercourses and underdrainage systems, and deal with any increased surface run-off to minimise all risks of water pollution.

**169** Before approving a scheme for extracting minerals, the Minerals Planning Authority should discuss the proposals with all interested parties, including the landowner, the occupier and MAFF or WOAD, if the land is to be restored for agricultural use. MAFF or WOAD will try to make sure that the soil depths, stripping and storage proposals are adequate to protect the soil quality before these requirements are written into planning conditions.

**170** As well as any planning conditions and private agreements (see paragraph 159), the operator should prepare a method statement to translate the working arrangements approved by the planning authority into practical instructions which can be used by those involved in the day-to-day working of the site. This is important as techniques for reinstating soil for agriculture often differ from techniques for preparing the ground for building.



### Site working

**171** The quality of the restoration depends on the standard of work of people on the site. The operator must make sure that all work which affects the soil proceeds in accordance with the working scheme and method statement. If you believe that these conditions are being broken, you should tell the operator. If the matter cannot be resolved satisfactorily, you should bring it to the attention of the Minerals Planning Authority. You should also tell the land agent, liaison officer or other person involved in working on the site that the authority has been told that the conditions may have been broken. Private legal action may be appropriate if a private agreement with the operator is broken. However, actual conditions and operational requirements rarely match up to those anticipated. Allowance should be made for adjustments that may be necessary in order to achieve the best results, e.g. changing weather conditions may require changes to soil handling operations. The following provides a general indication of good practice for the different stages of site working and restoration.

### Soil stripping

**172** Operations should only strip topsoils and subsoils to the depths agreed in the planning consent. Agricultural topsoil is the dark surface layer which normally varies in depth from 20 to 40 centimetres (but may be less). Subsoil is the underlying, usually lighter-coloured soil material which should be removed to at least 1.2 metres below the original ground surface, unless rock or other materials make this impossible or undesirable. If different soil types have been identified, strip them separately. If the upper layers of the subsoil are of significantly better quality than the lower layers, they should also be stripped separately. In some cases there are advantages for the

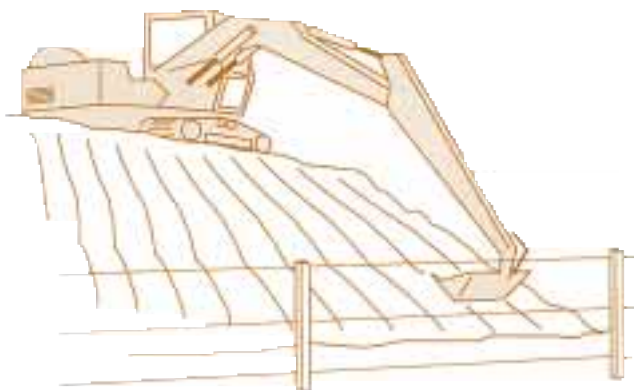
restoration in utilising soil forming materials identified at greater depths than 1.2 metres. Where this is the case such soils should also be stripped separately.

**173** Operators should only strip and transport soils when they are in a dry and friable condition (when they crumble easily). Site working should be planned to fit with the expected weather. Take care to make sure that machinery does not go across unstripped soils or storage mounds unnecessarily.

### Soil storage

**174** If restoration is already taking place elsewhere on the site, operators should not store soils unless it is essential. Instead, reinstate them immediately. However, on many sites, immediate replacement is not always practical and soil has to be stored. If this is the case, topsoil, subsoil and any other soil-forming material should be stored separately. Also, different soil types should be stored separately, e.g. sands separate from clay soils. Do not let them be moved from the site unless this is specifically agreed in the scheme of working and planning conditions.

**175** Before the operator builds subsoil storage mounds, they should remove the topsoil from the area where the mound will be. Topsoil and subsoil should be removed from areas used for storing other materials (e.g. clays and shales). The height of storage mounds will depend on operational and planning requirements.



