Department of the Environment
Industry Profile

Sewage works and sewage farms

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

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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).

ISBN 1 85112 282 6

Acknowledgements

The Department of the Environment is grateful to the members of the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), and the following individuals and organisations for assistance in the compilation of this profile:

Arup Environmental (Ove Arup and Partners)
Mr D L Barry (WS Atkins Environment)
Mr P Chave (National Rivers Authority)
Mr P Hall (The Water Services Association of England and Wales)
Mr R Oake (Thames Water Utilities plc)
Dr M R G Taylor (Consultants in Environmental Sciences Ltd)

DOE Industry Profile

Sewage works and sewage farms

This Profile is based on work by Aspinwall and Company Limited and was prepared for publication by the Building Research Establishment.

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.

Sewage works and sewage farms

1. Background

This profile deals with contamination that may be found at sewage works and sewage farms.

There was no controlled method for disposing of liquid waste effluent until Victorian times. Before then, rivers, streams, tidal estuaries and the sea provided the means of carrying away waste. The growth of towns and cities and the development of industry caused an acute disposal problem by the middle of the 19th Century. The major impetus to take action was the discovery that diseases such as cholera and typhoid fever are waterborne and are caused by drinking water and wastewater coming into contact.

The disposal problems of London were tackled from the 1850s by the construction of interceptor sewers, collecting all sewage draining into the Thames and carrying it several miles downriver, before discharging it into the estuary on the ebb tide.

The disposal of sewage in inland towns was effected in the second half of the 19th Century by treatment at sewage farms. They settled out the majority of solids as sludge from liquid. The sludge was spread on land and allowed to dry out before being ploughed into the soil. The liquid was distributed by field irrigation. Sewage farms were used for cereals, root crops and livestock. They were large, with up to 80 hectares of land being used for sludge-spreading and 300 hectares for irrigation.

By the end of the century, as the population continued to grow, many sewage farms became overloaded. To meet the growing demand, sewage treatment works using more intensive handling methods were built, often on sewage farm land. At first the percolating filter system, which still used large areas of land, was used in sewage treatment works. It has been gradually replaced by the more effective and less land-consuming activated sludge technique (developed between 1912 and 1915).

Before the Second World War much of the land used in connection with sewage farms was redundant and came on to the market. The subsequent uses of such land included housing, leisure facilities and industry.

There are currently over 5000 sewage treatment works serving populations in excess of 10 000 distributed throughout the United Kingdom.

2. Processes

2.1 Raw materials

2.1.1 General

Sewage arriving at the sewage treatment works is a complex mixture of suspended and dissolved materials. Less than 0.1% of the sewage consists of suspended solid material, 70% of which is organic matter and 30% is inorganic matter. The remainder is water. The chemical composition of incoming industrial effluents varies widely in terms of heavy metal and organic chemicals compounds, and could include, for example, solvents and pesticides.

Most sewage treatment comprise biological and physical processes, and consequently there are few raw materials. Some chemicals, including aluminium, iron and chlorine compounds are used in treatment. Polyelectrolytes may be used in the flocculation stage, and substances such as sodium hydroxide or hydrochloric acid may be added to adjust the pH of effluent to assist biological breakdown.

2.1.2 Delivery, transfer and storage

Sewage is carried from its source to the treatment works via two types of sewerage system. In more modern systems, foul sewers carry only domestic and industrial effluent with entirely separate systems to collect stormwater run-off, which is discharged directly into natural watercourses. It was common, particularly in older towns and cities, for foul and stormwater systems to be combined.

In combined works, the flow and concentration of sewage entering treatment plants vary with the rainfall, and when higher flows occur part of the sewage may be diverted and held in stormwater tanks. This is treated once the high flow has subsided or, if the flow is very high, the sewage may be discharged, untreated, into the surface watercourse.

Treatment chemicals, where used, are delivered to site by tanker or in drums and are stored in tanks or drums.

2.2 Sewage treatment processes

The original principle of settling solids from liquid still remains the primary treatment stage in modern sewage works. Over 50% of the solids or sludge is still spread on farmland with the remainder being disposed of by dumping at sea (which will cease by 1998), in landfill sites or by being incinerated. In some cases sludges are stored on sewage works or other dedicated storage sites in lagoons (in semi-liquid form) or on tips (in dry form).

