

Asbestos manufacturing 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

Asbestos manufacturing works

	Page
Preface	(iii)
1. Background	1
2. Processes	3
2.1 Asbestos products	3
2.2 Wastes	8
3. Contamination	10
3.1 Factors affecting contamination	10
3.2 Migration and persistence of contaminants	11
4. Sources of further information	12
Annex Potential contaminants	16
Table 1 Raw materials associated with asbestos products manufacture	4
Table 2 Main groups of contaminants and their probable locations	17
Figure 1 Location of major asbestos manufacturing works in the United Kingdom in the 1970s	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.

Asbestos manufacturing works

1. Background

A broad range of products may have been manufactured on former asbestos works sites. These products fall into the following main groups:

- Asbestos cement sheets, slates and pipes
- Asbestos insulating boards and tiles
- Asbestos insulation/lagging
- Sprayed asbestos coatings
- Asbestos textiles (rope, yarn and cloth)
- Millboard, paper and paper products
- Bitumen felts and coated metal
- Flooring materials
- Textured coatings and paints
- Reinforced plastics
- Mastics, sealants, putties and adhesives

Asbestos is a generic name used commercially for a group of impure fibrous silicate minerals of varied chemical composition and physical characteristics. The types of asbestos which have been used most extensively in the United Kingdom are:

Chrysotile

Chrysotile (white asbestos) is a hydrated magnesium silicate and is the most widely used asbestos commercially. In 1984, 96.6% of asbestos mined worldwide was chrysotile.

Crocidolite

Crocidolite (blue asbestos) is a sodium ferrous-ferric silicate. The principal use of crocidolite was for asbestos cement pressure pipes, for sprayed coatings and for asbestos insulation/lagging. It was also used in combination with other asbestos fibres to add strength and chemical resistance to other products.

Amosite

Amosite (brown asbestos) is a ferrous magnesium silicate. Amosite was principally used for insulating boards and other products. As with crocidolite it was used as an additive to reinforce asbestos cement pipes and other products.

Anthophyllite, tremolite and actinolite are less common forms of asbestos which can occur as trace contaminants in asbestos materials.

All forms of asbestos have good resistance to heat, electricity and chemicals, and have high tensile strength. Amosite has especially good resistance to heat. All except chrysotile are resistant to acid, crocidolite particularly so. Chrysotile has very good resistance to alkalis, which makes it very suitable as a reinforcement in cement. The fibres of all the forms except chrysotile are straight and needle-like; those of chrysotile are softer and more curly.

The main sites of chrysotile mining are currently in southern Africa, Canada and Russia and, to a lesser extent, in the USA, Italy, Greece and Cyprus. Crocidolite and amosite are mined in South Africa. Imports of asbestos originally entered the United Kingdom through Tilbury, the Medway and Liverpool/Manchester. Southampton, Tyneside, Felixstowe and the Clyde later became recognised routes of entry.

The importation of asbestos into the United Kingdom started around 1900 and was increasingly undertaken by a small number of large amalgamated companies. These larger companies supplied most of the manufacturers in the United Kingdom. In general, most asbestos products were manufactured close to import routes in and around Manchester and London. The manufacture of asbestos cement and friction materials (ie brake pads, clutch linings) tended to be more widely distributed. Figure 1 shows the distribution of the United Kingdom's asbestos industry in the early 1970s.

The industry developed through various amalgamations and acquisitions to be dominated by three major companies - Cape Asbestos, Turner and Newall, and British Belting and Asbestos. During the Second World War, asbestos manufacture was a controlled undertaking, with output almost completely taken up by the war effort. From this time up to the mid-1950s output reached a peak in the United Kingdom.

The United Kingdom Census of Production data indicate that in 1948 there were 38 establishments employing more than ten people involved in the spinning and weaving of asbestos, and 18 similar sized factories manufacturing asbestos cement. By 1958, the total number of establishments of all sizes involved in spinning and weaving asbestos was 93. In 1968, there were 74 establishments spinning and weaving asbestos and 22 establishments employing more than 10 people manufacturing asbestos cement.

Although the first Asbestos Regulations date from 1931, it was not until the 1969 Asbestos Regulations that all areas of asbestos usage came under control. By 1969, the effective means of measuring asbestos levels in the air, which had been developed during the 1960s, permitted the establishment and enforcement of meaningful standards. Dust levels in the asbestos industries today are very much lower than the levels which have occurred in the past.

