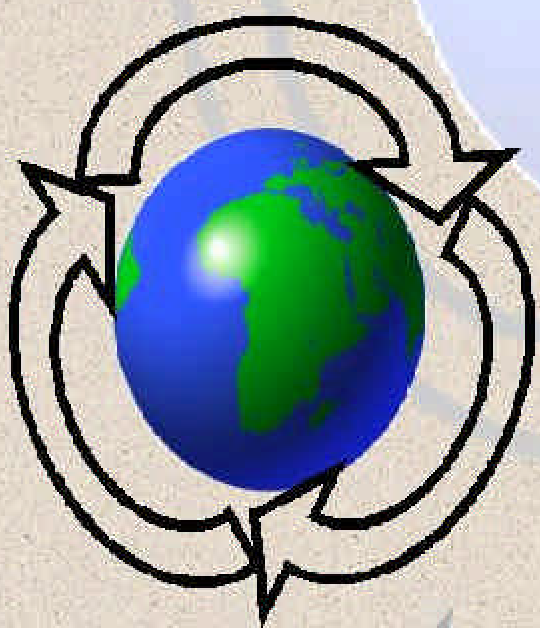
MINIMUM REQUIREMENTS FOR THE HANDLING, CLASSIFICATION AND DISPOSAL OF HAZARDOUS WASTE



waste management series

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Second Edition 1998

MINIMUM REQUIREMENTS FOR THE HANDLING, CLASSIFICATION AND DISPOSAL OF HAZARDOUS WASTE

Department of Water Affairs and Forestry
Republic of South Africa

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THE WASTE MANAGEMENT SERIES

This document forms part of the Waste Management Series, produced by the Department of Water Affairs & Forestry. Thus far, the series comprises:

Document 1: ***Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste***.

Document 2: *Minimum Requirements for Waste Disposal by Landfill.*

Document 3: *Minimum Requirements for the Monitoring of Water Quality at Waste Management Facilities.*

Document 1, ***Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste,*** sets out the waste classification system. In this, wastes are placed in two classes, General or Hazardous, according to their inherent toxicological properties. Hazardous wastes are further subdivided, according to the risk that they may pose at disposal, using a hazard rating. In this way, a less hazardous waste is distinguished from an extremely hazardous waste. Wastes with a hazard rating of 1 or 2 are very or extremely hazardous, while wastes with a hazard rating of 3 of 4 are of moderate or low hazard. The requirements for pre-treatment and disposal are appropriately set in accordance with the waste classification. Hazardous waste prevention and minimisation are briefly addressed, because of their importance, as is handling, transportation and storage.

Document 2, ***Minimum Requirements for Waste Disposal by Landfill,*** addresses landfill classification, and the siting, investigation, design, operation and monitoring of landfill sites. In the landfill classification system, a landfill is classified in terms of waste class, size of operation, and potential for significant leachate generation, all of which influence the risk it poses to the environment. Graded requirements are then set for all aspects of landfilling, including public participation.

Document 3, ***Minimum Requirements for the Monitoring of Water Quality at Waste Management Facilities,*** addresses the monitoring of water quality at and around waste disposal facilities.

The Department intends extending the Waste Management Series. At the time of writing, the National Waste Management Strategy was being formulated, as a joint venture between the Department of Water Affairs & Forestry, the Department of Environment and Tourism, and DANCED. Initially, three baseline study documents were drafted by South African consultants to provide data regarding waste generation, community waste and litter, and waste disposal sites in South Africa. These will form part of the series. Further work being carried out by Danish and South African consultants, assisted by Departmental staff will generate strategy documents which will also form part of the series.

Other documents envisaged for the series include Minimum Requirements for waste disposal site auditing, and training of operators and managers of waste management facilities.

PREFACE

The management of hazardous waste remains one of the central environmental issues throughout the world. With the Basel Convention the full title of which is the: "Basel Convention for the **transboundary m**ovements of Hazardous wastes and their disposal", that came into force in South Africa, this country has now become inseparably linked to international policy on hazardous waste.

At present, regulating measures for hazardous waste management in South Africa are still not on a par with international legislation. For this reason the department started the development of the *Waste Management Series* with the aim to upgrade the standard of waste management in South Africa and to provide a system whereby waste disposal can be regulated. To this end, the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste* sets out a systematic framework for identifying a Hazardous Waste and classifying it in accordance with the degree of risk that it poses. From the classification, requirements are set that will ensure Hazardous Waste is treated and safely disposed of. These requirements represent the lowest acceptable standard and are therefore termed **Minimum Requirements**.