Nowadays, the process of wastewater treatment incorporates a number of treatment stages. The intensity of the treatment varies depending on the quality of the incoming wastewater and the desired quality of the final effluent. These treatment processes are used to settle out solid matter and ensure the breakdown of the effluent biomass.

Chlorine or ultraviolet disinfection may be carried out prior to the effluent leaving the sewage works.

2.2.1 Preliminary treatment

Preliminary treatment processes render the sewage more amenable to further treatment by removing large objects, which could form blockages or damage equipment. Preliminary screening is also an important step in ensuring the production of good quality sewage sludge. The influent raw sewage passes through screens which remove large suspended objects, often putrescible organic matter. In addition, rags, wood, concrete and similar materials are removed. Small stones and grit, which may damage pumps and valves, are usually removed by grit channels and degritting installations, then washed and stored on site for ultimate disposal, generally on land. An alternative to using screens for removing large objects is the use of comminuters which reduce large solids to a size suitable for removal during the next stage of treatment.

2.2.2 Primary treatment

Primary sedimentation removes approximately 55% of the suspended solids in raw sewage. Various types of sedimentation tanks are used, the majority being submerged or partially submerged below ground. Sedimentation is controlled by the settling characteristics of the solids, the retention time of the sewage in the tank (usually 2-3 hours, but can be up to 8 hours) and the surface loading, that is the volume of sewage in relation to the surface area of the tank. The settled solids and floating scum are generally removed from the tank regularly, and are known as the primary sludge.

2.2.3 Secondary treatment

There are two methods of secondary treatment in operation in the United Kingdom, the percolating filter process and the activated sludge process. The percolating filter process has been in use for longer than the activated sludge process. Most new major sewage treatment plants use the latter method.

Percolating filter process

Percolating filters consist of circular or rectangular beds, generally from 1.8 metres deep in England and Wales, and up to 3.6 metres deep in Scotland. The filters contain coarse granular filtering media (for example, broken rock, gravel, clinker or slag) with 45-55% voids. The beds may be situated above or level with the ground. Liquid effluent from primary treatment is fed by a distributor mechanism onto the surface and trickles through the granular medium on which a film of micro-organisms has developed. This film consists of fungi, algae and bacteria and it is here that oxidation of the liquid effluent takes place. The microbial film, using the liquid effluent as a nutrient base, continues to grow and excess biological matter is sloughed off with the effluent. The percolating filter process is followed by secondary settlement in which the sloughed off microbial film is consolidated into humus sludge.

Activated sludge process

The activated sludge process is the preferred method of treating liquid effluent from primary treatment, in works serving large populations. In this process, micro-organisms are also utilised to degrade organic matter. The micro-organisms consist of flocculent cultures freely suspended in a liquid sludge, known as the 'activated sludge'. Activated sludge processes use aeration tanks or channels into which the liquid effluent and activated sludge pass. This 'mixed liquor' is aerated, either by air delivered to the bottom of the tanks through numerous air diffusers or jets, or by mechanical agitation of the surface using vertically or horizontally mounted rotating propellers.

The treatment process depends on the presence of an adequate concentration of activated sludge in contact with the settled sewage for an appropriate period of time in the presence of oxygen. There is a continuous production of new activated sludge in the aeration tanks as the micro-organisms grow and die. After the required period of aeration, the mixed liquor passes out of the aeration tanks into secondary settlement tanks to allow separation of the solids. Part of the settled sludge is returned from the secondary settlement tanks to the inlet of the aeration tanks to maintain the appropriate concentration of solids in the mixed liquor. The remainder of the sludge is passed to sludge treatment and disposal processes.

2.2.4 Tertiary treatment

The effluent from secondary treatment processes may be suitable for discharge to some watercourses and tertiary treatment, also referred to as 'polishing', is not used unless a high quality effluent is required. Several processes may be used to achieve high quality effluent.

Disinfection

Chlorine or exposure to ultraviolet light is used as a disinfecting agent, primarily to control odours and prevent septicity.

Lagooning

Effluent is retained to allow further settling of suspended matter and to continue the oxidation of dissolved organic matter. This system may require large areas of land.

