

Animal and animal products processing works

Industry Profiles, together with the Contaminated Land Research Report series, are financed under the Department of the Environment's contaminated land research programme.

The purpose of these publications is to provide regulators, developers and other interested parties with authoritative and researched advice on how best to identify, assess and tackle the problems associated with land contamination. The publications cannot address the specific circumstances of each site, since every site is unique. Anyone using the information in a publication must, therefore, make appropriate and specific assessments of any particular site or group of sites. Neither the Department or the contractor it employs can accept liabilities resulting from the use or interpretation of the contents of the publications.

The Department's Contaminated Land Research Report series deals with information needed to assess risks; procedures for categorising and assessing risks; and evaluation and selection of remedial measures.

General guidance on assessing contaminated land and developing remedial solutions which is complementary to the Department's publications is provided by the Construction Industry Research and Information Association (CIRIA).

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DOE Industry Profile

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	Page
Preface	(iii)
1. Background	1
1.1 Slaughterhouses, knacker's yards and rendering plants	1
1.2 Meat processing plants	1
1.3 Gelatine and glue works	1
1.4 Tanneries and fellmongers	2
2. Activities	3
2.1 Slaughterhouses and knacker's yards	3
2.2 Rendering plants	3
2.3 Meat processing plants	4
2.4 Gelatine and glue works	4
2.5 Tanneries and fellmongers	5
3. Waste handling	6
3.1 Slaughterhouses, rendering, gelatine, glue and meat processing plants	6
3.2 Tanneries and fellmongers	7
4. Contamination	9
4.1 Factors affecting contamination	9
4.2 Migration and persistence of contaminants	10
5. Sources of further information	11
Annex Potential contaminants	15
Table 1a Main groups of contaminants and their probable locations — slaughterhouses, rendering, gelatine, glue and meat processing plants	17
Table 1b Main groups of contaminants and their probable locations — tanneries and fellmongers	18

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Preface

DOE Industry Profiles provide developers, local authorities and anyone else interested in contaminated land, with information on the processes, materials and wastes associated with individual industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination.

Every site is unique. Investigation of a site should begin with documentary research to establish past uses. Information on the site's history helps to focus a more detailed investigation. This knowledge needs to be supplemented by information on the type of contamination that may be present and where on site it may be found. Profiles give information on the contamination which might be associated with specific industries, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on potential contaminants.

The date when industrial practices first commenced on a site and its location are important clues in establishing the types of operations that may have taken place, so each profile provides a summary of the history of the industry and its likely geographical spread within the United Kingdom.

Profiles should be read with the following reservations in mind:

- individual sites will not necessarily have all of the characteristics described in the profile of that industry;

- practices can vary between sites and change over time;

- as practices change, problems of possible contamination may also change;

- the profile may refer to practices which are no longer followed, and may omit current practices which avoid contamination.

The risks presented by contaminated sites depend on the nature of the contaminants, the targets to which they are a potential threat (such as humans or groundwater) and the routes or pathways by which they reach these targets. The current or proposed use of a site and its environmental setting are crucial in deciding whether treatment is necessary and if so, the methods to be used. Some sites may not need treatment.

The information in profiles may help in carrying out Control of Substances Hazardous to Health (COSHH) assessments for work on contaminated land - see Health and Safety Guidance Note HS(G) 66 *Protection of workers and the general public during the development of contaminated land*, Health and Safety Executive, 1991, and *A guide to safe working practices for contaminated sites*, Construction Industry Research and Information Association, 1995.

Note: the chemical names given to substances in this profile are often not the modern chemical nomenclature, but the names used historically for those substances.

Animal and animal products processing works

1. Background

Animal processing works include slaughterhouses, hide and skin processing plants (eg tanneries and fellmongers), knacker's yards, rendering plants for both edible and inedible products, glue and gelatine works and meat processing plants. Other by-products of animal processing are materials for the animal food, textile and fertiliser industries. A beef animal typically yields equal weights of meat to offal, internal organs, hide and bone.

The animal by-products industries, historically known as 'offensive trades', are often found in close proximity to each other, probably owing to official efforts to restrict their location to a particular area of a city or town. For example, a Proclamation of 1392 ordered that by-products should be dealt with on the south bank of the Thames to protect public health but still allow good access.

1.1 Slaughterhouses, knacker's yards and rendering plants

In the past, animal slaughtering was carried out on butchers' premises, and later in slaughterhouses. Higher concentrations of these and knacker's yards are located in major cattle and sheep-rearing areas. Most towns had a slaughterhouse or abattoir, often with the facilities to render the inedible offal into inedible fats such as tallow (beef and mutton/lamb fat) and grease.

The Public Health Act of 1936 led to a significant decrease in leakage of pollutants into the ground from slaughterhouses and knacker's yards. The number of slaughterhouses in England and Wales declined rapidly from the start of the Second World War and recent developments have led to fewer, larger, factory-scale slaughterhouses. The number of rendering plants has similarly diminished and many slaughterhouse and rendering functions are combined in larger operations. In 1994 there were 463 licensed redmeat slaughterhouses and 147 licensed poultry slaughterhouses in England and Wales, located in or near main towns, particularly historic market towns.