The aim is to ensure the sustained fitness for use of South Africa's water resources and to protect both the public and the environment from harmful effects of incorrect waste management, without impairing the essential economic development of South Africa. It follows that the application of the Minimum Requirements to the classification, treatment and disposal of unavoidable hazardous waste will contribute to a clean and healthy environment for all South Africans. In this way the Minimum Requirements project addresses an important aspect of the Government's Reconstruction and Development Programme.

This document addresses crucial aspects of the hazardous waste disposal process, so that cradle-to-grave control can be instituted. This minimum requirements document thus provides a basic national framework from waste management in South Africa. This must be expanded upon in the future. In addition, the minimum requirements are intended to facilitate conformity with international standards, required by future trading partners and by the Basel Convention.

The improvement of standards for waste disposal in South Africa will also rely on the co-operation of all participants. To this regard environmental groups and certain waste generators have already demonstrated their commitment by respectively promoting and exercising good waste management practices in South Africa and by contributing to the development of the minimum requirements. Nonetheless, the minimum requirements will also be enforced by means of permits for waste disposal sites, the future registration of waste generators and transporters and a manifest system, in order to address situations where good waste management practices have not been implemented. Costs that have in the past been externalised as social and environmental costs, because of the absence of standards, will now be internalised in accordance with the "polluter pays" principle.

It is accepted that improved standards will inevitably result in increased costs. Consequently, the Best Practicable Environmental Option (BPEO) approach is adopted, in order to provide affordable environmental protection. This is achieved by the promotion of a waste management process. The process comprises three basic steps: waste avoidance, correct classification and minimum requirements for the safe handling, treatment and disposal of hazardous waste.

Waste prevention, minimisation and recovery are not entirely within the scope of this document, which deals primarily with classification and disposal. Nonetheless, these issues are regarded as important, especially in view of future trends and developments, and so they are briefly explained and frequently referred to.

An Integrated Environmental Management Approach has been adopted throughout and this implies advance planning for all aspects of waste management. An Environmental Impact Assessment will form an essential stage in this planning process. This Environmental Impact Assessment will be necessary before a landfill is issued with a permit to operate.

The *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste* was first published in 1994. This edition has been revised in the light of use and comment. This will not be the final revision, however, and the document must be regarded as 'living'. Certain wastes may, with the development of new technologies, pose either a lesser or greater risk in the future. I expect the requirements to evolve with changing knowledge, expertise, political, social and economic circumstances in South Africa. I would therefore like to encourage you, and all other interested and affected parties, to submit written comment and input to the Department, so that your concerns can be addressed and your input included in future editions.

Kader Asmal

PROFESSOR KADER ASMAL M.P.
MINISTER OF WATER AFFAIRS AND FORESTRY

SYNOPSIS

In terms of Section 20 of the Environment Conservation Act, 1989 (Act 73 of 1989), waste can only be disposed of at a waste disposal facility that has a permit issued by the Minister of Water Affairs & Forestry. Such a facility must be sited, designed, operated and monitored strictly in accordance with the permit conditions. These conditions will include the requirements, standards and procedures set out in the Department's Waste Management Series, "Minimum Requirements" documents.

To date, three documents have been published. These are: *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Minimum Requirements for Waste Disposal by Landfill*, and *Minimum Requirements for Water Quality Monitoring at Waste Disposal Facilities*. The documents are intended to enforce the permit system and the environmentally acceptable disposal of waste. They also are intended to raise waste management standards in South Africa and to facilitate conformance with the international standards required by future trading partners and the Basel Convention.

The approach adopted is the Integrated Waste Management Approach. The aim is to curtail the risks associated with handling and disposal of waste to the point where they are acceptable to man and the environment. Waste management must therefore be carefully planned in advance and take place in the following order:

- **Waste prevention:** the prevention and avoidance of the production of a waste, perhaps by regulation.
- **Waste minimisation:** the reduction of the volume of waste during production by means of different processes or clean technology.
- **Resource recovery:** recycling of waste or the recovery of energy through incineration and biodegradation.
- **Treatment:** the treatment of waste to reduce volume or hazardousness
- **Disposal:** the safe disposal of waste so that it will not pollute the environment or cause health hazards.

The Department strongly recommends that waste be managed in accordance with the above principles. Waste prevention, minimisation and resource recovery are the best options for the management of waste.

For a waste to be properly managed, its properties and the risk that it poses must be fully understood. It must be known whether it poses little risk to the environment (termed a General Waste), or whether it poses a significant risk (a Hazardous Waste). A Hazardous Waste is a waste that, because of its toxic, chemical or physical properties, requires stringent technical control so as not to cause harm to man or to the environment.