Storage mounds should be carefully managed

- 176** If soils will be stored for more than six months, mounds should be seeded with grass to minimise erosion and weed growth. Control any excess weed growth, preferably by mechanical methods. Appropriate measures, such as settlement lagoons, may be necessary to prevent any eroded materials in run-off from polluting watercourses.

#### Soil reinstatement

- 177** Soils should be reinstated in dry conditions on appropriately contoured and prepared ground as specified in the restoration scheme. They should also be replaced in correct sequence; subsoils first and then topsoils to the depths previously agreed. Care must be taken to avoid soil losses or contamination with other materials. After soils have been replaced, they should be thoroughly loosened to remove any compaction. After they have settled, soil depths should normally be matched to those of the original undisturbed profile without leaving low spots in which water may settle. Wherever possible, try to provide 1.2 metres of cover for crop growth and to allow drains to be laid.

- 178** For most modern landfill sites, for non-inert material current good practice requires a low-permeability cap (usually of clay or synthetic materials) above the wastes to provide a seal to stop water entering and to enable proper management and control of any leachate or gas generated. Also, systems of pipework wells and vents for control and possible flaring of gas may be installed. It is therefore very important to provide an adequate depth of soil to allow normal agricultural operations such as underdrainage and subsoiling. Such agricultural operations should not damage the clay cap or other leachate or gas control systems. If it is not possible to provide enough soil cover, then agricultural restoration is unlikely to be possible and alternative afteruses should be considered. Professional guidance should be provided by the site operators for such installations.

- 179** For pipelines, the depth of the reinstated soil should be at least 0.9 metres above the top of the installed pipe. It is not unusual to have surplus soil after reinstatement. Any surplus subsoil should be spread on the excavated strip before the topsoil is replaced. All topsoil should normally be used on site. Disposing of it off-site should be agreed between the landowner and the operator. Particular attention should be given to the interception and reinstating of existing underdrainage systems and the need to install additional underdrainage as part of the reinstatement process.

- 180** Regular site meetings should be held between all interested parties to inspect the work and assess the need for remedial treatments such as levelling, loosening to remove soil compaction, removing stones and additional drainage.

### Agricultural aftercare

**181** Soil that has been reinstated may take several years to get back to normal. Restored soils usually suffer some structural damage and need a period of specialised aftercare before they are suitable for normal agricultural use. The aftercare period should be used to assist the recovery of soil structure in restored soils rather than trying to increase productivity immediately. The length of time during which you need to take particular care will vary greatly. It will not usually be less than four years and may be ten years or more.

**182** On restored minerals sites, agricultural management is normally controlled by planning conditions for five years from the soil being replaced. Information on the legislation and guidance on conditions for aftercare and the preparation of aftercare schemes is given in paragraphs 157-159.

**183** Although the operator is responsible for aftercare, there are many options for managing the land during the aftercare period. Operators may choose to manage the land themselves, or they may employ agricultural contractors. Licences and short-term lettings may be used, or share-farming arrangements may be made. It is important that aftercare management is carried out promptly and effectively and that everybody involved understands the need to restore land for the longer term and not for short-term gain.

**184** The operator may offer you the opportunity to take over responsibility for the aftercare. Before you take up this option, carefully consider the cost of meeting the aftercare obligations laid down by the Minerals Planning Authority, as any private agreement between you and the operator will be legally binding and you will then be liable for any penalties and costs for non-compliance with the aftercare scheme.

**185** Although legal aftercare obligations apply to most sites, there may be some sites which do not have to meet this legislation. However, even on sites where legal obligations do not apply but land is to be restored to agriculture, you should still take account of the following guidance to make sure the land recovers properly.

### Cropping

**186** It is not possible to make standard recommendations for aftercare cropping as a lot will depend upon the site, soil and climatic conditions. As a general rule, crop cover should be established as soon as possible after restoration, and maintained to protect sites from soil erosion and assist the recovery of soil structure. Planting a crop early allows roots to penetrate cracks and fissures. These roots will help the soil to dry out during the spring and summer, improving ground conditions for other farming operations and remedial treatments.