1.2 Meat processing plants

Meat processing plants and packing houses are required for the production of saleable products for human consumption. Meat processing plants are widespread but fewer in number than slaughterhouses.

1.3 Gelatine and glue works

Gelatine and glue are derived from a number of animal substances, primarily bones, hooves, horns, fish bones and scales, but some skins, tendons, intestines and trimmings from tanneries are also used. Historically, these works would have been located relatively close to their source of raw materials, ie the slaughterhouses and knacker's yards. Glues derived from bones etc are one of four main natural adhesives, the others being casein glue, blood albumin and vegetable adhesives. Their use rapidly declined during the second half of the 20th Century

with the formulation of more versatile and varied synthetic adhesives, although some natural glues are still used in the wood and paper products industries.

1.4 Tanneries and fellmongers

Hide and skin processing includes tanning, leather dressing and fellmongering. Tanning and leather dressing are concerned with the conversion of putrescible raw hides and skins into finished leather. Tanners and leather dressers do not generally recover hair. Fellmongering involves the removal of wool from sheepskins for the textile trade and the preparation of sheepskins for tanning. Some of the operations undertaken by the fellmonger might also be performed in a tannery; sheepskins with the wool attached are purchased by tanners for processing.

Tanning using tannic acid from vegetable sources (including oak bark, sumach bark, babul pods and various roots) dates back to 400 BC. By the early 11th Century, three basic tanning agents were in use: vegetable extracts, oil and potash alum. Towards the end of the 19th Century the value of basic chrome salt for tanning was discovered and in 1893 single bath chrome tannage was introduced. Synthetic organic tans have been in use since 1911. Early patented tans used phenols and cresols, and later naphthalene, as raw materials.

Tanneries and other skin processing plants were located throughout the country but with very high concentrations in the Pennine region and in Northamptonshire, associated respectively with the intense agricultural and leather products industries in these places. Usually, most tanneries were built close to rivers, as a good supply of clean water is essential for the tanning process. High concentrations of tanneries were also found in Glasgow, London and to a lesser extent on Merseyside and Humberside. This was probably because of the excellent import and export facilities available at these sites.

The number of firms in the leather and fellmongering industry has declined sharply in recent years. In the 1960s, over 600 premises were in operation; this had fallen to less than 200 by the late 1970s. Between 1958 and 1976 the tonnage of leather produced fell by 20–25%. This decline results from three main factors: competition from abroad whereby countries previously exporting skins in the raw state are now processing the skins further; the wider use of synthetic soles; and the rationalisation of manufacturing units within the United Kingdom itself. Approximately 75% of cattle hides and 50% of sheep, goat and pig skins processed in United Kingdom tanneries are supplied by the indigenous slaughter trade, the total being 100 000 tonnes of skins annually.

2. Activities

2.1 Slaughterhouses and knacker's yards

Animals for slaughter are transported, generally by road, from farm or market to the slaughterhouse. In a purpose-built holding area known as a lairage, the animals are rested and inspected for fitness for human consumption. Following slaughter, the carcasses are flayed or dehaired, eviscerated, inspected and trimmed. Depending on their intended use, the various carcass parts and offal are either refrigerated, salted or disposed of unprocessed. The stomach is taken for tripe or pet food production and the remaining internal organs are removed. These, together with heads, feet, blood and some bones, are stored for transport to a rendering plant. Some slaughterhouses have their own rendering plants for inedible materials. Other bones are collected for transport to glue factories. The meat is boned, cut and chilled in the cooling room, with off-cuts, scraps and some blood and edible fats being designated for meat processing plants.

Knacker's yards dismember the carcasses of dead animals or those killed on farms to recover carcass meat which is cooked and sold on local markets for pet food. Bones and other waste materials are normally sent to renderers for further processing and hides are sent to tanners for tanning.

Throughout the slaughterhouse process, the by-products are collected in designated containers with close-fitting lids. The storage and production of meat at slaughterhouses are subject to strict regulation with respect to cleanliness, temperature control and protection from contamination. Similar requirements are not applied to inedible by-products which are usually treated as waste materials. As a result, these by-products are often stored at ambient temperatures and usually in a wet state, such conditions being ideal for rapid putrefaction. Current legislation requires removal of by-products and wastes from slaughterhouses at least once every two days, the materials being destined either for further processing or disposal to landfill or incineration.

Manure and other refuse is collected in manure bays or pits which drain to sewers or treatment plants. The floors, bays and walls of slaughterhouses are lined with impervious material for hygiene reasons.

Poultry are killed from the age of six weeks. Blood is collected in drums, although in some plants the blood may be sprayed with a coagulant, the solid residue collected and the fluid left to drain to the sewer or treatment plant. Feathers, heads, feet, offal and scraps are collected in drums.

Detergents, bleach and disinfectants are used for cleaning. Very few slaughterhouses or knacker's yards use chemicals other than common salt.

2.2 Rendering plants

Rendering is the process whereby water is removed from tissues using heat, producing animal tallow and protein residue.

Approximately 1/4 million tonnes of chicken by-products and 1 million tonnes of sheep, pig and cow by-products are sent to rendering plants from slaughterhouses and knacker's yards each year. The material is usually transported in purpose-built,

water-tight vehicles to prevent spillage of material onto the highway, and may be subject to temporary storage at the rendering plant.