The first indication that a waste should be classified as Hazardous can be gathered from the industrial group or process whereby it is generated. If a waste emanates from a certain industry, for example the medical, metal, agricultural or textile industry, it is probably Hazardous. The waste will therefore have to be accurately tested and analysed to identify its composition and concentration.

If analysis confirms that a waste does contain hazardous substances (as listed in SABS Code 0228, the Basel Convention or the waste tables at the back of this document) the generator must register as a Hazardous Waste Generator and determine the relevant Minimum Requirements. These could include pre-treatment, destruction, venting, or disposal according to a specific Act.

Once the waste has been treated, it may be necessary to re-analyse the residue. Thereafter the toxicity (LD_{50}), ecotoxicity (LC_{50}), carcinogenicity, mutagenicity, teratogenicity, persistence, environmental fate and Estimated Environmental Concentration (EEC) of the waste or its residue must be determined. Using this information, the waste is given a Hazard Rating from which the Minimum Requirements for disposal are derived, e.g., certain wastes may not be landfilled and others must be pretreated.

Hazard Ratings correspond to the following hazard description levels:

Hazard Rating 1 and 2: extreme and high hazard
Hazard Rating 3 and 4: medium and low hazard.

The Hazard Rating (**HR**) determines the class of Hazardous Waste landfill at which the waste may be disposed. A H:h landfill may only accept Hazard Ratings 3 and 4. A H:H landfill may accept all four Hazard Ratings.

The Hazard Rating provides an assessment of the risk posed by a hazardous substance in the waste. Two factors are taken into account, the amount of the substance that is available to man and the environment (**Estimated Environmental Concentration** or EEC, which represents **exposure**) and the inherent toxicological hazard of the substance (**LC_{50}**, chronic toxicity etc., which represents a specific **effect** or **response**).

The EEC is calculated from the total amount of a hazardous substance in a waste stream which would be disposed of on one hectare of landfill, followed by a calculation of the resultant concentration in a body of water should the total amount of the hazardous substance leach to groundwater over an indefinite period of time. As such, it provides a worst case scenario. The EEC is expressed as (ppb) = dose (g/ha/month) x 0,66. It is used to determine:

- the amount of waste that can be disposed of within an acceptable risk;
- the maximum amount of a given hazardous substance in the waste that can be disposed of at a landfill site (Total Load); and
- whether a waste, initially regarded as Hazardous, can be delisted and handled and disposed of as a General Waste.

The EEC is always compared to 0,1 x LC_{50} of the specific hazardous substance in the waste, termed the **Acceptable Risk Level**. The Acceptable Risk Level is the concentration at which a substance would cause a mortality incidence of one in three hundred thousand in aquatic environment. It therefore represents the level at which a substance will have little adverse impact on the environment. When the EEC is higher than 0,1 x LC_{50}, then the waste remain in the Hazard Rating. When it is lower, a **HR1** waste remains **HR1**, but the other Hazard Rating can delist and will be disposed of on a General Waste landfill with a leachate collection system (**$G:B^+$**). A **HR1** waste can only delist to a **$G:B^+$** landfill when the EEC is lower than 0,01 x LC_{50}.

Where there is a difference of opinion regarding classification or Hazard Rating, the results of tests or other proof may be submitted to the Department. Such tests would include the Toxicity Characteristic Leaching Procedure and the Acid Rain tests. The Department will use the test results to determine whether it is safe to delist the Hazardous Waste to a lower Hazard Rating or not.

The information gained from classification and Hazard Rating must be applied in the handling of a Hazardous Waste, during collection, temporary storage and transportation. This is essential for safe disposal.

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Representatives of the following organisations were invited to form part of the Second Edition Steering Committee. However, they were either unable to attend or elected, at this stage, to partake on a strategic level through the project steering committee of the National Waste Management Strategy of South Africa.

Chamber of Mines
Chemical and Allied Industries Association (CAIA)
COSATU
Environmental Justice Network Forum (EJNF) / Earth Life Africa (ELA)
Parks Board Environmental Affairs
South African National Civics Organisation (SANCO)