**187** When choosing aftercare crops, remember that the structural properties of restored soils are usually not as good for crop growth or farming operations as soil that has not been disturbed. Nutrient reserves may be lower and the amount of air in the soil and the drainage poorer. Choose crops which can grow in these conditions.

**188** Grass is usually the preferred option for aftercare cropping, especially for clayey soils in areas that have a high rainfall. You must control grazing carefully and remove livestock when the soil is wet. Where possible cut grass rather than letting it be grazed. Avoid over-grazing as this may lead to soil erosion. However, you may have difficulty making use of the grass in an arable area; winter cereals may be an appropriate alternative, except on heavy soils or in areas that have a high rainfall. Do not grow winter barley on acid soils.

**189** Spring-sown cereals should generally be avoided except on well-drained land in dry areas. This precaution is due to the increased risks of erosion from uncropped land over-winter, damage to soil structure by cultivations in the spring and the problem of establishing a satisfactory crop in wet years. Oilseed rape and other similar combine-harvested crops are not recommended unless the soil conditions are good, an effective underdrainage system has been installed or the crop allows increased time for remedial work in late summer.

**190** Do not grow root crops such as potatoes and sugarbeet, as late harvesting will normally prevent remedial subsoiling and may result in bare land over the winter. There is also the risk of causing serious damage to the soil structure when harvesting in wet years.

#### Cultivations

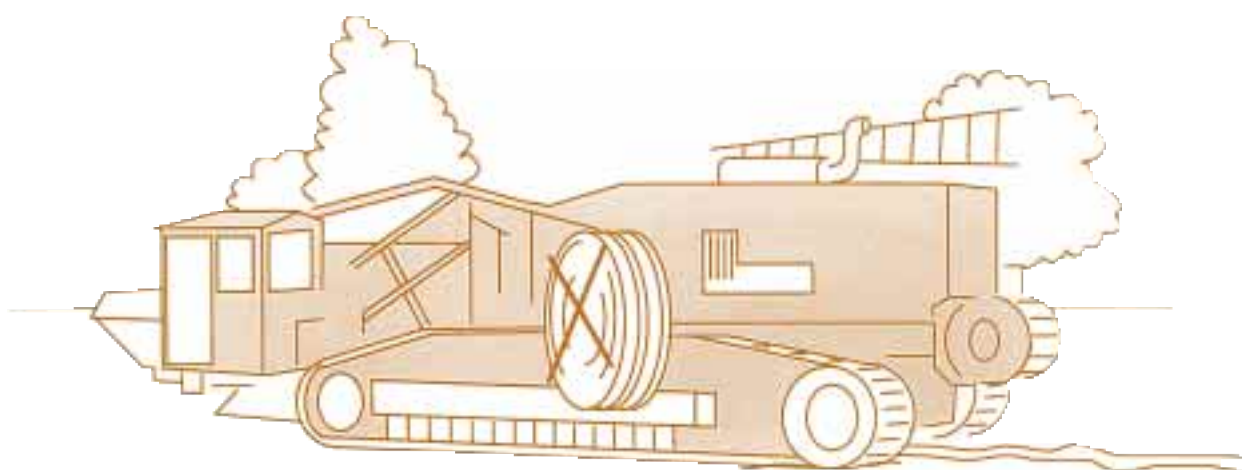
**191** In the early stages, restored soils are generally more sensitive than undisturbed land to damage by wheeled machinery. Take particular care over the timing and number of cultivations and minimise axle loads and wheel slip. You

should give disturbed soils a high priority when you are planning farm work as there are normally fewer suitable days available for cultivations on restored land.