Greater awareness of the hazards of asbestos caused a decline in the asbestos products industry. Imports of crocidolite and amosite into the United Kingdom ceased in 1972 and 1980 respectively. In 1985 their import, marketing and use were prohibited in the United Kingdom by the Asbestos (Prohibitions) Regulations 1985.

Asbestos cement manufacture continued at the locations shown in Figure 1 until after 1979. Figure 1 is compiled using data from the Merger and Monopolies Commission Report. Production at Rhoose, Watford, Erith, Tamworth and Durham (Bowburn) ceased between 1980 and 1990, whilst the Meldreth, Widnes and Livingston sites are still active. The manufacture of textiles, friction materials and sealants etc continues at the locations shown in Figure 1.

2. Processes

2.1 Asbestos products

The raw materials found in a range of asbestos products are given in Table 1. The following sections describe some aspects of the processing of asbestos in its main areas of usage.

Asbestos cement sheets, slates, pipes and other products

Asbestos cement products generally contain 10-15% of asbestos fibre bound in a matrix of Portland Cement or autoclaved calcium silicate. All three major types of asbestos have been used in the manufacture of asbestos cement in the past. Crocidolite was used between 1950 and 1969 and amosite from 1945 until at least 1976. Chrysotile asbestos is still used today in the manufacture of asbestos cement. Asbestos cement may be compressed into flat or corrugated sheets or moulded into a wide range of components. Semi-compressed flat sheets have a density of about 1200 kg/m³ with one smooth and one indented face. Fully compressed sheets have a density of about 1600 kg/m³ with two smooth faces. Corrugated sheets are largely used as roofing and wall cladding, and flat sheets (both semi-compressed and fully compressed) are used as panelling or partitioning.

Some manufacturers have used cellulose pulp in their asbestos cement mixes. This gives the product density and strength similar to ordinary board, allowing it to be used as a flexible partition board or lining with an improved bending strength.

Asbestos cement was first manufactured in the United Kingdom in about 1900. At this time, raw materials would usually be delivered in jute or hessian sacks. Although some of the components of asbestos cement were stored in bulk prior to use, asbestos itself was usually handled in individual compressed bags. As the technology improved, raw materials were brought in by bulk tanker transport and mechanically conveyed into storage silos. More recently, asbestos fibre was contained in polythene bags and later pelletised and delivered in containers.

In the manufacturing process, the powdered materials (cements or silicates) and asbestos fibres are transferred from storage in an enclosed process into a mixing container. Water is added to the powder and the mixture is then pumped to the production line as a slurry. The slurry is next conveyed to the board-making machines. The fibre and powders are mixed in even suspension and then lifted from the slurry on fine mesh gauze cylinders to form sheets.

The wet sheets are trimmed and cut to length on the conveyor. Corrugated sheets are profiled at this stage. The sheets are stored for up to 24 hours on metal templates or plates before being stripped off; they are then allowed to mature for up to three weeks. Some asbestos cement products, eg pressure pipes, were immersed in water to mature, while others, eg rainwater pipes and gutters and water tanks, were sprayed with water.

Asbestos fibres in asbestos cement are firmly bound in the cement matrix and will be released only if the material is mechanically damaged or deteriorates with age.

Table 1 Raw materials associated with asbestos product manufacture

Asbestos product	Associated secondary processes	Potential contaminants
Asbestos cement sheets		Amosite (1945- at least 1976) Chrysotile Crocidolite (1950-1969) Paint pigments (Cr, Cd, Pb etc) Solvents Iron oxide, carbon black
Asbestos insulating boards and tiles		Amosite Chrysotile (some lime silica boards) Crocidolite (1955-1962, uncommon) Paint pigments (Cr, Cd, Pb etc) Solvents
Asbestos insulation/lagging		Amosite (1920s-1970s) Chrysotile Crocidolite (1880s- mid 1960s) Magnesium carbonate Magnesium sulphate
Sprayed asbestos coatings		Amosite (until 1974) Chrysotile (until 1974) Crocidolite (until 1970)
Asbestos textiles	Coating and impregnation with rubber and plastics Boncing with aluminium Impregnation with thermosetting resins	Amosite (until 1970) Chrysotil Crocidolite (until 1970) Elastomers eg acrylonitrile, PVC based rubbers Aluminium Phenolic resins Phenolic-formaldehyde resins
Millboard, paper and paper products		Chrysotile Crocidolite (1896-1965)
Bitumen felts and coated metals		Usually chrysotile Bitumen
Flooring materials		Chrysotile
Textured coatings and paints		Chrysotile
Reinforced plastics		Chrysotile
Mastics, sealants, putties and adhesives		Asbestos