HOW TO USE THIS DOCUMENT

Section 1	**:**	Summarise the approach, the main characteristics and the legal basis of the Minimum Requirements, to provide the reader with a concise background.
Section 2	**:**	Provides a definition of waste and the waste classes (General Waste and Hazardous Waste). It also provides a brief overview of Hazardous Waste management and the Hazardous Waste classification system. From Figure 1, it can be seen that this document attempts to follow the logical sequence of actions recommended by the Integrated Waste Management approach.
Section 3	**:**	Briefly discusses the first step in the management of Hazardous Waste, i.e., waste prevention, minimisation and recovery. These issues are not directly related to Hazardous Waste classification and disposal. However, attempts to avoid and reduce Hazardous Waste at all stages of the cycle are so important that they are treated as a separate section.
Section 4	**:**	Shows how, as an initial coarse-screen, the industry, process or waste stream from which a waste is generated (listed in Diagram I), or the Basel Convention, can be used to identify waste that is probably Hazardous.
Section 5	**:**	Describes the tests and analytical techniques used to identify the substances, compounds and properties of a Hazardous Waste, prior to classification.
Section 6	**:**	Details the Hazardous Waste classification system. A waste is tested against the nine SABS Code 0228 classes, to see whether it is, for example, explosive, corrosive or toxic. It is then treated in accordance with the requirements of that class (set out in Diagram II). The Minimum Requirements are set out in Diagram III.
Section 7	**:**	Provides an overview of some of the treatment methods that can be used to reduce the hazardousness of a waste so that it complies with the Minimum Requirements or fits into a lower Hazard Rating.
Section 8	**:**	Outlines Hazard Rating (set out in Diagram IV). This is based on the toxicity, ecotoxicity and environmental fate of the waste. The Hazard Rating indicates the risk posed to man and the environment by the disposal of the waste or its residue. Delisting (proving that the waste belongs in a lower Hazard Rating) and Total Load (the quantities of a hazardous substance that can be landfilled at a particular site) are also discussed in Section 8.
Section 9	**:**	Sets out the allowed and preferred methods of Hazardous Waste disposal.
Section 10	**:**	Briefly discusses the collection, temporary storage, packaging, and transportation of Hazardous Waste.

Diagrams MUST be read in conjunction with the text. For example, it will not be possible to perform a Hazard Rating without using Diagram IV. The **Minimum Requirements** listed in the tables at the beginning of each section are compulsory. Guidelines are also provided in the text, in the form of explanation and discussion. These are not compulsory, however, they will be used by the Department as a standard. **Appendices** and **Tables** are numbered in accordance with the section from which they arise, e.g., Appendix 6 is derived from Section 6. **Waste Classification Tables** are placed behind the Appendices. A **glossary of terminology**, **bibliography and references** are also provided.

Section 1

MINIMUM REQUIREMENTS

1.1 Background

The Department of Water Affairs & Forestry is responsible for ensuring the correct management and disposal of waste in South Africa, in as mush as it has an effect on the National water resource. This is because the Department* is custodian of South Africa's water resources in terms of the Water Act, 1956, (Act 54 of 1956) which is gradually being phased out, to be replaced by the National Water Act, 1998 (Act 36 of 1998) and the Water Services Act, 1997 (Act 108 of 1997) and responsible for issuing waste disposal site permits (Environment Conservation Act, 1989 (Act 73 of 1989)). The Department, together with other government departments, is therefore setting in place a waste regulatory system.

This regulatory system includes:

- the issuing of waste disposal site permits and, in the future;
- a manifest system for the transportation of Hazardous Waste and;
- the registration of Hazardous Waste generators and transporters.

The aim is to protect the environment* and the public from the harmful effects of bad waste disposal practices.

1.2 Minimum Requirements

Before a waste disposal site permit will be issued, minimum procedures, actions and information will be required from the permit applicant. These are termed "Minimum Requirements".

* Hereafter termed “the Department”.

* “Environment” is used in the holistic sense and includes cultural, social, soil, biotic, atmospheric, surface and ground water aspects.

The Minimum Requirements provide the applicable waste management standards or specifications that must be met in the absence of any valid motivation to the contrary. They also provide a point of departure against which environmentally acceptable waste disposal practices can be distinguished from environmentally unacceptable waste disposal practices.

The objectives of setting Minimum Requirements are to:

- **prevent water pollution and ensure sustained fitness for use of South Africa's water resources;**
- **attain and maintain minimum waste management standards in South Africa, so as to protect human health and the environment from possible harmful effects caused by the handling, treatment, storage and disposal of waste;**
- **effectively administer and provide a systematic and nationally uniform approach to the waste disposal process;**
- **endeavour to make South African waste management practices internationally acceptable.**

1.3 Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste

There are currently three Minimum Requirement documents in the Waste Management Series, see Page (ii). These three documents are interrelated, and no one document should be read in isolation from the others.

This document, the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste,* addresses the principles of good waste management and sets out a waste classification system. It also sets the Minimum Requirements for the treatment and disposal of Hazardous Waste.

