Department for Environment, Food and Rural Affairs and The Environment Agency

POTENTIAL CONTAMINANTS FOR THE ASSESSMENT OF LAND

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Statement of Use
This publication identifies priority contaminants (or families of contaminants), selected on the basis that they are likely to be present on many sites affected by current or former industrial use in the UK in sufficient concentrations to pose a risk, either to humans, building, water or ecosystems. It also indicates which contaminants are likely to be associated with particular industries. The report has been written for technical professionals who are familiar with the risks posed by land contamination to human health but who are not necessarily experts in risk assessment. It is expected to be of use to all parties involved with or interested in contamination, but in particular to those concerned with the assessment of land contamination.

Keywords
Soil Guideline Values, land contamination, priority contaminants, risk assessment.

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Contents

LIST OF TABLES

1 Introduction

1.1 This report presents a selection of contaminants that may be relevant for the assessment of contaminated land because they are likely to be found on a large number of industrial sites in the UK and have the potential to affect human health and the environment.

1.2 The primary purpose of the selection has been to provide the Department for Environment, Food and Rural Affairs (DEFRA) with a guide to the substances it should cover in its research work on contaminated land. The report is one of a series published by DEFRA and the Environment Agency that is relevant to the assessment of the risks to human health arising from long-term exposure to soil contamination. These reports take into account the wider DEFRA and predecessor departments guidelines on assessing and managing environmental risk (DETR, Environment Agency and IEH, 2000). It is strongly recommended that each report in the series should be read in conjunction with the others, and Table 1.1 provides more information on the content of each report.

1.3 Regulators, developers and their advisers will be interested in the selection because it identifies contaminants that are important on a national basis. The selection can also be used for the assessment of individual sites. However, if the selection is put to this use it should be noted that it will not be necessary to investigate all the selected substances on every industrial site, and, depending on their particular industrial histories, some sites might need to be investigated for substances that are not included in the selection.

1.4 The report deals with the criteria for selection, the risks such contaminants are likely to pose, and the reasoning behind non-selection of certain substances.

Table 1.1 Assessment of risk to human health from land contamination. Key reports from DEFRA and the Environment Agency.

CLR 7 *Assessment of Risks to Human Health from Land Contamination: An Overview of the Development of Soil Guideline Values and Related Research* (DEFRA and Environment Agency, 2002a). CLR 7 serves as an introduction to the other reports in this series. It sets out the legal framework, in particular the statutory definition of contaminated land under Part IIA of the Environmental Protection Act (EPA) 1990; the development and use of Soil Guideline Values; and references to related research.
This document: CLR 8 *Priority Contaminants for the Assessment of Land*. This identifies priority contaminants (or families of contaminants), selected on the basis that they are likely to be present on many current or former sites affected by industrial or waste management activity in the United Kingdom in sufficient concentrations to cause harm; and that they pose a risk, either to human health, buildings, water resources or ecosystems. It also indicates which contaminants are likely to be associated with particular industries.
CLR 9 *Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans* (DEFRA and Environment Agency, 2002b). This report sets out the approach to the selection of tolerable daily intakes and Index Doses for contaminants to support the derivation of Soil Guideline Values.
CLR TOX 1–10 (DEFRA and Environment Agency, 2002c). These reports detail the derivation of tolerable daily intakes and Index Doses for the following contaminants, which are arsenic, benzo[*a*]pyrene, cadmium, chromium, inorganic cyanide, lead, phenol, nickel, mercury and selenium.
CLR 10 *The Contaminated Land Exposure Assessment Model (CLEA): Technical Basis and Algorithms* (DEFRA and the Environment Agency, 2002d). This report describes the conceptual exposure models for each standard land-use that are used to derive the Soil Guideline Values. It sets out the technical basis for modeling exposure and provides a comprehensive reference to all default parameters and algorithms used.
CLR GV 1–10 (DEFRA and Environment Agency, 2002e). These reports set out the derivation of the Soil Guideline Values for the following contaminants, which are arsenic, benzo[*a*]pyrene, cadmium, chromium, cyanide (free, simple, and complex inorganic compounds), lead, phenol, nickel, mercury (inorganic compounds) and selenium.
CLR 11 *Model Procedures for the Management of Contaminated Land* (DEFRA and the Environment Agency, in preparation). This report incorporates existing good technical practice, including the use of risk assessment and risk management techniques, into a systematic process for identifying, making decisions about and taking appropriate action to deal with contamination, in a way that is consistent with UK policy and legislation.

2 Potential Contaminants for the Assessment of Industrial Land

2.1 It is recognised that there is a need to focus the development of Soil Guideline Values on substances that are most likely to be of concern in the context of land in the UK. Selection criteria must be defined which allow appropriate prioritisation of substances, and the development of a coherent programme of research. The criteria used for making the selection are described, together with the reasoning behind exclusion of certain substances or types of substance. The programme of work is kept under review, and where it has become apparent that there is a need to include new substances, then the Soil Guideline Value programme has been amended accordingly.

Need for a Selection of Potential Contaminants

2.2 One of the conclusions of the House of Commons Select Committee on the Environment in its report on contaminated land in 1990 was that "standards must be set to cover a broad range of contaminants, at levels which ensure that not just public health, but the environment as a whole, is protected from pollution and harm" (House of Commons Environment Committee, 1989–90). Many substances are toxic to humans, given a sufficient dose, but it is not practicable to develop guidance in relation to all of them. Hence a shortlist of contaminants must be drawn up to provide a basis for work on toxicological data and Soil Guideline Values for chronic risks to human health. Regulators and others concerned with contaminated land also need to know what substances are likely to be important.