#### Lime and fertiliser

**192** Soil pH and available nutrient contents, especially phosphorus, can fall if soil is stored for a long time. As it is important to establish crop cover as quickly as possible, lime or nutrient deficiencies should be corrected by applying lime, fertilisers and (on well-drained sites) organic manures. To ensure that you use appropriate applications, the soil should be analysed immediately after soil replacement and repeated every two years throughout the aftercare period.

**193** During the aftercare period, you should apply fertiliser to help plant roots to grow vigorously and so help the soil structure to recover, and build up nutrient reserves to levels suitable for normal cropping at the end of the aftercare period. Avoid large single applications at high rates to minimise losses by leaching or surface run-off, which could cause water pollution.



### Drainage

**194** Establishing satisfactory soil drainage is an important part of aftercare. Poor drainage can affect crop growth, reduce work days, shorten the grazing period and generally increase the chance of agricultural operations causing damage to the soil.

**195** You will normally need underdrainage if there was artificial drainage before the soil was disturbed. It will also be needed where soils have been damaged during working or where other materials that water cannot pass through have been introduced below the topsoil. The system should be designed to control the water table within 48 hours of rain, at least 500 millimetres below the surface for arable crops and 300 millimetres for grass. On clay and compacted soils, you will normally need to carry out mole drainage or subsoiling, or both, to achieve this.

**196** On most sites, underdrains should be installed after soil reinstatement as soon as conditions are suitable, but not if the drainage work will cause more damage. Drainage will increase

opportunities for carrying out essential remedial treatments and reduce the risk of the soil structure deteriorating in wet conditions.

### Subsoiling

**197** Frequent subsoiling is usually necessary to improve the soils ability to absorb water and help root penetration. It should be carried out in late summer or early autumn when the subsoil is relatively dry, using a single or multi-bladed winged tine machine. When you carry out subsoiling in grassland, take care to select equipment and soil conditions that will minimise damage to the sward. Decide the depth, choice of machine and spacing after thoroughly examining the soil.

**198** Where compaction is serious, agricultural subsoiling is generally only effective to depths of about 350 millimetres. However, deeper benefits can be achieved by progressively increasing subsoiling depth over a number of years. Examine the soil profile to assess the need for subsoiling and the most appropriate depth of working. You may need professional advice on this. You should carry out a further

inspection immediately before starting work to confirm that the subsoil is dry enough. Also, inspect while the work is going on to make sure that the cultivation is effective. On pipeline sites, note the soil conditions under the running track where compaction may be severe and deep.

#### **Grazing management**

- 199 To reduce surface compaction and poaching, only graze with sheep and young cattle. All livestock should be removed in wet conditions and over-winter. It is preferable to cut the grass for hay or silage but only when topsoil conditions are suitable. Graze the aftermath carefully to avoid damaging the soil. Keep farm machinery off the land whenever the soil is wet.

#### **Monitoring**

- 200 Carefully monitor the soil structure throughout the aftercare period. For restored mineral sites, annual site review meetings are normally held between the site operators, Minerals Planning Authorities and other interested parties to agree the detailed aftercare programme for the coming year and the need for remedial treatments. A final meeting may also be necessary at the end of the aftercare period to make sure that all planning conditions have been met.

#### **Long-term management**

- 201 Once the land is released from aftercare, it is still important to maintain good soil-management practices. Do not suddenly increase agricultural use. Base decisions to grow more demanding crops or increase stocking rates on proven experience gained