Sand filtration

The effluent flows through beds of sand over a coarse basal layer, below which a system of drains collects the filtered liquid.

High rate irrigation

The effluent flows over grassland via distributing channels and is collected by a second series of channels. The grassed plots are constructed on gently sloping land to allow gravity flow. Large areas of land are required for periodic resting of the grass plots.

Low rate irrigation

This applies to the natural distribution of effluent over land. Irrigation would occur at a low rate since the flow depends on the natural topography rather than graded slopes.

High and low rate irrigation systems are mostly associated with sewage farms and are not in widespread use at present.

2.2.5 Sludge treatment

The sludges produced during primary, secondary and tertiary treatment are often combined for treatment and generally contain 1-7% solids. Primary sludges are highly putrescible and offensive, secondary sludges are less so. The aim of sludge treatment is to make final sludge disposal easier and safer given the possible presence of pathogenic micro-organisms such as *Salmonellae* and *Typhus* bacteria. However, although the numbers of pathogens are greatly reduced by sludge treatment, contamination by viruses is not entirely eliminated. The final disposal option will therefore determine what treatment is undertaken.

The treatment processes available include digestion (both aerobic and anaerobic), heat treatment, thickening, composting with domestic refuse, chemical conditioning, de-watering and heat drying.

Anaerobic digestion of the sludge is undertaken in some modern works. The organic matter present in the sludge is biologically converted to gas, containing around 70% methane and 30% carbon dioxide. The process is undertaken over a period of up to 20 days in an air-tight reactor. Anaerobic digestion reduces the volume of the sludge by removing organic components which drastically decreases the odour associated with raw sludge. The digested sludge may be further de-watered in lagoons prior to disposal.

Sludge de-watering by mechanical means may require the use of conditioners. Aluminium and iron compounds, and various polyelectrolytes are frequently used. These chemicals will be concentrated in the final sludge.

In older works, the sludge may be air dried in special drying beds where the sludge is spread in a layer 2-3 cm thick for up to two months. Water loss is encouraged both by evaporation and drainage through the base of the bed. The dried product, which contains approximately 25% solids, is then dug up for final disposal.

Incineration of sludge is another method of treatment and it produces ash which needs to be disposed of (generally to landfills).

2.3 Wastes

Sewage treatment results in a range of wastes which include final sludge, final liquid effluent, spent filter media, grit and screenings. In addition, the treatment of sludges by anaerobic digestion produces gas which is generally utilised within the treatment plant for maintaining the process temperature. The gas is also used for heating and for power production, by combustion in dual fuel engines which use oil in the absence of methane.

The five main waste streams are described below.

Final sludge
Sludges arise from various stages of the treatment process and present the most significant waste type. Air-dried sludge normally contains 25% solids and 75% water, whilst sludge de-watered by mechanical means may contain up to 50% solids. This method is unusual, as it is expensive. At present sludge is disposed of in four ways in the United Kingdom; 53% to land, 24% at sea, 17% to landfill, and 6% is incinerated.

Final liquid effluent
The final effluent is not normally stored on site but discharged either continuously or at frequent intervals from the site to the receiving waters. Effluent at various stages of treatment will be present on site at any given time.

Spent filter media
Spent materials removed from filter beds and other filter media include coke, clinker, slag, sand and gravel. These materials are usually deposited on site or to landfill when their removal becomes necessary.

Grit
The grit and small stones removed during preliminary treatment are washed and typically disposed of to landfill.

Screenings
These are materials removed during preliminary treatment and contain large suspended solids consisting of a wide range of materials which are not exclusively organic in nature. After removal from the effluent stream they are stored on site for disposal to landfill or, less commonly, by incineration.

Both dried and liquid sludges, 97% of which will have been treated in some way, are applied to agricultural land in accordance with the Sludge (Use in Agriculture) Regulations 1989. Arable land can be ploughed following application to speed up incorporation of the sludge into the soil and to reduce any odour problems. Dry sludges may be tipped by lorry and are often applied to the land using a muck spreader. Liquid sludges may be injected into the soil to give a uniform application and to virtually eliminate odour problems. However, sludges are mostly sprayed from tankers.

Disposal of both dried and liquid sludge at sea, either by ship or coastal outfall, is licensed by the Ministry of Agriculture, Fisheries and Food. In 1990 the government agreed to phase out the dumping of sludge at sea, and by 1998 this disposal method will cease.