Asbestos insulating boards and tiles

Asbestos insulating boards were developed in the early 1950s to provide an economical, lightweight, fire resistant insulating material. The market for these boards expanded until the mid-1970s when alternative fibre-reinforced boards became available. Asbestos insulating boards have not been manufactured in the United Kingdom since 1980.

Asbestos insulating boards have a medium density of approximately 700 kg/m³ and generally contain 16-40% asbestos mixed with hydrated Portland Cement or calcium silicate.

Amosite was normally used in the manufacture of asbestos insulating boards, although one manufacturer also included a mixture containing chrysotile (one-third chrysotile to two-thirds amosite) in a lime silica board. One small production volume insulating board (manufactured from 1955-1962) also contained 1-2% crocidolite.

The manufacturing process for asbestos insulating boards was similar to that for asbestos cement, but it was followed either by more tightly controlled maturing and drying processes or by steam autoclaving at high pressure (10-12 atmospheres). This process was used for the majority of the boards produced, ie asbestos/calcium silicate boards.

Asbestos insulating board was used to provide structural fire protection, heat resistance and acoustic insulation. It was used as partitioning, as a non-combustible core or lining for other products and as a general building board because it resists moisture movement. Consequently, asbestos insulating boards are found in all types of industrial, commercial and residential buildings and were especially used in 1960s and 1970s system-built housing.

Ceiling tiles were also produced from asbestos insulating board and were widely used in the 1950s and 1960s, particularly in schools, hospitals and shops.

Asbestos insulating boards are semi-compressed and may release asbestos fibre/dust as a result of damage or abrasion.

Asbestos insulation/lagging

Compound insulation lagging was manufactured by preparing a crude mix of asbestos fibres which was usually bound with magnesium sulphate in a plaster or cement matrix so that it could be moulded. The lagging could then be further processed or formed as required for a particular product, for example to make pipe sections, slabs, rope, tape, corrugated asbestos paper, quilts, felts, blankets and plastered cement. Asbestos was also used as a surface coating on felt and cork insulation. Asbestos lagging may have had a protective covering of cloth, tape, paper or metal or a surface coating of cement applied before use. The use of insulation products containing asbestos is now prohibited in the United Kingdom.

Crocidolite yarn and rope were used for lagging from the 1880s until the mid-1960s. As cheaper chrysotile products became available, crocidolite products were generally restricted to uses where acid resistance was required. Crocidolite was used in insulation mattresses between the 1890s and the mid-1960s, and in pre-formed thermal insulation from between the mid-1920s to around 1950. Amosite was used in pre-formed thermal insulation, pipes, slabs and moulded pipe fitting covers between the mid-1920s and late 1960s, and for insulation mattresses

between the beginning of the 1920s and the mid-1960s. Between the late 1950s and the mid-1970s, amosite asbestos was used to make reinforced calcium silicate high-temperature insulation. From the mid-1960s onwards, mineral fibre insulation materials such as glass fibre and vermiculite, introduced in the early 1950s, took over most of the thermal insulation market in the United Kingdom.

The asbestos content of insulation/lagging depended on the type of material. For example asbestos quilts, mattresses and blankets may have contained up to 100% asbestos; a common form of pipe and boiler lagging contained 15% asbestos with 85% magnesium carbonate and an asbestos surface coat; pre-formed thermal insulation materials made of magnesium carbonate, calcium silicate and diatomite were reinforced with some 10-15% amosite or a mixture of amosite and chrysotile.

Asbestos lagging was widely used in public buildings, factories and hospitals. The likelihood of fibre release from lagging depends on its composition, friability and state of repair. The potential for release increases as the materials age or if the materials are damaged or disturbed during maintenance work.

