ENVIRONMENT AGENCY

Hazardous Waste Management Market Pressures and Opportunities: Background Paper

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Statement of Use
This document sets out the pressures and opportunities acting in the hazardous waste market over the next 5 years. The findings provide a basis upon which the Environment Agency can inform the Government's hazardous waste forum, and prioritise broader actions for change. The report identifies areas for investigation where information and industry responses to the changes occurring are not fully quantified. This report is of interest to regulators, policy makers, waste producers, the waste management industry, and is a key reference for the Hazardous Waste Forum.

Keywords
Hazardous waste, waste treatment capacity, scenario analysis, special waste, priority waste stream.

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Executive Summary

The way in which hazardous wastes are to be managed in the future is set to change significantly. Several European Directives relating to hazardous wastes and the options for their management pose a major challenge for UK Government, industry and regulators.

This report sets out the pressures and opportunities acting in the hazardous waste market over the next 5 years. The findings provide a basis upon which the Environment Agency can inform the Government's hazardous waste forum, and prioritise broader actions for change. The report identifies areas for investigation where information and industry responses to the changes occurring are not fully quantified. The study has not sought to provide a definitive analysis of how the hazardous waste market will develop.

Underpinning the study has been a review of the issues arising from the Environment Food and Rural Affairs (EFRA) Select Committee on Hazardous Waste. These issues include considering the impact of legislation and improving data on hazardous waste production and management. The review includes a number of scenarios for hazardous waste management over the next 5 years.

The report identifies a number of issues for discussion and action:

1. The waste management industry is currently experiencing increased business risks associated with economic performance. The current cost of capital, delays associated with gaining planning permission and a perceived lack of enforcement of unscrupulous operators, means that the industry is unlikely to invest in new, large-scale treatment capacity, without absolute market certainty, i.e. the point at which material is being stockpiled. A common call from these operators is that regulations need to be enforced consistently across the board so that a level economic playing field is provided. In the short to medium-term, the industry will seek to work closer with waste producers to deliver on-site or localised solutions, and also with the water and cement industries, to provide an integrated network of reception facilities for hazardous wastes.
2. The ban on hazardous liquids and solids with prescribed properties to landfill since July 2002 has not as yet had a major impact on the hazardous waste supply chain. Waste management industry sources indicate that this is as a result of operators finding ways around the controls. Instances were given of wastes being blended such that they can still be disposed of to landfill. Such operators (legitimate or otherwise), are able to offer ongoing capacity for these wastes, at low cost. The resulting impact is that the larger waste management firms are unwilling to invest significant amounts of capital to develop new facilities as they may not attract sufficient waste at the target gate fee to deliver an economic return.
3. The market could change markedly in 2004 when co-disposal of hazardous waste must cease. The result will be an increase in costs of hazardous waste disposal and the need for a substantial increase in waste minimisation. Significant additional treatment capacity will be required over and above what is currently available, potentially of the order of 2 million tonnes per annum. Further investigation is needed to substantiate this figure and to establish the nature of treatment required.
4. The pressures on capacity at merchant waste treatment facilities and increases in costs would suggest an increase in on-site treatment at producer sites and/or process re-engineering is necessary. It is likely that the large producers will invest in technology that will allow them to reduce cost, operational and regulatory risks. Set against this, many producer companies will be reluctant to invest in options requiring capital expenditure, either because their operations

are already cost-marginal or because they believe that they will not be producing the same hazardous wastes in the future. It is very difficult to predict the way in which industry will react to these pressures, and at what point in time they will react. There will be an increase needed in waste minimisation. The threat of unlawful dumping of waste will rise.

5. There remains considerable uncertainty around the impact that the proposed changes to the classification of hazardous wastes will have on the number and type of producers, and the quantities of material generated in the UK.

6. In common with many EU Member States, the UK suffers from a lack of accurate data on hazardous waste arisings and the availability and capacity of facilities to deal with it. Improvements in this are key to better understanding of the likely future conditions. Ideally integrated data management systems are required that deliver timely and accurate information to support strategy formulation and investment decision making.

7. Some forthcoming legislation will lead to a phased reduction in the quantities of hazardous materials entering the waste management supply chain. The Waste Electrical and Electronic Equipment (WEEE), End of Life Vehicles (ELV), Solvent Emissions (SED), Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) and Batteries Directives all place controls on the input and treatment of hazardous substances within product streams. Pollution Prevention and Control (PPC) should lead to a reduction in the quantities of hazardous waste generated. However, the impact of these will take up to 10 years to be fully realised.

8. A list of priority wastes to be investigated further in the short-term is presented including oily sludges, hazardous agricultural wastes, waste mineral oils, contaminated soils and asbestos, and air pollution control (APC) residues from waste incineration processes.

Contents

Abbreviations

APC	Air Pollution Control
BCA	British Cement Association
BOD	Biochemical Oxygen Demand
CIA	Chemical Industries Association
COD	Chemical Oxygen Demand
DEFRA	Department for Environment, Food and Rural Affairs
DOC	Dissolved Organic Carbon
DTI	Department of Trade and Industry
EFRA	Environment Food and Rural Affairs
ELV	End of Life Vehicles
EPA	Environmental Protection Agency
ESA	Environmental Services Association
EU	European Union
EWC	European Waste Catalogue
GDP	Gross Domestic Product
HTI	High Temperature Incineration
HWL	Hazardous Waste List
LAPC	Local Authority Pollution Control
LFD	Landfill Directive
LOI	Loss on Ignition
MSW	Municipal Solid Waste
ORA	Oil recovery Association
PPC	Pollution Prevention & Control
RFO	Recovered Fuel Oil
RoHS	Restrictions of Hazardous Substances in Electrical and Electronic Equipment
SED	Solvent Emissions Directive
SIC	Standard Industrial Classification
SLF	Substitute Liquid Fuel
STW	Sewage Treatment Works
SWaT	Special Waste Tracking (database)
SWR	Special Waste Regulations
TOC	Total Organic Carbon
UK	United Kingdom
UWWTD	Urban Waste Water Treatment Directive
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WEEE	Waste Electrical & Electronic Equipment
WID	Waste Incineration Directive
WML	Waste Management Licensing
WOD	Waste Oils Directive
WRAP	Waste & Resources Action Programme

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- Knox Associates
- Lanstar
- Marcus Hodges Environment
- National Federation of Demolition Contractors
- Oil Recycling Association
- OSS
- PCI Membranes
- Shanks Waste Solutions
- Solutex
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- STARNET
- Tetronics

1. Introduction

The way in which hazardous waste is managed will change significantly over the next few years, driven by a series of European Directives affecting both resource use and waste management. Among other impacts, these Directives will direct hazardous waste away from landfill, impose more stringent requirements for waste treatment and incineration and increase the number of types of waste defined as hazardous.

The Environment Agency's Vision identifies provision of "A 'greener' business world" and "Wiser, sustainable use of resources" as key themes for the future[1]. Delivering these themes, the Environment Agency is working with Government to simplify and improve the regulatory process for business, improve access to environmental information for business and the public, and promote the prevention of pollution and minimisation of waste in industry. These aims are core to securing the long-term sustainable management of hazardous wastes.

1.1 Context - The EFRA Select Committee Report

The Environment, Food & Rural Affairs Committee report into Hazardous Waste (published 26th July 2002) reviewed the current status of hazardous waste management in the UK.

The Committee received evidence from a number of organisations including the waste management industry, trade associations, DEFRA and the Environment Agency. One of the key recommendations of the committee was that 'the Government should encourage the development of a national hazardous waste forum to address the issues outlined in the (also proposed) framework document. The forum must involve waste producers, the waste management industry, regulators and local government…'

In its evidence submitted to the EFRA Select Committee, the Environment Agency made a number of observations that underpin the need to better understand how the hazardous waste management market will evolve in the future:

- The costs of hazardous waste management are set to rise, making alternative waste recovery and treatment options economically viable; and
- Pressures on capacity at existing facilities to accept hazardous wastes will increase, resulting in higher costs throughout the supply chain. This will potentially increase the incentive for illegal hazardous waste disposal.

The Environment Agency also made a number of recommendations to the Select Committee. These included:

- Support of the Government's current review of the planning system such that timely and appropriate provision of new hazardous waste recovery or disposal facilities is made at the local level; and
- Strengthening and streamlining the Duty of Care provisions to reduce the risk of hazardous wastes being mis-classified as non-hazardous.

[1] Environment Agency website. http://www.environment-agency.gov.uk

The impact of the Landfill Directive was central to the evidence submitted, the Select Committee's recommendations and the Government's reply to the report. The concerns raised over the Directive and delays to the confirmation of Waste Acceptance Criteria (WAC) led to a number of recommendations concerning the process of engagement and drafting of future EC environmental legislation.

In their submissions to the inquiry both the Environment Agency and the Environmental Services Association (ESA) called for a national strategy for hazardous waste management. While the committee rejected this suggestion, the proposed Hazardous Waste Forum will provide a foundation for co-ordinated action by key players.

Environment Secretary Margaret Beckett announced the formation and membership of the forum on 4th December 2002[2]. The forum's key objectives are stated to be:

- To advise within 6 months on the way ahead over the next 5 years to achieve hazardous waste reduction and environmentally sound management of such wastes, including advice on key decisions to be made, the timing of those decisions and encompassing consideration of targets for hazardous waste reduction;
- To identify opportunities to reduce the production of hazardous waste and the recovery of that which is produced;
- To consider the impacts of existing and forthcoming legislation, and advise on the content and dissemination of Government and/or Environment Agency advice and guidance to waste producers and waste managers about that legislation; and
- To provide a better basis for forward planning by providing up to date and reliable data on hazardous waste production and management, and make any relevant recommendations about how data collection and analysis could be improved.

1.2 Project Aims and Objectives

The aim of this report is to explore the issues arising from the EFRA Select Committee on Hazardous Waste, the focus being on the considerations below:

- Regulatory and market uncertainties – the need to understand the impact of future regulatory changes and market forces, in order to better predict future market responses and scenarios;
- The provision of timely high-quality data on the amount and types of hazardous waste produced and projections for future years; and
- The development of management methods to assist in planning for future capacity.

In this report Chapter 2 discusses the drivers for change, predominantly legislative. Chapter 3 focuses on the capacity for treating waste in England and Wales, including a brief consideration of key technologies. Against this, the 'supply' side of waste treatment, Chapter 4 considers the trend in waste arisings from different sectors which might represent a 'demand' for treatment. Chapter 5 pulls together the findings of previous chapters by analysing a number of possible scenarios of arisings; in Chapter 6 the responses of various stakeholders are considered, and some of the key waste streams highlighted, where it is apparent from our analysis that closer investigation is needed. The driver for this is that there may be a specific shortfall in available management

[2] DEFRA website. http://www.defra.gov.uk/news/2002/021204c.html

methods for these 'priority wastes' given changing market conditions. Chapter 7 contains conclusions and recommendations for further work.

This report is the result of a short study of readily available data and information. It provides information to underpin the Environment Agency's knowledge of the hazardous waste market, to facilitate a dialogue with stakeholders and so develop a basis for forward planning. The information upon which the study is based is predominantly sourced from England and Wales, although the wider findings and market implications may be pertinent to the whole of the UK.

2. Hazardous Waste Management – Drivers for Change

2.1 Introduction

Currently consigned special waste arisings (expected to be redefined as hazardous) are transported across the country in significant volumes. The provision of merchant reception facilities operated by the private sector results in producer decisions being governed by market conditions. The result of this is that material flows vary on a short-term basis.

As an indication of current market forces acting, landfill has remained a cheap and readily available disposal option, particularly for contaminated soils. Industry sources have identified, at the time of this report being prepared, that tarry wastes are being landfilled at a gate fee of £12-15 per tonne. These wastes are apparently exempt from taxation (because their removal from site is necessary to allow the site to be developed in accordance with Customs and Excise rules[3]) and as such a 'dig and dump' approach for these waste types has been common throughout the industry.

New legislation and policy are key drivers affecting hazardous waste generation and management in the UK. An element of this study has been to review the relevant legislation and summarise the impacts on the hazardous waste market. Table A1 (Appendix A) presents the key findings of this review, summarising the impacts and timing of the legislation.

In order to set a benchmark of arisings against which the impacts of the legislation (and further market pressures introduced later in the report) can be assessed, details of the main sources of hazardous waste information and arising levels are presented. The main sources of hazardous waste data reviewed, and the limitations on their use for market analysis purposes, are summarised in Appendix B.

2.2 Waste Arisings – Present Situation

2.2.1 Special Waste

The Environment Agency collects data on hazardous waste movements as part of its regulatory responsibilities; this is achieved via the return of consignment notes. At the time of this report being prepared, the most recent Environment Agency data describing arisings of hazardous waste in England and Wales is for the year 2000, and indicates that some 5.2 million tonnes of waste were consigned[4]. Around 21 percent of the special waste produced in 2000 was oil and oil/water mixtures; a further 20 percent was construction and demolition waste and asbestos; 14 percent was 'not otherwise specified' and 11 percent was organic chemical process waste. Management methods for the special waste consigned in 2000 involved 40 percent (approximately 2 million tonnes) being sent to landfill, 30 percent for treatment, 19 percent for recycling / re-use and 3 percent for incineration[2].

The Environment Agency's Special Waste Tracking (SWaT) database, from which the above information is derived, represents a valuable source of information for the monitoring of special

[3] HM Treasury website. http://www.hm-treasury.gov.uk
[4] Environment Agency website. http://www.environment-agency.gov.uk

waste movements and to inform future policy and decision-making. These data lack some precision due to some duplicate waste entries, double counting of wastes and misclassification[5]. While the Agency is working on data quality improvements the current data inaccuracy is not believed to be critical to the overall needs for strategy purposes. Other factors also need to be taken into account that contribute to the confidence to be ascribed to the total measurement of waste arisings.

Wastes not caught by the consignment note system

A variety of wastes have not historically been caught by the consignment note system because they are treated or disposed of at the site where they are produced, typical management methods being deposition to lagoons, boreholes and in-house landfills. Common sources of these wastes are the metals and inorganic chemicals industries. The quantities of material managed in this way are significant - as much as 9 million tonnes per annum although much of this comprises carrier liquid. The solid element associated with these wastes may amount to 500,000 tonnes per annum[6].

A number of the larger in-house depositories taking these wastes are ceasing to operate, either as a result of reduced activity in heavy manufacturing or because, in the case of pulverised fuel ash lagoons, the material is being increasingly recovered[7].

Clearance of major contaminated land sites accounts for large quantities of potentially hazardous wastes that have not been formally consigned in the past, owing to the fact that they are often excavated, treated and re-deposited on site. Activity is normally licensed but does not result in the material being consigned and thus recorded on the SWaT database.

It should be an objective of future work to more thoroughly quantify the types and tonnage of waste not subject to the Special Waste Regulations (SWR) 1996, along with an assessment of how changing legislation will impact their future management.

2.2.2 Hazardous Waste

In its response to the Select Committee's report, the Government acknowledged the difficulty introduced by the reclassification of a number of waste streams as hazardous and hence the feasibility of generating a reliable baseline for hazardous waste production. Specific issues include the classification, numbers of producers and general awareness.

Classification

The replacement of the term 'special' with 'hazardous' and the associated classification of such wastes against the European Waste Catalogue Hazardous Waste List (EWC HWL) will result in an increased range of potentially hazardous wastes being generated in the UK.

The problems caused by changes to waste classification schemes are not restricted to the UK. Research across Europe has shown that a range of hazardous waste classification schemes have been used historically, with only a handful of member states fully adopting the HWL following its introduction in 1994[8]. As a result, it has been difficult to draw any meaningful conclusions about trends in hazardous waste production across Europe.

Hazardous Waste Producers

As a result of the way in which hazardous wastes are classified, with many mirror entries in the EWC HWL, it is not possible to accurately predict exactly how many hazardous waste producers will be active as the new classification system takes effect.

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[5] Environment Agency. Hazardous Waste Interrogator. 1998/99.
[6] Environment Agency website. http://www.environment-agency.gov.uk
[7] Industry source
[8] Hazardous Waste Generation in EEA Member Countries. European Environment Agency. 2002.

A limited number of waste and sector-specific pieces of research have been carried out providing hazardous waste arising data that can be used in addition to that collected by the Environment Agency under the existing consignment system. An example waste stream covered by such work is that of air pollution control (APC) residues from municipal waste incineration plants[9].

A key area where additional hazardous waste producers will be captured by the anticipated changes to the wider waste management regime is agricultural properties, including large-scale farms and smaller holdings. The Environment Agency has estimated that there are approximately 240,000 agricultural holdings in the UK[10], although it is unclear exactly how many of these will be producers of hazardous waste.

Industry Awareness

In support of the Environment Agency's preparations early in 2002 for the anticipated new hazardous waste regulations, a market research survey was undertaken to establish views and awareness of the planned changes to the SWR. An element of this work included contact with Trade Organisations. Of the Trade Organisations contacted, few, other than the British Cement Association (BCA) and Chemical Industries Association (CIA) for example, were aware of any impending changes to the hazardous waste system.

The findings of the market research have identified this apparent low level of awareness as a key issue to be overcome by the Environment Agency in communicating the requirements of the Hazardous Waste Regulations and encouraging the adoption of best practice in hazardous waste minimisation and management.

It is a conclusion of this report that it may be useful to repeat the Trade Association survey early in 2004 in order to assess whether the position of awareness and industry research has changed in the run up to the new Hazardous Waste Regulations being introduced.

2.2.3 Future Hazardous Waste Information

When the anticipated new hazardous waste regulations are implemented, any new data management system set up by the Environment Agency should be used to determine a baseline of hazardous (as newly defined) waste arisings. The accuracy of this data should improve rapidly as producers fulfil the requirements of the proposed registration system and targeted inspections minimise the occurrence of hazardous waste management outside the regulations.

2.3 Summary of Impacts – Hazardous Waste Projection

The primary trend and legislative drivers identified as affecting waste projections in this study are set out below:

2.3.1 The EC Landfill Directive

The Landfill Directive will deliver significant changes in the market through the imposition of controls on what has historically been the primary disposal option for hazardous wastes generated in the UK. Key issues include the banning of liquid disposal to landfill and an end to the co-disposal of hazardous and non-hazardous wastes.

9 Solid Residues from Municipal Waste Incinerators in England and Wales. Environment Agency. May 2002.

10 Towards Sustainable Agricultural Waste Management. Report produced on behalf of the Environment Agency by Marcus Hodges Environment. 2001.

The Environment Agency is concerned that landfills solely for hazardous waste disposal may require very long-term management and monitoring[11]. This type of landfill is relatively new to the UK, and the Agency is investigating other EU Member States' experiences to guide the controls needed for preparation, operation and after-care of these sites. A priority will be the period from the ending of co-disposal and requirement for treatment in July 2004, and the implementation of Landfill Directive Waste Acceptance Criteria, expected to be in 2005. During that period it would be possible to deposit something like the current range of hazardous wastes, but without the benefit of co-disposal landfill processes to decompose or immobilise the hazardous constituents. Over this timeframe, leachate may be quite different from that produced by co-disposal or under WAC, requiring new or reconfigured treatment processes to ensure its safe treatment and disposal.

The Landfill Directive will require management methods for a wide range of hazardous waste streams to change. The potential impact on a selected number of waste streams generated by the chemical sector are presented in Table 2.1.

[11] EFRA Select Committee on Hazardous Waste. July 2002.

Table 2.1 Implications of the Landfill Directive on selected chemical industry wastes

Waste / Industry	Properties	Current disposal method	Current cost[12]	Impact of Landfill Directive	Expected lowest cost option	New cost
Friedel Kraft reaction residues	Bulk acidic liquid, raw COD 300,000 mg/l (mixed toxic organics)	Neutralise and landfill	£10 – 40+ / tonne	Liquid banned from landfill, COD and toxicity too much for Physical / Chemical	Physical / Chemical, oxidation, separation, biological, then discharge	£100+ / tonne
Distillation residues	Drummed distillation residues, sludge, flashpoint < 21°C	Solidify and landfill	£10 – 130 / tonne	Sludge banned from landfill (flammability) in July 2002	Incineration / SLF / RDF / separation / recycling	£50+ / drum
Glycol waste	Contaminated monoethyleneglycol, irritant	Landfill	£10 – 40 / tonne	Banned from landfill in 2002 (hazardous liquid)	Streams with high concentration of glycol – SLF or separation & recycling Streams with low concentrations – filtration and biotreatment	£100 - £150 / tonne+
Photographic waste	Harmful liquid containing hydroquinones – H5	Landfill	£10 – 40 / tonne	Banned from landfill in 2002 (hazardous liquid)	1. Super Biotreatment – oxidation first stage to destroy toxicity of hydroquinone, wet air oxidation or treatment with ozone or peroxide, biotreatment, filtration and discharge to sewer	£120 - 150 / tonne
					2. Incineration	£200 / tonne
Drilling muds	Bentonite, synthetic and mineral oils – oil concentration >0.1% hazardous	Landfill	£10 – 40 / tonne	Hazardous liquid – banned from landfill in 2002	Simple solidification – to 2004? Recycling - Thermal or physical separation; Recycling oils if possible otherwise use as SLF; Solids recycled in building materials	£130 - £180 / tonne

Source: Shanks presentation. Countdown to July 16th - The Strategic Implications of the Landfill Directive. Joint CIA / ESA conference. May 2002.

[12] Waste industry estimate.

The broad requirements of the Landfill Directive are likely to lead to hazardous waste management costs increasing in the medium to long-term. This will place economic pressure on process industry waste producers and should encourage them to increase emphasis on unit cost reduction through waste minimisation and recycling activities. Based on our subjective assessment of possible market responses, it is assumed that this will promote waste reduction of between 2 and 10 percent per annum beyond 2004/5 (in process waste generating sectors).

An alternative response to the pressure of increasing costs is illegal disposal. In the short-term (until 2004/5), landfill operators are selling hazardous capacity at reduced rates in a bid to fill void space. Industry sources contacted for this report suggest that some sectors at least are taking advantage of lower landfill disposal costs. Decisions by managers of contaminated land clearance projects and those with stockpiled wastes are cited as those capitalising on low disposal costs.

2.3.2 The Proposed Hazardous Waste Regulations and Waste Classification Changes

Since 1996 the Hazardous Waste List (94/904/EC)(HWL) has been recast and incorporated within the European Waste Catalogue (EWC).

Classification of wastes against the EWC HWL will introduce a number of new waste streams as potentially hazardous, e.g. cathode ray tubes from televisions and personal computers. However, it is unclear to what extent the new classification will result in an overall increase in quantities of waste consigned as hazardous. Monitoring will reveal this as the changes take place.

2.3.3 Pollution Prevention and Control (PPC)

IPPC operates under the Pollution Prevention and Control (England and Wales) Regulations 2000. These Regulations have been made under the Pollution Prevention and Control (PPC) Act 1999, which implemented EC Directive 96/61 on IPPC. Separate systems have also been introduced to apply the IPPC Directive to Scotland, Northern Ireland and the offshore oil and gas industries. The Directive required member states to implementation by 2007.

The PPC Regulations make provision for the permits to include waste minimisation and opportunities for re-use on site. This should lead to a reduction in the quantities of hazardous waste generated.

A draft Environment Agency target for waste reduction[13] is to secure an overall 15% reduction in waste production by Agency regulated processes. This is likely to be sought partly through a 10% increase in resource efficiency via PPC. In determining the overall impact of these measures it will be useful to distinguish and quantify that element of hazardous waste minimisation attributable to IPPC.

For those waste handling companies operating facilities covered by PPC, the rigorous permitting process and associated cost implications (through increased process management and engineering), will result in some re-evaluation of the economic benefits of running such facilities. In a market where margins are low, this may lead to a contraction in capacity at a time when a net increase is required. In its submission to the EFRA Select Committee, Onyx claimed that the phased introduction of PPC permits in the waste sector will lead to 'waste tourism', i.e. waste streams will be diverted to sites applying later for PPC permits, as increased costs are passed on to producers.

2.3.4 Waste Electrical and Electronic Equipment Directive (WEEE)

The Waste Electrical and Electronic Equipment (WEEE) Directive seeks to promote the separate collection, re-use or recycling of electronic waste. The WEEE Directive requires producers to

[13] Environment Agency draft Corporate Strategy

recover 75 percent of goods taken back for disposal and to re-use 70 percent of those goods. A target for the separate collection of 4kg of WEEE per inhabitant per year is to be achieved by the end of 2006.

The final text of the Directive was ratified by the European Parliament on 18 December 2002 and is likely to enter onto the EU statute book in February 2003. Member States have 18 months to transpose the Directive into national law, with producer responsibility due to start in around March 2005.

Producer responsibility legislation such as WEEE will require increased segregation of wastes, and is likely to result in an increase in quantities of material managed as hazardous. There will be a subsequent requirement for new facilities for materials recovery and to treat and dispose of the hazardous wastes arising from that recovery.

2.3.5 Restriction of Hazardous Substances Directive (RoHS)

The Restriction of Hazardous Substances (RoHS) in Electrical and Electronic Equipment Directive is meant to complement the WEEE Directive by banning the use of certain hazardous substances in new electrical equipment.

The RoHS Directive will deliver a phased reduction in certain hazardous materials (lead, cadmium, mercury, hexavalent chromium, brominated flame retardants and PBB/PBDE) in the waste stream beyond 2007.