The rendering process comprises three main steps: preparation of raw materials, heat processing or cooking, and fat separation. The raw materials (heads, feet, blood and bones etc) are fed into the process line via a hopper where they are ground. In some systems, the material is made into a fluid suspension by mixing with hot tallow. The material is then cooked (eg for up to 6 hours in a batch process) to sterilise the product, remove moisture and liquefy the fats. The cooked material is separated into two fractions on leaving the processing equipment; the fat is separated from the protein meal by centrifuging or settling, followed by expeller pressing. Organic solvents have been used in the fat separation processes in the past. The fats are sold as tallow. The protein meal press cake is then milled and screened to produce the final meal and bone meal which are used as animal feed, pet food and fertiliser. The animal fat is usually cleaned by filtration to remove fine particles of contamination, for use in the animal feed, pet food or chemical fat splitting industries.

Rendering of edible tallows and lards may be carried out by similar methods either at meat processing plants or at specialist fat processing factories.

Feathers and blood are processed differently in one respect. These products do not contain significant quantities of fat; therefore the water is evaporated in a drier after initial processing (eg coagulation of blood). Both feather and blood meal are used as animal feed or fertiliser.

2.3 Meat processing plants

At meat processing plants products, such as pies, sausages, canned meats, stock for soup manufacture and stock cubes are prepared for human consumption. Edible fats are rendered into edible tallow and lard (pork fat). Some rendering of inedible fats and blood processing may also be carried out.

Common salt and a range of chemicals for curing, smoking, preserving and colouring are used. Among these are sulphur dioxide (a preservative), potassium nitrate (for pickling), sodium nitrate (a meat colour fixative) and sodium nitrite (for curing, colouring and preserving). Detergents, bleach (commonly sodium hypochlorite) and disinfectants are required for maintaining plant hygiene.

2.4 Gelatine and glue works

Gelatine and glue are produced by pressure-cooking bones, hooves, horns, hide and skin trimmings etc, for several hours, resulting in a solution which sets as a jelly on cooling. At low temperatures, the jelly gradually forms a dry, hard, glassy substance. If fresh materials of good quality are used, the product is gelatine; if the materials are crude, it is used as glue.

Most raw material is provided indigenously although until the 1960s, crushed bones were imported from countries such as India. On arrival at the works, the raw materials (treated bones or washed hides etc) are crushed, washed and then treated with dilute hydrochloric acid to remove calcium phosphates (which are sold as an animal feed additive or fertiliser). These materials are then cured in either cold dilute mineral acid (eg hydrochloric acid at pH 1.5–3) for 8–12 hours or in

alkali, usually lime water (calcium hydroxide solution, at pH 12), for 3–5 weeks. When curing is completed, the bones, hides, horns etc are rinsed until approximately neutral pH is obtained, and then cooked to obtain the gelatine or glue solution. Water is then evaporated off.

In addition to bone and other animal by-products, the primary ingredient in this process is hydrochloric acid (HCl). Approximately 6 tonnes of HCl are required to produce each tonne of gelatine or glue. Until the late 1960s it was common for this hydrochloric acid to be produced on site; thus many glue factories were also chemical works.

2.5 Tanneries and fellmongers

Tanneries and fellmongers process both imported hides and skins, and those arising as by-products of domestic meat production. Domestic hides and skins are normally transferred on the day of slaughter from the slaughterhouse to a hide market, where it is normal for them to be temporarily conserved by treatment with salt. After sale, the hides are transferred directly to a tannery.

Sheepskins are selected for processing by tanners or for fellmongering. Fellmongering operations may also be undertaken at tanneries.

2.5.1 Pre-tanning operations

Pre-tanning operations, or 'beamhouse operations' as they are known in the industry, prepare the hide or skin for tanning by removal of tissue and hair. The essential operations are:

Soaking in water to remove blood, dung, curing salt and soluble proteins;

Degreasing and softening of the hide. Solvents are used to clean particularly greasy types of raw stock, eg sheepskins and pigskins;

Removal of extraneous tissue by trimming and fleshing (by mechanically scraping the flesh side of the skin to remove the fat and tissue). This fat is sent to rendering plants to extract tallow and grease;

Unhairing; the hair and epidermis are chemically dissolved, generally using an alkaline-sulphide medium. Typically lime and sodium sulphide are used. In the past, arsenic sulphides were also used in the hair removal process;

Deliming; since residual lime would interfere with the subsequent tanning process, it is removed by treatment with a weakly acidic solution, frequently acidic ammonium salts;

Bating; an enzyme is used to remove hair remnants and degraded proteins;

Adjustment of the pH of the hides prior to tanning (typically using dilute sulphuric acid) and, in the case of sheepskin, pickling in brine.

While intact hair is occasionally recovered for resale instead of being dissolved, wool is almost always recovered. With greasy types of raw skins such as sheepskins, solvent degreasing is necessary. Separated grease and waste solvents arise as waste streams from this process.