3. 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 Table 1. 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.

3.1 Factors affecting contamination

As a result of the sewage treatment process, the metals, organic pollutants and pathogens which have not been removed during treatment are concentrated in the sludge, adsorbed on to the fine particles. Sludges with these contaminant groups, therefore, comprise the most common forms of contamination; relevant areas may include drying beds and storage areas.

Sewage works and farms comprise a complex system of pipework, tanks, open channels and drying/irrigation beds which do not conform to a standard pattern. Contamination may arise through leakages from pipework and tanks, leading to localised higher concentrations of contaminants, and from the use of land for temporary storage of screenings, grits and used filter media and for improving effluent quality by filtration or irrigation.

Contamination can relate to the biodegradable material in sludges. This can lead to the generation of methane, carbon dioxide and, where sulphur compounds exist, hydrogen sulphide. Sludges may also give rise to physical hazards on sewage works such as ground instability; for example, mature sludges left in tanks, lagoons and drying beds can take on the appearance of being solid at the surface, and possibly even be vegetated, but this may conceal liquid sludge below. Mature, well-dried and weathered sludge can have the appearance of soil. Dried sludge is generally combustible, as are some of the materials used as filter media, such as coke.

Where sludges were treated on site, the chemicals used may have caused contamination through leaking tanks, drums or the pipework used to transport them. The fuel oils for use in pumps, heating systems, plant or vehicles may have been stored on site. Some pipework and building materials, such as cladding and roofing, may have contained asbestos, which may cause contamination following decommissioning and demolition of plant and buildings.

Electrical transformers built since the 1940s may contain polychlorinated biphenyls (PCBs) as a dielectric fluid. After it was recognised that PCBs may cause environmental problems, their use was phased out. Contamination of soils may have occurred during spills, retrofilling or break-up of plant containing PCBs.

3.2 Migration and persistence of contaminants

3.2.1 Metals

Sludges and liquid effluents are the most significant sources of potential metal contamination. They might have been applied directly to land. A large proportion of the residual contaminants in sludges may have low solubility and be absorbed into fine particles. Therefore any leaching effects might be concentrated in the shallow soil zones. The downward movement of contaminants in liquid effluents will be largely dependent on ground permeability.

In all cases, the movement of metals through the soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals (eg copper, zinc and lead) may increase under acidic conditions. In other cases the relationship is more complex. For example, trivalent chromium is more soluble under acidic conditions, whereas the solubility of hexavalent chromium is increased under both acidic and alkaline conditions and arsenic may become more soluble at higher pHs.

3.2.2 Organic compounds

The presence of organic compounds, such as solvents or pesticides, will be influenced by the industries serviced by the works. Hydrocarbons such as fuel oils and solvents are highly mobile and can migrate to contaminate a wide area. Free product released at the surface or leaking from tanks or pipes will flow through the ground. On encountering groundwater, fuel oils and solvents that are lighter than water will spread out on the surface and migrate laterally, in the direction of the groundwater flow. Chlorinated solvents are denser than water and tend to migrate to the bottom of water bodies. Their migration may not be consistent with general groundwater flow. They are persistent chemicals.

Solvents and components of fuel oils may have limited but significant water solubilities. They pose a considerable threat to public water supplies, even at low concentrations.

PCBs have a low solubility in water and are highly persistent in the environment.

The higher the organic matter and clay content within the soil, the greater the adsorption of the organic contaminants, which will greatly reduce the level of contamination migration. The highest levels of migration will occur in coarse-grained sands and gravels with little organic matter. However, less soluble compounds, which become adsorbed on clay or organic matter, will provide on-going sources of water pollution long after the source has been removed by continuing to desorb into the soil water.

Biodegradation processes in soils can be influenced by a number of factors, namely moisture content, oxygen concentration and pH, acting separately or in combination. For example, low moisture content reduces microbiological activity, while high moisture content can reduce oxygen penetration and possibly lead to anaerobic soil conditions. Such conditions enhance the biodegradation of some materials, eg chlorinated compounds, while aerobic conditions are needed to biodegrade many oils. Also, low pHs tend to reduce the bacterial population and encourage fungal activity; at pHs lower than 5, microbiological activity is much reduced. The presence of heavy metals also inhibits micro-organisms. Because of these factors, at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

3.2.3 Inorganic compounds

Soluble inorganic contaminants may percolate through the soil to contaminate groundwater, or surface water through run-off in rain water. Dissolved anions such as nitrate and sulphate will migrate freely.