2.3.6 End of Life Vehicles (ELV) Directive

The End of Life Vehicles (ELV) Directive has the objective of preventing waste from ELVs and improving levels of recycling and reuse[14]. It aims to minimise the impact of such vehicles on the environment, e.g. by reducing the amount of waste going to landfill from vehicles reaching the end of their life by:

- Introducing controls on the 'scrapping' of ELVs (by restricting treatment to authorised facilities);
- Implementing new environmental treatment standards; and
- Setting rising re-use, recycling and recovery targets.

The targets require 85 percent of ELVs to be re-used or recovered (80 percent re-used or recycled) by January 2006, and 95 percent of all ELVs to be re-used or recovered (85 percent re-used or recycled) by 2015.

Two new consultations on the implementation of the Directive are to be published in early 2003, with the final regulations expected around July 2003.

The ELV Directive will encourage the limitation of hazardous materials in new vehicles in order to reduce the amount of hazardous waste eventually produced and to ease recycling. It will divert hazardous elements from mixed waste management disposal to targeted recycling and treatment. Manufacturers are already seeking to utilise materials that are easier to recycle and there will be a long-term downward trend in unit quantities of hazardous material being used in new vehicles and consequently arising in ELVs.

[14] DTI Website. http://www.dti.gov.uk

2.3.7 Batteries Directive

The European Commission has drawn up a proposal (latest draft issued March 2001) which will require the collection and recycling of all types of batteries. The Batteries Directive will result in an increase in the number of battery waste streams and the quantities segregated for treatment / disposal. The new Directive would ban the use of mercury in batteries immediately: all batteries containing more than 5ppm of cadmium by weight are scheduled to be banned by January 2008.

2.3.8 Waste Incineration Directive (WID)

The Waste Incineration Directive (WID) updates the requirements of the 1989 Municipal Waste Incineration Directives and, merging them with the 1994 Hazardous Waste Incineration Directive, consolidates new and existing incineration controls into a single piece of European legislation. WID also upgrades technical requirements to reflect technological advances, and broadens the scope of the waste incineration regime to cover wastes that were not previously regulated.

WID is likely to require expensive upgrading of some incinerators and plants burning wastes as fuel. The impact of the regime on market economics may inhibit some plants from burning wastes such as waste oil, raising the possibility of an increase in the illegal disposal of waste.

With limited incentives for oil recycling, the impact of the Directive is likely to be to increase the amount of waste oil entering the waste management system, at the same time as reducing the number of disposal sites. Off site treatment options for waste oils, other than recycling, include blending to make cement kiln or power station fuels. Combustion in roadstone coating plants is also a treatment option. There are approximately 300 of these plants in the UK, regulated under LAPC (Local Authority Pollution Control). The plants are used to dry limestone before coating it with bitumen. As a result of the Directive virgin fuel sources may replace waste oils. This will result in waste oil being primarily used when firing up coal fired power stations (where financially viable) and cement kilns. Producers of waste oil may in the future have to pay for its disposal, where as at present it has a positive value.

2.3.9 Solvent Emissions Directive (SED)

The Solvent Emissions Directive (SED) limits the emissions of VOC's due to the use of organic solvents by certain sectors. The aim is to play a part in reducing the release of more harmful VOCs and reducing ozone pollution in the EU.

Levels of organic solvents used will drop in the period 2003 – 2007, the extent will depend on how producers respond to the pressures on VOC emissions brought about by the SED.

3. Hazardous Waste Capacity and Options

3.1 Current and Future Capacity

This Chapter provides baseline information about hazardous waste landfill and treatment capacity and the range of management options available to support the future scenario analysis presented in Chapter 5.

There are currently no aggregate industry sources of capacity data for the management of hazardous waste in the UK. In the absence of this data a review of the most useful sources has been undertaken. This has focussed on information collected by the Environment Agency that can be used to inform estimates of capacity, a review of submissions made to the EFRA Select Committee and other industry sources.

The data presented should be taken as an indication of the potential capacity that might exist; it is not regarded as a quality sufficient for business planning purposes. A key recommendation of this study is that efforts be made to improve the quality of capacity data in the future.

Table 3.1 and 3.2 summarise available information on treatment capacities for different categories of hazardous waste management from a number of sources. Table 3.1 shows there is a wide range of views of capacity in the period up to 2004/5. Part of the reason for this is the comfortable margin provided by landfill through co-disposal (as indicated by data provided by the Environment Agency Conditioning Plan centre). Once this route is closed, treatment capacity is likely to be a significant limiting factor.

The data sources, analysis methods and assumptions used to derive the figures presented are contained in Sections 3.2 and 3.3.

Table 3.1 Estimates of Hazardous Waste Capacity to 2004/5

Management Method	Estimated Annual Capacity (tonnes) by Source							
	Environment Agency			Industry (data submitted to EFRA Select Committee)				**Range**
	Conditioning Plan data	Charge-band data	WML/site return data	Biffa	SITA	Cleanaway	BCA	
Landfill	6,400,000-9,600,000							6,400,000 - 9,600,000
Treatment		2,118,695	3,841,000	<1,000,000	1,500,000			<1,000,000 - 3,841,000
HTI						105,000		
Co-incineration							118,000 (SLF)	

Table 3.2 Estimates of Hazardous Waste Capacity Post 2004/5

Management Method	Estimated Annual Capacity (tonnes) by Source							
	Environment Agency			Industry (data submitted to EFRA Select Committee)				**Range**
	Conditioning Plan data	Charge-band data	WML / site return data	Biffa	SITA	Cleanaway	BCA	
Landfill	?[1]							
Treatment		2,118,695	3,841,000	<1,000,000	1,500,000			<1,000,000 - 3,841,000
HTI						105,000		
Co-incineration							200,000 (SLF) – 545,000 (SLF + waste oil)	200,000 (SLF) – 545,000 (SLF + waste oil)

1. Unknown, but capacity will be limited by number of sites operating as hazardous and the need for pre-treatment

3.2 Landfill Capacity

3.2.1 Site Conditioning Plan Data

Under the Landfill Directive implementation timetable, site operators have already submitted Site Conditioning Plans including their intentions to operate hazardous, non-hazardous or inert sites once the ban on co-disposal comes into force. This information has been collated on a regional basis within the Environment Agency, and summary data made available to inform this study.

The situation to July 2004

A total of 218 sites have been classified as interim hazardous in the period up until July 2004 where co-disposal of hazardous and non-hazardous wastes remains permissible. No void space data has been made available for 114 of the 218 sites (52 percent). For those sites for which data is available, total void space is estimated to be 207 million cubic metres. This would equate to a total national capacity of 400 million cubic metres.

Assuming an indicative bulk density of 0.8 tonnes per cubic metre, and 6 percent of the total capacity may be available for hazardous waste disposal[15], there could be capacity for as much as 19.2 million tonnes of waste until the ban on co-disposal and full implementation of WAC occurs. Over a two to three – year time horizon, this equates to a capacity of 6.4 – 9.6 million tonnes per annum. The 6 percent throughput assumption does not take up all available capacity. As such the capacity estimate has the potential to rise, the level of this rise being quantifiable through industry sources or a spot check of licenses.

This confirms information provided by the waste management industry suggesting that there is currently ample landfill void space, short-term, for hazardous waste disposal[16].

The situation post July 2004 and beyond implementation of WAC

Environment Agency data[17] indicates that operators intend to run 38 - 41 'hazardous' landfill sites beyond July 2004. Void space data has been provided for 17 sites, the total figure for these being 5.79 million cubic metres. From the data provided, there is no way of assessing what element of the available void space will be applicable to hazardous cells beyond 2004. Where future cell completion date information has been provided, it is clear that a considerable number of sites (just over half) only have capacity available up until 2007, indicating that they would be likely to cease taking hazardous wastes after 2004/5.

A preliminary assessment of the operators seeking a 'hazardous' classification has been undertaken as part of the Environment Agency's Landfill Directive project. The number of genuine merchant facilities accepting wastes from a range of sources is unlikely to be greater than 11. Of these, many are able to accept only a limited range of waste types.

Industry discussions have indicated that the likely number of operators opting to run long-term merchant hazardous waste landfill sites will be low, with as few as 2 – 3 sites being available nationally.

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[15] Environment Agency data on current inputs to co-disposal landfill sites (Table D3, Appendix D)

[16] Industry source

[17] Sourced from a number of Agency databases and Agency Areas via the Conditioning Plan Centre

3.3 Non-Landfill Capacity

3.3.1 Calculated Treatment Capacity from Facility Charge Band Data

Details of every site that is charged for keeping and/or treating special waste are contained on the Environment Agency's Regis database. This has been selected as the primary source of data upon which to base the estimate of treatment capacity in this study because it captures all facilities regulated under the Waste Management Licensing (WML) regime and provides indicative capacity data. The data does not capture capacity details covered by other regulatory regimes, e.g. IPC / IPPC. Capacity information for these regimes was not available at the time of this study but should be considered in future work undertaken.

Information fields for which data may exist for each site include:

- EA reference numbers, including WML;
- Facility type;
- Agency region;
- License holder, site address and operator details;
- Wastes acceptable; and
- Throughput charge band details.

The raw data has been provided in a sorted form showing the number of each type of facility in each charge band. This data is presented in Table D1 (Appendix D). For each charge band a figure representative of the tonnage capacity at each site in that band, has been assumed by the Environment Agency. This information is presented in Table D2 (Appendix D).

Using the data contained in Table D1 and D2, a total capacity associated with each facility type has been produced by multiplying the number of facilities in each charge band by the assumed capacity. The resulting capacity details represent the combined hazardous and non-hazardous waste throughput. In order to determine the element of this capacity that may be available for hazardous waste, an estimated percentage throughput applicable to these waste types is required.

Special waste management data obtained from site returns and Waste Management License data, as received from the Environment Agency, has been used to define an estimated throughput percentage for each facility type. Presented in Table D3 (Appendix D), this data also provides an indication of treatment capacity in its own right, as presented later in this section.

The percentage throughput applicable to hazardous wastes for each facility and the resulting annual capacity is presented in Table 3.3. Identified separately in the table are those facility types representing treatment only. The estimated annual hazardous waste capacity provided by these is 2,118,695 tonnes.

The treatment capacity figure and supporting data presented in Table 3.3 are based on a number of assumptions applied to the source data. These assumptions include the fact that indicative facility capacities are based on bands of capacity – actual capacities of individual facilities are not known. Also, hazardous percentage throughput figures applied to each facility type, as taken from WML and returns data, are based on existing practice, i.e. current hazardous waste percentage throughput against total available capacity. This will not represent true hazardous waste capacity unless operators are already maximising throughput at these sites.

The best way of addressing these issues will be through operator contact. It has not been possible in the time-scale of this study to explore these discrepancies further.

3.3.2 Treatment Capacity from WML and Site Returns Data

The site returns and WML data presented in Table D3 (Appendix D), contains reported special waste capacity that can be compared with that obtained from the analysis of charge band data as described above. Focussing on those facilities providing treatment only (being the primary group of interest and for which near complete hazardous throughput data exists), the available annual capacity for material recycling, physical, physico-chemical, chemical and biological treatment of special waste is 3,841,000 tonnes. It is not possible from the available data to determine how this capacity is split between the different treatment types.

Table 3.3 Estimated Non-Landfill Hazardous Waste Capacity

Facility Type	Annual Total Capacity (tonnes)	Hazardous Throughput (%)	Annual Hazardous Capacity (tonnes)
A9 – Special Waste Transfer Station	8548950	2	170979
A11 – Household, Commercial & Ind Waste Transfer Stn	6230000		124600
A12 – Clinical Waste Transfer Station	648000		12960
A14 – Transfer Station taking Non-Biodegradable Wastes	129000		2580
A13 – Household Waste Amenity Site	957000	0	0
A15 – Material Recycling Treatment Facility	1050000	11	115500
A16 – Physical Treatment Facility	2076000	15	311400
A17 – Physico-Chemical Treatment Facility	3790500		568575
A21 – Chemical Treatment Facility	1380000	66	910800
A23 – Biological Treatment Facility	1634000	13	212420
TREATMENT SUB-TOTAL			2118695
A19 – Metal Recycling Site (vehicle dismantler)	33450	1	335
A20 – Metal Recycling Site (mixed MRS's)	546000		5460
A18 – Incinerator	32000	0	0
Total	27054900		2435609

Analysis

In its evidence submitted to the EFRA Select Committee the Environment Agency provided details of current hazardous waste production and fate. The information provided for the year 2000 shows that just over 1 million tonnes of consigned hazardous waste was recycled / re-used (including diversion to cement and lime kilns) and 1.7 million tonnes of waste were treated. Based on the estimated range of treatment capacity available for hazardous wastes as presented, (taking into account the identified limitations of the supporting data), it would appear that between 400,000 and 2.14 million tonnes of additional treatment capacity is currently available for uptake (based on year 2000 waste arising figures).

3.3.3 *Non-Landfill Capacity Data from Industry Sources*

Treatment / Recycling

SITA Holdings UK Limited estimates that annual physical-chemical treatment capacity in the UK currently stands at 1.5 million tonnes[18]. Solvent recovery is estimated to have an annual capacity of 250,000 tonnes.

Evidence submitted by Biffa to the Inquiry suggests that there is currently less than 1 million tonnes of treatment capacity available[19].

High Temperature Incineration (HTI)

The UK's HTI industry has been in steady decline for nearly a decade. As recently as 1999, there were four merchant HTI plants operating in the UK with a combined capacity of more than 165,000 tonnes per annum. Today, there are two facilities remaining with a total capacity of 105,000 tonnes; Cleanaway's facility at Ellesmere Port has a throughput capacity of 70,000 tonnes, Shanks' facility at Fawley can accept 35,000 tonnes per annum[18]. There are likely to be periods of time, due to maintenance and shutdowns, where the UK has no HTI capacity[18]. There are currently no plans for new facilities in the UK.

In addition to the merchant hazardous waste incinerators, there are fourteen in-house incinerators, treating materials such as resin containing liquids, industrial gases, explosives, some metal containing wastes, volatile organic compounds containing liquids, catalysts, contaminated soil, and various wastes from the oil and pharmaceutical industries. These incinerators have design capacities between 0.15 tonnes per hour to 22.5 tonnes per hour[20], although no overall capacity information is readily available.

One drum reconditioning facility includes incineration as part of its operations. The primary aim is to remove hazardous materials from drums through incineration prior to reshaping, painting and finishing. Throughput capacity is unknown.

Co-incineration

The four members of the BCA – Castle Cement, Lafarge Cement, Rugby Cement and Buxton Lime Industries are responsible for the production of all the cement manufactured within the UK. The four companies operate 15 cement-producing plants across the UK, four of which already accept hazardous waste as fuels. In its supplementary evidence submitted to the EFRA Select Committee, the Environment Agency indicates that 5 plants are currently authorised to accept Substitute Liquid Fuels (SLF).

The BCA estimates that the UK cement industry currently has the potential to accept 118,000 tonnes of substitute liquid fuel (excluding waste oil) in its kilns. Based on data provided by the BCA, this represents 50 percent of the total suitable waste arising in the UK. It is stated that in the next 3-5 years use of SLF could increase to 200,000 tonnes.

Although no waste oils are currently burnt within cement kilns, it is suggested that 90,000 to 345,000 tonnes could be accepted over the next 3 – 5 years[18].

Pyrolysis, Gasification and high temperature Oxidation

There is little installed merchant capacity for hazardous waste treatment utilising pyrolysis and gasification. A facility at Avonmouth currently operates processing 8,000 tonnes of waste per annum. The plant is capable of accepting both municipal and difficult waste feedstocks, e.g. tyres and clinical.

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[18] EFRA Select Committee on Hazardous Waste. July 2002

[19] EFRA Select Committee on Hazardous Waste. July 2002

[20] Waste Strategy 2000. England and Wales – Part 2.

Stabilisation

Current capacity in the UK is small but it is conservatively estimated that stabilisation could be used to treat 25 percent of all hazardous wastes and 38 percent of soils requiring treatment or solidification[21]. It is feasible that operators of advanced stabilisation systems on the continent will transfer their technologies to the UK (on a larger scale than has been the case to date) when they consider the market conditions are suitable.

Underground Storage

The Environment Agency is currently dealing with an application for a PPC permit for an underground storage facility at the rock salt mine in Bostock, Cheshire. Once permitted, it is expected that the first year inputs will be less than 20,000 tonnes. The maximum annual input of the site will be 75,000 tonnes, with the maximum capacity of the area of the mine dedicated to waste storage being 2 million cubic metres. The planned life of the facility is therefore around 20 years. The types of waste are expected to be restricted to dry, solid/viscous industrial wastes packed into suitable containers – this will principally comprise of residues from heat treatment processes such as incinerators and the metals processing industry. This excludes many types of hazardous wastes, most obviously liquids and sludges.

3.4 Improving Capacity Data in the Future

There is scope for improving the accuracy of the data and its presentation to assist in making further analyses of the hazardous waste market. It may be useful to investigate the potential of mass balance approaches.

3.5 Management Options

The primary management options available to producers, carriers and consignees in the hazardous waste supply chain are described in Appendix C. The information presented identifies example waste types and industries to which each process is applicable, along with costs where available.
The majority of hazardous solid wastes can be treated thermally, chemically or biologically, although some hazardous wastes may require solidification or may not benefit from treatment as a means of reducing their polluting potential.

The bulk of hazardous liquids can be subjected to treatment involving relatively simple processes (pH adjustment, metals precipitation, oil removal, cyanide destruction etc) making the liquid waste suitable for discharge to a local watercourse or more likely for discharge to the trade effluent sewer feeding a local Sewage Treatment Works (STWs).

Table C4 (Appendix C) outlines the generic method of treatment that can be used for hazardous waste streams defined at 4-digit level in the EWC HWL. Due to the considerable variation in waste streams that arise from manufacturers in common sectors, it is not straightforward to map all waste streams (from the EWC HWL) on to industry sectors (via Standard Industrial Classification (SIC) codes). This also holds true when seeking to identify the optimum treatment option for a particular waste. As Table 2.1 proves, a wide range of treatment options may be applicable to any one waste type.

3.6 Key Treatment Processes

There are many factors influencing the key technologies that will be adopted by industry to undertake the treatment and disposal of hazardous wastes as landfill availability diminishes. This

[21] Industry source

section provides commentary on those options that are receiving most interest for economic, legal and physical restriction reasons.

A key issue affecting the options adopted is whether producer companies will undertake their own hazardous waste treatment, or whether centralised treatment plants will be used. Landfill has historically been attractive because it is robust and represents a low cost option (in the UK). The information provided in Appendix C demonstrates that as the treatment becomes more complex, the range of wastes that can be handled reduces and costs increase. For this reason, and given that the merchant hazardous waste management market is not based on long-term supply contracts, plant operators will want to be sure that there is a guaranteed supply of material if they are to invest in advanced facilities in the future.

It is likely that specialist recovery operations, e.g. solvent recovery through evaporation and distillation, will be introduced on-site by large producers. The market for merchant facilities taking similar wastes from smaller producers is likely to improve in locations where there is a high concentration of source sites.

3.6.1 Waste Minimisation

As a technique waste minimisation is applicable to all hazardous waste producing sectors and has the potential to reduce the quantity and 'hazardousness' of waste at low or even zero cost.

The Environment Agency, DTI (through the Sustainable Technologies programme and support of Faraday projects), Envirowise, trade associations and individual companies have a role in supporting and promoting waste minimisation, providing business models and funding mechanisms to help deliver 'clean technology' and long-term savings.

Waste Minimisation of between 5 to 10 percent of total hazardous wastes is quoted as being possible[22]. The prices in the hazardous waste management market, combined with the overall impact of waste disposal on the economics of some producing sectors has, in the past, made waste minimisation a low priority. As costs rise, in response to the Landfill Directive, supply-chain pressures and increases in landfill tax, this situation should change, promoting waste minimisation as a priority action for process industries.

The Environment Agency is considering using the inspection regime of the anticipated new hazardous waste regulations to further waste minimisation in target sectors.

3.6.2 Membrane Technologies

Membrane treatments are increasingly being improved to meet the demands of the chemical industry. Some large companies are already taking significant amounts of hazardous waste liquids on a commercial basis for filtration. **Ultrafiltration** membranes are being invested in allowing the re-use of process water and disposal of hazardous waste on producer sites. **Adsorption** techniques will also become a focus of interest as a result of the industries to which they are applicable, all of which are under pressure to reduce emissions, e.g. textiles and dyestuffs, petrochemical, organic chemicals and pharmaceuticals.

With all membrane technologies there is still however the barrier of cost, manpower and required expertise which will have an impact for years to come.

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[22] The Implications of the Landfill Directive on the disposal of hazardous and liquid waste in the UK. Babtie Group. July 2000.

3.6.3 Biological Treatment

Water Industry applications

A wide range of liquid hazardous waste streams may be handled via the water industry either as the sole treatment prior to disposal or following some other pre-treatment. There is a clear potential for industrial companies to pre-treat their wastes to make them suitable for discharge to the trade effluent sewer. The Water Industry also has the potential to provide on-site treatment services and many companies are promoting this with existing customers.

Analysis of a water industry case-study addressing the pressures and opportunities facing the water industry as a result of the Landfill Directive[23], has identified that pressure to accept more hazardous waste streams, e.g. landfill leachates is increasing. Given process and discharge consent limitations at STWs, companies are looking at options to provide additional treatment at their sites that will enable them to accept more commercial wastes. Treatment techniques that would be required for the treatment of potential special liquid waste received include; biological, acid neutralisation, alkali treatment, chromic acid treatment, cyanide treatment, precipitation, settlement, dewatering, filtration, immobilisation, oil processing and blending.

Remediation

An increasing body of knowledge and experience in the field of bioremediation, along with pressure to clean up brownfield sites with defined contamination, will result in this option being adopted more in the future.

3.6.4 Stabilisation

Stabilisation is potentially an effective treatment technology for contaminated soils and process derived hazardous and non-hazardous wastes. Under controlled operating conditions it is feasible that the technology can process hazardous waste for classification as non-hazardous waste prior to disposal to landfill.

It is likely that there will be increased uptake of solidification and stabilisation techniques in the next 5 years. These processes must meet WAC including the leaching limit values. The UK must define its own limit values for monolithic wastes, and these will therefore apply to solidified wastes. The proportion of waste arisings for which these processes will be necessary or suitable is not yet fully clear. A number of waste management companies operate systems abroad that could be used in the UK when the market matures.

3.6.5 Pyrolysis

Interest in pyrolysis has increased in recent years, however the market has not yet matured and there is only marginal installed capacity in the UK. Analysis of the pyrolysis / gasification market in Europe suggests that the technical viability of plants is limited by the ability to closely control input feed. This is also true of MSW pyrolysis plant. The problem will only be overcome where a plant of sufficient size can be developed where the operator is able to control the blend and thus stabilise the process. Indeed, the emergence of pyrolysis technology may be seen at an industry level, e.g. for the management of refinery wastes, rather than at merchant scale. It is likely that pyrolysis will be a long-term solution to hazardous waste treatment rather than emerging within the short term.

3.6.6 Co-Incineration

Co-incineration of hazardous waste is likely to increase in the future as demand for capacity increases. In the absence of new regeneration capacity, there will be opportunities for waste

[23] Entec study on behalf of water industry client. Client confidential. 2002.

mineral oils to be target feed stocks for co-incineration processes. Co-incineration has the benefit that plants capable of accepting hazardous wastes already exist.

The cement and lime industries are keen to increase use of alternative fuels in kilns for commercial, operational and legislative reasons. The prime commercial benefit is that use of SLF and other non-hazardous wastes improves the economics of cement and lime manufacture. The British Cement Association (BCA) states that progress against the targets set in the Climate Change Levy is dependent upon a year–on-year increase in the use of waste-derived materials as fuels, to a minimum level of 15 percent replacement by 2010[24]. They also point out that when SLF is recovered in a cement kiln it is subject to fuel duty, but when it is disposed of in an incinerator, it is exempt. SLF trials are ongoing or are planned at a number of cement and lime kilns. Further work will be required to estimate future developments in capacity.

[24] EFRA Select Committee on Hazardous Waste. July 2002

4. Sector Performance

4.1 Introduction

A key element of this study is to review the potential changes occurring in the hazardous waste market over the next 5 years. In order to do this, some indication of the likely hazardous waste arisings over that period is required. A number of indicators for change can be applied to inform future projections, these include historic trend analysis, socio-economic change and legislative requirements.

From the review of hazardous waste data and driving legislation carried out, it is possible to identify potential changes in waste production scenarios for the future. This element of the study investigates the wider economic performance of a number of key hazardous waste producing and handling sectors.

At the macroeconomic level it can be expected that hazardous waste volume will increase or decrease in line with the economic performance of the main producing industries, which are chemical and pharmaceutical, construction and demolition, engineering, waste treatment and petrochemical. This relationship has been demonstrated through analysis of hazardous waste production in Europe[25].

At national level, forecast growth in GDP (Gross Domestic Product) can be taken as a crude indicator of future trends in waste production. Forecast growth in UK GDP is expected to average 2.5 percent per annum in the period 2000 – 2005, reducing to 1.9 percent per annum between 2005 – 2010[26]. In the absence of other influencing factors, it is reasonable to assume that overall levels of waste production will follow a similar trend.