Criteria for selection

2.3 Two criteria have been used in this report for the selection of potential contaminants. The first criterion is that the contaminants must be likely to be present on many sites affected by current or former industrial use in the United Kingdom in sufficient concentrations to cause harm. The purpose of this criterion is to exclude substances that are rarely found or are very unlikely to be present in harmful concentrations.

2.4 A selection of contaminants based only on their prevalence would be of limited use, because contaminants are important only if they present an actual risk. The second criterion therefore is that the contaminants must pose a potential risk to human beings and to sensitive environmental receptors, that is, the water environment, the ecosystem, or the integrity of construction or building materials. Established approaches to risk assessment have been used in this connection, in particular the contaminant–pathway–receptor concept. Only substances meeting both criteria have been selected.

2.5 Consequently, the substances selected are:

- likely to occur on many industrial sites in sufficient concentrations to cause harm or pollution; and
- known or suspected to pose a significant risk of harm to humans (death, serious injury, cancer or other disease, genetic mutation, birth defects, or the impairment of reproductive functions);

- or
- known or suspected to pose a significant risk in the water environment, or likely to cause other adverse impacts in the water environment, as a result of their presence on land; or
- known or suspected to pose a significant a risk to ecosystems as a result of their presence on land; or
- known or suspected to have a significant effect on buildings or building materials; or
- known or suspected to be persistent and mobile in soils or have a tendency to bioaccumulate through exposure of sensitive organisms.

Contaminants likely to be present on many sites

2.6 The primary source used for identifying those contaminants likely to be present on many sites has been the Department of the Environment's *Industry Profiles* (Department of the Environment, 1995–96) which describe specific industrial processes and the chemicals that are commonly found on industrial land as well as chemicals that are less frequently found or are usually found only in low concentrations. In this exercise the chemicals that are likely to be found on many sites in significant concentrations have been considered. When an investigation is carried out on a particular site it will be necessary to explore the possibility that chemicals not taken into consideration in this work are important in the context of the site in question.

2.7 The substances included in ICRCL Guidance Note 59/83 (Interdepartmental Committee on the Redevelopment of Contaminated Land, 1987) and the substances identified by the Department of the Environment in its response to the House of Commons Select Committee on the Environment on contaminated land (Department of the Environment, 1990) have also been taken into account.

Contaminants likely to pose a risk

2.8 The substances found to occur frequently on sites have been assessed to establish whether they pose an actual risk. Risk will depend on the nature of the hazard, the probability of exposure, the pathway by which exposure occurs, and the likely effects on the receptor. Each substance has therefore been assessed to establish whether it is likely to be a hazard and whether there is a potential pathway to each of the receptors mentioned in the above paragraph. The assessment has been undertaken using data in the open literature, in reports prepared by contractors for DEFRA and predecessor departments and by consultation with a number of other public and private sector organisations.

2.9 In this report it would not have been sufficient to examine only the toxicity of the substances. To do so would have led to the exclusion of chemicals of low toxicity, which are frequently found in high concentrations and which therefore could pose a significant risk.

2.10 Contaminants have been selected where there is a significant risk because there is a high hazard or toxicity together with a low level of exposure, or a low hazard or toxicity together with a high level of exposure, if such levels of exposure can occur in practice.

2.11 Information on the toxicity and hazards of industrial chemicals can be found in key texts (Lewis, 1992). In addition, the Chemicals and Biotechnology Division of the Department of the Environment has published environmental hazard assessments for a number of substances (Department of the Environment, 1991–95).

The Selection of potential contaminants

2.12 Tables 2.1 and 2.2 show the contaminants that have been selected on the basis of the criteria discussed above. The tables also indicate the receptors most likely to be at risk from exposure to these contaminants.

2.13 Tables 2.3 and 2.4 show the industrial uses of land with which the selected contaminants are associated. This is based on the information contained in the *Industry Profiles*.

2.14 In Tables 2.1, 2.2, 2.3 and 2.4 the chemicals are divided into the following broad categories:

- metals
- semi-metals/non-metals
- inorganic chemicals
- organic chemicals
- others

2.15 It must be stressed that the non-selection of a substance does not guarantee that it could *not* pose a risk as a result of its presence in contaminated land. Each site must be considered on an individual basis taking into account previous site use and other local factors. Information in the *Industry Profiles* (Department of the Environment, 1995–96) is based partly on experience in the UK of investigation and redevelopment of industrial sites. Consequently, more information will have been available on contaminants of concern for which analytical methods and standards or criteria (whether UK-based or overseas) are available.

2.16 It is possible on certain sites that significant contamination could be caused by substances which have not previously been measured in site investigations, or which have not traditionally been associated with particular industrial uses, or which are not identified in the *Industry Profiles*. It is therefore important to ensure that individual site assessments are not over-dependent on the selection of potential contaminants presented in this report and that careful desk study research is undertaken by specialists prior to the commencement of detailed site investigation and testing work. Selection of substances has also taken account of the requirements of a number of European Directives.

Table 2.1 Potential inorganic contaminants for the assessment of industrial land and their receptors

Contaminants [a, b]	Receptors			
	Humans	Water	Vegetation and the ecosystem	Construction materials
Metals				
Barium		✓		
Beryllium	✓	✓	✓	
Cadmium	✓	✓	✓	
Chromium	✓	✓		
Copper		✓	✓	
Lead	✓	✓	✓	
Mercury	✓	✓	✓	
Nickel	✓	✓	✓	
Vanadium	✓	✓		
Zinc		✓	✓	
Semi-metals and non-metals				
Arsenic	✓	✓		
Boron		✓	✓	
Selenium	✓	✓	✓	
Sulphur	✓		✓	✓
Inorganic chemicals				
Cyanide (complex)	✓	✓	✓	✓
Cyanide (free)[c]	✓	✓	✓	
Nitrate		✓		
Sulphate		✓	✓	✓
Sulphide		✓	✓	✓
Other				
Asbestos	✓			
pH (acidity/alkalinity)	✓	✓	✓	✓

Notes

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be selected because of their infrequent occurrence generally.