Sprayed asbestos coatings

Sprayed asbestos coatings have been widely used in the United Kingdom for thermal, condensation and acoustic control in buildings and for fire protection of structural steel. They contained up to 85% of all three major types of asbestos. Sprayed asbestos in buildings mainly contained amosite but also crocidolite. Crocidolite was used until 1970 when imports effectively stopped, although existing stocks may have been used later than this date. Chrysotile mixed with mineral wool and cementitious binders was used to a limited extent until 1974.

Sprayed asbestos coatings were manufactured in a similar way to asbestos insulation/lagging, ie by blending asbestos fibres and cement into a slurry. The slurry was mixed with water during application.

The application of sprayed asbestos ceased in 1974 and asbestos spraying was prohibited in the United Kingdom in 1985.

Sprayed asbestos is not likely to be found in houses, but it is sometimes found in schools, for example on the ceilings of swimming pools. There is a potential for fibre release from these coatings unless they were sealed when applied. The potential increases as the materials age or become friable and disintegrate.

Asbestos textiles (rope, yarn and cloth)

The asbestos content of woven and spun materials approaches 100%. All three major types of asbestos (chrysotile, crocidolite and amosite) have been used to produce asbestos textile products for thermal insulation material, fire protective clothing and other products, and insulation for electric wires and cables. All types of asbestos were used in ropes and yarns until 1970. Since then only chrysotile has been used. Chrysotile has also been by far the most common type of asbestos used in cloth manufacture since the mid-1960s.

Asbestos textiles are produced by feeding asbestos fibres directly into a carding machine, where the fibres are mechanically aligned and then spun into a continuous thread. The fibres are then woven into yarns, cords, ropes, tapes and cloth etc. Since the mid-1960s, asbestos textile products have been treated to

suppress dust emissions during use; products which go on to secondary processing do not receive this treatment.

Secondary processes used on asbestos textiles include:

Coating and impregnation with rubber and other plastics to produce proofed fabrics and braidings;

Bonding with aluminium to produce aluminised fabrics;

Impregnation with thermosetting resins, usually phenolics, to produce high performance composites. These composite materials are used in the manufacture of products such as specialist mouldings and heat shields for automotive applications. High quality asbestos fibre can also be mixed with various blends of natural and synthetic rubbers to produce compressed asbestos fibre (CAF) which is formed into sheets for gasket and seal production.

Friction materials, for example brake linings and clutch facings, may also be made from woven or moulded asbestos (generally 50-70% chrysotile) bound by resins, rubbers and other fillers.

Fibres may be released from these materials if they are unbonded or if they are subject to abrasion.

Millboard, paper and paper products

These products were used for the insulation of electrical equipment, for thermal insulation and for fire protection (as a coating for wood fibre board). They were manufactured with an asbestos content approaching 100% in a similar way to asbestos insulating boards, although the laminate layers were much thinner (in the case of paper, only one layer was made). Crocidolite was used in millboard between 1896 and 1965, but since then only chrysotile has been used.

Uncoated asbestos paper and millboard is not highly bonded and has a high asbestos content.

Bitumen felts and coated metal

Some roofing felts, flashing tapes, damp-proof courses and other products may be made of asbestos fibre (usually chrysotile) or asbestos paper in a bitumen matrix. Roofing felts of this type are no longer manufactured in or imported into the United Kingdom.

Asbestos mixed with bitumen or bitumen reinforced with asbestos paper has also been used since the 1920s as a coating for corrugated steel sheeting, which is used as roofing or cladding in warehouses and factories.

Fibre release is unlikely during normal use of these materials.

Flooring materials

Asbestos fibre has been added to certain polyvinylchloride (PVC) and thermoplastic floor tiles and sheet materials. There have been examples of PVC flooring containing less than 10% chrysotile and thermoplastic flooring containing up to 25% asbestos fibre.

Some types of PVC flooring used in the past may have had a 100% chrysotile asbestos paper backing; this application has been discontinued in the United Kingdom.

Fibre release is unlikely to be a hazard under normal service conditions. Fibres may be released when the material is cut and there may be a substantial release when removing flooring, especially if it has paper backing.