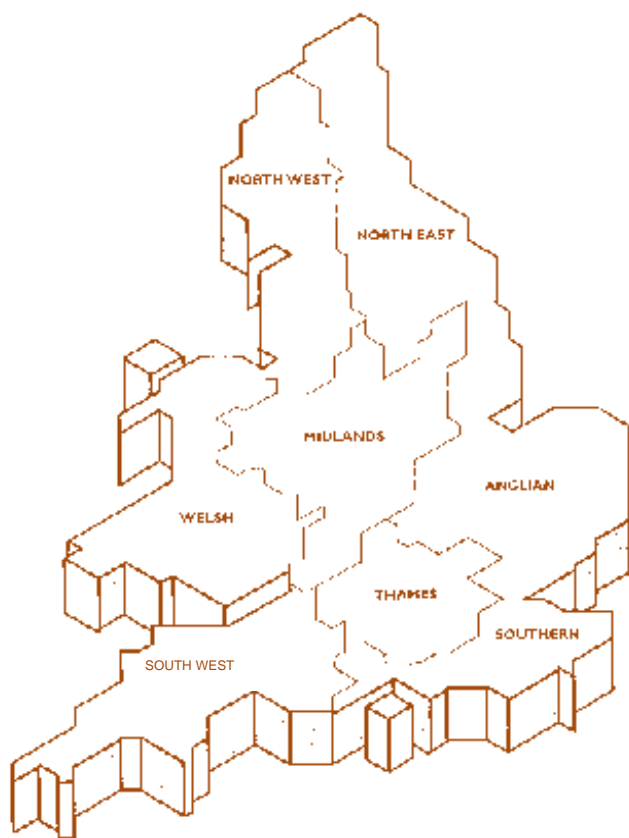
from farming the restored land. A cautious approach is usually best in the long term. Otherwise you may cause serious damage and this can be slow and expensive to put right.





# APPENDICES

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## INORGANIC CONTAMINANTS OF SOILS IN ENGLAND AND WALES

1. The concentration of potential contaminants in soils in England and Wales has been reported in a *Soil Geochemical Atlas* by McGrath and Loveland based on samples taken on a 5 km grid survey. The table below shows the most commonly occurring concentrations (median value) together with the values below which 10% of soils fall (ten percentile) and above which 10% fall (ninety percentile). The average concentration (arithmetic mean) is also shown.

**Concentrations (mg/kg dry matter) of metals in soils of England and Wales**

Metal	Ten percentile	Median	Ninety percentile	Arithmetic mean
Zinc	38	82	147	97
Copper	9	18	37	23
Nickel	7	23	42	25
Cadmium	0.2	0.7	1.4	0.8
Lead	20	40	131	74
Chromium	15	39	64	41

This table reports total metal concentrations in topsoils. The table does not represent particular conditions or levels of contamination to be expected on any one site, and it is not a substitute for a site assessment if you suspect or know of contamination.

2. Guideline values for screening contaminated land for risks to human health will be published to complement further legislation on contaminated land. They may not be directly applicable to agricultural situations where the following values should be taken as an indication of the need for action or further investigation. It is essential to remember that for livestock there are significant dietary interactions between many of these elements.

### Zinc

Zinc is an essential trace element for crop growth but in high concentrations it is toxic to plants. It is easily taken up by plant roots and moves to the leaves. Too much zinc restricts plant growth and affects how the plant deals with elements such as iron, resulting in a severe yellowing of the whole plant. These symptoms usually occur at concentrations well below those which cause any risk to an animal's health. It affects animals by interacting with other elements, such as copper.

Concentrations of zinc (up to 2000 mg/kg of soil) from materials such as mine-spoil may be tolerated by certain plants depending on the pH of the soil and other factors. For clover and productive grass species at a pH of 6.0, the maximum recommended concentration is 1000 mg/kg. Zinc from industrial wastes, atmospheric deposition or sewage sludge is more available to plants, and sensitive species may be affected above about 300 mg/kg of zinc in the soil when the pH is between 6 and 7. An Independent Review commissioned by the Government (*Review of the Rules for Sewage Sludge Application to Agricultural Land. Soil Fertility Aspects of Potentially Toxic Elements*) concluded that some soil micro-organisms may be affected by additions of zinc above 200 mg/kg in some soils but how important this is

## Appendix II

for soil fertility is not clear. Further research was recommended and this is in progress.