2.5.2 Tanning

The tanning process involves treating the skin with an agent that displaces water and combines with collagen fibres to increase resistance to heat, hydrolysis and micro-organisms. Current tanning agents include chromium (III) sulphate, various vegetable tans and some synthetic tans. These synthetic tans are often used in addition to chromium tan or vegetable tan to achieve a specific finish. The only major non-vegetable, non-chrome process is the oil-tannage process for chamois leather, utilising formaldehyde and fish oils.

Originally, the tanning process was carried out in submerged tanning pits with the hides hung vertically, supported by wooden slats, but light and many heavy leathers are now processed in vessels which provide for mechanical agitation to accelerate the wet chemical reactions.

2.5.3 Post-tanning and surface coating

Following tanning, the hides are trimmed and split mechanically (known as splitting and shaving) to obtain the required thickness prior to post-tanning and finishing processes. The finishing processes achieve the final moisture content, flexibility and appearance.

Surface coatings consist of dyes or pigments dispersed in a binder such as casein or acrylic polymer. They are applied by pad or sprayed using a dispersion in water.

The tanning process yields a range of materials which can be converted further, but not usually at the tanneries; eg untanned hide and trimmings for gelatine extraction, vegetable-tanned wastes for the manufacture of leather board, and fleshings scraped from hides which are sent to a rendering plant.

3. Waste handling

3.1 Slaughterhouses, rendering, gelatine, glue and meat processing plants

The risk from pathogenic organisms contained in the waste is variable, and some organisms (primarily micro-organisms) from diseased animals, especially at knacker's yards, may pose a considerable risk and the waste needs to be disposed of with great care.

3.1.1 Slaughterhouses

The wastes from slaughterhouses arise from the lairage (the pens used prior to slaughter) and from the slaughter hall; they also arise during the wash down of the premises. The wastes contain a considerable amount of suspended material such as varying amounts of hair, feathers, manure and dirt. These wastes have a high biological oxygen demand (BOD: average 2 g/l). Blood is normally collected as a by-product, although it decomposes readily if it gets into the waste stream.

Wastes also include inedible by-products. Current legislation requires removal of by-products and wastes from slaughterhouses at least once every two days, the materials being destined either for further processing, disposal to landfill or incineration. In addition, some of the waste from slaughterhouses is applied to land as a fertiliser.

The waste from poultry processing plants is primarily a liquid effluent containing varying amounts of blood, feathers, fats, digested and undigested foods, manure, dirt and wash waters. Blood is recovered, and solid waste is screened. After biological treatment such as that described in Section 3.1.2, the final effluent is suitable for discharge to the sewer.

3.1.2 Rendering plants

At rendering plants the waste originating in transport containers, conveyors and hoppers is normally processed with raw materials. Washing from floor areas (which may be discharged to the drainage system without treatment) as well as condensate from cookers and evaporation units are normally treated prior to discharge to the sewerage system.

Blood and grease are recovered prior to their entering the waste stream. Waste treatments include material recovery, screening to remove hair, flesh etc, and sedimentation resulting in a sludge. Biological treatments include aerobic processes (such as biofilters, activated sludge or percolating filters) which utilise aerobic micro-organisms to reduce the BOD of the waste stream. However, anaerobic digestion is often preferred. The digested waste may then be retained in an aerobic pond for up to three months to increase the removal of pathogens.

Recovery of protein may be achieved through precipitation using sodium lignosulphonate or other protein precipitants. The pH is first adjusted to about 3 and the protein removed as froth, thus reducing the BOD of the waste stream from about 2 g/l to 0.5 g/l. After biological treatment, the resulting protein sludge can be de-watered and sold as an animal feed ingredient.

3.1.3 Gelatine, glue and meat processing plants

Wastes from gelatine, glue and meat processing plants are similar in composition to domestic sewage in terms of BOD and ammonia content, although their total organic content is considerably higher.

3.2 Tanneries and fellmongers

The wastes derived from the beamhouse include aqueous effluents containing suspended and dissolved organic matter, curing salt and grease, and unused process chemicals. Solid and semi-solid wastes derived from beamhouse processes include trimmings and fleshings obtained before or after the dehairing processes; in the latter case they contain lime.

Tannery wastes are mostly liquid effluent with a typical BOD of 3 g/l which requires treatment prior to discharge to sewer. Some of these are acidic, eg pH 4. A large volume of sludge is usually obtained as a result of this effluent treatment.

Treatments include:

Screening of mixed liquors by mechanical brushes or perforated screens;

Aeration of the unhairing and washing liquors to oxidise the sulphides present to sulphates (this process may be accelerated by a manganese catalyst);

Flotation of fats, greases and fine solids;

Combining the treated liquors from the above processes with other process water with a low BOD, known as 'balancing';

Separation of suspended matter and precipitation of chromium (III) compounds;

Mixing with lime or acid results in precipitation of chromium (III) hydrated oxide which is concentrated in the sludge.

Effluent from tanneries containing chromium (VI) should be treated before disposal to reduce it to chromium (III). This may be achieved by a suitable reducing agent such as sodium metabisulphite.

The wool-removing process at fellmongers generates wastes similar to those from the unhairing process in pre-tanning beamhouse operations at tanneries, as described above.