At industry sector level more detailed predictions of performance, against a range of economic indicators, can be used to forecast material outputs (including waste). Analysis of growth in UK output and institutional / market factors affecting sector performance have formed the basis for review adopted in this study.

4.1.1 Historic Trends in Hazardous Waste Arising

Although the Environment Agency's SWaT (Special Waste Tracking) database indicates that arisings of special waste increased at an annual rate of 45 - 65 percent between 1997 and 1999, the Agency believes that this is as a result of variations in consignment practice, rather than dramatic increases in quantities of waste being produced. A more realistic historic rate of growth is thought to be 8 percent per annum, as indicated by the increase seen between 1998/99 and 2000[27], when the database was more established.

4.2 Sector Selection

Those sectors producing the largest quantities of hazardous waste and facing the greatest changes in the hazardous waste market were selected for inclusion in the review. The following information sources were used to support this:

[25] Environment in the European Union at the turn of the Century. EEA Report. January 1999
[26] Industry and the British Economy. Cambridge Econometrics. 2002.
[27] Environment Agency website. http://www.environment-agency.gov.uk

- Findings of research commissioned by the Environment Agency in May 2002 in to levels of understanding, attitudes and behaviour of businesses in hazardous waste management;
- Environment Agency Waste Statistics (available on the Agency website); and
- Cambridge Econometrics, 2002. Industry and the British Economy, Cambridge Econometrics, Cambridge.

The producer sectors chosen are presented in Table 4.1.

It has not been possible to carry out a full and comprehensive review of producer sectors as part of this study. It is a recommendation that additional, detailed work be carried out in this area, focussing on economic performance and the costs of waste management as a proportion of operating costs and margins. Additional industry sectors to be considered include automotive, pharmaceuticals, petrochemical, non-mineral oil producers and agriculture.

Table 4.1 Hazardous waste producer sectors reviewed

Sector	Basis for Inclusion in study
Construction and Demolition	Construction and Demolition waste and asbestos is identified as accounting for 20 percent of consigned hazardous waste in 2000
Organic Chemical Processes	Organic Chemical Processes are identified as accounting for 11 percent of consigned hazardous waste in 2000
Inorganic Chemical Processes	Inorganic Chemical Processes are identified as accounting for 7 percent of consigned hazardous waste in 2000
Waste mineral oil generators	Oils & Oil /Water Mixtures account for 21 percent of consigned hazardous waste arisings in 2000
	There are a high number of enterprises producing waste mineral oil
	Changing market conditions driven by WID
Electronics	Hazardous waste classification
	WEEE
	The relatively high increase in production forecast

4.3 Assessment of Major Hazardous Waste Producers

Table 4.2 presents data on the projected economic activity in the target sectors covered by the Cambridge Econometrics reports.

Assuming that the level of hazardous waste generation per unit of output remains unchanged, the data suggests that hazardous waste generation from the construction sector can be expected to steadily increase at a rate not exceeding 2 percent per annum. Hazardous waste generation from the chemical sector can be expected to increase at around 2.5 percent per annum in the short-term (to 2005) and then potentially increase at a modest rate in the years that follow. Hazardous waste generation from the mining sector can be expected to reduce by between 2.5 and 3.6 percent per annum. The electronics sector is forecast to see dramatic growth between 2003 and 2010, following a sharp fall in 2002.

Table E1 (Appendix E) contains forecast data for other hazardous waste producing sectors.

Table 4.2 Growth in UK Output (% per annum)

Industry Sector	Year / Forecast Period					
	2002	2003	2004	2000-2005	2005-2010	2010-2015
Construction	-	-	-	2.0	1.1	1.7
Chemicals	-2.0	2.8	2.4	0.9	0.9	0.3
Mining incl. Oil	-	-	-	-2.5	-3.6	-2.6
Electronics	-9.6	6.2	7.1	0.9	7.9	8.3

4.3.1 Industry Perspective

In addition to the economic data collected for the target sectors, an industry consultation exercise was carried out involving contact with a number of trade organisations and private operators. Outputs of this exercise and findings from past activity in the target industries have been used to collate the sector summaries that follow.

4.3.2 Construction & Demolition

Hazardous wastes produced by the construction and demolition sector include asbestos, contaminated soil, tar products, treated timber and varnish. There are an increasing number of initiatives in the sector to improve the sustainability of operations and subsequently to minimise the amount of waste materials generated. However, efforts to recycle wastes are often hindered by a lack of markets, lack of space on site to effectively segregate materials and time pressures during demolition projects.[28]

Industry discussions have indicated that as a result of factors such as increases in liability insurance premiums (ranging from 20 – 310 percent), the number of enterprises in the sector will reduce. However, it is expected that the total work available will remain relatively constant and for the waste generated by the sector as a whole to be unchanged.

4.3.3 Organic and Inorganic Chemicals

The slowdown of the global economy, along with rising costs of energy and raw materials, affected the profits of several leading chemicals companies last year. Despite this, organisations concentrating on niche markets or basic consumer goods, e.g. Unilever have continued to perform strongly. Entec discussions with industry would suggest the inorganic chemicals sector has been contracting, and the organic sector doing better.

Long-term output growth for the sector as a whole is forecast to remain very low at around 1 percent per annum over 2005-10. Messages coming out of the industry indicate that operators are considering the long-term economics of maintaining operations in the UK and Europe[29].

Although long-term employment in the sector is expected to fall, productivity is forecast to steadily increase.

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[28] Industry source

[29] Countdown to July 16th - The Strategic Implications of the Landfill Directive. Joint CIA / ESA Seminar. May 2002.

Data provided by the CIA, via SoCSA, indicates that levels of hazardous waste produced by the sector are increasing. CIA member sites (of which there are about 300) generated 720,376 tonnes of hazardous waste in 2001. The equivalent figure for 2000 was 700,590 tonnes. Despite this increase, the way in which these wastes are being managed is changing. Recycling by energy recovery or reprocessing, which accounted for 39 percent of the waste produced in 2000, dealt with 52 percent of arisings in 2001. Waste minimisation initiatives are common throughout the industry and will continue to be a focus of activity as process intensification increases.

4.3.4 Waste Mineral Oil Generation

The lubricant supply industry has seen a steady decline over the last 25 years, falling from production levels of 1.1 million tonnes in 1973 to around 0.8 million tonnes per annum now.[30] The current trend, which is expected to continue, is for an annual decline in sales within the UK in the region of 1 percent. This decline is attributed to the progressive move out of the UK of heavy industry, and the increased oil drain periods in motor vehicles.

Of the 800,000 tonnes of lubricant sold in the UK each year, approximately 50% of the product is thought to be recoverable. The remainder is lost in use.

Barriers to improving recycling performance

Recycling objectives have never really been progressed owing to sustained commercial viability of the disposal / fuel route in the past. There have been occasional periods where high crude oil prices have improved the economics of recycling, but these have been shortlived. Also, performance requirements of the automotive sector have increased. Other barriers include specialist protocols for certifying new formulations of base oils and the restrictive nature of the lubricants market where high-profile brands are dominant. Entec discussions with industry have indicated that the world market for recycled mineral oil is not strong; one operator in the UK has mothballed its regeneration plant due to market pressures.

4.3.5 Electronics

Of all the manufacturing sectors for which output projections are available, electronics shows the strongest consistent growth in the medium to long-term. Accordingly, volumes of hazardous waste generated from this source can be expected to increase in future years.

In the medium to long-term the requirements of WEEE and the RoHS Directive should result in downward pressure on the quantities of hazardous waste entering the market from electrical and electronic equipment.

4.3.6 Other Producer Sectors

During Entec's consultation process, a number of additional sectors have been identified as being impacted significantly by hazardous waste related drivers. Summary details are provided below for two example sectors where the specific requirements of EC legislation are having a major impact.

Surface Finishing

The Surface Engineering Association is urging electroplaters to switch from using the carcinogen chromium VI to cleaner processes using chromium III. Fewer than 5 percent of companies had switched by July 2002, but future legislation (PPC, ELV, WEEE and the RoHS Directives) and regulatory pressure will force the issue.

Hexavalent chromium has been used in metal plating for decades. But it is carcinogenic and highly toxic. Disposal of treated sludges containing this metal is also expensive. Chromium III plating solution costs more per litre than chromium VI, but savings from the new processes should leave

[30] Industry source

users no worse off overall. One company has reported a 90 percent reduction in waste sludge following a changeover to chromium III.

The ELV Directive which bans chromium VI from new vehicles from July 2003 will have a major impact. An exemption for corrosion prevention coatings will allow continued use of the compound on bolts and fittings until 2007. But motor manufacturers are demanding that platers phase out even this small use by 2003. Similar restrictions are included in the WEEE Directive.

The extension of IPPC to the industry from 2004 will also act as a driver. Chromic acid electrolyte will also be reclassified as ‘very toxic’ within the next 3 years under the CHIP Regulations on classification and labelling of dangerous goods.

Coatings
A ban on hexavalent chromium in electrical goods proposed by the European Commission is arbitrary and unworkable, according to the British Coatings Federation (BCF). It is asking instead for limits on the amount of the substance present in products at the point of recovery or recycling and exemptions for several coating applications. The Commission proposed the ban under the Directive to require manufacturers to take back and recycle waste electrical and electronic equipment (WEEE).

The BCF's response was drawn up in consultation with major upstream users, including steel-maker Corus, which pre-treats some of its products with chromium VI. But many downstream users are unaware of the implications of the Commission's proposals for their sectors. Major coatings suppliers like Akzo Nobel, PRC-DeSoto and Becker Industrial Coatings are said to be beginning to contact their clients to raise awareness.

4.4 Waste Handling and Management

Industry sectors responsible for handling and disposing of hazardous waste and the water industry have also been considered in the analysis, the emphasis being on the overall market pressures acting.

4.4.1 Waste Management Industry

The UK waste management market has continued to consolidate, with the result that much of the market is now owned by overseas companies. Many of the big operators offer ‘total waste management’ services to large (hazardous) waste producers and as such are well placed to support and influence producer waste management practices.

The hazardous waste supply chain comprises a diverse range of material handlers and processors. The views of the large players are well presented, both through the trade body ESA (Environmental Services Association) and through their own submissions to industry reviews such as the EFRA Select Committee. As a result, there is a clear communications route in to these companies. However, the large number of intermediate operators in the supply chain are less accessible, and also less well aware of the changes on the horizon.

The waste management industry is wary of investing in an uncertain hazardous waste marketplace. If investment had gone ahead based on previous projections made[31], one waste company believes there would have been a lot of excess capacity in expensive treatment plant in the current market.
All of the large players have indicated their concerns over the state of the hazardous waste management sector in the UK[32]. Key issues that have led to this position include:

[31] Implications of the Landfill Directive on the disposal of hazardous and liquid waste in the UK. Babtie Group. July 2000.

- The management of and impacts associated with the Landfill Directive;
- A lack of definitive knowledge on treatment standards to be met;
- Inconsistencies in regulation creating an uneven playing field; and
- The length of time required to deliver new facilities under existing planning and IPPC controls.

In the short to medium-term it is likely that the waste, water and producer industries will seek to work closer together to provide integrated solutions using existing assets.

4.4.2 Cement Manufacture

A glut of cement on the world market has led to rationalisation of the UK cement industry, which has seen the number of cement kilns halved to less than 20. Competitive pressures, especially from Eastern Europe, have forced the industry to look at fuel, which traditionally has been coal.
Waste derived fuels currently make up 6 percent of the input fuel requirements in the UK cement industry. This compares with an average rate across Europe of 12 percent. Germany and France, both using 30 to 40 percent waste-derived fuels in cement kilns and Belgium use 50 percent.

4.5 Water Industry

The Water Industry has a significant role to play in providing outlets for liquid wastes, both hazardous and non-hazardous.

Companies may obtain a consent to discharge effluent to the sewer. Historically, consents were determined mainly on the basis of BOD load (Biochemical Oxygen Demand). Along with Listed compounds and Toxicity considerations, Hard (recalcitrant non-biodegradable) COD (Chemical Oxygen Demand) is now an additional concern as many treatment works are at or approaching their discharge consent limits under the terms of the Urban Waste Water Treatment Directive (UWWTD). STW consents now require either a minimum of 75% removal across the STW or a maximum of 125 mg/l (250 mg/l upper tier failure) of COD in the final discharge.

Along with biological treatment capacity, which potentially could be made available to treat the organic component of liquid hazardous wastes, the Water Industry, potentially, have available land which could be utilised to provide treatment facilities local to the industrial source of the bulk of the liquid hazardous waste arisings.

4.6 Summary of Trends in Hazardous Waste Arisings

A wide range of economic and market pressures can be seen to operate in the selected sectors covered. The impact these will have on hazardous waste production in each sector are not fully quantified and it is a recommendation that this issue be considered in future work undertaken.

Of particular interest is the impact of waste management costs on the overall economics of the activity undertaken in each sector. The significance or otherwise of waste management to their business influence producer's decisions, whether for example to develop on-site treatment.
Factors presented describing forecast UK growth in GDP and the economic forecast data for key sectors have been taken account of in the scenario analysis.

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[32] EFRA Select Committee on Hazardous Waste. July 2002

It is very difficult to predict how hazardous waste arising will change in the future as a result of the diverse industries, processes and materials contributing to its production. Predictions based on growth to date will at best be tentative.

5. Scenario Analysis

5.1 Aims & Objectives

The scenario analysis element of the study is designed to provide a preliminary indication of how the hazardous waste market may develop over the short to medium-term, i.e. over the next five years.

Based on forecasts and assumptions of sector growth, coupled with facility capacity estimates, an assessment of the generic availability of treatment and disposal routes for hazardous wastes has been undertaken. The primary objective of this has been to illustrate potential shortfalls in capacity occurring over the analysis period.

The scenario analysis is restricted to that element of the market where wastes are formally consigned. Should it be possible to more accurately quantify the arisings and management of wastes outside this regime in the future then the analysis may be extended.

5.2 Methodology

The methodology adopted in carrying out the scenario analysis is summarised below. Underpinning the analysis is year 2000 hazardous waste arising data, broken down to 4-digit EWC HWL level. At this level of detail it is possible to map waste-specific drivers on to waste streams, whilst providing a data set of manageable size; the analysis covers 101 individual waste streams.

A key assumption around the source data has been made. As the most up to date data set available, consigned arisings of special waste in the year 2000 are taken to represent current arisings, i.e. 2002 levels. No attempt has been made to build in changes that will have occurred over the intervening period. Additionally, none of the scenarios examined attempts to apply any historic trends in waste increase / decrease as derived from SWaT data. For each of the scenarios considered, the analysis has gone through the following phases:

1. **Impact definition**. The first stage of the analysis has been to define the impact of the scenario driver on hazardous waste management practices and the wider market. This assessment is based on earlier findings in the report, focussing on the drivers for change presented in section 2.3 and sector performance data contained in section 4.3.
2. **Waste stream identification.** The waste streams and sectors to which the scenario driver applies are identified.
3. **Development of annual impact coefficients.** Coefficients have been produced indicating the impact of the scenario driver on annual quantities of waste entering the hazardous waste market. These coefficients, which simply involve the previous year's figure being increased or decreased by a given percentage, have been defined for each year of the analysis. They are subjective values derived using our experience and judgement.
4. **Profile generation and analysis.** The outputs of each scenario have been graphed and reviewed.

5.3 Market Scenarios

Given the complex legislative pressures acting in the hazardous waste market, a wide range of market scenarios could be considered. In the timescale available for this study, four key drivers for change have been considered, these being the impact of the Landfill Directive, changes around the proposed hazardous waste classification, and the competing market forces of waste minimisation and GDP.

5.3.1 Scenario 1 – Landfill Directive

This key scenario assesses the potential impact of the Landfill Directive in delivering a reduction in the quantities of hazardous waste entering the market through rising costs and contracting capacity. The assumption applied in the analysis is that the Landfill Directive will deliver this reduction through encouragement of waste minimisation and on-site pre-treatment to non-hazardous status.
Based on current market conditions, the assessment assumes that these pressures will come in to effect in 2004. No change to waste arising levels has been applied up to this point, as at present low disposal costs are not encouraging on-site treatment and waste minimisation.

Beyond 2004/5, a moderate impact assessment of the Landfill Directive is assumed to result in an annual reduction in waste arising levels of 5 percent per annum. A high market impact scenario has also been considered delivering a 10 percent reduction per annum beyond 2004.

The downward impact of the Landfill Directive is assumed to apply to all producer waste streams. However, there are certain waste streams that can be assumed to increase as a result of the changes. Arisings from treatment processes will increase. Quantities of waste arising at codes 1901, 1902, 1903, 1904 and 1908 (chapter 19 covers waste from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use) have been increased by 2 percent per annum to 2004, 5 percent per annum beyond.

5.3.2 Scenario 2 – Hazardous Waste Classification

This scenario looks at the possible impact that the changing hazardous waste classification will have on waste streams over the analysis period.

Changes are assumed to apply to absolute entries and new entries on the EWC HWL, and to entries which have been highlighted as being notably affected, e.g. diesel. The annual impact coefficients applied assume a 5 percent increase in waste in 2003, a 10 percent increase in 2004 and a 5 percent increase in 2005. No change is applied thereafter.

Further development of this scenario could assess the sensitivity of the results to changing assumptions.

5.3.3 Scenario 3 – Waste Minimisation

A waste minimisation scenario has been applied to all waste streams affected by the drivers for change resulting in a long-term downward impact on arisings. A 2 percent per annum decrease has been applied over each year of the analysis period, in line with the Environment Agency's aspiration of delivering a 10 percent reduction through PPC. The coefficients applied assume waste minimisation slightly below 10 percent occurs over the analysis period.

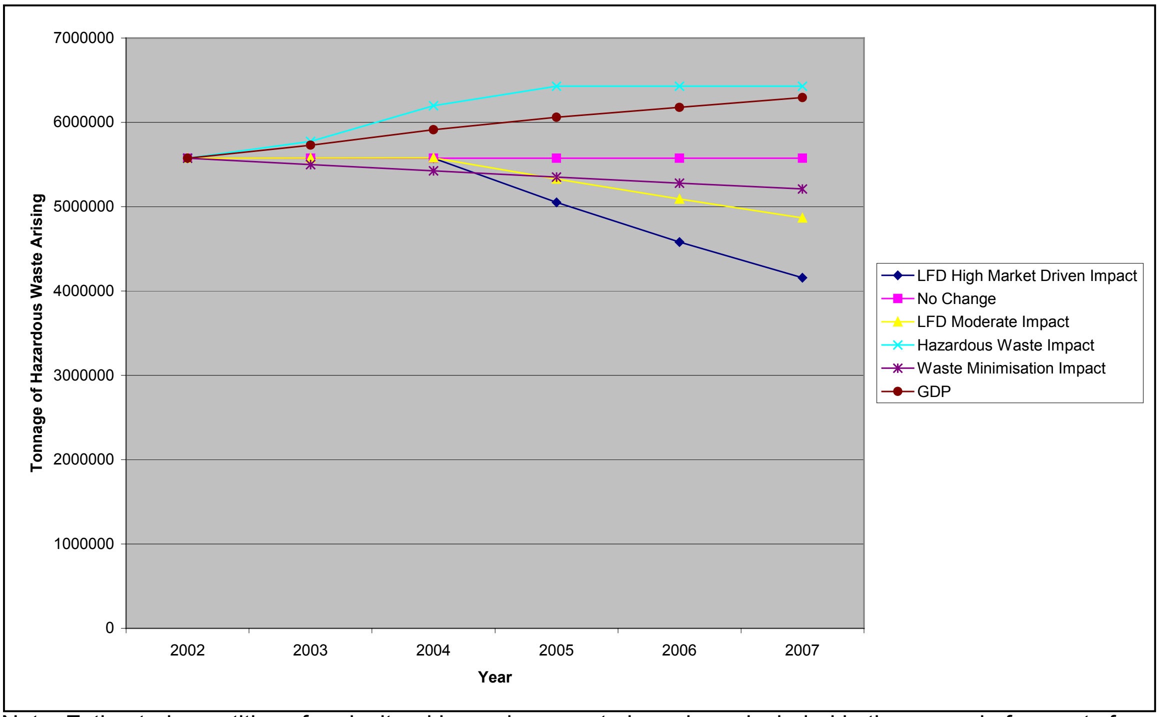
5.3.4 Scenario 4 – GDP

The overall impact of forecast GDP has been tested in this scenario based on UK figures as presented in section 4.1. The impact of GDP is assumed to apply to all waste streams.

5.3.5 Outputs

Each of the market scenarios have been applied in isolation. The outputs from each are presented in Figure 5.1.

Figure 5.1 Single Scenario Forecast



Note: Estimated quantities of agricultural hazardous waste have been included in the scenario forecasts from 2002, raising the initial annual quantity to approximately 5.5 million tonnes.

5.4 Combined Scenarios and Capacity Requirements

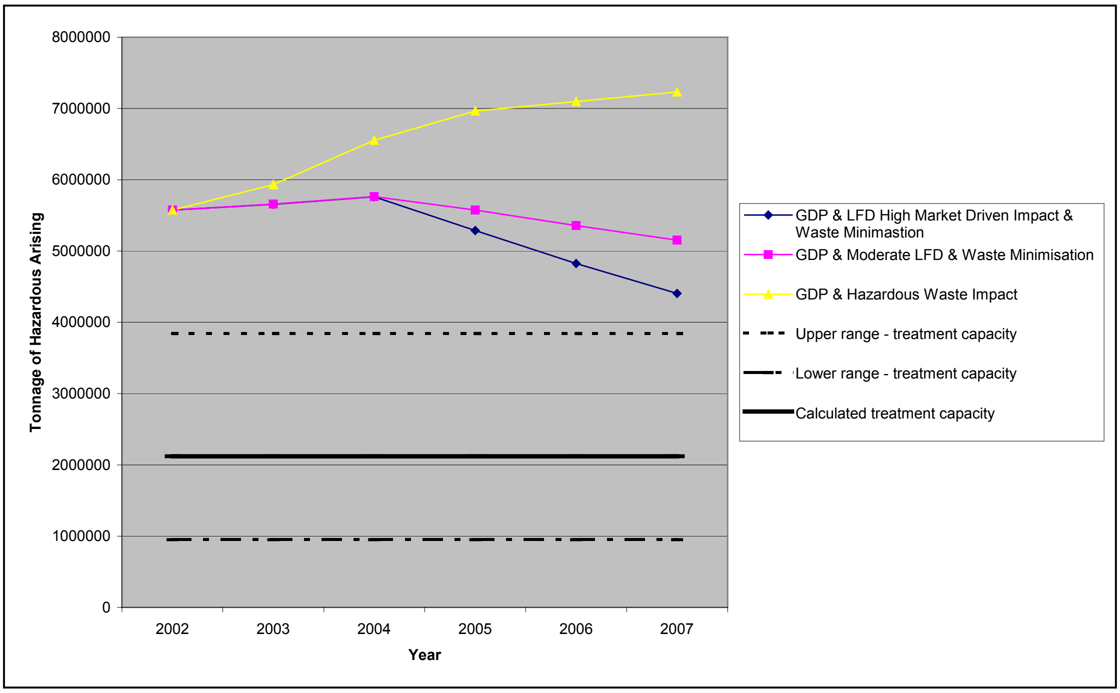
The market drivers assessed in the single scenario forecast are not mutually exclusive and will have a range of complementary and competing influences over the analysis period. As a result, a number of these drivers for change have been combined to give a picture of how the overall market may develop, and to provide a range of possible treatment 'demand' scenarios for the future.

In order to cover the full spectrum of possible market scenarios, complementary drivers promoting an increase in hazardous waste arisings, and those promoting waste minimisation, have been combined. The three forecast scenario combinations considered are as follows:

1. **High waste production.** This scenario combines GDP and the impact of the hazardous waste classification changes as drivers for increasing hazardous waste production.
2. **Moderate waste production.** This scenario combines GDP, moderate Landfill Directive impact and waste minimisation.
3. **Low waste production.** Factors combined in this scenario are GDP, high market driven Landfill Directive impact and waste minimisation.

Outputs from these scenarios are presented in Figure 5.2. Included with the outputs are estimated levels of treatment capacity as calculated in Chapter 4. This provides an indication of the possible extent of a capacity treatment shortfall based on the available data. The treatment capacity presented does not represent the total capacity of the market; landfill, high-temperature incineration and co-incineration will provide additional capacity over the analysis period.

Figure 5.2 Forecast scenario combinations with treatment limits



5.5 Waste / Sector-Specific Scenarios

A number of scenarios assessing the impact of changes to specific hazardous waste streams and producer sectors have been investigated. This work demonstrates the additional level of detail that can be applied in the scenario analysis where information allows. Such assessment also facilitates a more detailed review of the availability of treatment capacity to deal with specific waste streams and producer sectors. This has not been carried out as part of this study.

Three scenarios have been developed, focussing on example sectors that are either producing large quantities of waste or face changes in the future as a result of legislative drivers (Chapter 2). For each of the scenarios considered, sector-specific economic forecast data (as presented in Table 4.1) has been applied to the waste impact coefficients.

5.5.1 Construction and Demolition Waste

The consigned hazardous waste streams produced by construction and demolition activities have been included in this scenario analysis. Impact coefficients applied to all waste streams are the Landfill Directive (moderate impact) and the forecast in UK growth output for this sector (Table 4.1).