The objectives of the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste* are to:

- promote the avoidance, re-use, recycling and treatment of waste;
- develop a waste classification system whereby waste can be classified in accordance with the risk it poses;
- provide controlling authorities, generators, transporters and managers of waste with guidelines and graded Minimum Requirements so that waste, and in particular Hazardous Waste, can be effectively controlled from generation until its safe disposal;
- prevent Hazardous Waste entering the environment illegally;
- effectively manage and administer the issuing of waste disposal site permits.

The other two documents in the Waste Management Series address waste disposal by landfill and the monitoring of water quality at waste disposal facilities, respectively.

1.4 Approaches used in the formulation of the Minimum Requirements

Integrated Waste Management

The Integrated Waste Management (IWM) approach maintains that waste management can be planned in advance*. This is because the nature, composition and quantities of waste generated can be predicted at each point in the materials cycle. Advance planning means that an orderly process can ensue, involving:

Waste prevention: the prevention and avoidance of the production of certain hazardous wastes or hazardous substances, sometimes by regulation.

↓

Waste minimisation: the economic reduction of the volume of waste during production, by means of different processes or clean technology.

↓

Resource recovery: recycling or the recovery of energy through incineration and bio-degradation.

↓

Waste Treatment: the treatment of waste to reduce waste volumes or hazardousness.

↓

Waste Disposal: the environmentally safe disposal of waste.

BPEO as a minimum standard

The Best Practicable Environmental Option (BPEO) is, "the outcome of a systematic consultative and decision-making procedure that emphasises the protection of the environment across land, air and water. It establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole at acceptable cost in the long term as well as the short term."

* As recommended by the Presidents Council Report, “A National Environmental Management System”, October 1991.

Of particular note is:

1. The holistic approach to the environment. Reduction of pollution in one medium, such as the air, must not take place at the expense of another, such as the ground or surface water.

2. The emphasis on a long-term solution. There should be **no bad legacy**. The present generation should not leave the future generation with a bad legacy of community health and contaminated sites or with solutions that impose an unreasonable risk or cost on the future generation.

3. The term "acceptable cost". Minimum Requirements make allowance for the need to control costs in that only crucial elements of the waste management process are regulated. The system of graded classification of Hazardous Waste set out in this document is specifically aimed at avoiding unnecessary expenditure without lowering standards.

All new, approved or existing projects that generate Hazardous Waste should conform to a minimum standard of BPEO.

Integrated Environmental Management

The Minimum Requirements also acknowledge the Integrated Environmental Management (IEM) procedure*. The objective of IEM is to integrate environmental considerations into all stages of the waste management process, in order to achieve the benefits of social or industrial development with minimal harm to the environment.

IEM consists of four stages:

- careful planning of new developments;

- an efficient process of assessing the environmental effects of developments, i.e., an Environmental Impact Assessment (EIA);

- an open and accountable decision making process;

- enforceable programmes to reduce the harmful effects of developments on the environment.

The above principles form part of responsible advance planning and so have a direct bearing on all aspects of development that would involve waste, especially Hazardous Waste.

The rule rather than the exception decide a Minimum Requirement.

As it is impractical, if not impossible, to cover every situation in the Minimum Requirements, exceptions must be identified and addressed in consultation with the Department. This approach is fundamental to all of the Minimum Requirements documents.

Minimum Requirements tend to concentrate on principles, rather than on detail

To avoid being over prescriptive, the Minimum Requirements generally specify the objective that must be met rather than the method that must be used. For example, it may be stated that a waste must be pre-treated to pH > 6, but the method of pre-treatment will not be specified.

The Minimum Requirements address basic administrative procedures

For example, it is a Minimum Requirement that all generators of Hazardous Waste, after the promulgation of the relevant regulations, register with the Department or another institution as may be required.

Liabilities and the Responsible Person

The Generator must understand that there is a liability risk associated with basing decisions on the Hazard Rating.

* The IEM procedure is discussed in detail in the publication "Integrated Environmental Management in South Africa" available from the Secretary of the Council for the Environment in Pretoria.

In this document, the Department has provided lists and a classification procedure to alert generators to the risks involved. The Department cannot, however, take responsibility for every chemical. In using the lists and procedure, therefore, the Generator must realise that he is dealing with a complex science.

The person who undertakes to apply this document must therefore be able to understand and apply the principles underpinning the toxicological discipline, and to use published information and data to protect human health and the environment in a liable manner.

1.5 Governing principles

The following principles, many of which are considered internationally as being essential for the management of Hazardous Waste, are acknowledged in the Minimum Requirements, and will also be acknowledged in future regulations.