Insecticides occur at fellmongers' sites, due to sheepskin washing and wool grease processing, and at tanneries, from imported hides which were treated at source. An important example is hexachlorocyclohexane, HCH. (HCH exists as eight isomers, the insecticidal activity being a property of the gamma isomer; lindane is the common name for HCH containing at least 99% of this isomer, although technical HCH may contain much more of the others). Although lindane is no longer manufactured in the United Kingdom, it is imported, formulated into various products and employed in wood treatment and agriculture. The practice of using it as a sheep dip, though permitted in some countries, was banned in the United Kingdom in 1985. However, lindane and technical grade HCH are imported into the United Kingdom on fleeces and hides, the concentration being particularly high on material imported from South America. HCH isomers are found in relatively high concentrations (400 mg/l) in the aqueous effluent from wool-scouring, and will appear in the sludge.

Insecticides more commonly used now in sheep dips are pyrethroids, eg permethrin and cypermethrin, which can similarly appear in the waste sludge from fellmongers and tanneries. Cypermethrin is used to control sheep scab, lice and biting flies in animal housing. Permethrin is used to control parasites, biting flies, and as a wool preservative. These are both fairly insoluble in water. Other veterinary medicines applied externally are pyrethrum, as an ectoparasiticide and boric acid as an antibacterial and antifungal agent. These two may therefore also be found on hides.

In the past, pentachlorophenol and sodium pentachlorophenoxide were used in the United Kingdom to protect partially processed hides and skins from mould growth. Although this use has now ceased, there is no way that importers of skins, partially processed leathers and finished leathers, can know what biocides have been used to treat them in their country of origin. Sodium pentachlorophenoxide is normally used to treat raw hides or as an addition to the brine used in pickling.

Hydrogen sulphide can be generated in tanneries when sulphide-containing wastes, eg sulphide liquor from the unhairing process, become mixed with acidic wastes from tanning and pickling. Untreated sludges or residual concentrations of sulphide in treated sludges may also generate hydrogen sulphide if brought into contact with acidic wastes. Therefore, process waste streams should be

segregated during treatment and landfill. Sulphides are mostly oxidised to sulphates.

The composition of the sludge produced by the on-site pre-treatment processes will depend on the tannery's activities, but is likely to contain water, lime, hydrated chromium (III) oxide, residual sulphides, pesticides and organic matter (hide and hair, proteins, fats, oils and dyestuffs). The main disposal route for these sludges, as well as trimmings and fleshings, is to landfill, both in admixture with other wastes and to dedicated sites adjacent to the tanneries. Other disposal routes are very limited although small amounts of sludges have been applied to agricultural land. Historically, a very small proportion of tannery sludges was disposed of at sea.

4. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials produced there. Potential contaminants are listed in the Annex and the probable locations on site of the main groups of contaminants are shown in Tables 1a and 1b. It is most unlikely that any one site will contain all of the contaminants listed. It is recommended that an appropriate site investigation be carried out to determine the exact nature of the contamination associated with individual sites.

4.1 Factors affecting contamination

4.1.1 Slaughterhouses, rendering, gelatine, glue and meat processing plants

Liquid blood and fat wastes may carry pathogens and present the greatest potential for movement away from the controlled areas. Leaking tanks, pipework or storage chambers, together with construction joints in floor slabs and permeable surfaces outside buildings, may allow leakage of liquid wastes containing pathogens. Leakage may also occur from waste water treatment systems such as tanks and aeration ponds.

Surface water may be contaminated by spillage of liquid or solid wastes, but the impact of this is likely to be greatest during active operation of a slaughterhouse. Groundwater may also be affected depending upon site-specific conditions such as geology.

Odour and flies, and the associated health risk, may be a problem if buried organic matter becomes exposed.

Pathogens may occur in unfit meat, or in any of the waste or breakdown products that occur at slaughterhouses.

4.1.2 Tanneries and fellmongers

Drying of hides may lead to run-off water contaminated with biocides entering the soil, particularly at tanneries where hides may have been dried in the open air.

Drums of chemicals as well as pits or tanks employed for tanning of hides may have leaked contaminants into the ground.

Metallic wastes such as chromium, are generally limited to sites where tanning has taken place and are likely to be associated with sludge tanks, drying beds or open

storage areas on permeable ground. Trivalent chromium is typically present in the sludge in concentrations up to 3.5%, and hydrated chromium oxides are present in dry solids. Historically, arsenic-based preservatives were used to preserve raw skins for transport. Very old tannery landfill sites are known which contain up to 1% arsenic as calcium salts in an excess of lime.

4.2 Migration and persistence of contaminants

4.2.1 Pathogens

The risk of encountering pathogens on land formerly used for animal processing plants diminishes with time, owing to the hostile conditions in soil which prevent the survival of many pathogens for more than a few months. However, some can persist over a period of several years and the length of time since closure of the plant should be taken into account when assessing the site. Monitoring the site for the presence of the organisms is recommended since this may be more helpful than relying on the ageing process to remove or reduce the risk.

The persistence of pathogens is the most critical factor affecting spread of contamination. Viruses such as those of influenza usually only persist for a few hours or days. Vegetative bacteria may survive for as little as a few hours, but may persist for 2–3 months in some circumstances. Spore-forming bacteria, such as tetanus and anthrax are much more resistant and may remain viable in soils for months or even years.