Asbestos is not soluble or biodegradable and persists in the soil. Wind dispersal of contaminated soil may be a further transport mechanism where there is gross surface contamination by some of the less mobile contaminants such as asbestos and metals.

4. Sources of further information

4.1 Organisations

Further information on the United Kingdom sewage industry may be obtained from the Regional Water Companies of England and Wales, the River Purification Boards in Scotland, and the Department of the Environment in Northern Ireland. In addition, the following organisations should be consulted:

British Effluent and Water Association
5 Castle Street
High Wycombe
Buckinghamshire
HP13 6RZ

Chartered Institute of Water and Environmental Management
15 John Street
London
WC1N 2EB

Water Services Association
1 Queen Anne's Gate
London
SW1H 9BT

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

Chartered Institute of Water and Environmental Management (CIWEM). *Unit process publications.*

Council Directive 86/278/EEC (of 12 June 1986). *The protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.*

Department of the Environment. *Report of the working party on the disposal of sewage sludge to land.* DOE/NWC Standing Technical Committee. Report No. 5, 1981.

Lester J N. *Sewage and sewage sludge treatment pollution: causes, effects and control. Ed R.M.* Harrison. Cambridge, Royal Society of Chemistry, 1990.

Metcalf and Eddy Inc. *Waste water engineering: treatment, disposal and reuse.* Third edition; McGraw-Hill Inc, 1991.

Viessman W and Hammer M J. *Water supply and pollution control.* 5th Edition; Harper Collins, 1993.

Water Services Association. *Sewerage, sewage and sludge disposal.* Water Facts, pp 20-21, November 1990.

White G C. *Handbook of chlorination for potable water, wastewater, cooling water, industrial processes and swimming pools.* Van Nostrand Reinhold Company. 1972.

United Kingdom legislation relating to this profile:

Sludge (Use in Agriculture) Regulations 1989. SI (1989) No. 1263.

Case study including information relevant to this Industry Profile:

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.

4.3 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 relevance is:

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling sewage sludge incineration.* Chief Inspector's Guidance to Inspectors, Process Guidance Note 1PR5/11, HMSO, 1992.

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:

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

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.

4.4 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 is:

Department of the Environment. *The control of landfill gas.* Waste Management Paper 27. London, HMSO, 1989.

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.

Metals, metalloids and their compounds	arsenic aluminium cadmium chromium copper iron lead mercury nickel zinc
Inorganic ions	cyanides sulphates sulphides chlorides fluorides ammonium nitrates phosphates
Organics (depend on source of industrial influent)	halogenated compounds partial oxidation products of organic compounds pesticides
Other organics	fuel oils polychlorinated biphenyls (PCBs)
Micro-organisms	pathogens eg *Salmonella* and *Typhus* bacteria
Treatment chemicals	aluminium chlorohydrate aluminium sulphate (alum) ferrous sulphate polyelectrolytes sodium hydroxide (pH adjuster) hydrochloric acid (pH adjuster) calcium oxide (lime) ferric chloride
Hazardous gas generation potential in buried sludge	methane carbon dioxide hydrogen sulphide
Asbestos	

Table 1 Main groups of contaminants and their probable locations

Sewage works and sewage farms

Main group of contaminants	Location						
	Process areas						
	Sewage works	Sewage farms	Sludge treatment/ storage	Detritus storage/ disposal	Pipework channels	Electricity transformer areas	Chemical storage
Metals, metalloids and their compounds	■	■	■	■	■		
Inorganic compounds	■	■	■		■		■
Acids/alkalis	■		■				■
Asbestos	■			■	■		
Organic compounds	■		■				
Polychlorinated biphenyls (PCBs) and other transformer oils						■	
Micro-organisms (pathogens)	■	■	■		■		
Methane carbon dioxide, hydrogen sulphide	■		■	■			

Shaded boxes indicate areas where contamination is most likely to occur

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
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