Textured coatings and paints

The supply and application of any paint or varnish containing asbestos for use at work is now prohibited by the Asbestos (Prohibitions) (Amendment) Regulations 1988. However, asbestos may still be found in some existing textured coatings or paints, eg 'Artex'. In the past, these materials have contained chrysotile at levels of 3-5%.

Fibres may be released when old coatings are being rubbed down or replaced.

Reinforced plastics

Cladding, panels and a variety of other products including household items such as plastic handles and battery cases, have been made from asbestos-reinforced PVC, reinforced with chrysotile.

No significant release of fibres should occur from these materials under normal use.

Mastics, sealants, putties and adhesives

Small quantities of asbestos fibre (0.5-2% asbestos content) may be included in mastics, weather-proofing sealants, putties and adhesives to impart anti-slumping characteristics, to improve covering power and to prevent cracking and crazing.

The only possible hazard may be from fibre release when sanding down hardened materials.

2.2 Wastes

The main manufacturing period for asbestos products in the United Kingdom was prior to the earliest effective waste legislation in the 1970s (the Control of Pollution Act 1974). Disposal of wastes, handling of materials and housekeeping on site before this time would generally have been haphazard and uncontrolled. The following sections summarise disposal practices during this period.

2.2.1 Asbestos waste

Tanks were often used on asbestos works sites for storing suspended asbestos cement waste prior to re-use. Some board and sheet manufacturing sites had outdoor slurry ponds to allow asbestos solids to settle out prior to disposal. The material was excavated and disposed of either on or off site, but in some cases may have been abandoned.

Off-cuts, off-specification materials and broken cement sheets were often sold for use as hardcore by builders and at factory sites. Occasionally this type of waste was used as fill material on site or was dumped on or off site.

Waste insulating board could be pulverised and recycled within the process; its re-use was economic and improved the quality of the finished product. Where recycling was not undertaken, waste was dumped on or off site.

Asbestos dust arose from many stages of processing, mainly when handling materials, when cutting and machining asbestos sheets and at all stages of the manufacture of asbestos textiles. Some works employed local dust extraction systems where the dust was collected, bagged and tipped off or on site. Where space was available, waste asbestos was often buried or used as fill or sub-base material on site or in the locality.

2.2.2 Other process wastes

Process wastes varied depending on the manufacturing process involved. In general wastes will have arisen through the following activities:

When paints were used for the surface coating of asbestos insulating board and asbestos cement.

Paints used before 1960 would have contained metallic pigments such as chromium, cadmium and lead salts. Paints for external use on asbestos cement were normally solvent-based rubber or acrylics, frequently containing iron oxides or carbon black fillers. Epoxy-based paints were not introduced until the 1960s and were generally supplied in smaller quantities. Residual waste paint and contaminated solvent would have arisen at batch ends, eg during colour changes and washdown of machinery using solvents.

When friction materials were impregnated with powdered or liquid resins.

These were usually phenolic-formaldehyde resins (each company had its own closely guarded formulations).

When moulded materials were produced.

A rubber matrix was commonly used, combined with curing agents and anti-oxidants. Alternatively, synthetic elastomers, such as acrylonitrile and PVC-based rubbers were used.

When asbestos packing materials were mixed with other fibres such as cotton and jute, to which petroleum oils and other hydrocarbon-based lubricants were added.

In more modern production processes it was more common to mix asbestos with polytetrafluoroethylene (PTFE).

A number of solvents (see Annex) were commonly used for thinning resins and oils and for cleaning equipment and treatment tanks etc. Re-distillation or disposal of dirty solvents may have occurred on site. Spillage and poor housekeeping were widespread.

Sites may also have their own electrical sub-stations which may have utilised polychlorinated biphenyl oils (PCBs).

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 2. 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

3.1.1 Asbestos

The prime potential contaminant is asbestos itself, the sources of which can be related to the following:

Storage areas and raw materials handling

Asbestos materials were stored in warehouses. Sacks were packed under compression and were prone to breakage when handled, thus releasing fibres into the environment.

Manufacturing

Asbestos fibres in dust and discarded materials would have spread generally throughout the site as a result of movement of materials and wastes. In the early years (1900s to 1960s) there was little knowledge of the hazards of asbestos and attitudes toward its handling were lax. For example in textile mills raw asbestos was often strewn on the floor of operational areas. The mixing of dry materials and movement of raw materials and products around the site would have resulted in spillage of asbestos materials, causing general surface contamination around the site.