Zinc alone is unlikely to affect animals until they eat more than 300-1000 mg/kg of dry food, depending on the type of animal, the form of the zinc and the balance of other nutrients in the diet. Concentrations in herbage that are greater than about 220 mg/kg of dry matter are likely to have a significant effect on copper metabolism in grazing livestock.

### Copper

Copper is held by organic matter in the soil and is not as easily taken up into the leaves of plants as zinc, but it can accumulate in the roots. Soil pH has little effect on the amount of copper the plant takes up, except in very acid conditions (less than pH 4.5) when it appears to be more available and is taken up by acid-tolerant species. Although copper is an essential plant nutrient, it can be toxic to plants at high concentrations. If material containing copper (such as pig slurry) is applied to a growing crop, copper can be adsorbed by the leaves. The resulting forage may be a health risk to grazing sheep.

At a soil pH of 6.0 or above, a total soil concentration of copper from geological materials of up to 500 mg/kg of dry solids would allow the growth of productive grasses, but clovers and other sensitive species may be affected at 250 mg/kg. The effect of a given concentration of copper on livestock depends upon its chemical form and on how it interacts with other elements. When the concentration of copper in soil is more than 500 mg/kg, the soil and plants are likely to exceed the toxic threshold and may poison susceptible animals, especially sheep and lambs. A copper concentration in the diet greater than 10 mg/kg of dry food is toxic for the most susceptible

breeds of sheep. If you have to let livestock graze on contaminated land, they should only be grazed for short periods and with adequate herbage on offer so that the amount of soil eaten is kept to a minimum. Cattle are unlikely to be affected by copper.

### Lead

Lead in soils with a pH of above 6.0 is not usually toxic to plants but eating soil-contaminated herbage can be dangerous to livestock. Monogastric animals (pigs, poultry and horses) are considerably more at risk of lead poisoning than are ruminants such as cattle and sheep. Consider precautions where soils have a natural total lead concentration greater than about 300 mg/kg of dry solids. In alkaline soils (pH of more than 7), lead is not available to plants. If contaminated soil is eaten by grazing animals, the lead may be absorbed by them whatever the soil pH. The chemical and physical form of the lead will affect its absorption.

Lead contamination of crops is unlikely to exceed the legal limit for food offered for sale of 1 mg/kg lead in fresh material, except when vegetables are grown and sold from a soil which contains lead at more than about 300 mg/kg of dry solids. Under these circumstances you should take care that the crop is not contaminated by soil to ensure that this limit is not exceeded. Crops grown on high lead soils for home consumption should always be thoroughly washed before being eaten.

### Cadmium

Cadmium is often found with geological deposits of lead and zinc. It is taken up by plant roots and moves to the leaves and seeds. This effect is greater at low pH and varies with the type of plant. If a grazing animal ingests

cadmium, it builds up in that animal, especially in the kidneys and the liver. The guideline concentration of 3 mg/kg of cadmium in soil is set to protect the food supply of animals and man. Plant growth is not affected at this level. The amount of cadmium that plants take up varies according to the physical and chemical form of the cadmium and the species of plant. The total cadmium concentration limit in soil of 3 mg/kg of dry solids must not be exceeded when you apply sewage sludge to agricultural land and you should observe this limit in other situations. If land is contaminated by wastes from lead mines, the high concentrations of zinc and lead will have a much greater effect on plants and animals than the cadmium. Although the cadmium content of fertilisers is generally lower than it was 15 years ago much of the cadmium added to agricultural soils still comes from phosphate fertilisers.

### Arsenic

Plant roots absorb and store arsenic. In high concentrations, it may kill them. However, it does not move freely to leaves or stems. An arsenic concentration of 250 mg/kg of dry soil is not likely to cause any ill effects to plants or animals. Concentrations above 500 mg/kg can result in animals eating sufficient soil whilst grazing to increase the arsenic in their liver and kidneys and, in extreme cases, to poison them. Soil concentrations of arsenic in land used to grow fresh produce should not exceed 50 mg/kg of dry soil. This will minimise the risk of exceeding legal limits in food (generally 1 mg/kg).