Duty of care

The individual or organisation that generates a waste incurs a duty of care that is owed to society. This means that the generator is responsible for the fate of the generated waste in all circumstances. The generator retains the ultimate responsibility for ensuring that the waste is handled, stored, transported and disposed of according to the legislation and in an environmentally sound and responsible manner.

In accordance with this principle, a "cradle-to-grave" responsibility is placed on the generator for the safe management of his waste.

Polluter pays principle

The "polluter pays principle" holds that the person or organisation causing pollution is liable for any costs involved in cleaning it up or rehabilitating its effects.

It is noted that the polluter will not always necessarily be the generator, as it is possible for responsibility for the safe handling, treatment or disposal of waste to pass from one competent contracting party to another. The polluter may therefore not be the generator, but could be a disposal site operator or a transporter. Through the 'duty of care' principle, however, the generator will always be one of the parties held accountable for the pollution caused by the waste. The generator must be able to prove that the transferral of management of the waste was a responsible action.

Precautionary principle

The precautionary principle assumes that a waste or an identified contaminant of a waste is both highly hazardous and toxic until proven otherwise. Since the legislation is stricter for highly hazardous and toxic wastes, the costs for their treatment and disposal are consequently higher than for wastes of low hazard. It is therefore obviously in the generator's interest to obtain the necessary information to prove that the material or waste product is of a lesser hazard. The burden of proof shall always be on the generator of the waste in question.

1.6 The enforcement of Minimum Requirements

The Minimum Requirements are enforceable in terms of existing legislation.

The Water Act, 1956 (refer to Section 1 paragraph 1.1) and the Environment Conservation Act, 1989 (Act 73 of 1989)*, provide the Department with a legal mandate for control over the safe disposal of waste.

The Water Act (Sections 22A and 22B) (refer to Section 1 paragraph 1.1) enables the Minister of Water Affairs & Forestry to take steps to prevent the pollution of water by the actions of any person. The Minister can also, under specified conditions, recover costs from such a person.

* Hereafter referred to as the “Environment Conservation Act”.

Section 23 of the Water Act, 1956, (refer to Section 1 paragraph 1.1) states that any person who wilfully or negligently commits any act which could pollute public or private water, including underground or sea water, in such a way as to render it less fit for certain specified uses, is guilty of an offence.

Section 31A of the Environment Conservation Act, contains a similar provision. The Minister of Environment Affairs & Tourism or the Administrator, local authority or government institution concerned may take specified action if any person performs any activity or fails to perform any activity as a result of which the environment is or may be seriously damaged. Costs incurred may be recovered under specified conditions from such a person.

Section 20(6) of the Environment Conservation Act, states that, subject to the provisions of any other law, no person shall discard waste or dispose of it in any other manner, except:

a) at a disposal site for which a permit has been issued;

b) in a manner or by means of a facility or method and subject to **such conditions** as the Minister may prescribe.

"Prescribe" means prescribe by regulation. "Minister" means Minister of Environment Affairs and Tourism. It is noted that the permit will contain conditions, based on the Minimum Requirements that will be relevant to the classification, treatment and disposal of waste.

Section 20(1) of the Environment Conservation Act, states that no person shall establish, provide or operate any disposal site without a permit issued by the Minister of Water Affairs & Forestry and except subject to the conditions contained in such a permit. The permit conditions will be based on the relevant Minimum Requirements relating to the classification, treatment and disposal of the waste.

Conformance with the Minimum Requirements means conformance to the objectives of Minimum Requirements. These objectives include the prevention of water pollution, and the protection of human health and the environment.

Section 20(3) of the Environment Conservation Act, states that if the Minister of Water Affairs & Forestry should require any further information to enable him to make a decision on the permit application referred to in Section 20(1), he may demand such information from the applicant. Information, which may be required by the Minister of Water Affairs & Forestry, could include waste disposal site operational aspects. These would be based on the applicable Minimum Requirements.

1.7 International acceptability

International acceptability in terms of environmental policy and practices is closely related to South Africa's acceptability as a trading partner and to her ability to participate in international affairs. It is thus important that the regulation of waste, and hence the Minimum Requirements, be internationally acceptable.

South Africa therefore takes full cognisance of international efforts to address the control of waste, and in particular, Hazardous Waste.

Of relevance to this document are the United Nations Environment Programme's *Code of Practice* (1993), the *Cairo Guidelines* (1985), the *International Register of Potentially Toxic Chemicals* (1985) and the *Guidelines for Hazardous Waste Management in Asia and the Pacific* (1986).