[b] For references to synonyms of substances refer to Appendix C.

[c] Free cyanide is broadly equivalent to "easily liberatable cyanide", which covers compounds that can release hydrogen cyanide at pH 4 and 100^{o}C (see paragraph B.15 in Appendix B).

Table 2.2 Potential organic contaminants for the assessment of industrial land and their receptors

Contaminants [a, b]	Receptors			
	Humans	Water	Vegetation and the ecosystem	Construction materials
Acetone	✓	✓		
Oil/fuel hydrocarbons	✓	✓	✓	✓[c]
Aromatic Hydrocarbons				
Benzene	✓	✓	✓	✓[c]
Chlorophenols	✓	✓	✓	✓[c]
Ethylbenzene	✓	✓	✓	✓[c]
Phenol	✓	✓	✓	✓[c]
Toluene	✓	✓	✓	✓[c]
o-Xylene	✓	✓	✓	✓[c]
m,p-Xylene	✓	✓	✓	✓[c]
Polycyclic Aromatic Hydrocarbons	✓	✓		
Chlorinated Aliphatic Hydrocarbons [d]				
Chloroform	✓	✓	✓	
Carbon tetrachloride	✓	✓	✓	✓[c]
Vinyl chloride	✓	✓		
1,2-Dichloroethane	✓	✓	✓	✓[c]
1,1,1-Trichloroethane	✓	✓	✓	✓[c]
Trichloroethene	✓	✓	✓	✓[c]
Tetrachloroethene	✓	✓	✓	✓[c]
Hexachlorobuta-1,3-diene	✓	✓	✓	
Hexachlorocyclohexanes	✓	✓	✓	
Dieldrin	✓	✓	✓	
Chlorinated Aromatic Hydrocarbons				
Chlorobenzenes	✓	✓	✓	
Chlorotoluenes	✓	✓	✓	
Pentachlorophenol	✓	✓	✓	
Polychlorinated biphenyls[e]	✓	✓	✓	
Dioxins and furans[f]	✓	✓	✓	
Organometallics				
Organolead compounds	✓		✓	
Organotin compounds	✓	✓		

Notes

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be selected because of their infrequent occurrence generally.

[b] For references to synonyms of substances refer to Appendix C.

[c] The impact of chlorinated hydrocarbons and other organic substances is probably limited to concentrations in the free phase.

[d] Some chlorinated aliphatic hydrocarbons are considered to be of secondary importance (see paragraphs B.16 and B.17 in Appendix B) and are therefore excluded because they are less toxic, highly volatile or have limited industrial use. However, some highly volatile substances may be significant due to their solubility and are not excluded on grounds of volatility alone.

[e] There are 209 polychlorinated biphenyl (PCB) congeners, the significance of which can be expressed using toxic equivalency factors (TEFs) relative to the best-characterised member of the group.

[f] There are 210 possible isomers of chlorinated dioxins and furans, of which the most studied and most toxic representative of the group is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). Other dioxins and furans could be expressed in terms of TEFs relative to 2,3,7,8-TCDD.

Substances not selected

2.17 It is important to emphasise that not all the chemicals, which appear on pollutant lists such as those above, should be considered as relevant contaminants for the assessment of contaminated land. Such substances may be hazardous, but may not fulfil the other selection criteria. Some substances may not be persistent enough to cause long-term hazardous effects, while for others there may be no suitable pathway from contaminants to sensitive receptors.

2.18 Many pesticides such as dichlorvos, atrazine and simazine are on the UK Red List and are prescribed substances for release to water, but have not been initially selected as potential contaminants for the assessment of industrial land as set out in this report. The selection of contaminants is mainly confined to substances, which are found in land as a direct result of the industrial use of the land. As the programme of work progresses, the range of substances under consideration will increase, and it is likely that some pesticides will be brought into the work where it is considered appropriate.

2.19 However, the most common and important reasons for substances not being selected are either the relative infrequency of their occurrence at contaminated sites or the lack of evidence regarding their presence at contaminated sites. Appendix B sets out the reasoning behind exclusion of certain substances from this report.

Table 2.3 Examples of association of important contaminants with industrial uses of land – metals, semi-metals, non-metals, inorganic chemicals and others

Industry	Key Contaminants [a]																				
	Metals										Semi -metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_0	Complex CN^-	Free CN^-	NO_3^-	SO_4^{2-}	S^{2-}	Asbestos	pH
Airports				✓	✓										✓					✓	✓
Animal and animal products processing works			✓	✓							✓							✓	✓		
Asbestos manufacturing works			✓	✓		✓												✓		✓	
Ceramics, cement and asphalt manufacturing works			✓	✓	✓	✓	✓	✓		✓	✓								✓	✓	✓
Charcoal 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 and other rubber products)										✓				✓					✓		
Chemical works: soap and detergent manufacturing works																					✓
Dockyards and dockland			✓	✓	✓	✓	✓	✓		✓	✓							✓	✓	✓	
Dry cleaners			✓	✓	✓	✓	✓			✓	✓		✓			✓	✓	✓		✓	✓