### Fluoride

Fluoride in soils is normally present as insoluble calcium fluoride. In this form it is not readily taken up by plant roots. If soil that is

high in fluoride, or grass that is contaminated by waste materials containing fluoride, is eaten over a long period, the teeth and bones of livestock can suffer due to a condition called fluorosis.

A total concentration of fluoride, from whatever source, of 500 mg/kg of dry soil could result in the diet of grazing animals exceeding the safe limit of 30 mg/kg of dry matter.

### Nickel

Nickel is toxic to plants. In order to protect against damage to crops or animals, a limit for nickel of 75 mg/kg of dry soil exists for soil at pH 6-7 receiving sewage sludge. Other limits apply for different soil pH values. (See Appendix III).

### Chromium

There has been some concern about chromium being added to soil because the chromate (VI) ion is toxic to plants and animals. However, due to the conditions found in organic waste materials or in soil, it will only exist as the relatively inactive chromic (III) ion.

Chromium (III) is unlikely to be toxic to plants except in extremely acidic soils. Land which has sewage sludge applied to it must contain chromium at less than 400 mg/kg of dry soil.

### Mercury

The amount of mercury in soil which will kill plants is far greater than that which arises under natural conditions or from any likely form of contamination. Plant roots do not take up mercury very effectively. However, mercury is one of the most poisonous elements to many



## Appendix II

animals and man. Soil concentrations of mercury should not be greater than 1 mg/kg of dry soil.

### Selenium

Where soils are contaminated by selenium, the safe concentration of 2 mg/kg of dry matter in plants can be exceeded. Livestock are not normally poisoned until they take in selenium at more than 5 mg/kg of dry food. To minimise risk, the concentration of selenium in soil should be kept below 3 mg/kg. Soils naturally high in selenium are very rare in England and Wales but may be a risk to grazing livestock where they occur.

### Molybdenum

High molybdenum levels in soil may result in the need to take precautions to limit the amount taken in by livestock. High molybdenum in plants (more than 5 mg/kg of dry matter) reduces the availability of copper to livestock and may cause a copper deficiency. Do not apply waste materials to land if this would raise soil concentrations of molybdenum above 4 mg/kg of soil. However, if the concentration in the soil is naturally higher than this value, and livestock are receiving copper therapy, you can apply sewage sludge which only contains trace levels of molybdenum. Obtain veterinary advice before you take any action. Some clay and shale soils naturally contain molybdenum at more than 100 mg/kg of soil.

### Sodium and chloride

Plants growing on sea-flooded land may be damaged by lack of oxygen or by the soil around their roots being disturbed. Salt water deposits sodium and chloride in the soil. High

chloride levels restrict plant growth and decrease the ability of their roots to take up water from the soil. High levels of sodium in the soil will disperse clay particles and cause problems in soil structure, especially in non-calcareous soils.

**MAXIMUM PERMISSIBLE AND ADVISABLE CONCENTRATIONS OF POTENTIALLY TOXIC ELEMENTS (PTES) IN SOIL AFTER APPLICATION OF SEWAGE SLUDGE TO AGRICULTURAL LAND AND MAXIMUM ANNUAL RATES OF ADDITION**

	Maximum permissible concentrations of PTE				Maximum permissible average over a 10-year period (kg/ha) <sup>3</sup>
	pH <sup>1</sup> 5.0-5.5	pH <sup>1</sup> 5.5-6.0	pH 6.0-7.0	pH <sup>2</sup> >7.0	
Zinc	200	200 <sup>4</sup>	200 <sup>4</sup>	300 <sup>4</sup>	15
Copper	80	100	135	200	7.5
Nickel	50	60	75	110	3
<hr/>					
	For pH 5.0 and above				
Cadmium	3				0.15
Lead	300				15
Mercury	1				0.1
Chromium	400 (Provisional)				15 (Provisional)
*Molybdenum <sup>5</sup>	4				0.2
*Selenium	3				0.15
*Arsenic	50				0.7
*Fluoride	500				20

\* These parameters are not subject to the provisions of Directive 86/278/EEC.