Additional impact coefficients have been applied to those waste streams containing asbestos as a result of discussions with industry indicating that arisings of asbestos are expected to continue to rise in the future. The Control of Asbestos at Work Regulations and long-term insurance requirements are predicted to result in arisings of these wastes increasing by 5 percent per annum in 2003 and 2004, reducing to 1 percent per annum in 2007. Waste streams linked to the redevelopment of brownfield land have also been considered, with arisings assumed to increase by

3 percent and 2 percent per annum in 2003 and 2004 respectively (fuelled by cheap landfill disposal costs), and then by 1 percent per annum beyond.

The scenario analysis outputs for construction and demolition waste are presented in Figure 5.3.

5.5.2 Agricultural Waste

Agricultural waste is not controlled and falls outside of the requirements of the Special Waste Regulations 1996. However, the requirements of the Framework Directive on Waste will result in agricultural waste being captured by the hazardous waste system in the future.

EWC chapter 02 includes 'Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing' with one hazardous waste stream 02 01 08 'agrochemical wastes containing dangerous substances'. Further hazardous wastes from this sector have been identified that fall within other EWC HWL codes. These include 'End of Life Vehicles' and 'Wastes from human or animal healthcare and/or related research'.

As wastes from this sector have not previously been consigned and subsequently held on SWAT, the scenario has taken estimated agricultural arising data from research recently published by the Environment Agency[33]. This work estimated that the agricultural sector currently produces 292,000 tonnes of hazardous waste per annum.

UK growth output in the agricultural sector is predicted to decline by 0.3 percent in the period 2000-2005 and by 0.4 percent thereafter (Table E2 (Appendix E)). Therefore, although the quantities being consigned as hazardous from this sector will increase as a result of these wastes being 'controlled' from 2003, it is expected that arisings will fall over the remainder of the analysis period.

The outputs from the agricultural waste scenario analysis are presented in Figure 5.4.

5.5.3 Hazardous Electronic Waste

There is expected to be an increase in electrical and electronic waste types captured by the new hazardous waste regime. Hazardous electronic and electric waste streams from EWC Chapter 16 02 'Wastes from Electrical and Electronic Equipment', EWC Chapter 16 06 'Batteries and Accumulators and EWC Chapter 20 01 'Separately Collected Fractions' have been forecast. Hazardous wastes generated through the disposal of electrical and electronic equipment will require changing management practices as the requirements of WEEE, RoHS and the Batteries Directive take effect, encouraging hazardous components to be either designed out of equipment or separable from the non hazardous components.

The generation of electronic equipment waste has been factored against the forecast performance of the electronics sector. More general wastes such as fluorescent tubes and batteries have been factored against variations in GDP.

The outputs from the hazardous electronic waste scenario analysis are presented in Figure 5.5.

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[33] Towards Sustainable Agricultural Waste Management. Report produced on behalf of the Environment Agency by Marcus Hodges Environment. 2001.

Figure 5.3 Scenario Forecast – Construction and Demolition Waste

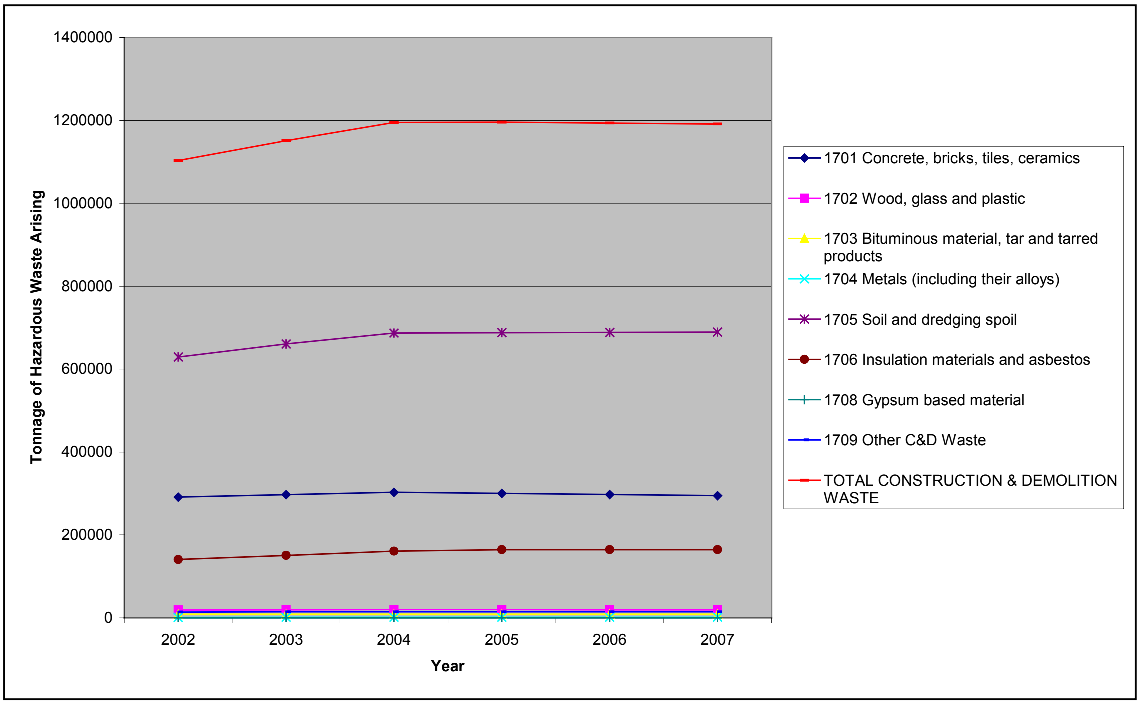


Figure 5.4 Scenario Forecast – Agricultural Waste

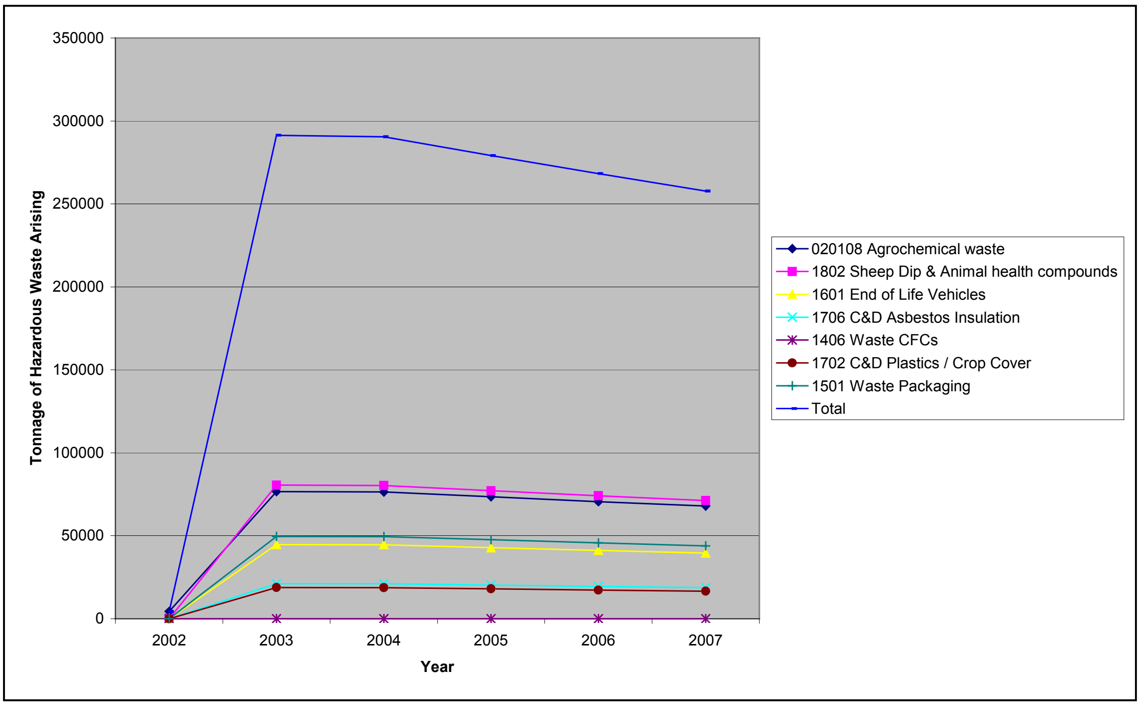
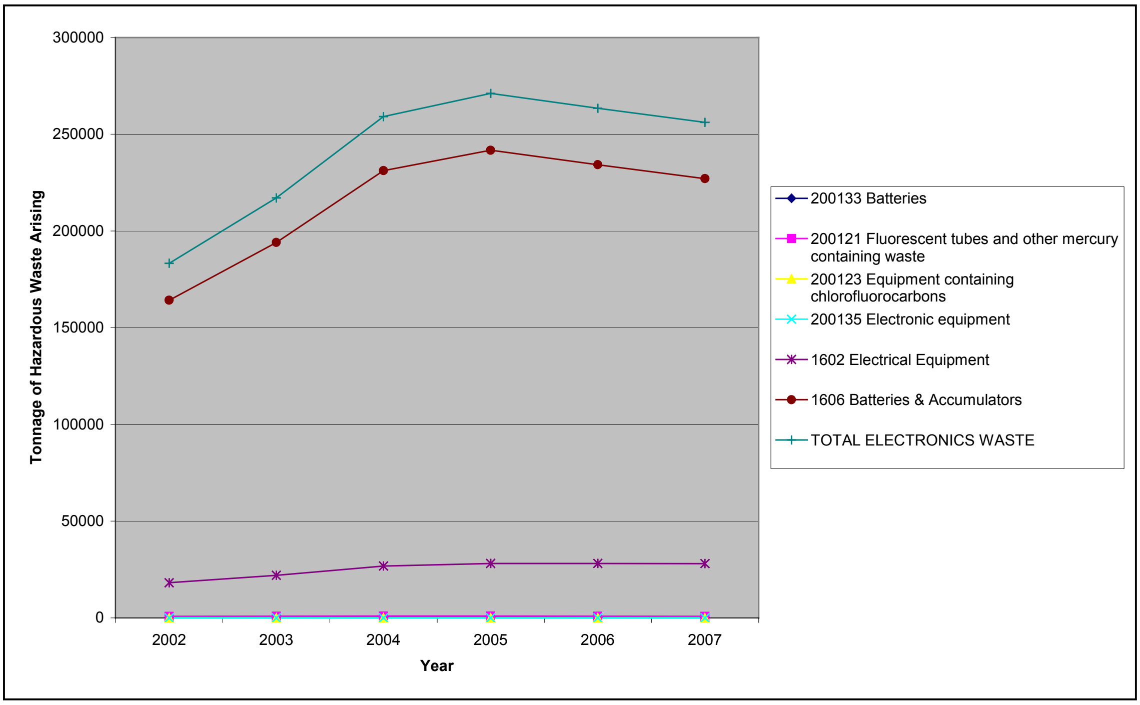


Figure 5.5 Scenario Forecast – Hazardous Electronic Wastes



5.6 Results

There are major uncertainties in the outputs of our scenario analysis for both waste arisings and treatment capacities. However, in all cases, hazardous waste treatment capacity appears to be inadequate to deal with the current levels of waste arisings. Most of this shortfall is met at present by co-disposal in landfill. Post 2004, this route will be unavailable.

Our estimate of the gap in capacity ranges from 2 – 4.8 million tonnes a year in 2004, but could be greater (up to 5.7 million tonnes) depending on the effect of the changing hazardous waste classification. Although hazardous landfills and incineration will fulfil part of this need, their capacity is unlikely to be sufficient to meet the lower figure. It is not possible from the available data to determine how the shortfall will be apportioned. This should form part of future work in this area that seeks to better quantify the potential shortfall.

Longer term, arisings could fall under certain scenarios. This uncertainty has implications for investment in treatment plant.

The scenarios presented in this chapter are based on a number of assumptions on how the market is expected to respond to legislative changes and economic forecasts. Behind the GDP and sector forecast growth scenario analyses is the assumption that waste generation is coupled with economic growth. Analysis of hazardous waste and economic data across the whole of Europe in 1995 demonstrated that this was the case[34], although this correlation was not maintained during a period of change in hazardous definition and classification procedures.

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[34] Environment in the European Union at the turn of the Century. European Environment Agency (EEA) Report. January 1999.

Accordingly, the change in classification of waste in England and Wales and the introduction of agriculture to the controlled waste management are likely to be the primary drivers for changing quantities of waste classified as hazardous over the next 2-3 years. It is imperative therefore that further research be carried out to quantify the ongoing impact these changes will have with reference to the size of the UK hazardous waste market.

6. Market Evaluation

6.1 Introduction

The way in which the market will respond to the changing pressures over the next 5 years is not known. At the moment, operators of merchant treatment facilities are adopting a holding position until a clear indication of an upturn in demand is evident. This chapter sets out a discussion of the key issues facing the hazardous waste market and its stakeholders, the priorities of which are summarised below.

Regulators – Environmentally sustainable management of hazardous wastes and identification of key waste streams / sectors where the risks of pollution are highest.

Planning Authorities – Provision of facilities to handle wastes arising, in line with the proximity principle.

Central Government – Compliance with legislation and the health of the economy.

Waste Management Industry – Provision of technically and economically viable solutions for wastes produced.

Waste Producers – Duty of Care achieved at economic cost.

6.2 Future Scenario Implications

6.2.1 Market Response to Legislation

Chapter 2 set out the key responses to legislation and policy affecting the future management of hazardous waste materials. The impact of these new controls, along with the raft of other regulations being imposed on UK business, is a cause for concern for many involved with running companies and representing their common interests.

On the one hand, the British Chamber of Commerce stated in 2001 that "the sheer quantity of red tape on business is damaging our economy, stifling enterprise, job creation and economic growth."[35]. Figures indicate that Britain's annual productivity growth has halved in recent years.
On the other hand, the UK has been quoted as the country that provides the most entrepreneur-friendly environment, with a more flexible labour market than its major EU competitors. It is also stated that only 3 percent of statutory instruments and primary legislation produced in 2001 imposed any costs on business[33].

The overall impact of new legislation and policy on business is, therefore, unclear. However, the combined impact of those controls targeted at producers and managers of hazardous wastes (as defined in Chapter 2) are predicted to result in a net increase in costs for UK industry.

There are current conditions where underlying market demand for certain wastes has been poor. By way of an example, the economics associated with recovering and recycling WEEE components in the UK do not yet make it a commercially viable option. Facilities set up to recover fluorescent tubes have struggled to attract significant quantities of feedstock purely because landfill is still

[35] Red Tape Tangle. The Times, 21 October 2002.

available as a cheap disposal option for these waste streams. The UK's only household battery recycling plant in Avonmouth is now closing.

6.2.2 Costs

There is limited accurate and up to date cost data in the public domain for the various hazardous waste management options. The waste management industry does not publish detailed cost information for reasons of commercial confidentiality. The number of variables influencing cost are great, including volume, packaging and location, not to mention actual waste description. From a review of published and confidential sources of cost data less than 10 years old, a range of costs has been compiled and presented in Table 6.1. Additional combined management cost data is contained in Table 2.1.

Table 6.1 Hazardous Waste Management Costs

Management Method	Estimated Range of Costs (£/tonne (unless stated otherwise))
Landfill	
• Solids and sludges	10 – 40[1]
• Contaminated soils	10 – 15[1]
• Bonded asbestos	50[2]
Treatment	
• Solvent recovery (clear acetone)	40 – 90 per drum[2]
• Physico-chemical (liquid)	20 – 60[1]
• Stabilisation	30 – 50 per cubic metre[1]
High Temperature Incineration (HTI)	
• Solids	350 – 950 (60 – 250 per drum)[1]
• Liquids	0 – 250[1]
Co-incineration	
• Substitute Liquid Fuels (SLF)	20[2] - 28[1]

1. 2002 Figures 2. 1996 Figures

Prices in the hazardous waste marketplace are not static. Many landfill operators in the sector are currently seeking to maximise inputs to their sites, in preparation for the changing practices that will be adopted post July 2004. The effect of this is that gate fees for the landfill of hazardous wastes are falling. As stated in section 2.1, gate fees as low as £10 - 15 per tonne are currently reported. The impact of this is that investment in alternative options is being held up.

As cement kilns have continued to take high CV wastes as fuels for combustion, the economics of high temperature incineration have suffered. Operators of HTI have had to purchase fossil fuels, e.g. diesel, in order to maintain temperatures in the absence of sufficient high CV material feedstock.

6.2.3 Technical Limitations

Because landfill and incineration technologies are extremely robust, operators of these facilities have had considerable freedom to react to the waste production market and take in a wide variety of waste streams. With landfill availability set to reduce dramatically, and no foreseeable increase in the provision of high temperature incineration capacity, the focus is on intermediate treatment technologies. Because the systems developed, whether they be physico-chemical, biological etc., are targeted at specific waste types, their window of waste acceptance is dramatically reduced. By way of an example, one of the large waste companies has run a number of trials using DEM CELL technology. In applying the technology to two theoretically identical waste streams from two different producers, the technology was found to be ineffective in treating one of the wastes. This means that target waste streams will have to be available in significant quantities, with some confidence that their production will continue for a long time into the future, if either merchant facility operators or producer sites are likely to invest in the technology to treat them.

6.2.4 Planning

Because the management of hazardous waste is not procured through long-term contracts as is typically the case with household waste, there is currently an imbalance between the mobility of the customer and the service provider. The planning system and public opposition to waste management facilities means that any proposals for new plant are likely to take a minimum of several years to move from the planning to the development phases. Even if the market develops such that the private sector feels that investment is a risk worth taking, it is likely to be many years before it is capable to deliver capacity on the ground.

6.2.5 Government Intervention

There is increasing evidence that the Government intends to take a more pro-active role in stimulating market capacity for recycled materials, both hazardous and non-hazardous. Through the setting up of WRAP (The Waste and Resources Action Programme) and a move towards providing grants for capital schemes to stimulate investment in new facilities, the Government is directly intervening in the waste management marketplace.

Experience has shown that reliance on market forces to deliver suitable facilities for waste management results in a tendency for the option at the bottom of the available waste management hierarchy to be favoured. As an example, the use of SLF results in solvents being diverted from recovery processes, effectively dropping them down the hierarchy. Unless there are controls on how wastes can be treated, and these are enforced, more expensive treatment options will not be adopted.

6.3 Priority Waste Streams

The definition of a set of priority waste streams is dependent upon the key parameters against which future hazardous waste management is driven. In the context of the hazardous waste forum and the need to identify capacity issues for the future, determinants against which priority waste streams may be defined are:

- Quantity of material produced and number of sources;
- Hazardousness:
- Treatability;
- Diversion from existing management methods, i.e. is a new approach required?; and
- Capacity (this will be driven by issues such as the final Waste Acceptance Criteria position and the availability of non waste management industry outlets to take hazardous waste streams).

This study has not sought to relate waste streams to specific treatment options. As a result, first-hand determination of a set of priority wastes in terms of their treatability and available capacity has not been possible. However, from the literature reviewed and the identified sources of large waste streams and impending changes, it has been possible to develop an initial list of waste streams to be investigated further.

The list is not exhaustive and could be expanded through further investigation, in parallel with a more detailed assessment of treatment options available to each waste stream. Examples of additional wastes that might be classed as priorities through such an analysis include metal bearing wastes, and specific metal compounds such as Chromium VI.

6.3.1 Organic Sludges and Oily Wastes

Organic sludges and oily wastes going to landfill such as separator sludges from petrol stations are considered priority wastes as a result of controls that will be placed on residues arising from their treatment[36]. It is important to recognise that physico-chemical treatment plants are usually driven by their trade effluent consent limits, with the residues disposed of to landfill. The EU Waste Acceptance Criteria (WAC) are likely to modify that approach, which may require restrictions to inputs of, for example, organics or wastes with chelating agents. The result will be a need for alternative treatment capacity, e.g. through thermal processes.

6.3.2 Agricultural Waste

Hazardous wastes from agricultural sources are considered a priority waste stream due to the potential quantities produced (estimated at 292,000 tonnes[37]), the high number of possible producers (up to 240,000 in the UK[37]) and a general lack of information describing current management methods.

It is anticipated that, due to the lack of previous regulation of agricultural holdings, the resultant poor waste management practices prevalent across the sector and the current down turn in profits within farming, engaging the potential number of hazardous waste producers in the sector will be challenging.

In excess of half of the total amount of identified hazardous waste arisings from agriculture relates to pesticide washings and sheep dip, a significant proportion of which is applied to land under Groundwater authorisations issued by the Environment Agency. Information on other means of disposal does not currently exist and is subject to ongoing research[38].

6.3.3 Waste Mineral / Fuel Oil

Waste mineral oils are residual products typically originating from vehicles, ships, industrial machines etc. On the one hand, the handling of lubricant-derived waste oils, of which approximately 400,000 tonnes are produced each year, has been regulated for many years by EU Directive 75/439/EEC - the Waste Oils Directive (WOD). On the other hand, over 120,000 tonnes per annum are fuel-derived and are not covered by the WOD but may be covered under the WID.

In the opinion of the Oil Recovery Association (ORA), waste oil remains the largest liquid hazardous waste being handled by an industry historically characterised by low capital investment. Good collection depends on getting recovered fuel oil (RFO) to markets at a competitive and discounted cost compared to heavy virgin fuel oils which act as a price cap, being the ‘bottom of the barrel’. The ORA have pointed to the rising cost of PPC implementation in this sector and feel that eventually RFOs use will be limited to cement kiln operation at negative values. They believe many small collectors of waste oil will therefore exit this market.

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[36] Industry source
[37] Towards Sustainable Agricultural Waste Management. Report produced on behalf of the Environment Agency by Marcus Hodges Environment. 2001
[38] Industry source

The UK recovery rate of waste oil is one of the best in Europe, due in part to the current positive value of Recovered Fuel Oil (RFO). All oil recovered in England and Wales is used as RFO; none is re-refined back to base oil, which is used to produce lubricating oil. Two re-refining plants operated in England during the late 90s. One closed as a result of being unable to comply with permit conditions issued by the Environment Agency. The other, which had operated for some 8 years, closed in 2000 after a Company take-over. RFO has a number of different outlets; small scale waste oil burners in factories, as a start up fuel in power stations, a fuel to dry road stone in the aggregate industry and in cement kilns.

From 2006 the WID may prevent waste oil being burnt in many of the current outlets because of the additional monitoring and operating costs. This could leave only cement kilns and incineration as the major source of disposal capacity.

In response to a recent EC ruling to ensure UK compliance with the Waste Oils Directive, DEFRA are considering a wide range of options to encourage the regeneration of used lubricating oil[39].
The demand for regeneration to occur without any plants operating within the UK could lead to excessive stockpiles of oil to occur. However, the fact that within Europe there is spare regeneration capacity and the UK currently imports approximately 20% used oil, may mean that the likelihood of any stockpile is reduced in the short term.

Whilst the viability of a regeneration plant will be dependent on a stable supply, market and the right economic conditions, permitting the plant may be not be straightforward. The UK also has a surplus of base lubrication oil refining capacity in excess of local demand and currently exports product. Any regeneration plant will therefore be operating in a market surplus scenario.

6.3.4 Construction and Demolition Wastes

As a result of the quantities and nature of the potentially hazardous wastes generated through construction and demolition activities, these waste streams should be considered a priority.

Asbestos

The Control of Asbestos at Work Regulations (2002) have doubled the number of asbestos related consignment notes that demolition companies are generating. Discussions with industry suggest that over the next 5 - 10 years there will be a noticeable increase in asbestos removal from buildings, as the regulations require it to be identified, and in the interests of minimising liabilities and meeting insurer pressure, companies elect to have it removed.[40] Although no figures have been obtained on projected increases in arising over time, asbestos is expected to be present within buildings long into the future.

Contaminated Land

As the availability of brownfield sites for development decreases, it is expected that within 5 - 10 years the more contaminated sites, which have previously been avoided, will begin to be developed for housing[39]. As a result, it is expected that there will be an increase in the amount of contaminated soil generated as hazardous waste in 5 – 10 years time, and that contamination levels in the soil removed will also increase.

Initial work reviewing the impact of WAC on waste streams that will be prohibited from hazardous waste landfill[41] suggests that contaminated soils may be caught by this restriction. The regulatory drivers governing when and how brownfield sites are to be tackled are complex, with the Town and Country Planning Act, Part IIa of EPA'90, PPC, the Environmental Liabilities Directive, Water

[39] Discussions with DEFRA
[40] Industry source
[41] Knox, K. (2002). The Future Direction of Hazardous Waste Management. Wastes Management, September 2002.

Resources Act, Groundwater Regulations and Water Framework Directive all having an impact. There is also a new regime for radioactively contaminated land currently underway. The development of a risk-based, 'fit for purpose' approach to assessing the extent to which sites need to be remediated may mean that sites come in and out of the equation, linked to change of use. The increasing costs of treatment and limited (or non-existent) availability of disposal routes will put pressure on developers to adopt land uses where the pathway from source to receptor is cut.

The price charged for contaminated soil disposal rarely reflects whole - life costs of disposal, but rather the state of the market, and the need for waste management companies to maintain volume and turnover at landfills to meet business targets. One large operator recently raised prices by £2 - 3 per tonne, and lost substantial volumes of waste business as a consequence[39].