Industry	Key Contaminants [a]																				
	Metals										Semi -metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_0	Complex CN^-	Free CN^-	NO_3^-	SO_4^{2-}	S^{2-}	Asbestos	pH
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			✓	✓	✓	✓				✓			✓			✓	✓	✓	✓	✓	✓
Fibreglass and fibreglass resin manufacturing works			✓	✓	✓	✓	✓	✓		✓	✓		✓			✓	✓	✓		✓	✓
Gasworks, coke works and other coal carbonisation plants			✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓		✓	✓	✓	✓
Glass manufacturing works			✓	✓	✓	✓	✓	✓		✓	✓	✓				✓	✓	✓		✓	✓
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 metals (excluding lead works)			✓	✓	✓	✓	✓	✓	✓			✓							✓	✓	
Metal manufacturing, refining and finishing works: precious metal recovery works			✓	✓	✓	✓	✓			✓	✓						✓	✓	✓	✓	✓
Oil refineries and bulk storage of crude oil and petroleum products					✓	✓		✓								✓			✓	✓	✓
Photographic processing industry			✓	✓	✓	✓	✓			✓	✓		✓			✓	✓	✓		✓	✓
Power stations (excluding nuclear power stations)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓					✓	✓	✓	✓
Printing and bookbinding works			✓	✓	✓	✓	✓			✓	✓		✓			✓	✓	✓		✓	✓
Pulp and paper manufacturing works			✓	✓														✓		✓	✓

Industry	Key Contaminants [a]																				
	Metals										Semi -metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_0	Complex CN^-	Free CN^-	NO_3^-	SO_4^{2-}	S^{2-}	Asbestos	pH
Railway land			✓	✓	✓	✓		✓	✓									✓		✓	
Road vehicle servicing and repair: garages and filling stations				✓	✓	✓				✓										✓	✓
Road vehicle servicing 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: solvent recovery works			✓	✓	✓	✓		✓		✓											✓
Waste recycling, treatment and disposal sites: metal recycling sites	✓		✓	✓	✓	✓	✓	✓		✓	✓					✓		✓	✓	✓	✓

Notes

[a] The information in this table is not comprehensive. The selection of contaminants for assessment of individual sites must be based on a detailed evaluation of the past uses of the land in question. Individual sites may be contaminated by substances that pose significant hazards but which do not meet the overriding criteria for inclusion in this report or the above table. More detailed reviews of such substances appear in the *Industry Profiles* (Department of the Environment, 1995–96) corresponding to each of the industries listed in this table.

Table 2.4 Examples of association of important contaminants with industrial uses of land – organic chemicals

Industry	Key Contaminants[a]													
	Phenol	Acetone	Chloro-phenols	Oil/fuel hydrocarbons[b,c]	Aromatic hydrocarbons	PAHs	Chlorinated aliphatic hydrocarbons	α, β and γ-hexachloro-cyclohexane	Dieldrin	Chlorinated aromatic hydrocarbons	PCBs[d]	Dioxins and furans	Organolead compounds	Organotin compounds
Airports		✓		✓	✓		✓				✓			
Animal and animal products processing works	✓				✓	✓	✓		✓					
Asbestos manufacturing works					✓	✓	✓				✓			
Ceramics, cement and asphalt manufacturing works		✓		✓		✓					✓			
Charcoal 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				✓	✓	✓	✓			✓	✓			

Industry	Key Contaminants[a]													
	Phenol	Acetone	Chloro-phenols	Oil/fuel hydrocarbons[b,c]	Aromatic hydrocarbons	PAHs	Chlorinated aliphatic hydrocarbons	α, β and γ-hexachloro-cyclohexane	Dieldrin	Chlorinated aromatic hydrocarbons	PCBs[d]	Dioxins and furans	Organolead compounds	Organotin compounds
Chemical works: rubber processing works (including works manufacturing tyres and other rubber products)	✓				✓		✓				✓			
Chemical works: soap and detergent manufacturing works		✓			✓	✓								
Dockyards and dockland	✓			✓		✓	✓	✓		✓	✓			
Dry cleaners					✓		✓				✓			
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		✓		✓	✓	✓	✓				✓			
Fibreglass and fibreglass resin manufacturing works	✓	✓			✓		✓				✓			
Gasworks, coke works and other coal carbonisation plants	✓				✓	✓								
Glass manufacturing works		✓			✓		✓				✓			
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 metals (excluding lead works)				✓	✓	✓					✓			

Industry	Key Contaminants[a]													
	Phenol	Acetone	Chloro-phenols	Oil/fuel hydrocarbons[b,c]	Aromatic hydrocarbons	PAHs	Chlorinated aliphatic hydrocarbons	α, β and γ-hexachloro-cyclohexane	Dieldrin	Chlorinated aromatic hydrocarbons	PCBs[d]	Dioxins and furans	Organolead compounds	Organotin compounds
Metal manufacturing, refining and finishing works: precious metal recovery works				✓			✓				✓			
Oil refineries and bulk storage of crude oil and petroleum products	✓	✓		✓	✓						✓		✓	
Photographic processing industry		✓			✓		✓				✓			
Power stations (excluding nuclear power stations)				✓		✓	✓				✓			
Printing and bookbinding works		✓			✓		✓				✓			
Pulp and paper manufacturing works				✓			✓	✓		✓	✓	✓		
Railway land						✓	✓				✓			
Road vehicle servicing and repair: garages and filling stations				✓	✓	✓	✓						✓	
Road vehicle servicing 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: solvent recovery works							✓			✓				
Waste recycling, treatment and disposal sites: metal recycling sites				✓			✓				✓			

Notes

[a] The information in this table is not comprehensive. The selection of contaminants for assessment of individual sites must be based on a detailed evaluation of the past uses of the land in question. Individual sites may be contaminated by substances that pose significant hazards but which do not meet the overriding criteria for inclusion in this report or the above table. More detailed reviews of such substances appear in the *Industry Profiles* (Department of the Environment, 1995–1996) corresponding to each of the industries listed in this table.