Disposal

Waste asbestos would have been re-used where possible. Dust extracted from process areas would have been the prime source of raw asbestos requiring disposal. However, waste materials containing asbestos were often dumped on site if space was available. Asbestos cement was often used for making up ground and as foundation material for new buildings, car parks etc. Other asbestos waste may have been dumped in numerous localities on site or in nearby sites. Random, uncontrolled disposal of asbestos may have occurred when sites were due for closure, leaving unprocessed asbestos materials on site. Therefore discrete areas of buried asbestos may be found on sites during redevelopment.

Deposits of asbestos should be relatively easy to identify as fibrous grey/white/light brown or bluish material. If asbestos has been buried, this would probably be in discrete concentrated deposits as raw asbestos or identifiable asbestos products, possibly mixed with rubble or other general industrial waste.

3.1.2 Fuels

Coal or oil would have been stored on site for the operation of process machinery. The storage (especially underground) of fuel oil has often resulted in spillage or leakage on sites. Whether contamination is limited or extensive would depend on factors such as ground conditions, duration and volume of leaks etc.

3.1.3 Process chemicals

The storage, use and disposal of the process chemicals previously described could have resulted in contamination of soils.

3.1.4 PCBs

If the site has had transformers containing PCBs then localised soil contamination may have occurred due to leakage and spills of the oil.

3.2 Migration and persistence of contaminants

3.2.1 Asbestos

Asbestos is not soluble or biodegradable, and is therefore persistent in the environment. Chrysotile is the only form that is attacked by acid. Asbestos fibres can be spread throughout the soil of a site and its surroundings by water or by the action of tunnelling animals. Dust or fibres on the surface can be moved around a site by wind dispersal.

It is possible that plant buildings and infrastructure were insulated with asbestos lagging, or asbestos cement sheeting was used in roofing or cladding. This waste asbestos material may be found in discrete dumps on the site where plant has been dismantled or is still associated with existing buildings and plant.

3.2.2 Solvents

Solvents contaminate ground and surface water supplies as they are generally low viscosity liquids and mobile in soil. They are liable to percolate through soil or to be washed off in surface run-off. These compounds may dissolve synthetic materials such as plastics, causing damage to infrastructure, or they may infiltrate water supplies carried by plastic piping. The non-chlorinated solvents are reasonably biodegradable, the chlorinated solvents are less so.

3.2.3 Fuel oils

Many of the components of oils are mobile and/or water soluble. Therefore, contamination of ground and surface water may occur. Oil (and solvent) vapours may build up in confined spaces such as disused pits, tanks and pipework. Although oils are biodegradable under favourable conditions, bitumen is much less degradable.

3.2.4 Coal products

Carbon residues may build up from the stockpiling of coal or coke for use as fuels. The mobility of these residues is low, unless they are in the form of dusts, in which case wind may disperse them. Where coal or coke has been in use or stored for many years, carbon residues may also be found in the form of impacted coal carpets.

3.2.5 Resins, rubber and elastomers

Although a range of resins, rubbers and elastomers are potential contaminants at sites of asbestos works, they are not expected to occur in large quantities. However, as many of them will have been used in solvent-based formulations, they are potentially mobile and may be found in groundwater. They are persistent in the soil.

3.2.6 *Metals*

The lead compounds found in paint pigments are fairly soluble and can therefore enter the water environment. Acid conditions increase the mobility of cadmium allowing contamination of ground and surface water. It is possible for water to be contaminated by chromium since magnesium and sodium chromates and dichromates, and chromic acid are very soluble in water. Because lead, cadmium and chromium were used in solvent-based paints, they will be mobile and could pollute the groundwater. Their presence may also inhibit micro-organisms, reducing the biodegradation of other pollutants, such as oils and solvents, which may be present.

3.2.7 *PCBs*

PCBs, present in certain types of electrical equipment, have a low solubility in water and do not degrade. They are fat-soluble and tend to accumulate in food chains.