6.3.5 APC Residues

Air Pollution Control residues have been identified as a possible priority waste stream as a result of the implications of WAC and the fact that they may not be allowed to landfill even with pre-treatment. The operators of the proposed underground facility in Cheshire are marketing the site as an outlet for APC residues, and as such, their priority may fall. However, arisings of APC residues from MSW incineration plant were in the region of 80,000 tonnes in 2000, a figure that is increasing year on year by about 7 - 8 percent per annum[42]. Assuming the underground storage facility is able to operate to design throughput capacity by 2004/5, the majority of APC residues generated by MSW incineration could be handled via this disposal route, but there will still be a shortfall to be managed through other means.

6.4 European Perspective

The EEA member countries generate about 36 million tonnes of hazardous waste per annum.[43] About 1.4 million tonnes of hazardous waste (equivalent to 4%) is not treated in the country of origin but is exported, either to other EU countries, other OECD countries or to non-OECD countries.

According to the EU strategy, waste for disposal generated within the Community should be disposed in one of the nearest appropriate installations and should not be disposed outside the Community. For hazardous waste the EU has already banned export of all such waste for disposal to other countries except to EFTA countries. Export of hazardous waste for recovery to non - OECD countries has been prohibited restricted since 1996. This initiative follows a 1995 decision taken in the context of the Third Conference of the Parties of the Basel Convention on shipment of hazardous waste.

EU exports to other OECD countries corresponds to 8% of the total, the destination mainly being the US, Norway and Switzerland. The remaining (91%) is exported among EU countries. The Community is thus also fulfilling the aim of treatment of hazardous waste within its borders. This conclusion does not however mean that sufficient treatment capacity for hazardous waste exists within the EU. About 75% of exported hazardous waste from the EU and Norway is exported for recovery and about 20% for disposal. Portugal, Spain, Luxembourg and the Netherlands export a large part for disposal.

As a result of a lower level of dependence upon landfill in many of the European member states, compliance with the requirements of the Landfill Directive poses less of a challenge than is the case in the UK. As an indication of the higher use of thermal treatment in Europe, 239 incineration

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[42] Solid Residues from Municipal Waste Incinerators in England and Wales. Environment Agency. May 2002.

[43] OECD (1997). Environmental data compendium.

plants for hazardous waste are reported to be in operation[44]. There is also greater use made of wastes as fuel inputs to cement kilns.

The case-studies below present summary examples of how hazardous wastes are being managed in two EC countries.

France

In France, only 'ultimate wastes' can go to landfill. The definition of 'ultimate' has evolved into a list, including incineration residues, asbestos, hydroxide sludges, contaminated soils and metal extraction industry wastes. Wastes landfilled must pass French WAC, with or without solidification; if they cannot, they must go to salt-mine.

Criteria exist for hazardous waste sites ('K1') which include greater than 35 percent dry matter, less than 10 percent soluble, less than 2000 mg/l COD in leachate. A waste with high chloride can be stabilised and then meet the 10 percent criterion afterwards, so that the stabilisation effectively just controls the rate of solution and release of the chloride. Very highly soluble wastes have to go to ('K0'), i.e. salt mines. Wastes which meet the criteria without pre-treatment are landfilled in separate cells from the solidified wastes.

Wastes are characterised by a 3-stage, each 16 hours, leaching test. A 10 minute test is carried out in parallel, which is used for acceptance thereafter.

One company develops treatment 'formulae' for each waste. They have about 1000 formulae, but most wastes can be attributed to a 'family' which takes a particular formula; there are then some wastes with unique formulae. Treated samples are kept, and if they fail the strength and monolithic leaching tests, the waste could be recovered from the site for re-treatment. This has not yet happened, but the low input rates mean it is feasible.

One example K1 landfill takes 50,000 tonnes of waste per annum, 67 percent of which is stabilised. Gate fees at the site in 1991 were 700 francs per tonne for landfill, 600 for stabilisation, approximately £130 per tonne in all. The site takes 16 lorries per day. Waste testing takes about an hour, and the lorries wait. All leachate generated is returned to the hydration process.

In addition to landfill, soil biotreatment and washing are also carried out on site. 23,000 tonnes of hydrocarbon contaminated soil are biotreated each year at a cost of 400 francs per tonne (approximately £40 per tonne). Material brought on to the site for this treatment is transported up to 300km. Approximately 6,000 tonnes of soil (containing PCBs and other halogenated hydrocarbons) are 'washed' with DCE each year, at a cost of 2,500 francs (£250) per tonne. The DCE is recovered by distillation plant on site.

In summary, the limitation to 'ultimate' wastes leads to many hazardous wastes being incinerated, so that much of the ultimate waste is ash from both MSW and hazardous wastes. The controlled landfill process appears to work well, the limitations on waste types making the rigorous testing regime manageable. The high landfill gate fees appear to be acceptable in the market; this is in part due to the fact that the national waste strategy requires one site to be provided for each region.

Belgium

Belgium does not have hazardous and non-hazardous landfills, it has inorganic and organic, to which limit values apply. The result is landfills that are very different to those historically operated in the UK. As an example, one site is operated only for dredgings and sewage sludge. The dredgings do not pass the limit values for organic content for inorganic landfill. These wastes are

[44] ETC/WMF website. Http://waste.eionet.eu.int/activities/0000218.html

completely enclosed in HDPE cells. The leachate collected from the waste may be treated on site by ultrafiltration with the residues taken to a chemical waste treatment plant.

Wastes with high soluble inorganics, notable APC residues, are deposited in 'salt cells', which essentially provide more layers of containment around the waste.

One physico-chemical treatment plant has a number of features that are different to those historically operated in the UK. Organic wastes, such as oily and solvent wastes are mixed with sawdust to render them handleable as a fuel which is then supplied to cement kilns. Cement is used to stabilise inorganic waste streams – this is not solidification, but simply to reduce leachability. There is evidence that this mixing of wastes is increasing in the UK in the wake of the ban on liquids and certain hazardous substances to landfill since July 2002. The final destination for these blended wastes is still co-disposal in the UK presently, but this must change in 2004/5.

Wider Initiatives

The European Topic Centre on Waste and Material Flows (a consortium of Environmental Agencies headed by the Danish EPA) is developing a catalogue on safe recovery and disposal facilities in the 18 EEA member countries. In common with the UK's need to ensure that the capacity of recovery and safe disposal facilities is adequate to handle the quantities of waste generated, the initiative is in response to an overall poor level of data associated with hazardous waste management.

When complete, the catalogue will contain information on waste management facilities and landfills for hazardous waste for all 18 EEA member countries. As a first step the information on the facilities and landfills will cover:

- The location of the facility/landfill;
- Which type of waste can be managed at the facility/landfill;
- Which kind of operation takes place at the facility/landfill; and
- The capacity of the facility/landfill.

The catalogue is expected also to contain a template for the Member States so that it can be used as a tool to fulfil the reporting obligation according to the Hazardous Waste Directive.

7. Conclusions and Recommendations for Further Study

Long term investment in hazardous waste treatment infrastructure in the UK is dependent upon private sector confidence.

The current situation in the waste industry is not one of confidence, due to a number of legislative, regulatory and market response areas of uncertainty. As a result, there is widespread concern that, as the landfill option becomes constricted as a result of the requirements of the Landfill Directive, there will be a serious shortfall in treatment and disposal capacity for a number of hazardous waste streams. The simple scenario analysis presented in Chapter 5 reinforces this concern. Under current supply-chain conditions, this may lead to the situation where wastes are stockpiled or managed outside of the law, until the market for technologies develops and management practices further up the sustainability hierarchy are introduced.

Producer responsibility legislation will require considerable investment in collection and processing infrastructure if the recovery targets are to be met. Decisions on the type and location of such investments need to be made in the near future, bearing in mind the length of time taken to set up waste management facilities under existing planning and IPPC controls.

Although certain scenarios suggest that, in time, arisings could fall to the level of treatment currently available, there is likely to be a need for more specialised treatment of hazardous wastes. Key to the UK meeting the hazardous waste challenges ahead will be effective communication between stakeholders, the establishment of agreed objectives and priority waste streams and clear, consistent guidance from both the Government and the Regulator.

7.1 Study Recommendations

The key recommendations arising from the study, to be considered by the Environment Agency and the hazardous waste forum, are presented below:

- The current change in classification of waste in the England and Wales from special to hazardous, is likely to be the primary driver for changing levels of arising over the next 2-3 years. It is imperative, therefore, that further research be carried out to quantify the ongoing impact these changes will have with reference to the size of the UK hazardous waste market. This may be achieved through selecting of a number of target producing sectors and companies within, and then carrying out detailed site-based reviews of the effect of consigning under the SWR and the hazardous waste regime. It would be useful to target both producers where the output of the exercise will be dependent primarily upon the classification changes (who do not rely on a waste carrier to classify waste on their behalf) and also producers who are covered by a number of drivers, e.g. producers of solvents or vehicle shredders;
- Following the same rationale, it is a recommendation that the impact of PPC in delivering waste minimisation aspirations be investigated. This should include an assessment of the level of priority likely to be given to waste minimisation against the other requirements of the PPC permit, and whether PPC should be the target vehicle for delivering improvements in the future;

- If hazardous waste minimisation is to be realised across industry sectors, the profile of both the Environment Agency and Envirowise should be increased to ensure that best practice is adopted at a local level. This is especially true as applied to SMEs, who are unlikely to be affected by other drivers promoting waste minimisation, e.g. PPC. At the moment much depends on the interest of individuals to set up waste minimisation clubs and therefore some areas are more active than others;
- Producer responsibility legislation and its impact on industry and the general public is receiving significant media attention. Fundamental to delivering the requirements associated with WEEE is the development of infrastructure to support the new supply chain. Barriers to this occurring should be reviewed and perhaps an organisation such as WRAP, who have a remit to stimulate demand for recycling, encouraged to include these waste streams in their target portfolio;
- The value of data collected by the Environment Agency under the SWR has been demonstrated. In the transition to the new hazardous waste regime, it is essential that sufficient resource is available to the Agency and that the opportunity is used to develop an integrated data management system delivering accurate, up-to-date information on hazardous waste arisings and their management. Support should also be given to R&D to help quantify arisings and management;
- Given the uncertainty surrounding the exact capacity of the treatment and disposal market in the UK, it is a recommendation that a study be carried out to build on the existing data and hence to quantify more accurately the ability of operators to meet future demand. This study needs to consider the technological limitations of treating segregated hazardous wastes and may take a mass-balance approach;
- Further market research and Trade Association surveys should be repeated to establish trends in awareness of producers by sector; and
- The quantity and nature of wastes not subject to the SWR 1996, e.g. where on-site disposal is used, should be investigated to assess the associated compliance requirements.
- An initial list of high priority waste streams has been identified. This list should be investigated further with respect to quantity of wastes, nature of hazard, treatability, treatment capacity and comprehensiveness.

Appendix A
Hazardous Waste Legislation – Impact Summary and Information

EC LANDFILL DIRECTIVE

The Landfill Directive (Council Directive 1999/31/EC) seeks to reduce the environmental risk from waste going to landfill, to promote waste minimisation and recycling, to reduce atmospheric emissions leading to climate change and to create a uniform standard for landfill in the EC.

As a piece of legislation affecting landfill as a process, the Landfill Directive applies to all wastes for which disposal to land is a management option. Owing to the UK's reliance on landfill as a disposal route for a wide range of waste streams, the Landfill Directive poses arguably the greatest challenge to waste producers and managers of recent years, requiring change and investment throughout industry.

KEY REQUIREMENTS

The Landfill Directive will divert many hazardous wastes away from landfill and will require greater levels of treatment prior to residues being acceptable for landfill disposal. The subsequent impact on producers of the waste streams affected will be:

- To promote waste minimisation and more thorough waste classification and segregation prior to disposal;
- To encourage provision of enhanced on-site treatment prior to disposal; and
- To seek service provision from operators with non-landfill treatment and disposal facilities.

The key requirements of the Directive relating to hazardous waste management include:

- Classification of sites according to the nature of the waste acceptable (inert, non-hazardous and hazardous). This will mean that the three types of waste must be disposed of separately, although stable and non-reactive hazardous wastes, including asbestos, can be disposed of in separate cells in non-hazardous landfill sites;
- A complete ban on the disposal of liquid wastes, wastes with prescribed hazardous properties (explosive, corrosive, oxidising, highly flammable or flammable), hospital and other clinical wastes which arise from medical or veterinary establishments and which are infectious and unknown chemical substances from R&D or teaching; and
- A ban on the disposal of untreated waste to landfill, unless the waste is inert where treatment is not feasible or is a waste for which treatment will not reduce the quantity of waste or the hazards to human health or the environment.

The Landfill Directive is set out in 20 articles, with 3 annexes providing supporting technical information. Table A2 sets out the elements covered by the Directive and provides a summary of the legislative requirements associated with each.

Table A1 Summary Impacts of Key Legislation Affecting Hazardous Waste Production and Management

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Legislation & Policy	Requirement	Year: 2002 (Quarters 3–4), 2003 (1–4), 2004 (1–4), 2005 (1–4), 2006 (1–4), 2007 (1–2)	Impact on hazardous waste management
Landfill Directive			
	Ban on: hazardous liquids to landfill hazardous solids that are explosive, corrosive, oxidising, highly flammable, flammable infectious hospital or other clinical wastes from medical or veterinary establishments chemical substances from R&D or teaching, whose effects are unknown End to hazardous waste co-disposal Waste Acceptance Criteria implementation		Hazardous liquid wastes will require an alternative treatment / disposal outlet Hazardous solid wastes with the prescribed properties, infectious clinical / veterinary wastes and unknown substances from R&D will reuquire an alternative outlet and/or pre-treatment to an acceptable standard prior to landfill disposal Landfill capacity available for hazardous wastes significantly reduced Implementation of the TAC WAC will determine levels of pre-treatment required and diverted wastes
Hazardous Waste Regulations			
	The proposed Hazardous Waste Regulations will result in wastes being classified according to the EWC HWL,hence widening the scope of materials potentially classed as hazardous.		The new Regs will place regulatory emphasis and responsibility on to the waste producer. It is likely that the Environment Agency will develop a new registration and data collection system to support the changes which should improve the quality of data available on hazardous waste arisings
PPC			
	The PPC Regulations create a framework to prevent and control pollution. Covering the whole installation of prescribed processes (including waste management), BAT must be applied in minimising pollution throughout the site's life cycle. PPC is being phased in by sector.		The requirements of PPC should reduce the hazardousness and quantities of wastes generated by producer sectors covered. Equally, the requirements on waste handling sectors may lead to reduced capacity for wastes, e.g. should Water Companies restrict waste acceptance to avoid PPC threshold. It will also lead to increased costs of waste treatment / disposal.
WEEE Directive			
	Promotes re-use and recycling of electronic waste through producer responsibility measures. A target recovery level of 4kg per inhabitant per year is to be achieved by the end of 2006. Linked with the requirements of the RoHS Directive (below), WEEE will ban the use of lead, cadmium, mercury and haxavalent chromium in the manufacture of electrical goods as well as brominated flame retardents PBB and PBDE by July 2006		Diversion of waste will increase steadily from the start of 2006, probably sooner in sectors, e.g. mobile phone recycling. Despite the ban onsubstances taking effect in mid-July, this will only start to be seen through a reduction of these hazardous materials in the waste stream in to 2007.
Restriction on Hazardous Substances Directive			
	Restriction on heavy metals and brominated flame retardents in electrical and electronic equipment. Phase in 2006 for 2008.		Impacts consistent with those of WEEE
ELV Directive			
	New cars to be recycled without charge to owner All cars to be recycled without charge to owner. The targets require 85% of ELV's to be re-used or recovered by January 2006.		ELV will result in a reduction in the quantities of hazardous waste produced by scrapyards and dismantling sites. Only authorised dismantlers will be permitted to operate, resulting in a possible decrease in the number and capacity of outlets for ELVs.
Waste Incineration Directive (WID)			
	No real change for hazardous wastes as these are already covered by Hazardous Waste Incineration Directive as transposed by Environmental Protection (Prescribed Processes and Substances) (Amendment) (Hazardous Waste Incineration) Regulations 1998 (SI 1998 No. 767). These are implemented through IPC and IPPC.	New Plant → Existing Plant →	WID may result in a reduced number of small burners, e.g. space heaters in garages and roadstone plants, burning waste oil as fuel.
Hazardous Waste Incineration Directive (HWID)			
	See Waste Incineration Directive - this directive has been implemented through IPC and IPPC. It will be superceded by the WID. Requirements include: Emission standards Automated shut off		
Solvents Emissions Directive			
	SED limits the emissions of VOCs due to the use of organic solvents by certain sectors. IPPC will implement these requirments across may industries. Dry cleaning and surface cleaning will need to implement. Requirements are phased in from the end of 2002.		Emissions of VOCs from sectors covered by SED should progressively fall over the period 2003 - 2007.
Batteries Directive (draft of revised Directive) New Directive not yet proposed			
	Collection and recycling of all types of batteries across Europe. The latest draft was issued in March 2001. 75% of all consumer batteries and 95% of spent automotive lead acid and industrial batteries to be collected within 2 years of the Directive coming in to force. Minimum recycling target of 55% to be met by the end of 2003 No mercury in batteries		Reduction in quantities of batteries sent for final disposal. Batteries containing mercury will no longer require an outlet.

Table A2 Elements of the Landfill Directive

Element	Summary Requirement
Definitions	Article 2 provides definitions for key terms used, including waste types, landfill types, treatment and parameters such as leachate & landfill gas
Site Location	Annex 1 to the Directive provides general requirements for all classes of landfill, including reference to the location of landfills in the vicinity of residential areas and sensitive environmental receptors
Permitting	Articles 7, 8 and 9 provide guidance on the permit application process and the conditions / content of the required permit
Financial Provision	Article 10 requires that the costs over the full life cycle of a landfill are covered by the price to be charged by the operator, and that operators have financial provisions in place to guarantee the aftercare of sites
Banned wastes	Article 5 lists wastes that shall no longer permitted for disposal at landfill
Reduction in landfilling of municipal wastes	Article 5 sets out details of the phased reduction in the landfilling of the biodegradable fraction of municipal wastes
Site types	The future classification of landfill sites will be according to 3 types (hazardous, non-hazardous and inert) as set out in Article 4 of the Directive
Site engineering	Annex 1 to the Directive provides engineering guidance, including liner requirements for each landfill type and gas controls
Waste acceptance criteria	Details of those wastes permitted at each landfill type are set out in principle within Annex 2 to the Directive.

Associated with the need to define the exact types of waste that may be deposited at the different classes of landfill, waste acceptance criteria (WAC) have been agreed by the Council of the European Union on 19 December 2002, and must be implemented by 16 July 2005. Waste will be unable to be deposited in a landfill for hazardous waste unless it complies with the WAC for hazardous waste landfill. A waste may therefore not be prohibited, and may have been treated, yet still may not be deposited. The WAC therefore influence the management of a waste; they can be seen as setting a standard for treatment prior to landfill or as simply another factor influencing the overall selection of a waste management option.

From a landfill perspective, the options for treatment of a hazardous waste are:

- Treatment such that the waste remains a hazardous waste, and complies with the WAC for a landfill for hazardous waste;
- Treatment such that the waste is still a hazardous waste but meets the criteria for deposit, separately from biodegradable waste, in a landfill for non-hazardous waste (Regulation 10(3)(c)); or
- Treatment such that the waste becomes non-hazardous waste.

TIMESCALES

The most important dates with reference to the management of hazardous wastes are:

- The banning of hazardous liquids and solids with prescribed properties from landfill from July 2002;
- The requirement to pre-treat all hazardous waste prior to landfill and the end of co-disposal from July 2004; and

- The full application of the EU Waste Acceptance Criteria - WAC (likely 2005).

The key dates at which the full requirements of the Directive must be implemented within Member States are presented in Table A3.

Table A3 Timetable for Implementation of the Key Requirements of the Landfill Directive

Date	Requirement
July 2001	• New landfills must comply with the Directive – implemented through PPC
July 2002	• Operators submit site conditioning plans for existing landfill sites, indicating classification as either hazardous, non-hazardous or inert
	• Hazardous liquids banned from landfill
	• Solid wastes with the following hazardous properties banned from landfill - flammable, explosive, oxidising, corrosive and infectious
July 2003	• Whole tyres banned from landfill
July 2004	• Pre-treat all hazardous waste prior to landfill
	• Exclude non-hazardous waste from 'hazardous' landfill sites (end of co-disposal)
July 2006	• Shredded tyres banned from landfill
Likely July 2007	• Non-hazardous liquids banned from 'non-hazardous' landfill
	• Pre-treat all non-hazardous waste prior to landfill
July 2010, 2013, 2020	• Phased targets for the reduction of biodegradable municipal waste going to landfill

Current status

Industry discussions have indicated that the landfill ban on hazardous liquids and solids with prescribed properties since July 2002 has not had a major impact, with many of these wastes still being disposed of to landfill. The reasons for this are:

- Disposal via the 'back door', i.e. consignment to facility operators not fully implementing the requirements of the Directive;
- Increased use of consolidation plants. Plants of this type, mixing waste streams and rendering them manageable via landfill are currently running flat out. As a result there is currently high demand for ash material that can be mixed with hazardous waste streams; and
- Increased pre-treatment.

There is evidence that an element of stockpiling has occurred and some new waste streams that were previously landfilled are now being diverted to high temperature incineration. Discussions with the waste management industry identified one treatment operator who claims that the July 2002 changes have resulted in no discernible upturn in the market for its operations and that there is little evidence of any market recovery in the medium term. The result of this is that they may close one of their chemical treatment facilities. Despite this, most of the large waste management companies have been carrying out research in to technologies higher up the waste hierarchy in anticipation of a step-change in market conditions.

WASTE ACCEPTANCE CRITERIA

The Council of the European Union has approved waste acceptance procedures, including waste acceptance criteria. The numerical criteria relating to the landfill of hazardous waste are reproduced below, in order to assist understanding of the possible implications for hazardous wastes management. The extracts are not intended as a substitute for reference to the full text of the Decision document and any implementing Regulations.

It should be noted that the extracts are amended to take account of Environment Agency interpretation in three respects:

- The Decision Document allows Member States to set more restrictive values. The tables include such restrictive values for leaching of cadmium and mercury, based upon the hydrogeological modelling undertaken for the Agency in support of the TAC work;
- The Tables do not include C_0 values, as these require a percolation test, which will not be used for regulatory purposes by the Agency; and
- Whilst the Tables include L/S 2 values, these will not be used for regulatory purposes. The Agency will regulate by reference to the L/S 10 values obtained from the draft CEN standard two part batch test for inorganic constituents PrEN12457-3. This also provides L/S 2 values, but these will be used, for the time being, only to increase understanding of the leaching behaviour of wastes.

The Decision Document provides that:

> In certain circumstances, up to three times higher limit values for specific parameters listed in this section (other than Dissolved Organic Carbon (DOC) in sections 2.1.2.1, 2.2.2, 2.3.1 and 2.4.1, BTEX, PCBs and mineral oil in section 2.1.2.2, Total Organic Carbon (TOC) and pH in section 2.3.2 and Loss on Ignition (LOI) and/or TOC in section 2.4.2, and restricting the possible increase of the limit value for TOC in section 2.1.2.2 to only two times the limit value) are acceptable, if:

- The competent authority gives a permit for specified wastes on a case by case basis for the recipient landfill, taking into account the characteristics of the landfill and its surroundings, and
- Emissions (including leachate) from the landfill, taking into account the limits for those specific parameters in this section, will present no additional risk to the environment according to a risk assessment.

It is not yet known how the UK will implement this provision. The waste industry has opposed it at the drafting stage, on the basis that it fails to provide the certainty required to allow investment in treatment capacity.

Criteria for waste acceptable at landfills for hazardous waste

Leaching limit values

The leaching limit values in Table A4 apply for waste acceptable at landfills for hazardous waste, calculated at a liquid to solid ratio (L/S) of 2 and 10 l/kg for total release.

Table A4 Leaching limit values for the acceptance of wastes in landfills for hazardous waste

Components	L/S = 2 l/kg	L/S = 10 l/kg
	mg/kg	mg/kg
As	6	25
Ba	100	300
Cd	0.6	1
Cr_{total}	25	70
Cu	50	100
Hg	0.1	0.4
Mo	20	30
Ni	20	40
Pb	25	50
Sb	2	5
Se	4	7
Zn	90	200
Cl	17,000	25,000
F	200	500
SO_4	25,000	50,000
TDS*	70,000	100,000
DOC**	480	1,000

* The values for TDS (Total Dissolved Solids) can be used alternatively to the values for Sulphate, Fluoride and Chloride.

** If the waste does not meet these values for dissolved organic carbon (DOC) at its own pH, it may alternatively be tested at L/S = 10 l/kg and a pH of 7.5 – 8.0. The waste may be considered as complying with the acceptance criteria for DOC, if the result of this determination does not exceed 1000 mg/kg. (A draft method based on PrEN 14429 is available).

Other criteria

In addition to the leaching limit values in Table A3 above, hazardous wastes must meet the limit values shown in Table A5.

Table A5 Additional limit values for the acceptance of wastes in landfills for hazardous waste

Parameter	Values
LOI*	10 %
TOC	6 %**
ANC (Acid Neutralisation Capacity)	Must be evaluated

* either Loss on Ignition (LOI) **or** Total Organic Carbon (TOC) must be used

** If this value is not achieved, a higher limit value may be admitted by the competent authority, provided that the DOC value of 1000 mg/kg is achieved at L/S=10 l/kg either at the material's own pH or at a pH value between 7.5 and 8.0.