Pathogens may multiply and spread where conditions such as temperature are suitable. If they are present in soil, their mobility will depend on the porosity and permeability of soils.

4.2.2 Metal compounds

Trivalent chromium is of low solubility in soils at pH values normally found in the environment, but will increase in solubility in the presence of acids. Arsenic is of low solubility but may be leached to a limited extent if in conjunction with alkalis. Thus, under acidic or alkaline conditions, the compounds may contaminate surface and groundwater as a result of leaching from underground deposits and rainwater run-off from surface deposits. However, the metals are usually relatively immobile. At high translocation they may pose a hazard to plant life. Crops for human consumption grown on soils containing high levels of arsenic may exceed the 'Arsenic in Food' Regulations. Livestock grazing such land may be at risk if rates of arsenic ingestion are high over a long period.

4.2.3 Biocides

Lindane will be adsorbed onto soil particles and is bio-degradable to some extent, ie 75–100% disappears from soils in 3–10 years. The other isomers of HCH are more persistent. All the isomers are sparingly soluble in water and are only likely to impact groundwater in areas of high HCH contamination, where the soil organic matter content is low, or where the groundwater level is close to the surface.

For a more detailed treatment of the fate and persistence of organic pesticides, the DOE Industry Profile on pesticides manufacturing works (see Section 5.3) should be consulted.

4.2.4 *Solvents and fuel oils*

Relatively small amounts of solvent pose a considerable threat to water resources, both through surface run-off and groundwater infiltration. The less soluble compounds which become adsorbed onto clay or organic matter will provide on-going sources of water pollution, long after the original source has been removed, by continuing to allow the contaminant to slowly desorb and dissolve into the soil water. Generally, the higher the organic matter and clay content within the soil, the greater the adsorption of solvents and the lower their mobility. Conversely the greatest migration of contaminants will occur in coarse-grained sands and gravels with little organic matter.

The non-chlorinated solvents are mostly less dense than water and the non-soluble components will float on the water-table. Most compounds within this group are potentially biodegradable but may persist in soil owing to unfavourable conditions for microbial activity.

Chlorinated solvents can contaminate drinking water at very low concentrations. They are generally more dense than water and will tend to migrate to the bottom of aquifers, sometimes in the opposite direction to the general groundwater flow. Chlorinated solvents are persistent, they degrade slowly and only under specific conditions. Various intermediates formed as a result of their partial degradation may accumulate in the environment.

Organic solvents may also increase the solubility of less mobile organic chemicals, eg the synthetic tanning agents, and increase the risk of their reaching groundwater.

Fuel oils behave in a similar manner to non-chlorinated solvents and are readily biodegradable if suitable soil conditions are provided.

5. Sources of further information

5.1 Organisations

For further information concerning the animal processing industry in the United Kingdom, the following organisations should be consulted:

The British Leather Confederation
Kings Park Road
Moulton Park
Northampton
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The British Meat Manufacturers Association
19 Cornwall Terrace
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The British Poultry Meat Federation Limited
High Holborn House
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The Licensed Animal Slaughterers and Salvage Association
28 Blenheim Gardens
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Ministry of Agriculture, Fisheries and Food
Meat Hygiene Division and Animal Health Division
Tolworth Tower
Surrey
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KT6 7DX

The United Kingdom Renderers' Association Limited
60 Claremont Road
Surrey
Surrey
KT6 4RH

5.2 Sources of further information concerning the activities described in this profile

Nemerow N L. *Liquid waste of industry, theories, practices and treatment.* Reading, Addison Wesley Publishing Company, 1987.

Sykes R L and Corning D R. *Pollution abatement and control in the leather industry.* UNEP Industry and Environment. April/May/June 1987.

Wilson N R P. *Meat hygienists pocket book.* 2nd Edition. Taunton, The Association of Meat Inspectors, 1986.

Case study including information on tanneries:

Paul V. *Bibliography of case studies on contaminated land: investigation, remediation and redevelopment.* Garston, Building Research Establishment, 1995.

Information on researching the history of sites may be found in:

Department of the Environment. *Documentary research on industrial sites.* DOE, 1994.

5.3 Related DOE Industry Profiles and other UK legislation of particular relevance

Chemical works: inorganic chemicals manufacturing works
Chemical works: pesticides manufacturing works

The Processed Animal Protein Order 1989 (SI 1989 No. 661)
The Zoonoses Order 1989 (SI 1989 No. 285)
The Animal By-Products Order 1992 (SI 1992 No. 3303)
The Environmental Protection Act 1990 (BATNEEC Notes)

PG 1/9 (91) Poultry litter combustion processes between
0.4 and 3 MW net rated thermal input
PG 5/3 (91) Animal carcasses incinerators under 1 tonne an hour
PG 6/1 (92) Animal by-product processing
PG 6/6 (92) Fur breeding processes
PG 6/37 (92) Knacker's yards
PG 6/38 (92) Blood processing
PG 6/39 (92) Animal by-product dealers