[b] Oil/fuel hydrocarbons are often found on sites where they were used as fuel in e.g. oil-fired boilers or auxiliary power generators. Thus, they could be found on virtually any industrial site of significant size, irrespective of the industrial use itself.

[c] Oil/fuel hydrocarbons are often determined analytically as "total petroleum hydrocarbons (TPH)".

[d] PCBs may be found on sites where they were used as dielectric fluids in capacitors in electricity substations. Thus, they could be found on virtually any industrial site of significant size, irrespective of the industrial use itself.

3 Use of the selection of potential contaminants for the on-going research programme

3.1 The primary reason for producing the selection of contaminants has been to identify the contaminants that DEFRA and the Environment Agency should deal with in their research on contaminated land, and in particular the research relating to the effects of contaminants on human health. This wider research therefore focuses on those contaminants for which a human receptor is identified in Tables 2.1 and 2.2.

3.2 The Contaminated Land Exposure Assessment (CLEA) programme of work being undertaken by the Environment Agency on behalf of DEFRA includes two main components: the collation of toxicological data; and their use to derive Soil Guideline Values for contaminated land where this is practicable.

3.3 It should be noted that it is not currently envisaged that Soil Guideline Values will be derived for asbestos and pH although they are identified as having human receptors in Table 2.1. Asbestos is an important contaminant in the sense used in this report, that is, it is found on a large number of industrial sites in the UK and it is a hazard to human health. Its assessment is discussed in ICRCL Guidance Note 64/85 (Interdepartmental Committee on the Redevelopment of Contaminated Land, 1990) and other publications. Site-specific assessment of pH will be relevant as a measure of acidity/alkalinity and an indication of and influence on contaminants.

3.4 The programme also includes work on producing Soil Guideline Values for a number of explosive substances. Explosives have not been included in the selection of contaminants presented in this report because they are not found on a large number of industrial sites in the UK. However, they have become of greater concern more recently with the introduction of the Contaminated Land (England) Regulations (2000) which define two categories of potential Special Site where explosives may occur (Ministry of Defence land, and land used for manufacturing or processing of explosives).

Appendix A Risks posed by contaminants on land

A.1 This appendix discusses hazards, pathways of exposure and risks posed by various contaminants to human health, the water environment, plants, ecosystems and construction materials. In this context, a contaminant is a substance which has the potential to cause harm, while a risk is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.

Risk to humans

A.2 One of the principal concerns related to contaminated land is that the contaminants present may represent a risk to human health. Contaminants appearing in Tables 2.3 and 2.4 include those that are known to be toxic and those that are known or suspected to be carcinogens, mutagens and/or teratogens, irritants or sensitisers. Such compounds, while representing a hazard, are only a risk if there is a pathway for them to be taken up by the human body.

A.3 Human exposure to soil contaminants can occur via many pathways. Direct human exposure pathways of importance include dermal absorption, inhalation of soil/dust, inhalation of volatilised compounds and inadvertent soil ingestion (or, in the case of some children, deliberate soil ingestion). Indirect pathways include plant uptake of contaminants followed by human ingestion, contaminant presence in groundwater/surface water followed by human ingestion, and pathways involving transfers through the food chain.

A.4 Humans potentially exposed to substances at contaminated sites through the pathways indicated above include those employed on operational sites, personnel involved with site investigations and the general public who may use the site before or after development. It is also possible that pathways such as contaminant volatilisation, migration to groundwater/surface water and contaminants associated with wind-blown dust can affect humans on surrounding sites.

Risk to the water environment

A.5 Some substances present at contaminated sites may be able to affect the aquatic environment adversely. The principal pathway by which contaminants reach the water environment is through a slow seepage or leaching to either groundwater or surface waters. The potential for various chemicals to migrate by such pathways is dependent on many factors, including their physico-chemical characteristics and the local hydrogeology. Substances that are water-soluble, and thus liable to leaching, would appear to be the primary candidates for reaching controlled waters. However, hydrophobic substances can reach the aquatic environment if they themselves are liquids such as solvents and fuel oils. In addition, processes such as erosion can deliver some substances associated with soil to surface watercourses where they may accumulate in sediments.

A.6 The presence of contaminants in the water environment can potentially adversely affect humans, aquatic life and the wider ecosystem, as well as construction and building materials. Contaminants that leach to groundwater not only cause environmental impairment, but may pose a threat to

drinking water supplies where groundwater is abstracted for potable supply. Contaminated groundwater seepage into surface waters can also result in deterioration in water quality. Groundwater contaminated with substances such as sulphate may also migrate and adversely affect concrete foundations and other structures.

A.7 In the water environment, contaminants may pose a threat through toxicity to aquatic flora and fauna, and/or by persisting in and accumulating in water/sediment/biota. Contaminants may also discolour water, thus interfering with the water's physico-chemical characteristics as well as causing aesthetic nuisance. In addition, substances that are not generally considered as being soil contaminants, if leached into watercourses, can result in a nutrient imbalance and/or enrichment, possibly causing eutrophication.

A.8 The Environment Agency has a duty to protect controlled waters (including groundwater and surface water) from contamination, including contaminated land sources. Its policy with respect to potential water pollution from contaminated sites has been defined (Environment Agency, 1998). The selection of potential contaminants in this report has been made with due regard to the contaminants of concern to the Environment Agency.