Criteria for hazardous wastes which may be deposited in landfill for non-hazardous wastes

Hazardous wastes may not, in general, be deposited at landfills for non-hazardous waste. However, regulation 10(3)(c) provides that stable, non-reactive wastes with leaching behaviour equivalent to non-hazardous wastes may be deposited, provided that they are not deposited in cells used, or intended to be used, for the disposal of biodegradable non-hazardous waste.

Stable, non-reactive

"Stable, non-reactive" means the leaching behaviour of the waste will not change adversely in the long-term under the landfill design conditions:

- in the waste alone (for example, by biodegradation);
- under the impact of long-term ambient conditions (for example, water, air, temperature or mechanical constraints);
- by the impact of other wastes (including waste products such as leachate and gas).

Leaching behaviour

The wastes must meet the limit values provided in Table A6. These leaching limit values apply to:

- non-hazardous waste accepted in the same cell as stable, non-reactive hazardous waste; and
- granular stable, non-reactive hazardous waste acceptable at landfills for non-hazardous waste.

The values are calculated at liquid to solid ratios (L/S) of 2 and 10 l/kg for total release.

Table A6 Leaching limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste

Components	L/S = 2 l/kg	L/S = 10 l/kg
	mg/kg	mg/kg
As	0.4	2
Ba	30	100
Cd	0.06	0.1
Cr_{total}	4	10
Cu	25	50
Hg	0.005	0.02
Mo	5	10
Ni	5	10
Pb	5	10
Sb	0.2	0.7
Se	0.3	0.5
Zn	25	50
Cl	10,000	15,000
F	60	150
SO_4	10,000	20,000
TDS*	40,000	60,000
DOC**	380	800

* The values for TDS (Total Dissolved Solids) can be used alternatively to the values for Sulphate, Fluoride and Chloride.

** If the waste does not meet these values for dissolved organic carbon (DOC) at its own pH, it may alternatively be tested at L/S = 10 l/kg and a pH of 7.5 – 8.0. The waste may be considered as complying with the acceptance criteria for DOC, if the result of this determination does not exceed 800 mg/kg. (A draft method based on prEN 14429 is available)

Other parameters

Wastes which are candidates for this disposal option, and any non-hazardous wastes deposited in the same cell, must also meet the limit values in Table A7, which assist in evaluating whether the waste is stable and non-reactive.

Table A7 Additional limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste

Parameter	Value
TOC	5 %*
PH	minimum 6
Acid Neutralisation Capacity	Must be evaluated

If this value is not achieved, a higher limit value may be admitted by the competent Authority, provided that the Dissolved Organic Carbon (DOC) value of 800 mg/kg is achieved at L/S = 10l/kg either at the material's own pH or at a value between 7.5 and 8.0.

Timetable for Waste Acceptance Criteria

The wording of the Directive makes for a complex timetable for WAC, as presented in Table A8.

Table A8 Timetable for Implementation of the WAC

	All new landfills	Existing hazardous landfills	Other existing landfills
National interim WAC	Via permit	From 16 July 2002	When re-permitted, unless after 16/7/05
WAC	16 July 2005	16 July 2005	16 July 2005

In addition to these requirements of the Regulations, the Agency considers that four provisions of the WAC should be introduced immediately:

- The acceptance of hazardous waste in a new landfill for hazardous waste should be subject to the expected WAC;
- The acceptance of hazardous waste in a landfill for non-hazardous waste (Regulation 10(3)(c)) should be subject to the expected WAC;
- The facility to accept asbestos at landfills for non-hazardous waste (under Regulation 10(3)(c)) should be made available from the outset; and
- In view of problems at existing landfills, gypsum wastes should be separated from biodegradable wastes at all landfills.

These provisions further complicate the timetable, and the combined timetable is provided in the consultation draft of the Agency *Guidance on National Interim Waste Acceptance Procedures.*

Implications of the WAC on hazardous waste management

The Environment Agency believes the key implications of the WAC for hazardous wastes are:

- The limit values for organic parameters will prevent many wastes from being landfilled without treatment to remove the organics, i.e. thermal or biological treatment;
- Limit values for conservative species, primarily chloride, will impact disposal of wastes such as APC residues;
- Physico-chemical treatment plants will require closer pH control in order to limit leaching, in addition to any limits on organic inputs; and
- Treatment to render wastes suitable for disposal under Regulation 10(3)(c) or to render wastes non-hazardous will be attractive due to the larger number of non-hazardous landfills and to the absence of limit values for non-hazardous waste.

It is important to note that there are no limit values for non-hazardous waste, unless it is to be deposited with "stable, non-reactive" hazardous waste. Thus, for example, a waste which exceeds the leaching limit value for chloride for a hazardous waste may be deposited in a landfill for non-hazardous waste if the waste is, or can be rendered, non-hazardous (and complies with the landfill permit based on site-specific risk assessment).

Data limitations

Consideration of implications has been hampered in the UK by a lack of data comparable with the CEN leaching tests. With the exception of a few wastes such as MSW incinerator ash and APC residues, it is not possible to assess wastes against the proposed values because the wastes have historically been tested for total composition or using a different leaching test.

The UK has therefore been reliant on using other MS data in the discussions to date.

It is also the case that with the requirement for treatment prior to landfill, many of the candidate wastes will be unlike those currently being landfilled. Wastes are more likely to be fined grained filter-cakes and ashes, rather than, for example, contaminated packaging. Data from other Member States tends to relate to such homogeneous inorganic wastes.

Quantification

Due to the absence of data, it is not possible go through the HWL and decide which wastes may pass or fail the limit values, and it is therefore not possible to quantify the capacity implications of the WAC.

It may be possible to eliminate some wastes which are likely to fail the organic limits by a large margin, such as distillation residues or contaminated packaging.

There are two other possible sources of information:

i) Netherlands database

During the sub-group work for TAC, the Dutch organisation ECN were able to use a database of leaching data for comparison with model outputs. This had two drawbacks:

- The database contained mainly candidate inert wastes. ECN requested data for more wastes, utilising any leaching tests comparable with the CEN test. This resulted in some additions to the database; and

- The "classification" of the wastes in the database does not follow the EWC, and it can therefore be difficult to be sure what wastes are represented in each "class" of samples.

The last version provided pre-dated the finalisation of the values; in particular, it did not include assessment of the organic parameters.

Annex II provides the list of waste types in the database. It can be seen that it cannot be compared with EWC/HWL.

ii) Filter cake study

The Agency has asked a consultancy to samples filter cakes from merchant physico-chemical treatment plants. The scope of the exercise is detailed below:

- Filter cakes will be sampled from ten merchant treatment plants for aqueous liquid wastes;
- The exercise will be a one-off sampling 'snap-shot' at each plant;
- Each plant will be visited once, and a composite sample of filter cake obtained by 'thief' sampling from different points within a collection bin;
- The composite will then be mixed and sub-sampled prior to testing; and
- The cakes will be subjected to the CEN leaching test and the results compared with draft acceptance criteria being proposed by the Commission.

In order to encourage participation by plant operators, anonymity will be guaranteed: results from the study will be published without any reference to the names, locations or other details of the plants. The Agency will receive a list of the plants that participate in the study but will not be told which sample comes from which plant. Each operator will, however, be told which results come from their plant. None of the information from the study will be used for any regulatory purpose. Whilst it is recognised that filter cake quality can vary a great deal, even within a single batch, this short term exercise is considered a helpful step in identifying which components are likely to be the most problematic for the UK as a whole, and by how much they may exceed the acceptance criteria.

The results are not available, but may become available early in 2003.

It is important to recognise that physico-chemical treatment plants are usually driven by their trade effluent consent limits, with the residues disposed of to landfill. WAC are likely to modify that approach, which may require restrictions to inputs of, for example, organics or wastes with chelating agents. The study described will sample the residues "as they come", without any attempt at such controls of input to achieve compliance.

The Way forward

Testing

It would appear that the only reliable way forward is to test wastes against the criteria, using the correct test. It may be possible to focus the testing on wastes which appear likely to fail, based on knowledge of total composition, and/or on large arisings. In the latter respect, contaminated soils may not be regarded as one arising, as each site would need to be tested against the WAC. The filter cake study can be seen as a part of this work.

ECN Database
The Netherlands, or ECN, could be asked for assistance. For example, a review of the database against the DOC limit could be carried out, and clarification could be sought as to the exact nature of the wastes in each class and those which pass and fail. An extract from the ECN (Netherlands) database output is provided on the next page.

Other Member State approaches
Lessons on the management of hazardous wastes can be gained from other Member States, but it is necessary to recognise that:

- Not all current MS practices accord with the requirements of the Directive, including WAC; and
- Consideration would have to be given to the sustainability of practices in other Member States, for example, the need for long-term treatment of leachate.

Underground Storage
Underground storage falls within the definition of landfill, but can be excluded from some of the provisions of the Directive. The key provisions of the Directive which impact on the UK management of hazardous waste *do* apply: landfill classification, end of co-disposal, prohibited wastes, pre-treatment.

Section 2.5 and Annex A of the Council Decision document deal with underground storage. A very detailed risk assessment of each facility is required, to show the long-term separation of the waste from the biosphere and groundwater.

Regardless of the risk assessment, only material meeting the inert waste criteria can be stored in an inert underground storage, and non-hazardous criteria in a non-hazardous storage. As there are no limit values for non-hazardous wastes, the latter essentially means the criteria for “stable, non-reactive”, low leaching Regulation 10(3)(c) hazardous wastes; this also applies to gypsum and asbestos wastes, for which underground storage might represent a useful option.

For hazardous wastes, the limit values do not apply – the wastes are determined by the site specific risk assessment detailed in Annex A of the Council Decision.

Annex A:

- Excludes certain types of waste;
- Permits such remaining wastes as are shown suitable by the risk assessment; and
- Applies requirements for separation from active mining areas, and separation of incompatible wastes.

Figure A1 Extract from ECN (Netherlands) - Database Output

Updated 16/03/02

HAZARDOUS WASTE

	limit at LS10 in mg/kg
SO4	50000
Cl	25000
Br	
F	500
As	15
B	
Ba	300
Be	
Cd	**1.0**
Co	
Cr Total	70
Cu	100
Hg	**0.40**
Mo	30
Ni	40
Pb	50
Sb	5
Se	7
Sn	
V	
Zn	200
CN complex	
CN free	
DOC	
pH	

Low Cd and Hg values of specified range

	nr above lir	nr below limit
Aggregate	0	47
Gypsum waste	2	1
Blast furnace slag	0	9
Breaker sand	0	9
CN waste	4	2
C&D	0	23
Desulfurization waste	0	7
Destillation residue	6	6
Construction materials	0	16
HW bottom ash	0	3
Drinking water purification sludge	0	6
E bottom ash	0	11
E fly ash	0	16
Stabilized waste	6	17
Foundry sand	1	4
Metalurgical slag	1	0
Metal rich waste	7	2
APC waste	15	11
LD-slag	0	35
Wood ash	0	9
Filter dust	13	8
Mine stone	0	8
Pigment waste	3	2
MSWI bottom ash	7	83
MSWI fly ash	22	5
Other	17	38
P slag	0	17
Polluted soil	5	65
Hg waste	1	4
Oil sludge	1	8
Sand blasting waste	2	11
Shredder waste	0	7
Sieve sand	0	30
Sewage sludge	0	20
Soil	0	30
Industrial sludge	20	51
Steel slag	0	6
Treated soil	0	26

index=emission in test/norm value for test

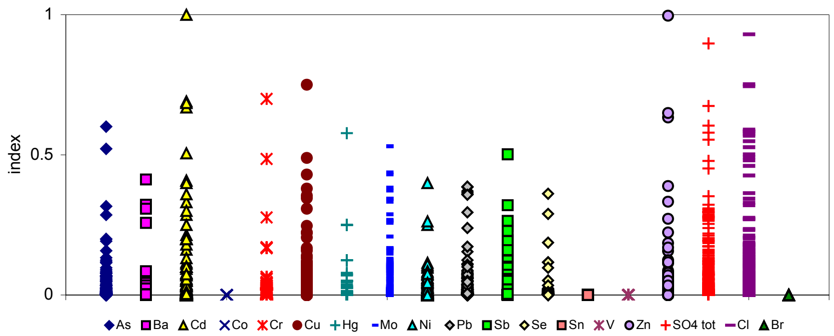

Fig. 1 Emission of the relevant components relative to target value for samples for which emission for all components are below the norm.

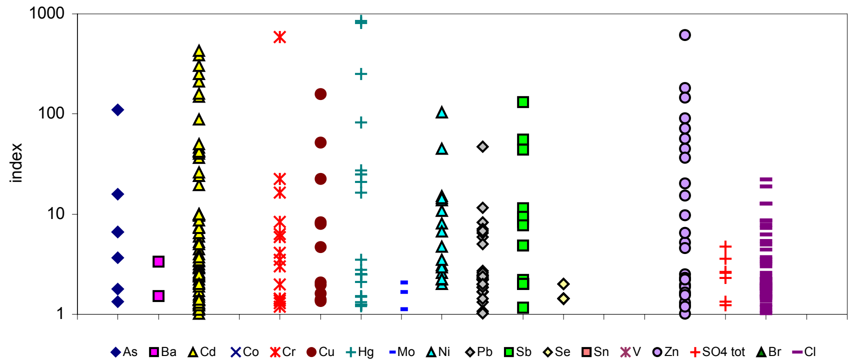

Fig. 2 Emission of the relevant components relative to target value for all the samples.

HAZARDOUS WASTE REGULATIONS

DEFRA's root and branch review of the Special Waste Regulations (SWR) resulted in a number of recommendations for changes to be made. These form the basis of the anticipated new hazardous waste regulations and include:

- Replacing the term "special waste" with "hazardous waste", defined in accordance with the European Hazardous Waste Directive and List;
- Removing the requirement for movements of special waste to be pre-notified to the Environment Agency;
- Registration of hazardous waste producers (shifting the burden of responsibility onto the waste producer); and
- Requiring waste producers to submit quarterly returns of waste consignments to the Agency.

Following initial consultation, a second review together with the draft Hazardous Waste Regulations is soon to be issued.

It is anticipated that a new data management system would be developed by the Environment Agency to deliver the requirements of the anticipated regulations. Such a system will reduce the administrative burden placed on the Environment Agency by the current consignment note arrangement, freeing up resources for increased compliance inspection activity. The resulting increase in producer visits should lead to improved practices on site and deliver a long-term reduction in the quantities of hazardous wastes being generated.

A new technical guidance note for the interpretation of the classification of hazardous wastes is due to be published. Once formally adopted, this should result in an improvement to the way in which wastes are classified. This, combined with a more dynamic, and integrated, data management system, should improve the accuracy of the data available on the quantities and types of hazardous waste generated in England and Wales.

PPC

The PPC Regulations create a new framework to prevent and control pollution, with systems similar to the old regimes of IPC and LAAPC, although local authorities now regulate integrated pollution control on some sites. There are also some further requirements that apply solely to waste management activities under IPPC.

Whilst the spirit of the PPC regulations is comparable to those of IPC, they are more onerous because the parameters on which process justification is based are more extensive, incorporating 'macro environment' considerations and the overall lifecycle of the scheme from construction to decommissioning. It is a specific requirement that waste production is avoided and where waste is produced it is recovered or where that is technically and economically impossible it is disposed of while avoiding or reducing any impact on the environment.

The entire regulatory process for IPPC consists of a number of elements. IPPC applies to specified 'installations' - both 'existing' and 'new' - requiring each 'operator' to obtain a permit from the regulator - either the Environment Agency, Scottish Environmental Protection Agency or the Local Authority.

For installations recovering or disposing of waste, the specific requirements of the 1994 Waste Management Licensing Regulations must be considered.

The Landfill Directive (LFD) applies to all existing landfills and IPPC to those receiving more than 10 tonnes of waste in any day or with a total capacity of more than 25,000 tonnes, but excluding landfills taking only inert waste. The landfills that fall outside of the above criteria will require PPC permits but will not have to meet all of the requirements of the IPPC Directive, just those of the LFD.

Waste disposal other than incineration and landfill is due to be brought into IPPC in 3 tranches during 2004 and 2005. A number of installations are covered in Section 5.3 (of Schedule 1 to the Regulations). These include:

- The disposal of hazardous waste (other than by incineration or landfill) in plant with a capacity exceeding 10 tonnes per day;
- The disposal of waste oils (other than by incineration or landfill) in plant with a capacity exceeding 10 tonnes per day;
- The disposal of non-hazardous waste in plant with a capacity exceeding 50 tonnes per day by – biological treatment specified in paragraph D8 of Annex 11A to Directive 75/442 or physicochemical treatment specified in paragraph D9 of Annex 11A to Directive 75/442.

The IPPC Guidance is also relevant to operations involving hazardous wastes under D13 blending or mixing, D14 repackaging and D15 storage of Annex 11A to Directive 75/442. This means for example that hazardous waste transfer stations will also be covered by the guidance.

The essence of IPPC is that operators of processes should choose the best option available to achieve a high level of protection for the environment taken as a whole.
Other differences include:

- The whole installation is covered rather than just the process, as was the case under IPC;
- A wider range of substances are defined as pollutants for the first time;
- A range of other effects beyond emissions to land, air and water must be considered;
- Noise and vibration are defined as pollutants;
- Discharges to sewer are affected by IPPC, thus “hard” COD or potentially harmful breakdown products may give rise to problems;
- Site condition reports are now mandatory for part 'A' installations;
- Site closure and clean-up plans are now part of the permit requirements;
- There is an emphasis on management systems to 'self-regulate' the activities;
- There are links into Health and Safety;
- There is no exemption from permitting under triviality; and
- BAT is required to incorporate the best techniques known from a global perspective, not just the UK level.

PPC & Landfill

The Environment Agency, on 29 November 2002, published a list of the application dates for the first tranches of landfill sites that must apply for Pollution Prevention and Control (PPC) permits under the Landfill Regulations. Sites in these first tranches are all those that can currently accept hazardous waste, in accordance with their existing waste management licence.

The permitting process will bring existing sites into compliance with the Landfill Regulations. This will ensure that sites will be regulated to tougher standards designed to enhance protection of the environment and human health.

The Environment Agency has written to operators of landfills classified as sites that accept hazardous waste asking them to submit an application for a PPC Landfill Permit as follows:

- Tranche 1 (49 sites): application due no later than 9 June 2003;
- Tranche 2A (66 sites): application due no later than 9 October 2003;
- Tranche 2B (65 sites): application due no later than 9 December 2003; and
- Tranche 3 (47 sites): application due no later than 9 May 2004

Operators have been given at least six months notice of the application deadline by the Environment Agency.

Landfill sites have been allocated to tranches following a broad risk assessment, based on information that was supplied by all landfill operators to the Environment Agency earlier in the year. The risk assessment allowed the Agency to prioritise the permitting of landfill sites, with those landfill sites with potentially high-risk activities being issued PPC permits first.

Tranche 3 will be supplemented in March 2003 with additional sites after the Environment Agency has assessed and prioritised the remaining conditioning plans for landfills that accept non-hazardous and inert waste. In March 2003, the Agency will also announce details of all remaining tranches.

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT DIRECTIVE

The Directive will affect manufacturers, sellers and recyclers of electrical and electronic equipment, including household appliances, IT and telecoms equipment, audiovisual equipment, lighting, electrical and electronic tools, toys, leisure and sports equipment.

The initial collection target of the Directive is probably already being achieved in the UK through white goods collection, but this target will be increased in the future. Local Authorities are likely to have an ongoing role in the collection of WEEE through bulky waste collections and CA site operations.

A DTI study, which includes a life-cycle assessment conducted by Ecobalance UK and a life cycle financial analysis carried out by Dames & Moore, reports that the proposed EC requirements are cost effective. Despite this, the report cautions that in reality markets for secondary materials and refurbished products do not yet exist in sufficient quantity to realise all the potential cost gains. Hazardous waste generation is higher under the Directive because the Life Cycle Assessment model treats the insulation foam associated with CFC blowing agents as hazardous. The report emphasises the importance of ensuring that reprocessors can be confident that markets will be available for secondary materials and components and that this is an ongoing and growing realisation of the significance of the issue.

An investigation into the remarketing of white goods parts has shown WEEE mountains will not occur if the industry acts to create an infrastructure to support the new sector, estimated to be worth £235 billion world-wide[45].

[45] WEEE Remarketing Report: An investigation into the Remarketing of White Goods Parts, funded by Biffaward.

All costs associated with collection, treatment, re-use and recycling are to be covered by the producer, who will have to provide a financial guarantee at the time a new product is put on the market. The guarantee will ensure that the management of the waste will be paid for once the equipment reaches the end of its useful life. Cost estimates based on DEFRA's Partial Regulatory Impact Assessment suggest that the additional costs of the WEEE Directive will be between £190 million and £390 million in the UK, depending on how the Directive is implemented.

Electronic equipment is the fastest growing waste stream in the EU, with each person producing (on average) 14kg each year. Currently, 90 percent of electrical and electronic waste is disposed of via landfill or is incinerated.

RESTRICTION OF HAZARDOUS SUBSTANCES DIRECTIVE (ROHS)

The Directive will ban the use of heavy metals: lead, cadmium, mercury and hexavalent chromium in the manufacture of most electrical goods as well as brominated flame retardants PBB and PBDE from July 2006.

Coming into force 3 years after the WEEE Directive, the RoHS Directive will minimise hazardous materials associated with new electrical and electronic equipment, thus having a long-term impact on hazardous waste arisings.

END OF LIFE VEHICLES DIRECTIVE

The requirements of the Directive should promote segregation of hazardous and non-hazardous elements within ELVs. Also, so as to prevent the disposal of lead, mercury, cadmium and hexavalent chromium by landfill or incineration, the use of these substances has been severely restricted (Croners).

In 2000, 1,630,597 cars were manufactured in the UK and 2,221,647 new cars were registered on the road. The current estimate of ELVs generated in the UK is approximately 2 to 2.25 million per annum[46].

The current estimate of recycled ELV ferrous and non ferrous metals is approximately 75 percent, so a further 10 percent of waste that currently goes to landfill must be reused or recovered. The current number of dismantling sites is approximately 1,500, with a further 1,000 scrapyards also handling ELVs. The estimated cost of treating ELVs under the Directive is approx. £40 – 50 per end of life vehicle[47].

Estimates made in Germany for the sort of figure that might potentially add to the cost of each vehicle range from £113 to £244. In Holland where a levy has been applied to all new vehicle sales since 1995 to contribute towards the cost of disposal, the actual amount is currently £27. The levy goes into a central fund to support the nation's recycling system that was established and is run by a non-profit making company set up by Holland's four motoring organisations[48].

Details of the options for developing targets for producers (vehicle manufacturers) have been considered. The current preferred option being named 'producer choice option' allows the car manufacturers to have recovery / processing targets based on a tonnage target relative to current market share or based on own marque at the automotive treatment facilities. The tonnage targets require treatment / recycling evidence on the open market, and it is likely that Vehicle Recovery Notes (VRNs) will provide evidence of recycling.

[46] Factsheet written by ERM for the DTI
[47] Environment Agency website
[48] MIRA New Technology 2002

The Directive is seen as a major step towards implementing the principle of producer responsibility. Car owners wishing to scrap their vehicles will have to obtain a 'certificate of destruction' from an authorised dismantler and if the disposal resulted in a net cost to the owner, they can obtain a refund from the car manufacturer. Manufacturers will have to fund the collection and recovery of existing vehicles from 2007 and new vehicles from 2003.

New processes to recover greater volumes of plastics are being developed. Many are based on the techniques developed within the minerals processing industries. Examples include flotation methods using high density fluids to aid separation of different plastics and elutriation techniques using high velocity air flows to achieve separation of small particles into their various densities. Other techniques to sort plastics have been developed that employ infra-red analysis, and machine sorting by colour is likely. Thermosetting plastics that are difficult to recycle are being replaced by glass filled thermoplastics such as polypropylene and polyamides (nylon). Much of the recycled plastics can be combined with virgin plastic in limited quantities (up to 25 percent) to produce new polymer 'alloys' that the automotive industry can use for moulded components. Results of research show that there are potentially many industries that could utilise plastics made partly with recycled material sourced from ELVs.

In its evidence submitted to the EFRA Select Committee the Environment Agency estimates that the hazardous components of End of Life Vehicles make up approximately 4 percent of the total weight and primarily include lead/acid batteries, sump and gearbox oil, brake fluid, anti-freeze, fuel and air bags.

BATTERIES DIRECTIVE

The European Commission has drawn up a proposal (latest draft issued March 2001) which will require the collection and recycling of all types of batteries. Member States are required to set up systems to collect 75 percent of all consumer batteries within 2 years of the Directive coming into force. Over the same timescale, 95 percent of spent automotive lead acid and industrial batteries are to be collected. A minimum recycling target of 55 percent is to be met by the end of 2003.

Current battery legislation requires the separate collection of certain batteries including those which contain 0.4 percent lead by weight, this includes vehicle lead acid batteries. Currently approximately 90 percent of lead acid vehicle batteries are recycled at lead smelters.