South Africa became a signatory to the *Basel Convention on the control of transboundary movements of hazardous wastes and their disposal* (1992) on 3 August 1994.

All of the above are briefly discussed in Appendix 1.

Section 2

OVERVIEW

2.1 Introduction

The first principle in waste management is to avoid the generation of waste in the first place. Waste prevention, minimisation and recovery are always the most cost-effective and environmentally acceptable waste management options.

Once, however, the generation of a waste is unavoidable, it must be controlled and a strategy for its safe disposal planned.

The objectives of Hazardous Waste management are to:

- **ensure the correct identification and classification of a Hazardous Waste;**
- **keep Hazardous Waste from entering the environment illegally;**
- **implement "cradle-to-grave" principles by means of planned waste management strategies;**
- **control a Hazardous Waste until it is safely disposed of, by setting Minimum Requirements at crucial points in its management*.**

The waste classification system and the Minimum Requirements are therefore integrated, as far as possible, into a waste management process. This process is depicted in **Figure 1.**

2.2 Definition of waste

In the Government Gazette, 24 August 1990, waste is defined as:

"an undesirable or superfluous by-product, emission, residue or remainder of any process or activity, any matter, gaseous, liquid or solid or any combination thereof, which:-

(a) is discarded by any person; or

(b) is accumulated and stored by any person with the purpose of eventually discarding it with or without prior treatment connected with the discarding thereof; or

(c) is stored by any person with the purpose of recycling, re-using or extracting a usable product from such matter, **excluding** -

(i) water used for industrial purposes or any effluent produced by or resulting from such use which is discharged in compliance with the provisions of section 21 (1) of the Water Act, 1956 (Act No. 54 of 1956) (refer to Section 1 paragraph 1.1) or on the authority of an exemption granted under section 21 (4) of the said Act;

(ii) any matter discharged into a septic tank or french drain sewerage system and any water or effluent contemplated by section 21 (2) of the Water Act, 1956 (refer to Section 1 paragraph 1.1);

(iii) building rubble used for filling or levelling purposes;

(iv) any radio-active substance discarded in compliance with the provisions of the Nuclear Energy Act, 1982 (Act No. 92 of 1982);

(v) any minerals, tailings, waste-rock or slimes produced by or resulting from activities at a mine or works as defined in section 1 of the Mines and Works

* In this context, safe disposal implies that the entire waste management process has been carried out safely, as safe disposal cannot be divorced from correct identification, classification, management, storage, packaging and transportation.

Figure 1

HAZARDOUS WASTE MANAGEMENT PROCESS

Consider Options:

- Is it possible to prevent the production of a waste?
- Is it possible to minimise the waste?
- Is it possible to recover or recycle the waste?
- Is it possible to treat the waste? (3)✷

Consult a specialist

The unavoidable waste is probably hazardous if it is generated from certain:

- Industrial groups
- Processes
- Waste streams
- Or if it is listed in the Basel convention (4)✷

Where necessary, test and analyse the waste to identify hazardous substances and characteristics. Compare substances and characteristics with those listed in the SABS Code 0228, the Waste Classification Tables and the Basel Convention. (5)✷

Non Hazardous

- Treat as General Waste
- Consult Minimum Requirements for Waste Disposal by Landfill and Monitoring at Waste Management Facilities.

Hazardous?

Determine SABS Code 0228 class
Register with Department as Generator of Hazardous Waste. (6)✷

Fits no class

Consult Specialist

Treat, incinerate or destroy in accordance with Minimum Requirements (7)✷

Analyse the residue
Determine Hazard Rating of waste or residue
Possibly re-treat to reduce Hazard Rating.
Use EEC, TCLP test or Acid Rain test to motivate delisting to lower Hazard Rating.
Notify Department and obtain approval of classification (8)✷

Consult relevant policy and exercise environmental responsibility to minimise risk to Man or the Environment prior to disposal, during

- Storage
- Containment
- Packaging
- Labelling
- Emergency action collection
- Transportation (10)✷

Use Hazard Rating to determine Minimum Requirements for disposal . (9)✷

Consulting Minimum Requirements for Waste Disposal by Landfill and Monitoring at Waste Management Facilities

✷ The number refers to the Section in which this is discussed.

Act, 1956 (Act No. 27 of 1956); and

(vi) ash produced by or resulting from activities at an undertaking from the generation of electricity under the provisions of the Electricity Act, 1987 (Act No. 41 of 1987)."

Note that wastewater effluents are not defined as waste because they are regulated and controlled by the Water Act, 1956 (Act 54 of 1956) (refer to Section 1 paragraph 1.1). Similarly, radioactive waste is regulated and controlled by the Nuclear Energy Act (Act 92 of 1902) and the Hazardous Substances Act (Act 15 of 1973).