Food Safety Act 1990
The Fresh Meat (Hygiene and Inspection) Regulations 1992
The Food Hygiene (Market Stalls and Delivery Vehicles) Regulations 1966, as amended
The Imported Food Regulations 1984
The Meat (Sterilisation and Staining) Regulations 1982, as amended
The Slaughterhouse Act 1974
The Slaughter of Animals (Humane Conditions) Regulations 1990
The Animal Health Act 1981
The Poultry Meat, Farmed Game Bird Meat and Rabbit Meat (Hygiene and Inspection) Regulations 1994
The Bovine Offal (Prohibition) Regulations 1989, as amended
The Anthrax Order 1991

5.4 Health, safety and environmental risks

The Notes issued by the Chief Inspector of Her Majesty's Inspectorate of Pollution (HMIP) provide guidance for the processes prescribed for integrated pollution control in Regulations made under the Environmental Protection Act 1990. Of particular interest is:

Her Majesty's Inspectorate of Pollution. *Processing of animal hides and skins.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR6/7. London, HMSO, 1995.

The Control of Substances Hazardous to Health (COSHH) Regulations 1994 and the Management of Health and Safety at Work Regulations 1992 are available from HMSO. Information on relevant health and safety legislation and approved codes of practice published by HSE publications are available from Health and Safety Executive Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS (telephone 01787 881165), as well as HMSO and other retailers.

Information on the health, safety and environmental hazards associated with individual contaminants mentioned in this profile may be obtained from the following sources:

Sax N and Lewis R. *Hazardous chemicals desk reference*. New York, Van Nostrand Reinhold Company, 1987.

Verschueren K. *Handbook of environmental data on organic chemicals*. 2nd Edition. New York, Van Nostrand Reinhold Company, 1983.

Howard P H. *Handbook of environmental fate and exposure data for organic chemicals*. Vols I and II. USA, Lewis Publishers, 1990.

5.5 Waste disposal and remediation options

Useful information may be obtained from the Department of the Environment series of Waste Management Papers, which contain details of the nature of industrial waste arisings, their treatment and disposal. A current list of titles in this series is available from HMSO Publications Centre, PO Box 276, London, SW8 5DT. Of particular relevance are:

Department of the Environment. *Wastes from the tanning, leather dressing and fellmongering industries*. Waste Management Paper No. 17. London, HMSO, 1978.

Department of the Environment. *Special waste*. Waste Management Paper No. 23. London, HMSO, 1982.

Publications containing information on the treatment options available for the remediation of contaminated land sites, prepared with the support of the Department of the Environment's Research Programme, can be obtained from National Environmental Technology Centre Library, F6, Culham, Abingdon, Oxfordshire, OX14 3DB.

A full list of current titles of Government publications on all aspects of contaminated land can be obtained from CLL Division, Room A323, Department of the Environment, Romney House, 43 Marsham Street, London, SW1P 3PY.

Advice on the assessment and remediation of contaminated land is contained in guidance published by the Construction Industry Research and Information Association (CIRIA), 6 Storey's Gate, Westminster, London, SW1P 3AU.

Annex Potential contaminants

The chemical compounds and other materials listed below generally reflect those associated with the industry and which have the potential to contaminate the ground. The list is not exhaustive; neither does it imply that all these chemicals might be present nor that they have caused contamination.

Slaughterhouses, rendering, gelatine, glue and meat processing plants

Pathogens	pathogens that might occur at slaughterhouses include a variety of bacteria, viruses, protozoal parasites and the eggs and cysts of parasites. Specifically, unfit meat from animals may be infected by agents causing anthrax, tetanus, swine fever, pneumonia, tuberculosis, actinomycosis, glanders, brucellosis, meningitis and BSE (bovine spongiform encephalopathy) and by organisms such as Clostridium perfringens, actinobacillus, various round worms, cystic forms of dog and human tapeworm, and liver flukes
Solvents	used in the past in rendering plants (see section on solvents on next page) in their fat separation processes
Acids and alkalis	acids, particularly hydrochloric or sulphuric, and alkalis may also be found in association with former gelatine or adhesives plants
Detergents and bleaches	all premises which handle fats as products or wastes tend to use caustic detergents, disinfectants or bleaches for cleaning purposes
Fuel oils	for steam production