To date it has proved expensive and inconvenient to arrange separate collections for the small quantity (approximately 2 percent) of batteries currently required to be recycled, and the existence of separate national recycling schemes has led to distortions of the single market. The national producer responsibility strategy for batteries (issued in 1993) has failed to meet its recycling targets, prompting the Commission to issue a warning about inadequate implementation of the new Directive.

All batteries would be collected separately from household waste. To facilitate collection, Member States will also have to ensure that electrical appliances, e.g. power tools are designed in such a way that batteries can be easily removed. The Directive to date has been delayed due to opposition by the battery manufacturers.

WASTE INCINERATION DIRECTIVE

The WID sets stringent requirements that will apply to all new incinerator installations from 28 December 2002 and to all existing installations from 28 December 2005. It specifies air emission limits that must not be exceeded. It also sets requirements concerning normal and abnormal operating conditions, water discharges from cleaning exhaust gases, ash recycling, plant control and monitoring, and public access to information. WID also requires all incinerators and co-incinerators to have continuous monitors for certain pollutants. The requirements of the WID have been transposed in England and Wales by a combination of the WI Regulations, and Secretary of

State's Directions under Part I EPA 1990 and the PPC Regulations. The Directions require regulators to set conditions in permits that transpose the technical requirements of WID.

Approximately 2,000 of the 2,600 plants affected by the Directive (in England and Wales) are waste oil burners. The potential impact of WID is therefore large. However, Government consultation on WID guidance indicated their opinion that appliances such as waste oil space heaters do not fall within the scope of WID.

Authorisations under the Directive will require residues to be minimised in terms of quantity and degree of hazardousness, and where appropriate recycled. The overall impact of the Directive is that the cost of incineration will rise and smaller incinerators may cease to operate.

The Regulatory Risk Assessment carried out for WID indicates that the cost to businesses will be between £0 - £1,100,000 per annum, but is likely to be between £30,000 - £300,000 per annum.

SOLVENT EMISSIONS DIRECTIVE

The Directive requires programmed organic solvent use, therefore minimising organic solvent waste production. Table A8 (Appendix A) suggests that the Directive will result in an overall 69 percent reduction in emissions of VOCs across a range of industry sectors. The Environment Agency has identified that the reductions will come mainly from the coating of textiles, pharmaceuticals, surface cleaning and vehicle finishing sectors. In order to deliver these reductions (which are closely linked to quantities of solvents used and disposed of), industry (paint, inks and surface cleaning sectors particularly) are investing in end of pipe abatement solutions and product re-formulation.

All installations (except dry cleaners) using the more harmful VOCs, carcinogens, mutagens and repro-toxic (CMRs (substances assigned risk phrases R45, R46, R49, R60 and R61)), are required to replace these solvents by less harmful substances as far as possible within the shortest possible time. The suitability of replacements should be assessed taking into account fitness for use, potential effects on human health and occupational exposure, potential effects on the environment and economic consequences.

In addition, emissions of VOCs which are CMRs or Halogenated VOCs which are assigned the risk phrase R40, should be captured and controlled as far as technically and economically feasible to safeguard public health and the environment within the shortest possible time. Where the mass release of those VOCs is greater than or equal to the mass release rate specified in the SED for those substances, then the final discharge to atmosphere should meet the specified concentration with the shortest possible time.

New installations are required to meet the SED before they are put into operation. For substantially changed installations, the substantially changed part of the installation should be treated as a new installation. If however the total emissions of the whole installation (substantially changed and existing) do not exceed those that would have resulted, had the substantially changed part been treated as a new installation, the whole installation may be treated as an existing installation.

Operators of existing installations who opt for the reduction scheme must notify the regulator in writing by 31st October 2005. For installations not using the reduction scheme, any VOC abatement equipment installed must comply with the emission limit values in the SED. All other existing installations must comply with emission limit and fugitive values for the total emission limit as specified within the SED by 31st October 2007. Operators can opt to comply with the SED earlier, e.g. if they wish to have the SED requirements included in their new permits as they are phased into the PPC regime.

Table A9 shows the predicted impact of the Solvent Emissions Directive on VOC emissions.

In addition to the requirements of the SED, the European Commission has proposed the first ever EU limits on solvent content in paints, varnishes and vehicle coatings, with targets applicable in 2007 and 2010. The aim of the proposed limits is to reduce emissions of VOCs by 280,000 tonnes by 2010[49].

Table A9 Effect of the Solvents Directive on VOC Emissions from Sectors Affected

Sector	UK VOC Emissions (ktpa)				% Reduction from 1990		VOC Emissions Reduction (ktpa) 1999-2007
	1990(1)	1997(1)	1999	2007	to 1999	to 2007	
Adhesive coating	54	38	23	23	57%	57%	0
Coating of new vehicles	25	15	9.1	9.1	64%	64%	0
Coating of Metals & Plastics - All	79 (3)	52	26.9 (5)	26.9	66%	66%	0
of which Ship building	9	4	4	4	56%	56%	0
Metal packaging	11.6	16	2.81	2.59	76%	78%	0.22
Aerospace	--	---	---	--	--	--	--
Railway vehicles	0.66 (2)	0.46	0.26	0.26	40%	40%	0
Drums	--	--	--	--	--		--
Coating of textiles	11	9	2.82	2.2	74%	80%	0.62
Coating of wood	17	17	5.9	5.9	65%	65%	0
Coil coating	5	6	1.5	1.3	70%	74%	0.20
Dry cleaning	10	7	1.3	0.79	87%	92%	0.51
Film coating	15	12	12 (4)	12	20%	20%	0
Impregnation of wood	25	21	13.66	8.89	45%	64%	4.77
Leather coating	2	1	1	1	50%	50%	0
Manufacture of coatings	10	8	5	5	50%	50%	0
Paper coating	--	--	--	--	---	---	--
Pharmaceutical processes	14 (2)	11	7.92	6.20	43%	56%	1.72
Printing processes	40	34	15.25	10	62%	75%	5.25
Rubber manufacture	9	10	3.23	2.87	64%	68%	0.36
Surface cleaning	75	55	23.4	2.3	69%	97%	21.1
Vegetable oil extraction	10 (7)	10	2.8	2.8	72%	72%	0
Vehicle refinishing	22	12	11.2	10.637	49%	55%	0.563
Winding wire coating	---	---					--
TOTAL	**423**	**318**	**166**	**130.9**	**61%**	**69%**	**35.31 (Note 6)**

Notes:
1. Source National Atmospheric Emissions Inventory (NAEI)
2. Industry estimates
3. NAEI 1990 figure (total) for all metals and plastics coating processes including general industrial, heavy duty, marine and metal packaging.
4. 1997 figure taken instead of 1999 figure as 1999 estimation considered too high.
5. The emissions in 1999 and 2007 have been calculated through applying an average percentage reduction from shipbuilding and metal packaging. No further information was available.
6. Based on the summation of specific rather than rounded figures.
7. Entec estimates

49 EU paint and varnish solvent curbs proposed. Environment Daily 1355, January 2003.

Appendix B
Sources of Hazardous Waste Data

Data Source / Type	Source format and wastes covered	Years available 1998	1999	2000	2001	2002	2003 ⇨	Limitations on use
SWaT (Special Waste Tracking Database)								
Primary	Database sets: 1998 1999 2000 (currently available through the Hazardous Waste Interrogator - EA website) The SWAT database is compiled by Environment Agency staff inputting information that has been recorded on Special Waste consignment notes. Data fields include, but are not limited to, consignor details, consignee details, Special Waste Category / EWC, hazardous properties, consignment number, consignment destination type (landfill, treatment, transfer etc.), and a text descriptor.							Double-counting transfer only waste. Some waste movements from Scotland are included Over consignment - disposal of non hazardous waste as hazardous. Incorrect allocation of hazardous properties Many erroneous entries e.g. EWC code 999999. Double entries for multiple hazardous properties.
National Waste Survey database								
Primary	The national waste survey covered 20,000 companies (producing 100,000 commercial and industrial waste streams). The survey was structured to encompass size, sector (SIC) and location of the company. The survey did not specifically target hazardous waste streams, but picks up details of special waste arisings, where produced.							Extraction of data mapping to EWC code has involved multiple conversions with evident mis-mapping.
	The next national waste survey is planned for 2003/4.							
Strategic Waste Management Assessments (SWMAs)								
Secondary	Regional SWMAs provide a baseline for planning and strategy activity, containing waste arisings and management information for all controlled and priority waste streams. SWMAs will be updated on an annual basis.							Fundamentally dependent upon SWaT and the National Waste Survey for source data. SWMAs are a mechanism for presenting the collected data.
Towards Sustainable Agricultural Waste Management (Marcus Hodges)								
Primary	The Marcus Hodges report includes estiamtes of selected non-natural agricultural waste streams arising in the UK. From the information presented it is possible to extract likely hazardous waste arisings from this sector.							The report states that reliable data has been scarce for many waste streams. The estimated arisings are based on a calculation methodology combining literature review results (resulting in a 'unit waste estimate'), MAFF census data and an assessment of accuracy. No data was available for a number of known waste arisings, e.g. veterinary medicines / dressings.
Solid Residues from Municipal Waste Incinerators in England and Wales (EA)								
Primary	The data provided in the report on air pollution control (APC) residues comes from a combined review of plant operator records, SWaT and treatment/landfill site returns. Annex 2 of the report contains a breakdown of APC residues from easc MSW incinerator over the period 1996 - 2000.							The report contains accurate data (as is reasonably available) for specific waste streams (bottom ash and APC residues (fly ash)) arising from MSW incinerators.It does not contain details of similar residues that may arise from other thermal processes.
Implications of the Landfill Directive on the disposal of hazardous and liquid waste in the UK (Babtie)								
Secondary	This report is very informative about the specific issues of the Landfill Directive. It contains data on waste arisings, treatment options, capacity and projections in shortfall as a result of the requirements of the LFD.							The Babtie report is notably interested in liquid wastes and wastes which have the hazardous properties that will no longer be accepted by landfill sites. The study suffers from the same base data limitations in the assumptions made over future capacity requirements. The projections made take no account of WAC.
Trade Associations								
Primary / Secondary	There are hundreds of UK Trade Bodies representing the interests of their members. The technical remit of these bodies varies enormously and as such the skill base within the organisation to discuss process and waste issues varies accordingly.							Entec's Trade Association survey of February 2002 showed a poor understanding of legislative and regulatory changes amongst the majority of Trade Organisations contacted. As such, the data returned was not accurate. Sector-specific hazardous waste data is however available from a few notable exceptions, e.g.. the Chemical Industries Association.
Waste Minimisation Projects								
Primary	A number of geographically-based commercial / industrial waste minimisation projects have been carried out in the UK. These have identified specific hazardous waste streams and identified opportunities to minimise arisings							The waste minimisation studies carried out to date contain localised (producer-specific) data that may not be accurately extrapolated across other producers in the same sector.
Hazardous Waste Regulations IT System								
Primary	Anticipated database and information system will facilitate collection and analysis of data on hazardous waste producers (and associated risk profiles), waste production (by EWC) and fate							Functional specification not yet reviewed

Appendix C
Hazardous Waste Treatment Options

The treatment and capacity review presented has been built up from the following information sources:

- The Implications of the Landfill Directive on the disposal of hazardous and liquid waste in the UK. Babtie Group. July 2000;
- Submissions made to the EFRA Committee Report;
- Environment Agency information (Site Conditioning Plan Submissions, Best Practice Guidance on the Recovery and Disposal of Hazardous and Non Hazardous Wastes, Landfill Directive project information provided by Atkins);
- Literature searches, e.g. Envirowise, CIWM; and
- Discussions with representatives from the waste management industry

RECOVERY AND RECYCLING

SEPARATION

Separation is an important process for waste treatment and is a prelude to the recovery, further treatment or diversion of waste from final disposal of one or more components. Separation can therefore reduce the hazardousness of a product.

Sorting or separation includes a wide range of techniques for separating solids from solids, solids from liquids, liquids from liquids and ions from solution. Separation techniques include; membrane technology; evaporation and distillation, air stripping, oil/water separation, soil vapour extraction, soil washing (for organics and / or fines from contaminated soil), electrical technology, adsorption and thermal separation of volatile organic compounds.

EVAPORATION AND DISTILLATION

Evaporation uses a heat input, sometimes coupled with a reduction in pressure, to vaporise and remove one or more components from a liquid feed stream. Distillation exploits the difference in volatility between the components of a liquid mixture.

Examples of waste: solvents

Examples of Industries: The separation of solvent mixtures for recovery and reuse. The removal of large fractions of volatile organic compounds from aqueous feed streams.

Economics: These technologies are suitable for dedicated, toll and merchant use, for both batch and continuous operation. Because of the diversity of evaporator and distillation designs, little detailed information is available on system costs.

An example of waste recovery, is that of solvents. At the moment the large solvent consumers generally use large central processors to dispose of their waste liquid. Smaller solvent users use in house technology. Industry discussions suggest that it is currently uneconomical for the large companies to use a central processor for the reasons of treatment cost as well as not recovering the solvent for re-use. It is believed that in the future more companies, especially the large companies, will realise the negative cost impact and buy in house equipment.

ELECTRICAL TECHNOLOGIES

Electrical technologies use an electrical current to bring about a change in feed stream. Applying an electrical potential across a conducting fluid causes ions to migrate to the appropriate electrode.

Direct Electrical Technologies

Direct electrical technologies transform a substance that is in solution to another state, through the deposition of a solid, the generation of a gas or a change in chemical state.

Examples of waste: recovery of copper, nickel and chromium from waste streams

Economics: Application of the technology has occurred involving attachment of a 0.5 m self-contained unit to an alkaline cadmium static rinse tank. The unit has a typical flow rate of 25 litres / minute and is capable of removing 11g of cadmium per hour. The cadmium concentration in the rinse tank is maintained at 10 - 100mg/litre. The system cost approximately £5,000 and the electrical operating costs are 1.2 pence / m^3. Operating costs are dictated by the current and voltage required. These, combined with capital costs normally limit scale of operation.

Electrocoagulation

In electrocoagulation, a sacrificial anode dissolves in the feed stream. In the presence of suitable anions (usually hydroxide) this produces an insoluble floc which encapsulates or adsorbs the impurity ions and causes them to precipitate out.

Examples of waste: Removal of fluoride from solution

Economics: A pilot plant for treating a 0.6m3 / hour fluoride stream, reducing the concentration from 40mg / litre to 5mg / litre, costs about £25,000. A plant with a feed stream flow of 600 litres/ hour and a fluoride concentration of 40mg/lire has an operating cost of £10 / 3.75m^3. Electrocoagulation can be used to treat very small or very large quantities of material.

Electrochemical Ion Exchange

Electrochemical Ion Exchange uses an electrical driving force which enhances both the adsorption and regeneration reactions at the ion exchanger.

Examples of waste: Pressurised water reactor wastes and radioactive waste from hospitals.

Economics: A 200 litre / hour unit for treating the pressurised water reactor waste stream in Belgium cost £40,000 to construct and install. Operating costs were about 5 pence/m^3 and were dominated by electricity charges. Only small or pilot scale plants have been installed to date. The maximum flow rate achieved has been of the order of 1m^3 / hour. The design is modular and therefore commercial considerations define the limit on the treatment rate. Very small-scale units have been produced and tested on radioactive hospital wastes at flow rates of only a few ml/hour. The size of the plant will increase with total flow rate.

MEMBRANE TECHNOLOGIES

Micro and ultra filtration is used to remove particulates. Nano filtration and reverse osmosis can be used to removed dissolved molecules, but are not currently utilised for physico-chemical treatment. Pervaporation is a membrane separation process that can separate water from organic solvents and vice versa. One side of the membrane is kept under vacuum that vaporises the permeating component, heat is also required.

Examples of Industries: Membrane technology is developing to meet the demands of the chemical industry and new membranes are being produced which can operate in more extreme conditions such as high temperature, high/low pH and are more resistant to solvents.

Reverse Osmosis and Nanofiltration
This is a modular process with virtually no limit to the capacity of the system. Large desalination plants produce tens of thousands of cubic metres of potable water each day, whereas, for small applications, single modules can give product flows of as little as $1m^3$ / day.

Examples of waste: Separation of ionic species from effluents such as the rinse waters from plating processes. Removal of general chemical oxygen demand (COD) or solvents from effluent streams.
Economics: Systems for the removal of COD from effluent at a throughput rate of 40 m^3 / day cost approximately £100,000. Plant cost varies with design throughput. One method of estimating this cost is to evaluate the membrane area required for a certain duty, then multiply the cost of the membrane elements and modules by between about 5 and 8 to provide an approximate total plant cost. Operating costs are particularly significant for pumping power and cleaning chemicals. In both cases costs are generally proportional to plant size.

Ultrafiltration
This is a modular process that can be engineered to produce large or small flows.

Examples of waste: The recovery of sizing agents in the textile industry. The recovery and recycling of electrophoretic paints in the automotive industry.

Economics: Total plant cost can be estimated by multiplying the cost of the membrane units needed for a particular duty by about 4 - 5, however the cost of membrane modules varies greatly, from £50 / m^2 (spiral wound) to £2,000 / m^2 (ceramic tubular). Industry sources believe that with the onset of the forthcoming legislation more companies will invest in ultrafiltration membranes, this will for example allow for the reuse of water and the disposal of the hazardous waste on site.

Pervaporation
As with other membrane technologies, pervaporation is modular and can be engineered to a given throughput. Installations for flows of up to $150m^3$ / day are operational.

Examples of waste: The removal of solvents from water streams.

Economics: There are no pervaporation plants of significant scale operating in the UK at present. An important limitation is the energy cost of the process; this is proportional to the flow rate of permeate removed. Pervaporation is therefore usually applied to the de-watering of organic solvents in which the water content is low (10 - 20%), thereby minimising the operating costs.

ADSORPTION
Adsorption is a commonly used physical and / or chemical process in which a substance becomes bound or attached to a surface and is thereby removed from a liquid stream.

Examples of waste: Adsorption is typically used for removing moisture dissolved in gasoline, decolourisng petroleum products and aqueous sugar solutions, and removing objectionable taste, colour and odour.

Examples of Industries: Table C1 provides examples of industries to which adsorption is applicable[50].

[50] Envirowise, GG37 Guide

Table C1 Industries to which Adsorption technologies are applicable

Type of Industry	Typical Impurity Removed	Plant Size (m^3/ day)
Textiles and Dyestuffs	Total organic carbon, colour, dyes	200 - 6000
Oil Refinery and Petrochemical	Chemical oxygen demand (COD), biological oxygen demand (BOD)	8,000 - 15,000
Detergents, resins, chemicals	TOC, COD, xylene, alcohols, phenolics, resin intermediates, resorcinol, nitrated aromatics, polyols	60 - 10,000
Herbicides and insecticides	Chlorophenals, cresol	500 - 2,000
Pharmaceuticals	Phenol	50 - 100
Explosives	Nitrated phenol	20 - 100

Economics: Table C2 gives typical capital costs for system purchase (excluding installation). The two smaller systems would be skid mounted, pre-assembled units. The large system would require additional field assembly.

Table C2 Adsorption Separation Systems: Typical Capital Costs

Bed Capacity (kg capacity)	Typical Max Series Flow Rate (m3 / hour)	Capital Cost (including carbon)
1,000	14	30,000
5,000	60	75,000
10,000	120	110,000

Apart from the treated water, the main output of adsorption is spent carbon. This can be landfilled, incinerated as a solid waste, or reactivated (at a great cost). The range of ancillary plant needed will depend on the nature of the feed stream, including the degree of contamination and the pH level. For example, pre-treatment is usually necessary to remove suspended solids, oils and greases, particularly where suspended solids are present in concentrations greater than 50mg/litre. Chemical clarification, air flotation and filtration are common pre-treatment processes.

ION EXCHANGE

Ion exchange is a method of separation that depends on the interchange of ions between a solution and the surface of the ion exchange material.

Examples of waste: There are several types of ion exchange material including:

- Natural minerals such as phosphates
- Organic polymers with attached functional groups, which can be specific for cations or anions.

Examples of Industries: Ion exchange is applied to the treatment of spent process solutions and waste waters in a wide range of industries. Typical examples include the decontamination of various rinse waters generated in the metal finishing industry. Table C3 lists a number of primary applications for Ion Exchange technologies.

Table C3 Ion Exchange Industrial Applications

Metal Industry Applications	Non-Metallic Applications
Cyanide plating baths	Photographic processing effluent
Nikel, copper, tin, or zinc rinses	Choroalkali Brines
Aluminium anodising rinse waters	Textile and Tannery Effluents
	Pigment Manufacture

Economics: Capital costs depend greatly on the nature of the feed system. For a packed height of 1 m, an 'off the shelf' column of 1 m diameter may cost about £60,000 (vessel, valves, and resin only). Costs rise by about £20,000 for each 0.5 m increase in column diameter. Ancillary plant may be required for the following processes:

- Pre-filtration of feed stream and / or removal of large organic species to ensure that the ion exchange bed does not become fouled;
- Temperature control; and
- Additional process vessels to cope with on-line / off - line regeneration of the ion exchange material.

CHEMICAL AND PHYSICAL TREATMENT

REDUCTION / OXIDATION

Examples of waste: Cyanide treatment, e.g. sodium cyanide from metal surface treatments converted to less hazardous cycanate maintaining pH>10 using oxidising agent, I hexavalent chromium. The resultant trivalent chromium requires further processing (e.g. precipitation and separation) to remove organophosphorous and organosulphur contaminants.

Examples of Industries: Merchant treatment has been largely confined to: Oxidation of cyanides and sulphides; and Reduction of hexavalent chromium compounds. Such processes usually result in liquid waste for further treatment or sewer discharge, and a sludge for landfill. Such sludges will need dewatering to avoid the prohibition on liquid wastes. An advantage of the large waste volumes handled by merchant plants is that inputs can be balanced to optimise the residues for disposal to landfill and foul sewer.

Economics: Only a few processes have been operated at the merchant scale, where there are sufficient similar waste streams to justify facilities, and the producers are too small to treat their own waste. Specific waste streams can have in house chemical treatment tailored to suit them, and the chemical industry has undertaken much of its own treatment, often using wastes from some processes as feedstocks for others. Development of chemical treatments has been hindered by the availability of cheap landfill for liquids.

NEUTRALISATION

Example of wastes: hydrochloric, sulphuric, nitric, hydrofloric, phosphoric acids and acid salts e.g. aluminium chloride, sodium and potassium hydroxide, lime, ammonia solution, ammonium salts and amine compounds.

Example of Industries: Neutralisation of acidic and alkaline wastes is widely used as a component process in both dedicated and merchant waste treatment plants. Where discharge to sewer is permitted, it may be possible to discharge the neutralised solution direct. However, it is more likely that further treatment will be required to meet discharge standards. Neutralisation of acids and alkalines also results in the precipitation of heavy metals in metal treatment acids as low solubility hydroxides.

PRECIPITATION

Precipitation is widely used as a component process, followed by separation. It may act in two ways:

- Insolubilisation and subsequent separation of hazardous constituents (e.g. heavy metals and organics) to leave an effluent (the filtrate) suitable for discharge to sewage, and / or
- Adsorptive precipitation and flocculation that can agglomerate and bring down other suspended and colloidal matter.

Examples of waste: Zn, Ni, Cr, Pb, Cu.
Example of Industries: Precipitation is used in both dedicated and merchant waste treatment plants. It is a useful technique for treatment of effluents and some waste streams.

BASED CATALYSED DECHLORINATION (BCD)

The BCD process involves the addition of sodium bicarbonate, or an alkaline polyethylene glycol (APEG) reagent to the contaminated medium, which is then heated to 330 degrees Centigrade in a reactor to partially decompose and volatilise the contaminants, which then require separate treatment.

Examples of waste: The US EPA developed a process called Based Catalysed Dechlorination to remediate soils and sediments contaminated with chlorinated organic compounds, especially PCBs, dioxins and furans.

Example of Industries: Construction, mining
Economics: This technology has not yet been used in the UK.

AIR STRIPPING

Air passes through activated carbon, or biological filters, or catalytic filters to remove the entrained material prior to discharge to atmosphere.

Examples of waste: This may be an important pre treatment stage, primarily to remove species such as halogenated hydrocarbons, or excess ammonia, from aqueous waste streams.

BIOLOGICAL TREATMENT

All biological processes change the characteristics of the waste, by lowering the biodegradable content and hence the potential for leachate and gas generation if the residue is landfilled. The processes reduce the mass of the waste, facilitate its handling, and may reduce its hazardousness (for example, the reduction of carcinogenic organic concentrations) and enhance recovery (if compost or digestate can be used rather than landfilled).

Example of Industries: Broad ranging.

Economics: Biological treatment is currently largely operated by water companies utilising existing capacity on Waste Water Treatment Works (WWTW). It is estimated that there are potentially around 30 possible facilities. The volumes of waste are small, typically less than 1% of input of the

WWTW, but in some cases represent a significant COD load (in one case 50% of total COD input to the works).

AEROBIC TREATMENT

Examples of wastes: Widely used as a component process for dilute waste waters with a BOD <500mg/l, in both dedicated and merchant waste water treatment plants. Contaminated soils, and materials such as organic-contaminated filter aid, can also be treated aerobically in windrows.
Example of Industries: Broad range

Economics: Aerobic biological systems are generally more robust than anaerobic systems, which are sensitive to chlorinated and sulphur compounds, pH and temperature fluctuations and may require a pre-acidification stage.