Risk to plants and the wider ecosystem

A.9 Soil contaminants, if present at sufficient concentrations, can have an adverse effect on the plant population. Phytotoxic effects can be manifested by a variety of responses, such as growth inhibition, interference with plant processes, contaminant-induced nutrient deficiencies and chlorosis or yellowing of leaves. All chemicals are probably capable of causing phytotoxic effects. Thus the phytotoxic potential of substances is dependent on the concentrations capable of having adverse effects on plants and the concentrations likely to be found at contaminated sites. Phytotoxicity is a difficult parameter to quantify given that experimental techniques vary widely and variations exist in plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals.

A.10 Contaminants may be taken up and accumulated by plants through a range of mechanisms. The principal pathways are active and/or passive uptake through the plant root, adsorption to root surfaces and volatilisation from the soil surface followed by foliar uptake. After plant uptake, contaminants may be metabolised or excreted, or they may be bioaccumulated.

A.11 Many of the substances capable of adversely affecting vegetation exert this effect due to their water solubility, a characteristic that could result in their transport from contaminated sites into adjacent locations where the chemical may generate a phytotoxic response. This could be important if, for example, the adjacent site has important conservation status.

Risk to building and construction materials

A.12 In addition to soil contaminants possibly having adverse effects on human health and the environment, some can have deleterious effects on building and construction materials.

A.13 Materials at risk from attack from possible soil contaminants include inorganic matrices such as cement and concrete, as well as organic materials such as plastics and rubbers (Environment

Agency, 2001). Plastics and rubbers are generally used for piping and as service ducts, and are potentially attacked by a variety of chemicals, most of which are organic chemicals, particularly petroleum-based substances. Drinking water supplies can also be tainted by substances that can penetrate materials used in piping.

Appendix B Review of individual contaminants not selected

B.1 This appendix considers certain important substances that were candidates for the selection in Tables 2.1 and 2.2, but which were not considered to meet the criteria for inclusion. It is important to stress that non-selection does not mean that a substance will not be present on some sites, or that it cannot represent a significant risk to human health and/or the environment under certain circumstances. The number of different chemical substances currently or formerly used in industry now probably exceeds 20,000. Many of these are hazardous to some extent, while the hazardous and toxic properties of a few are not yet understood. While the *Industry Profiles* will identify a larger number of substances than those in Tables 2.1 and 2.2 specifically associated with individual industries, the substances listed in the *Industry Profiles* and others identified in this appendix together represent only a small fraction of the known hazardous industrial chemicals. The brief review given below of some of the important substances not selected for inclusion in Tables 2.1 and 2.2 must therefore be read in that context and not taken to be a comprehensive review of hazardous industrial chemicals.

B.2 Certain metals, such as titanium, tellurium and uranium, were omitted from Table 2.1 because they have only rarely been found at UK contaminated/industrial sites. Other metals, including aluminium, antimony, cobalt, iron, manganese, molybdenum, silver, thallium and tin, were also excluded because they are not considered to meet the necessary criteria for inclusion described in Section 2. Non-metals excluded include ammonia, chloride, bromide, iodide, fluoride, nitrite and phosphate due to the low frequency with which they are identified at UK contaminated/industrial sites. Some of the organic substances omitted are the less toxic or less frequently encountered representatives of large groups of substances (for example, the chlorinated solvents).

Aluminium

B.3 At sites such as chemical works (cosmetics and toiletries manufacture; inorganic chemicals manufacture; pharmaceuticals), electroplating works, engineering works (aircraft, marine), metal works and power stations, aluminium may be present in soils at elevated concentrations. However, aluminium is not included because it does not pose a significant environmental risk, although it has been reported to have a detrimental effect on the performance of building materials (Building Research Establishment, 1994) and has been implicated in Alzheimer's disease, a degenerative brain disease in humans.

Antimony

B.4 Antimony contamination may be present at sites involved with vehicle manufacture, glass manufacture, metalliferous ore processing, metal reprocessing, timber treatment, waste disposal and power generation. Such contamination may represent a risk to vegetation because antimony is suspected to be moderately phytotoxic (Worthing and Hance, 1991). Antimony is also capable of having an adverse effect on aquatic life forms and is moderately toxic to animals. It is not selected because of its moderate toxicity and infrequent occurrence on contaminated sites in the UK.

Cobalt

B.5 Cobalt contamination may be apparent at coatings and printing works, linoleum and plastic floor covering manufacturing plants, electrical and electronic manufacturing works, fibreglass works, glass manufacture works, electroplating works and power stations. Cobalt is considered to be one of the more phytotoxic metals to higher plants. It may also be accumulated in certain plant tissues and therefore may have a harmful effect on grazing livestock. In addition, cobalt can be toxic to aquatic life. Toxicity to humans by ingestion is relatively low, although dermatitis may be caused through skin contact. Its low toxicity and relatively infrequent occurrence are the reasons why it is not selected.

Iron

B.6 Iron is a common soil component. Elevated soil iron concentrations may be found at numerous industrial sites such as chemical works, engineering works, power stations and scrapyards. While iron is not considered to represent a risk to humans or vegetation, for which reason it is not included, it may have a deleterious effect on water supply due to colour and precipitation, and may cause iron staining in surface waters. Iron is also reported to have a detrimental effect on the performance of building materials (Building Research Establishment, 1994).

Manganese

B.7 Soils at coatings and ink manufacture plants, chemical works, pharmaceutical works, glass works and textile and dye works are potentially contaminated with manganese. Soil manganese contamination may present a risk to the water environment because it may have a deleterious effect on water supply due to colour and precipitation. It is not included because its moderate toxicity to human health in a contaminated land context would not often represent a significant hazard.