4. Sources of further information

4.1 Organisations

For information concerning the past operation and potential hazards associated with asbestos industry in the United Kingdom, the following organisations and trade associations should be consulted:

Health and Safety Executive (HSE)

The HSE have regional offices all over the United Kingdom (see local telephone directory for the address and telephone number for the relevant HSE Area Office). They have published 'Approved Codes of Practice' and 'Guidance Notes' which detail compliance with legislation through recommended identification, removal and monitoring methods for asbestos. They also provide information on relevant health and safety legislation (see Section 4.4).

Asbestos Information Centre
PO Box 69
Widnes
Cheshire
WA8 9GW

This was formerly the Asbestos Research Council, funded by the asbestos industry. It is a useful source of information on past and present asbestos companies.

Society for the Prevention of Asbestos and Industrial Diseases
6a Station Road
Cuffley
Hertfordshire
EN6 4HT

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

Department of the Environment. *Asbestos wastes.* Waste Management Paper No. 18. London, HMSO, 1971.

Department of the Environment. *Special wastes: a technical memorandum providing guidance on their definition.* Waste Management Paper No. 23. London, HMSO, 1981.

Department of the Environment. *Asbestos materials in buildings.* 3rd Edition. London, HMSO, 1990.

EC Council Directive 87/217 EEC *on the prevention and reduction of environmental pollution by asbestos.*

Health and Safety Commission. *Asbestos: final report of the Advisory Committee.* Volume 1. London, HMSO, 1979.

Inter-Departmental Committee on the Redevelopment of Contaminated Land. *Asbestos on contaminated sites.* Report No. 64/85. 2nd Edition. ICRCCL, 1990.

Institute of Wastes Management. Code of Practice for the disposal of asbestos waste. 1988.

Mattison M L. *Asbestos and asbestos related diseases.* Medical Advisory Group. Asbestos Information Centre. Epsom, the Centre, 1987.

Merger and Monopolies Commission Report: *A Report on the Supply of Asbestos and Certain Asbestos Products.* HMSO, 1973.

Selected Written Evidence Submitted to the Advisory Committee on Asbestos. HMSO, 1977.

References to the United Kingdom Census of Production and other sources of information concerning the size of the asbestos industry can be obtained from the following: Central Government statistics, held principally by the Guildhall Library, Aldermanbury, London and the City Business Library, 1 Brewers Hall Garden, London.

Case study including information relevant to this 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 Related DOE Industry Profiles

Chemical works: coatings (paints and printing inks) manufacturing works
Chemical works: linoleum, vinyl and bitumen-based floor coverings manufacturing works
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works
Pulp and paper manufacturing works
Textile works and dye works

4.4 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 relevance are:

Her Majesty's Inspectorate of Pollution. *Processes involving asbestos.* Chief Inspector's Guide to Inspectors, Process Guidance Note IPR 3/3. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Tar and bitumen processes.* Chief Inspector's Guidance to Inspectors, Process guidance Note IPR 6/2. 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.

4.5 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.

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.

Asbestos	actinolite amosite (brown asbestos) anthophyllite chrysotile (white asbestos) crocidolite (blue asbestos) tremolite
Solvents	methylated spirits toluene trichloroethylene white spirit xylene
Oils and oil products	bitumen fuel oils lubricating oils
Coal products	carbon residues
Other organic compounds (only produced with certain processes/products)	elastomers eg acrylonitrile, PVC-based rubbers epoxy resins phenolic resins phenolic-formaldehyde resins polytetrafluoroethylene (PTFE) polycyclic aromatic hydrocarbons (where carbon black used as a filler) eg anthracene phenanthrene benzo(a)pyrene
Polychlorinated biphenyls (PCBs)	
Metal pigments in paints	aluminium cadmium chromium lead
Antioxidants	based on amines eg dimethylamine, para- phenylenediamine based on substituted phenols and dibenzyl disulphide
Curing agents	
Inorganic compounds	iron oxides magnesium sulphate magnesium carbonate magnesium dichromate sodium chromate sodium dichromate chromic acid