ANAEROBIC TREATMENT

Examples of Wastes: Many of these processes are applied to industrial effluents and to some organic solid waste.

Examples of Industries: Broad ranging

Economics: Anaerobic biological treatment plants are much less common than aerobic treatment plant in the UK, but more widely used in Europe.

ADVANCED

Traditional aerobic and anaerobic methods are being continually developed by combining pre-treatment (for example, intensive oxidation) with controlling the environment (e.g. support media and temperature) and the types of micro-organisms to produce treatment tailored to particular process wastes.

Examples of Wastes: Broad Ranging

Example of Industries: Broad ranging

DECONTAMINATION

Niche solutions are being developed for specific pollutants, many of which depend on the selection of a suitable strain of micro-organisms.

IMMOBILISATION

Immobilisation involves mixing the waste with other constituents which will set like cement. Ions may react with the added constituents, such as lime, be adsorbed to them or simply be trapped within the solid matrix. The matrix also inhibits the passage of water that could leach soluble materials. Such processes are also commonly referred to as fixation, solidification or encapsulation. Stabilisation techniques are used in the United Kingdom to stabilise soil profiles and slopes and to lock up metal contaminants. The main methods for in-situ rotary mixing by fixed and mobile plant are mechanical and pressure mixing and for ex-situ direct and drum mixing. Such techniques are also used in the USA, France, Germany and the Netherlands.

Examples of waste: Liquid and semi-solid hydrocarbons e.g. paints, viscous solvents.

Examples of Industries: Brownfield land re-development.

Economics: There are concerns about solidification techniques, related to poor performance in the past due to poor control of the waste input quality and/or reagents, leading to failure to meet the desired performance initially or to breakdown with time. Such processes are reversible, that is the immobilised ions can be released, due both to poor process control and to subsequent mixing with other waste types. There is UK experience at the merchant scale (details provided below), though not for the last 10 years or so.

The stabilisation of hazardous and non-hazardous waste has been practised in the United Kingdom since the 1970's when a patented process, the Sealosafe process, was used by the waste management companies: Leigh Environmental and Cory Environmental. Leigh Environmental operated two plants of 80,000 and 120,000 tonnes per annum of waste input and Cory Environmental operated a plant of 15,000 tonnes per annum waste input.

Typically the types of waste treated through this process were: Sulphuric acid, Chromic acid, Al-Chloride solutions, Solid and liquid cyanides, Neutral sludge, Other sludge, Paint washing, Hydrochloric acid, Mixed acids, Fe-chloride solutions, Caustic solutions, Lime sludge, Filter cakes, and Ferrous sulphate.

The Sealosafe process homogenised acid and alkali wastes in mixing tanks and used wastes with high levels of suspended solids to raise solid levels, physically binding contaminants before adding cement. Cement and specialised cements were added before disposing of them to landfill under waste management licence conditions that required the mixture to solidify. The process ceased to be used in this way in the mid 1990's because direct disposal to landfill or other pre-treatment processes were commercially competitive. Commercial pressure resulted in operational experimentation that affected the quality of the material, by way of an example the addition of organics meant that the cement did not cure, and resulted in the breach of licence conditions by Leigh Environmental who were prosecuted under the Trade Descriptions Act.

There is a significant body of research in the United Kingdom at the Department of Engineering of Cambridge University and at Imperial College. The research supports and publicises applications and near market applications and focuses on the application of stabilisation techniques in the management of contaminated soils and hazardous and non-hazardous waste.

Oil and drilling wastes represent a treatment and disposal problem for oil companies. Shell Global Solutions for example, have developed a process known as Shell C-Fix that uses heavy refinery residues as a binding agent prior to stabilising with cement. The purpose of this process is to develop products for use in construction, where water repellent qualities are beneficial, from oily sludge and drilling wastes.

Technology for the treatment of contaminated soils can be applied using two on-site treatments referred to as 'in-situ' and 'ex-situ'. Generally in-situ treatment is undertaken by mixing the soil with binders in the ground whereas ex-situ treatment consists of temporarily excavating the soil, mixing with binders in equipment such as a pug mill and then replacing the treated soil. Both technologies are subject to Mobile Plant Licensing (MPL) requirements. The basic argument made is that where material is treated 'ex-situ', the site is subject to a Waste Management Licence. It is claimed that this places ex situ technologies at an unjustifiable disadvantage. This is against claims that ex-situ methods are actually more robust and easier to test than in-situ equivalents. When put in context, it was found under the USEPA Federal Superfund initiative, 1982 to 1999, that 25 percent of all sites remediated were done so using using stabilisation / solidification; of these sites, 24 percent employed in situ technology, 76 percent used ex-situ technology.

The Centre for Contaminated Land Research at the University of Greenwich, in its evidence submitted to the EFRA Select Committee, stated that the lack of a clear enforcement position for the ‘ex-situ’ process of binder-based stabilisation/solidification of contaminated soils poses a threat to the level of brownfield land redevelopment being sought.

THERMAL SYSTEMS

HIGH TEMPERATURE INCINERATION

The incineration process decomposes organic compounds mainly to water and carbon dioxide, other gases and inorganic ash residues. A well designed, maintained and operated incinerator can achieve destruction efficiencies or greater than 99.99%.

Examples of waste: Incineration can handle complex waste mixtures such as household waste or contaminated soil, removing most of the organic material and leaving ash residues for recovery or landfill. In its submission to the EFRA Select Committee, Cleanaway states that ‘High Temperature Incineration (HTI) has traditionally been the major disposal route for the most toxic and reactive wastes. Some of these wastes, by-products of chemical and manufacturing processes, are extremely dangerous substances, for which there is no alternative to disposal by HTI’.

Example of Industries: The main areas of current application in hazardous waste management are in the areas of organic chemical wastes and animal and clinical wastes, but they will handle a proportion of inorganic materials, trapping them in bottom ash or flue gas cleaning systems. Mixed laboratory chemicals are often consigned to incineration.

Economics: The economics of HTI have been depressed for a number of years, primarily as a result of wastes going to cheaper alternatives. As a result, capacity has contracted. High calorific value wastes which would ideally be used as feedstock for HTI are going to fuel blending applications, resulting in HTI plant operators having to buy in diesel to maintain temperatures.

These technologies reduce the mass of waste for landfill, facilitate handling and may reduce hazardousness and enhance recovery.

CO-INCINERATION

This technique is predominantly focused on energy containing wastes in the form of a waste derived fuel blended to meet well defined physical / chemical criteria. Efficient destruction of the waste materials requires sufficiently high temperatures, residence time, turbulence and the presence of excess oxygen. Processing conditions within cement kilns result in waste-derived fuels being subject to flame temperatures in excess of 2,000□C, material temperatures of at least 1,450□C, and gas residence times above 1,100□C of between four and five seconds. The minimum residence time for non-gaseous material is about 30 minutes. Cement making requires stable burning conditions and as such all waste-derived materials to be used as fuels are subject to strict compositional control.

It is claimed that any ash from the combustion of the hazardous waste is fixed safely in the glassy matrix of the product clinker. Also, the main emissions of concern occur as a result of the raw materials used in the cement production process, not the fuel used to heat the kiln.
Examples of waste: solvents, oil sludges, distillation residues and tank bottom sludges. The blend in particular is set to meet calorific values and limits on contaminants e.g. chlorine and heavy metals.

The US market has seen cement manufacturers starting to tackle solids with tars and oily wastes put in to suspension prior to combustion. Associated with this practice, there will be advances needed to enable these to be blended, via tanks that continually circulate liquids.

Examples of Industries: This technique is predominantly focused on energy containing wastes in the form of a waste derived fuel. Industrial waste streams, which contain high percentages of iron, alumina and silica, have also been identified as a potential source of the correctors sometimes needed when mineralogical anomalies occur in the prime raw material source for cement production.

Economics: Since 1992 the UK cement and lime industry has experimented with using hazardous waste to provide up to 40 percent of the thermal input to their kilns, resulting in the classification as a co-incineration process under the Hazardous Waste Incineration Directive. The economic attractions of this practice are clear. Instead of paying approximately £28 per tonne of coal, the industry are paid £20-25 per tonne to dispose of hazardous waste[51].

As a result of public opposition to co-incineration, in light of its environmental impacts, two House of Commons Environment Select Committee enquiries have been held on the matter.

VITRIFICATION

The process uses a bath of molten glass or feedstock (e.g. asbestos) to dissolve residues and form an environmentally sound product by the inorganic content of the waste input being encapsulated in the glassy matrix.

Examples of waste: A wide range of waste materials including contaminated soils, fly ash and asbestos.

Examples of Industries: All that are relevant to soils. Soils can be melted in situ by the passage of an electrical current, driving off or decomposing organics, and subsequently allowing the melt to cool to a glass like material. Alternatively inorganics can be mixed with and bound in glass. The technique would reduce hazardousness and facilitate handling, and may result in a construction material.

Economics: These are expensive, energy intensive techniques, not used in the UK. In view of its energy consumption, it is unlikely to be the BPEO.

This technique would reduce hazardousness and facilitate handling.

THERMAL DEGRADATION

This process alters the crystalline structure of some minerals, by heating them to 1100 degrees centigrade, which then destroys their hazardous nature.

Examples of wastes: Asbestos

Economics: Because bagging for landfill has been the UK practice, there is no UK experience of this technique. Whether it is the BPEO for asbestos would depend upon an assessment of the energy requirements of the process, and the risks of release in transport and processing.

These technologies reduce the mass of waste for landfill, facilitate handling and may reduce hazardousness and enhance recovery.

GASIFICATION AND PYROLYSIS

Examples of waste: Toxic sludges produced during industrial cleaning, waste from the manufacture and use of paints, inks, resins and adhesives (pyrolysis), clinical waste.

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[51] The environmental impact of cement manufacture. Third Report from the Environment Committee – Session: 1996-7 HC124-I. HMSO, London

Example of Industries: Petrochemical, industries using chemical cleaning.

Economics: Interest in pyrolysis and gasification technologies has increased in recent years as mass-burn incineration has met public opposition and landfill void space has reduced. Despite the attention, the market has not yet matured and there is only marginal installed capacity in the UK.

Coal and oil gasifiers have proven robust. It is likely that refineries will seek to increase capacity in these technologies. It would be a useful exercise to ascertain whether the facilities that have previously used landfill are considering investment in alternative thermal technologies.

It should be easier to develop these technologies on a smaller scale than that which is demanded by mass-burn incinerators as capital costs are lower and individual gasification/pyrolysis units generally deal with only between 25,000 and 40,000 tonnes per annum. There is, therefore, greater scope for application of this technology in smaller communities than the large cities which typically support incinerators today. Likewise, there is less need to keep the gasifier running 100 percent of the time as start-up periods are less than for mass burn incinerators which allows for possible plant closing at nights or weekends. Systems are capable of operating at less than 100 percent capacity making them flexible to changing market conditions.

One disadvantage with the process is the necessary fuel preparation. The fuel material needs to be shredded in many systems before being inputted to the gasifier, which entails cost.

Advanced thermal technologies like these are still categorised as incineration when it comes to planning. The absence of a smokestack, however should help with planning permission applications.

PLASMA SYSTEMS

Plasma Arc treatment involves directing an electric current through a low-pressure gas stream to create a thermal plasma field. Plasma systems use the electric arc formed when a current jumps between two electrodes. The high temperature dissociates waste into its atomic elements by injecting the waste into the plasma, or by using the plasma arc as a heat source for combustion or pyrolysis.

Examples of waste: PCB and Shredder Residue destruction; dioxins and furans.

Examples of Industries: Steel works (the plasma treatment is principally used to recover valuable materials from the dust), waste management industry.

Economics: Technology suppliers believe that there will be a rapid growth in the high-temperature plasma treatment industry within England and Wales in the next couple of years. It is envisaged that industries such as steel works will invest in plasma plant, with bespoke system design for their own wastes.

Currently plant sizes come in 3 size types:

- 0.5 tonnes per hour (for example for hospitals);
- 2 tonnes per hour; and
- 10 tonnes per hour (for example for use at steel works).

The construction of centralised plasma plants for use by smaller hazardous waste producers has been considered, it is not thought that this will be possible for a couple of years as data recording still has to be fine tuned.

MICROBIAL INACTIVATION

A number of low temperature processes have been developed for the inactivation of microbes in order to render clinical waste safe. The main technologies in use are autoclaves (steam sterilisation), microwaves and dry heat systems.

Examples of waste: Clinical Waste, but not anatomical wastes or pharmaceutical wastes.

Type of Industries: Hospitals

Table C4 has been built up based on a review of: 'Environment Agencies' - Guidance on the Waste Treatment Requirements of Article 6(a) of the Landfill Directive version 2.1 Draft for External Consultation October 2001. Those ticks underlined represent the primary treatment option for each waste.

Table C4 Hazardous Waste Treatment Matrix

Code	Waste description	Solidification	Chemical	Biological	Thermal
01 01	Wastes from mineral excavation	✓	✓		
01 03	Wastes from physical and chemical processing of metalliferous minerals	✓	✓		
01 04	acid-generating tailings from processing of sulphide ore	✓			
01 05	drilling muds and other drilling wastes		✓		
02 01	wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing				✓
03 01	wastes from wood processing and the production of panels and furniture		✓		✓
03 02	wastes from wood processing and the production of panels and furniture	✓	✓	✓	✓
04 01	wastes from the leather and fur industry			✓	✓
04 02	wastes from the textile industry	✓			✓
05 01	wastes from petroleum refining	✓	✓	✓	✓
05 06	wastes from the pyrolytic treatment of coal				✓
05 07	wastes from natural gas purification and transportation	✓			
06 01	wastes from the manufacture, formulation, supply and use (MFSU) of acids				✓
06 02	wastes from the MFSU of bases		✓	✓	✓
06 03	wastes from the MFSU of salts and their solutions and metallic oxides	✓	✓		
06 04	metal-containing wastes other than those mentioned in 06 03	✓			
06 05	sludges from on-site effluent treatment	✓			
06 06	wastes from the MFSU of sulphur chemicals, sulphur chemical processes and desulphurisation processes	✓	✓		
06 07	wastes from the MFSU of halogens and halogen chemical processes	✓	✓		✓
06 09	wastes from the MSFU of phosphorous chemicals and phosphorous chemical processes	✓			
06 10	wastes from the MFSU of nitrogen chemicals, nitrogen chemical processes and fertiliser manufacture	✓		✓	✓
06 13	wastes from inorganic chemical processes not otherwise specified	✓			✓
07 01	wastes from the manufacture, formulation, supply and use (MFSU) of basic organic chemicals	✓	✓	✓	✓
07 02	wastes from the MFSU of plastics, synthetic rubber and man-made fibres	✓	✓	✓	✓
07 03	wastes from the MFSU of organic dyes and pigments (except 06 11)	✓	✓	✓	✓
07 04	wastes from the MFSU of organic plant protection products (except 02 01 08 and 02 01 09), wood preserving agents (except 03 02) and other biocides		✓	✓	✓

Code	Waste description	Solidification	Chemical	Biological	Thermal
07 05	wastes from the MFSU of pharmaceuticals	✓	✓	✓	✓
07 06	wastes from the MFSU of fats, grease, soaps, detergents, disinfectants and cosmetics		✓	✓	✓
07 07	wastes from the MFSU of fine chemicals and chemical products not otherwise specified	✓	✓	✓	✓
08 01	wastes from MFSU and removal of paint and varnish		✓	✓	✓
08 03	wastes from MFSU of printing inks		✓		✓
08 04	wastes from MFSU of adhesives and sealants (including waterproofing products)		✓	✓	✓
08 05	wastes not otherwise specified in 08		✓		✓
09 01	wastes from the photographic industry	✓	✓	✓	✓
10 01	wastes from power stations and other combustion plants (except 19)	✓	✓		
10 02	wastes from the iron and steel industry	✓	✓	✓	
10 03	wastes from aluminium thermal metallurgy	✓	✓	✓	✓
10 04	wastes from lead thermal metallurgy	✓	✓	✓	✓
10 05	wastes from zinc thermal metallurgy	✓	✓	✓	✓
10 06	wastes from copper thermal metallurgy	✓	✓		✓
10 07	wastes from silver, gold and platinum thermal metallurgy		✓	✓	✓
10 08	wastes from other non-ferrous thermal metallurgy	✓	✓	✓	✓
10 09	wastes from casting of ferrous pieces	✓	✓	✓	✓
10 10	wastes from casting of non-ferrous pieces	✓	✓		✓
10 11	wastes from manufacture of glass and glass products	✓			✓
10 12	wastes from manufacture of ceramic goods, bricks, tiles and construction products	✓			
10 13	wastes from manufacture of cement, lime and plaster and articles and products made from them	✓			
10 14	waste from crematoria	✓			
11 01	wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodising)	✓	✓	✓	✓
11 02	wastes from non-ferrous hydrometallurgical processes	✓	✓	✓	✓
11 03	sludges and solids from tempering processes		✓		
11 05	wastes from hot galvanising processes	✓	✓		✓
12 01	wastes from shaping and physical and mechanical surface treatment of metals and plastics	✓	✓	✓	✓
12 03	wastes from water and steam degreasing processes (except 11)	✓	✓	✓	
13 01	waste hydraulic oils		✓	✓	✓
13 02	waste engine, gear and lubricating oils		✓	✓	✓
13 03	waste insulating and heat transmission oils		✓	✓	✓

Code	Waste description	Solidification	Chemical	Biological	Thermal
13 04	bilge oils		✓		
13 05	oil/water separator contents	✓	✓̲	✓	✓̲
13 07	wastes of liquid fuels				✓
13 08	oil wastes not otherwise specified				
14 06	waste organic solvents, refrigerants and foam/aerosol propellants		✓̲	✓	✓̲
15 01	packaging (including separately collected municipal packaging waste)	✓	✓		✓
15 02	absorbents, filter materials, wiping cloths and protective clothing		✓		
16 01	end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)	✓	✓		✓
16 02	wastes from electrical and electronic equipment	✓	✓̲		✓
16 03	off-specification batches and unused products	✓	✓	✓	✓
16 04	waste explosives				
16 05	gases in pressure containers and discarded chemicals	✓	✓	✓	✓
16 06	batteries and accumulators		✓		
16 07	wastes from transport tank, storage tank and barrel cleaning (except 05 and 13)		✓		✓
16 08	spent catalysts	✓	✓		
16 09	oxidising substances		✓		
16 10	aqueous liquid wastes destined for off-site treatment	✓	✓	✓	
16 11	waste linings and refractories		✓̲	✓̲	✓
17 01	concrete, bricks, tiles and ceramics	✓			
17 02	wood, glass and plastic	✓	✓		
17 03	bituminous mixtures, coal tar and tarred products		✓		✓
17 04	metals (including their alloys)	✓	✓		✓
17 05	soil (including excavated soil from contaminated sites), stones and dredging spoil	✓			
17 06	insulation materials and asbestos-containing construction materials	✓			
17 08	gypsum-based construction material	✓			
17 09	other construction and demolition wastes	✓	✓		✓
18 01	wastes from natal care, diagnosis, treatment or prevention of disease in humans	✓	✓	✓	✓̲
18 02	wastes from research, diagnosis, treatment or prevention of disease involving animals	✓	✓	✓	✓
19 01	wastes from incineration or pyrolysis of waste	✓̲	✓	✓	✓
19 02	wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)	✓	✓	✓	✓̲
19 03	stabilised/solidified wastes	✓			
19 04	vitrified waste and wastes from vitrification	✓	✓		

Code	Waste description	Solidification	Chemical	Biological	Thermal
19 05	wastes from aerobic treatment of solid wastes				
19 06	wastes from anaerobic treatment of waste				
19 07	landfill leachate		✓		
19 08	wastes from waste water treatment plants not otherwise specified	✓	✓	✓	✓
19 09	wastes from the preparation of water intended for human consumption or water for industrial use	✓	✓		
19 10	wastes from shredding of metal-containing wastes				✓
19 11	wastes from oil regeneration	✓	✓		✓
19 12	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	✓			✓
19 13	wastes from soil and groundwater remediation	✓	✓	✓	✓
20 01	separately collected fractions (except 15 01)	✓	✓	✓	✓
20 02	garden and park wastes (including cemetery waste)	✓			✓
20 03	other municipal wastes				

Appendix D
Hazardous Waste Management Capacity – Supporting Information

Table D1 Charge band information

Facility Type	Charge bands (tonnes) and number of facilities in each band							
	<500	**<5000**	**>=2500**	**25000-75000**	**500-2500**	**5000-25000**	**>=75000**	**Total**
A1 – Co-Disposal Landfill Site		4		2		3	1	10
A10 - In-House Storage Facility	9	8	25		14	1	1	58
A11 – Household, Commercial & Ind Waste Transfer Stn		42	1	32		44	30	140
A12 – Clinical Waste Transfer Station		72		1		11		84
A13 – Household Waste Amenity Site		2		5		12	3	22
A14 – Transfer Station taking Non-Biodegradable Wastes		2				5		7
A15 – Material Recycling Treatment Facility		28		5		11	3	47
A16 – Physical Treatment Facility		16		7		11	11	45
A17 – Physico-Chemical Treatment Facility		21		8		14	24	67
A18 – Incinerator		6	1					7
A19 – Metal Recycling Site (vehicle dismantler)	1	2				1		4
A2 – Other Landfill Site taking Special Waste		1				1		2
A20 – Metal Recycling Site (mixed MRS's)		12		1		8	2	23
A21 – Chemical Treatment Facility		8		4		6	8	26
A23 – Biological Treatment Facility		2	1	7		10	8	28
A3 – Borehole				1			1	2
A4 – Household, Commercial & Industrial Waste Landfill		1	1	1			3	6
A7 – Industrial Waste Landfill (Factory curtilage)			1					1
A8 – Lagoon		1	2				1	4
A9 – Special Waste Transfer Station	1	193		40		75	29	338
Total	11	422	32	105	14	213	125	922

Table D2 Facility Capacities linked to WML Charge Bands

Charge band (tonnes)	Assumed facility tonnage
<500	450
500 – 2500	2400
<5000	4500
>=2500	5000
2500 0– 75000	60000
5000 – 25000	24000
>=75000	120000

Table D3 Other Capacity Information

	Special Waste Handled	Total Waste Handled 2000-01	Special Waste %	Reported Capacity 1/04/01	Special Waste Capacity 1/04/01
	000s tonnes			*000s m3*	
A1 – Co-Disposal Landfill Site [10%?]	2,358	41,663	6%	610,652	344,954
A2 – Other Landfill Site taking Special Waste					
A4 – Household, Commercial & Industrial Waste Landfill	293	24,297	1%		
A5 – Inert and Construction/Demolition Waste Landfill	3	9,875			
A3 – Borehole	134	256	52%	Very large	
A7 – Industrial Waste Landfill (Factory curtilage)	388	6,905	6%	91,705	12,478
A8 – Lagoon	8,074	16,626	49%	not calculable	
				000s tonnes per annum	
A9 – Special Waste Transfer Station	540	30,226	2%	78,730	10,551
A11 – Household, Commercial & Ind Waste Transfer Stn					
A12 – Clinical Waste Transfer Station					
A14 – Transfer Station taking Non-Biodegradable Wastes					
A13 - Household Waste Amenity Site	10	5,330	0%	capacity data not collected	

A15 - Material Recycling Treatment Facility	120	1,067	11%	18,226	3,691
A16 - Physical Treatment Facility A17 - Physico-Chemical Treatment Facility	953	6,373	15%		
A21 - Chemical Treatment Facility	244	369	66%		
A19 - Metal Recycling Site (vehicle dismantler) A20 - Metal Recycling Site (mixed MRS's)	74	9,638	1%	capacity data not collected	
A23 - Biological Treatment Facility	268	2,048	13%	6,892	150
A18 – Incinerator (storage at)	4	1,162	0%		
IPC authorised Incinerator throughput*	29	2,097	1%		
A10 – In-House Storage Facility					
Total All Facilities	13,493	157,932			
*incinerator throughput data for East of England, East Midlands, London, and West Midlands only					

Appendix E
Sector Information

Table E1 Forecast Growth in Domestic Supply (% per annum)

Industry Sector	Year / Forecast Period					
	2002	2003	2004	2000-2005	2005-2010	2010-2015
Agriculture	-	-	-	-0.3	0.4	0.7
Chemicals	-2.0	2.8	2.4	0.9	0.9	0.3
Pharmaceuticals	4.0	7.9	6.9	6.5	5.6	5.3
Rubber & Plastics	-1.1	2.0	2.9	0.4	1.9	1.9
Non Metallic Mineral Products	-2.2	0.2	0.6	0.0	-0.3	-0.6
Mechanical Engineering	-4.2	2.7	2.4	0.7	1.3	1.4
Electrical Engineering	-3.7	2.9	2.9	0.1	2.1	1.3
Instruments	-0.8	2.6	0.7	1.3	-0.1	0.0
Manufacturing nes & Recycling	-1.4	3.3	4.2	1.3	1.8	2.2
Basic Metals	-10.4	0.8	0.6	-2.3	0.7	0.2
Metal Goods	-3.9	0.9	1.0	-0.4	0.1	0.0

Source: Industry and the British Economy, Cambridge Econometrics. January 2002.