Molybdenum

B.8 Molybdenum contamination is a possibility at mechanical engineering and ordnance works. It may represent a risk to humans and vegetation because it may be toxic at elevated concentrations and may be accumulated in some root crops. Molybdenum may also enter and adversely affect the aquatic environment. There are apparently no reports of industrial poisoning, and so it seems unlikely that a significant hazard would commonly occur on contaminated industrial sites. It has therefore not been included.

Silver

B.9 Silver contamination at sites involved in electroplating and metal finishing, photographic processes and mining activities can result in soil concentrations well in excess of typical levels. Silver may be toxic to higher plants and micro-organisms, while if it becomes incorporated into the water environment it may exert an adverse effect on some life forms. Metallic silver is not considered to be toxic to humans, although some silver compounds are corrosive. Silver oxide and silver salts are accumulated in various body tissues. Silver has not been selected because it has low toxicity to

humans and because, as it is valuable, it is likely to be recovered and not allowed to accumulate in soil in hazardous concentrations.

Thallium

B.10 Thallium may be found as a soil contaminant at some pesticides manufacturing plants, lead works and glass manufacture works. Thallium is one of the most toxic metals, causing neural, hepatic and renal injury in humans, and is also toxic to some aquatic species. It may also exert a phytotoxic response at contaminated sites. It is not included because it is not often encountered during investigations of contaminated land in the UK.

Tin

B.11 Soil found at coatings and printing inks manufacturing works, electrical and electronic equipment manufacturing works, ordnance works, electroplating works and scrapyards may contain tin in excess of typical levels. Although tin is not very toxic to humans, for which reason inorganic tin has not been selected, it may be toxic to plants and fungi and may accumulate in some plant tissues such as roots. Incorporation of tin into the aquatic environment may have an adverse effect on some life forms. Organotin compounds have been included in Table 2.2 because they are particularly toxic.

Ammonia

B.12 While ammonium salts are not considered to be important soil contaminants and are therefore not included, they are highly soluble, and if leached from contaminated sites into surface watercourses can exert a toxic effect on the flora therein. Landfill leachate may contain elevated ammonia levels. In addition, ammonia is reported to have a detrimental effect on the performance of building materials (Building Research Establishment, 1994).

Halides

B.13 **Bromides, chlorides** and **fluorides** have very similar chemical properties. Chloride is an essential micronutrient and is not considered to be an important contaminant in most soils, although it may be phytotoxic at elevated concentrations. It is reported to have a detrimental effect on the performance of building materials (Building Research Establishment, 1994). Fluoride contamination is possible at industrial sites such as inorganic chemical works, glass and china works and scrapyards. While fluoride is not considered to be a soil contaminant capable of having an adverse effect on human health, vegetation or building materials, it is potentially a contaminant in the water environment. Some bromides are used medicinally as sedatives. These anions are not included because they have a relatively low toxicity.

Phosphate

B.14 Phosphates are not considered to be important soil contaminants because they enhance plant growth. They have low toxicity to animals. Therefore, they are not included. However, phosphates are highly soluble and if able to enter surface water they may cause nutrient enrichment, which can result in eutrophication.

Thiocyanate

B.15 Cyanide in soils may be present in many forms and CONTEST (an analytical proficiency scheme for chemical testing managed from the Laboratory of the Government Chemist) has defined them as: easily liberatable cyanide, complex cyanide, total cyanide, and thiocyanate. Easily liberatable cyanides are compounds that may form hydrogen cyanide at pH 4 and boiling temperatures. These are very toxic and may be absorbed by humans via all exposure pathways. Complex cyanides are compounds liberating hydrogen cyanide at pH 2 and boiling temperatures. These are less toxic. Easily liberatable and complex cyanides are included in Table 2.1 because they can release hydrogen cyanide. Total cyanide is the sum of easily liberatable and complex cyanides. Thiocyanates are not selected because they are the least toxic of the cyanide species, although prolonged exposure can result in skin irritation and other non-acute symptoms. In addition, thiocyanates may be a concern for water supplies owing to their colour as well as to their toxicity.

Chlorinated Solvents

B.16 Several important chlorinated solvents are omitted from Table 2.2. These include **chloronaphthalene, dichloromethane, dichloropropane** and **dichloropropene.** A relatively large range of chlorinated solvents is used in industry; however, many of the *Industry Profiles* refer only to "chlorinated solvents" and do not name individual substances. Of those omitted, dichloromethane is probably identified most frequently in the *Industry Profiles*, being used as a solvent and degreaser in metal recovery, electroplating and vehicle manufacturing, service and repair. However, it is one of the least toxic of these compounds. 1-Chloronaphthalene is used as an industrial solvent, but other chlorinated naphthalenes are of little industrial importance. Dichloropropane and dichloropropene are also used as solvents and degreasers and have been used in admixture as a pesticide. They are toxic, but appear to have been less widely associated with industry than the listed compounds.

B.17 Toxic chlorinated aliphatic hydrocarbons of lesser industrial importance include 1,1-dichloroethane, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane.

Cyclohexanone

B.18 Cyclohexanone is used in the manufacture of caprolactam, nylon, adipic acid, nitrocellulose lacquer, celluloid and some printing inks. It has not been selected because it is only slightly to moderately toxic and is not frequently identified on industrial land.