Tanneries and fellmongers

Tanning agents	chromium-containing tanning agents most tanning undertaken at present in the United Kingdom uses chromium sulphate, also potassium dichromate vegetable tans polyphenolic plant extracts, still used for some heavy leathers synthetic tans usually contain sulphonic acid and phenol groups. Derivatives of cresols, phenols and naphthalene form the basis of some synthetic tanning agents and may be found in the sludges arising from waste treatment processes. Glutaraldehyde tans are less commonly used
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	<p>oil tans</p> <p>formaldehyde (not now used in the United Kingdom) and fish oils (used for chamois leather)</p> <p>alum</p> <p>potassium alum is an obsolete tanning agent which may be found on older sites</p>
Biocides	<p>hexachlorocyclohexane (HCH)</p> <p>the gamma isomer has insecticidal properties; the technical product may contain other isomers</p> <p>arsenic sulphide</p> <p>pyrethroids - permethrin, cypermethrin (synthetic)</p> <p>pyrethrum (natural)</p> <p>boric acid</p> <p>sodium pentachlorophenol and sodium pentachlorophenoxide</p>
Solvents	<p>white spirit and kerosene are the usual solvents; isopropanol, ethyl acetate, xylene, toluene and chlorinated solvents (eg trichloroethylene) are also used</p>
Acids	<p>sulphuric</p>
Alkalis	<p>sodium hydroxide</p> <p>calcium hydroxide (lime)</p>
Sulphides	<p>sodium</p> <p>arsenic</p>
Metals and metal compounds	<p>manganese</p> <p>titanium tetrachloride (used in dyeing leather)</p> <p>ammonium titanium oxalate (used in dyeing leather)</p> <p>pigments for leather finishing (eg titanium dioxide)</p> <p>cadmium</p>
Other inorganic compounds	<p>sodium borate</p> <p>sodium carbonate</p> <p>ammonium carbonate</p> <p>sodium sulphate</p> <p>ammonium salts</p>
Organic compounds	<p>lubricants</p> <p>dyestuffs</p> <p>binders (eg casein and acrylic polymers)</p> <p>enzymes</p> <p>lacquers (eg nitro-cellulose and urethane)</p>
Fuel oils	

Table 1a Main groups of contaminants and their probable locations

Animal and animal products processing works – slaughterhouses, rendering, gelatine, glue and meat processing plants

Contaminant		Location						
Main group	Sub-group	Raw material delivery and storage	Process areas	Tanks, pipework and pumps	Product storage and blending	Waste storage/on-site disposal	Wastewater treatment facilities	Fuel storage
Acids and alkalis								
Organic compounds	solvents							
	fuel oils for boiler/steam production							
Pathogens ¹								

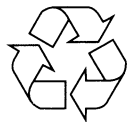
¹These organisms can cause diseases such as anthrax, tetanus, swine fever, pneumonia, tuberculosis, glanders, brucellosis, meningitis and bovine spongiform encephalopathy (BSE)

Shaded boxes indicate areas where contamination is most likely to occur

Table 1b Main groups of contaminants and their probable locations**Animal and animal products processing works – tanneries and fellmongers**

Contaminant		Location						
Main group	Sub-group	Raw material delivery and storage	Process areas	Tanks, pipework and pumps	Product storage and blending	Waste storage/ on-site disposal	Wastewater treatment facilities	Fuel storage
Metals and metalloid compounds	dyeing and tanning agents							
	chromium-containing tanning agents							
	potassium alum (an obsolete tanning agent — may be found on older sites)							
Inorganic compounds	sulphides							
	others							
	biocides							
Acids and alkalis								
Organic compounds	vegetable oils							
	oligomers of formaldehyde, phenolic materials or naphthalene							
	oil tans							
	insecticides							
	solvents							
	lubricants, dyestuffs, binders, enzymes and lacquers							
	fuel oils							

Shaded boxes indicate areas where contamination is most likely to occur



Recycled paper

DOE Industry Profiles

Airports

Animal and animal products processing works

Asbestos manufacturing works

Ceramics, cement and asphalt manufacturing works

Chemical works: coatings (paints and printing inks) manufacturing works

Chemical works: cosmetics and toiletries manufacturing works

Chemical works: disinfectants manufacturing works

Chemical works: explosives, propellants and pyrotechnics manufacturing works

Chemical works: fertiliser manufacturing works

Chemical works: fine chemicals manufacturing works

Chemical works: inorganic chemicals manufacturing works

Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works

Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works

Chemical works: organic chemicals manufacturing works

Chemical works: pesticides manufacturing works

Chemical works: pharmaceuticals manufacturing works

Chemical works: rubber processing works (including works manufacturing tyres or other rubber products)

Chemical works: soap and detergent manufacturing works

Dockyards and dockland

Engineering works: aircraft manufacturing works

Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)

Engineering works: mechanical engineering and ordnance works

Engineering works: railway engineering works

Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards)

Engineering works: vehicle manufacturing works

Gas works, coke works and other coal carbonisation plants

Metal manufacturing, refining and finishing works: electroplating and other metal finishing works

Metal manufacturing, refining and finishing works: iron and steelworks

Metal manufacturing, refining and finishing works: lead works

Metal manufacturing, refining and finishing works: non-ferrous metal works (excluding lead works)

Metal manufacturing, refining and finishing works: precious metal recovery works

Oil refineries and bulk storage of crude oil and petroleum products

Power stations (excluding nuclear power stations)

Pulp and paper manufacturing works

Railway land

Road vehicle fuelling, service and repair: garages and filling stations

Road vehicle fuelling, service and repair: transport and haulage centres

Sewage works and sewage farms

Textile works and dye works

Timber products manufacturing works

Timber treatment works

Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants

Waste recycling, treatment and disposal sites: hazardous waste treatment plants

Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites

Waste recycling, treatment and disposal sites: metal recycling sites

Waste recycling, treatment and disposal sites: solvent recovery works

Profile of miscellaneous industries incorporating:

Charcoal works

Dry-cleaners

Fibreglass and fibreglass resins manufacturing works

Glass manufacturing works

Photographic processing industry

Printing and bookbinding works

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