<sup>1</sup>For soils in the pH ranges 5.0-5.5 and 5.5-6.0 the permitted concentrations for lead, zinc, copper, nickel and cadmium are provisional and will be reviewed when current research into their effects on certain crops and livestock is completed.

<sup>2</sup>The increased permissible PTE concentrations in soil of pH greater than 7.0 apply only to soils containing more than 5% calcium carbonate.

<sup>3</sup>The annual rate of application of PTE to any site shall be determined by averaging over the ten-year period ending with the year of calculation.

<sup>4</sup>These zinc concentrations are advisable limits as given in *The Code of Practice for Agricultural Use of Sewage Sludge* (revised, 1996).

<sup>5</sup>The accepted safe concentration of molybdenum in agricultural soils is 4 mg/kg. However, there are some areas in UK where, because of local geology, the natural concentration of this element in the soil exceeds this level. In such cases there may be no additional problems as a result of applying sludge, but this should not be done except in accordance with expert advice. This advice will take account of existing soil molybdenum levels and current arrangements to provide copper supplements to livestock.

## Appendix IV

### SOURCES OF INFORMATION

#### Legislation

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*Ancient Monuments and Archaeological Areas Act 1979*, Chapter 46, HMSO (ISBN 0 10 544 679 3)

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*Town and Country Planning (Assessment of Environmental Effects) Regulations 1988*, HMSO (ISBN 0-11-0871995)

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*Waste Management Licensing Regulations 1994*, SI 1994, No 1056, HMSO (ISBN 0 11 044056 0)

*Water Act 1989*, Chapter 15, HMSO (ISBN 0 10 541589 8)

*Water Industry Act 1991*, Chapter 56, HMSO (ISBN 0 10 545691 8)

*Water Resources Act 1991*, Chapter 57, HMSO (ISBN 0 10 545791 4)

The above publications are available from Stationery Office Bookshops or The Stationery Office Publications Centre (Tel: 0171 873 0011)

### Codes of Practice

*British Standard (BS) 8010 Code of Practice for Pipelines*

Section 2.1: 1987 – Pipelines on land: design, construction and installation. Ductile iron

Section 2.3: 1988 – Pipelines on land: design, construction and installation. Asbestos cement

Section 2.4: 1988 – Pipelines on land: design, construction and installation. Prestressed concreted pressure pipelines

Section 2.5: 1989 – Pipelines on land: design construction and installation. Glass reinforced thermosetting plastics

Section 2.7: 1989 – Pipelines on land: design, construction and installation. Precast concrete

Section 2.8: 1992 – Pipelines on land, design,

construction and installation. Steel for oil and gas

The above publications are available from the British Standards Institution, Linford Wood, Milton Keynes, MK14 6LE (Tel: 01908 220908)

*The Air Code – Code of Good Agricultural Practice for the Protection of Air.* MAFF/WOAD, 1992. revised 1998. PB 0618. Available free of charge from MAFF Publications

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*Agricultural Land Classification of England and Wales 1988*. MAFF Publications (UR 146)

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*Soil Survey of England and Wales, 1984. Soils and Their Use in South East England*. Soil Survey of England and Wales Bulletin No 15

The above publications are available from the Soil Survey and Land Research Centre (SSLRC), Silsoe Campus, Silsoe, Bedfordshire, MK45 4DT or (Tel: 01525 863000 and ask for SSLRC)

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The above publications are available from the Environment Agency, Rio House, Aztec West, Almondsbury, Bristol BS12 4UD (Tel: 01454 624400)



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