Dihydroxybenzenes

B.19 The 1,2- (catechol) and 1,4- (hydroquinone) isomers are used in photographic developers and as anti-oxidants. Catechol and the 1,3- isomer (resorcinol) are used in the manufacture of dyes, although neither is specifically mentioned in the relevant *Industry Profile*. While these compounds are toxic through ingestion, inhalation and skin absorption, they are not frequently identified on industrial sites in the UK and are therefore not included.

Glycols

B.20 Monoethylene, diethylene and propylene glycols (hydroxyethane, 1,2-dihydroxyethane and hydroxypropane, respectively) are widely used as coolants and antifreezes. They are also used in the manufacture of some polymers. Large quantities are used at airports for de-icing both aircraft and runways. Glycols are very soluble in water and appear to be easily washed out of soil in runoff. They are also biodegradable. Their low toxicity, solubility and biodegradability are reasons for non-selection.

Isopropanol

B.21 Isopropanol is used in the manufacture of acetone and other organic chemicals. It is also used as a solvent for resins and antifreeze. It has properties similar to those of ethanol, although it is more narcotic. It is not considered an important toxic hazard in industry and is therefore excluded.

Methanol

B.22 Methanol is used in the manufacture of a wide range of organic chemicals. It is slightly to moderately toxic, and is therefore not selected, although sufficiently high doses can cause blindness. It has been used as a food additive.

Pesticides

B.23 Pesticide is a term that covers algicides, fungicides, herbicides, insecticides, rodenticides and wood preservatives. In the UK there are over 300 pesticide formulations available for use (Worthing and Hance, 1991).

B.24 Pesticides may pose risks to humans because of their toxicity and some are known or suspected carcinogens/mutagens. In soil they may affect microbial processes and terrestrial flora and fauna. Pesticides entering groundwater may threaten drinking water supplies, and their presence in surface watercourses may affect aquatic life.

B.25 Their toxicity and potential to cause harm to the environment do not make their selection for the assessment of land automatic. Some pesticides, such as pentachlorophenol, PAHs and organotin compounds, appear in Table 2.2 because they are included in other chemical groups. These groups have been selected because they meet the criteria of being found on many industrial sites and of being hazardous. With two exceptions, other pesticides fail to meet the criteria because there is no evidence to date that they are likely to be found on large numbers of industrial sites. The two additional pesticides that are selected are hexachlorocyclohexanes (the γ-isomer is a major constituent of lindane) and dieldrin. They were identified in the *Industry Profiles* on timber treatment works and textile and dye works as being potential contaminants on those sites. The selection includes the α- and β-isomers of hexachlorocyclohexane as well as the γ-isomer because these substances were by-products of lindane manufacture and were sometimes dumped as wastes. Other pesticides may be added to the research programme in the future if it is found that they are more regularly encountered on industrial sites.

B.26 One of the uses of the selection is to identify substances on which to collect toxicological information (see Section 3). In the case of pesticides there is already a considerable volume of literature on their toxicology.

Phthalates (phthalate esters)

B.27 Phthalates are very common in the environment. The di-n-octyl and diethyl esters are used as plasticisers in plastic manufacture, while other esters are used as insect repellents and in alkyd resins. They are mainly only slightly toxic through ingestion and inhalation. They are not specifically identified with large numbers of industrial sites and are therefore excluded.

Pyridine

B.28 Pyridine is used as a solvent in the plastics industry and in the manufacture of pharmaceuticals and rubber derivatives. It is moderately toxic, but is not frequently identified as a potential contaminant in the *Industry Profiles*.

Quinoline

B.29 Quinoline is a moderately toxic substance used in the manufacture of dyes and pharmaceuticals, although it is not specifically mentioned in the *Industry Profile* covering dye works and is therefore excluded.

Styrene

B.30 Styrene is used almost exclusively in the manufacture of polymers, most notably polystyrene. This very restricted range of uses is the reason for its exclusion.

Tetrahydrofuran

B.31 This compound is used as a solvent for some resins and plastics. Although it is fairly toxic, it is not selected because it is not specifically mentioned as a contaminant in a large number of *Industry Profiles*.

Thiophene and derivatives

B.32 **Thiophene** is a moderately toxic substance used in some organic chemical syntheses. **Tetrahydrothiophene** is a solvent and intermediate and is used to give natural gas an odour. Neither of these substances is selected because they are only rarely identified as potential contaminants on industrial sites in the UK.

Appendix C Naming of chemical substances

C.1 While organic compounds are in general named in accordance with the IUPAC nomenclature (IUPAC, 1979), trivial names or names conforming to other conventions are often used to identify contaminants. This is especially true in historical documents pre-dating the IUPAC convention.

C.2 The following list shows some of the commonly used synonyms and trivial names for contaminants listed in this report. A complete reference on synonyms for any chemical substance is available (Lewis, 1992).

Common names	**Other names**
Phenol	Hydroxybenzene
Acetone	2-Propanone, dimethylketone
Oil/fuel hydrocarbons	Petroleum hydrocarbons
Toluene	Methylbenzene
Xylenes	Dimethylbenzenes
Polycyclic aromatic hydrocarbons	Polycyclic aromatics, PAHs
Chloroform	Trichloromethane
Carbon tetrachloride	Tetrachloromethane, perchloromethane
Vinyl chloride	Chloroethene, chloroethylene
1,1,1 – Trichloroethane	Methylchloroform
Trichloroethene	Trichloroethylene, ethinyl trichloride
Tetrachloroethene	Tetrachloroethylene, perchloroethylene
γ- Hexachlorocyclohexane	Lindane, γ-benzene hexachloride
Dioxins	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin and other isomers
Furans	2,3,7,8-Tetrachlorodibenzo-*p*-furan and other isomers

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