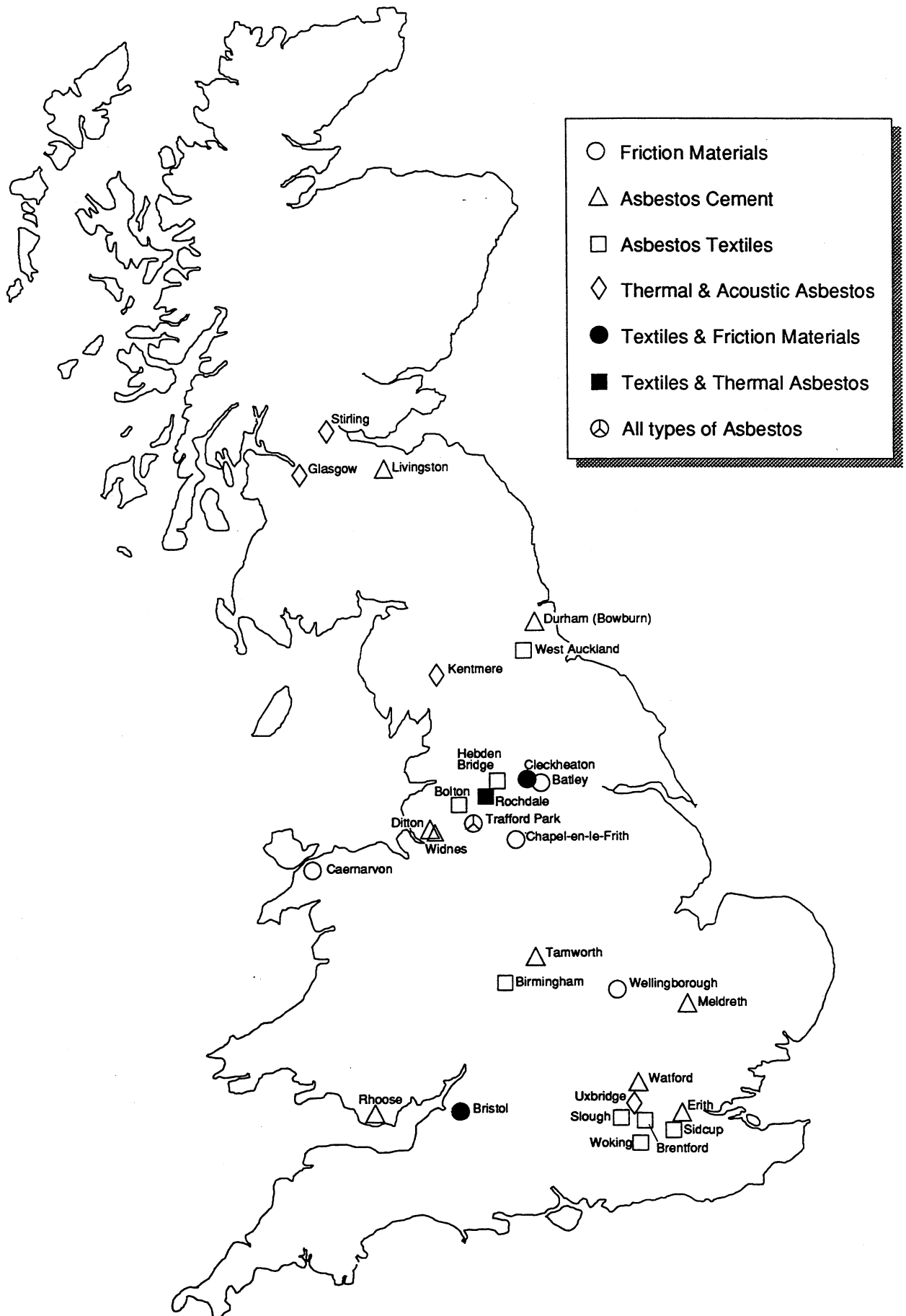
Table 2 Main groups of contaminants and their probable locations

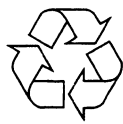
Asbestos manufacturing works

Contaminant	Location								
	Process buildings and building fabric	Raw material storage and handling	Manufacturing areas	Pipework and pumps	Product storage areas	Waste storage areas	On-site waste disposal (inc made ground and foundations)	Fuel storage	Electrical transformer capacitors
Metals									
Inorganic compounds									
Asbestos									
Organic compounds									
Fuels									
PCBs									

Shaded boxes indicate areas where contamination is most likely to occur

Figure 1 Location of major asbestos manufacturing works in the United Kingdom in the 1970s. (From Merger and Monopolies Commission Report, see Section 4)





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

Gasworks, 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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