Sewage sludge from sewage works and building rubble contaminated by other waste or not used for fill **would** fall under the definition of waste.

2.3 Waste classes

The waste classification system based on the concept of risk.

It is accepted that there are no wastes that are truly "non-hazardous", since nothing is entirely safe or non-hazardous *per se*. No matter how remote the risk posed to man and the environment by a waste, it nevertheless exists. It is possible, however, to assess the severity of the risk, and to make informed decisions on this basis. The quality and quantity of waste, the manner and conditions of handling and the susceptibility of man or any other organism can be used to determine the degree of hazard posed by a waste.

The classification system therefore distinguishes between waste of extreme hazard, which requires the utmost precaution during disposal, and waste of limited risk, which needs less control during disposal.

Waste is divided into two classes in accordance with the risk it poses: **G**eneral Waste and **H**azardous Waste.

2.3.1 General Waste

"General Waste" refers to any waste that does not fall within the definition of Hazardous Waste.

It is a generic term applied to waste that does not pose a significant threat to public health or the environment if properly managed. Examples would include domestic, commercial, certain industrial wastes and builder's rubble. General Waste may be disposed of on any landfill that is permitted in terms of the Environment Conservation Act.

Domestic waste is classified as "General Waste" even though it may contain hazardous components. This is because the quantities and qualities of hazardous substances in domestic waste are sufficiently small to be disregarded as a potential risk. In addition, the *Minimum Requirements for Waste Disposal by Landfill* require leachate control at certain General Waste disposal sites where the risk of leachate generation exists.

2.3.2 Hazardous Waste

"Hazardous Waste" is waste that has the potential, even in low concentrations, to have a significant adverse effect on public health and the environment because of its inherent toxicological, chemical and physical characteristics.

Hazardous Waste requires stringent control and management, to prevent harm or damage and hence liabilities. It may only be disposed of on a Hazardous Waste landfill (see Section 3, *Minimum Requirements for Waste Disposal by Landfill*).

Since the Precautionary Principle is applied, a waste must always be regarded as Hazardous where there is any doubt about the potential danger of the waste stream to man or the environment.

2.4 Definition of Hazardous Waste

A Hazardous Waste is defined as:

"an inorganic or organic element or compound that, because of its toxicological, physical, chemical or persistency properties*, may exercise detrimental acute or chronic impacts on human health and the environment. It can be generated from a wide range of commercial, industrial, agricultural and domestic activities and may take the form of liquid, sludge or solid. These characteristics contribute not only to degree of hazard, but are also of great importance in the ultimate choice of a safe and environmentally acceptable method of disposal."

Further to this, a Hazardous Waste can be defined as a waste that directly or indirectly represents a threat to human health or the environment by introducing one or more of the following risks:

- explosion or fire;
- infections, pathogens, parasites or their vectors;
- chemical instability, reactions or corrosion;
- acute or chronic toxicity;
- cancer, mutations or birth defects;
- toxicity, or damage to the ecosystems or natural resources;
- accumulation in biological foodchains, persistence in the environment, or multiple effects to the extent that it requires special attention and cannot be released into the environment or be added to sewage or be stored in a situation which is either open to air or from which aqueous leachate could emanate.

* The South African definition of Hazardous Waste complies with the UNEP definition, primarily because of its content and scope, but also in order to obtain International acceptance for South African Waste Management Legislation Practice (see Section 1.7 and Appendix 2).

The definition of Hazardous Waste is very broad, since wastes can vary substantially in nature, composition, size, volume, appearance and degree of harmfulness. In terms of the Minimum Requirements, therefore, Hazardous Wastes are grouped into four Hazard Ratings.

This further classification, termed the Hazard Rating, **differentiates between a Hazardous Waste that is fairly or moderately hazardous and one that is very or extremely hazardous**. The Hazard Rating also indicates the class of Hazardous Waste landfill at which the waste may be disposed.

Hazard Rating 1 (extreme risk) }
Hazard Rating 2 (high risk) } = **H:H** landfill

Hazard Rating 3 (moderate risk) } = **H:H or H:h**
Hazard Rating 4 (low risk) } landfill

An **H:H** landfill is more stringently designed, operated and monitored than an **H:h** landfill.

2.5 The Hazardous Waste Generator

The Generator would be an individual, an industry or any other party whose activities result in the production of waste.*

In accordance with the "cradle-to-grave" principle, it is the Generator who is responsible for the management of a Hazardous Waste from its inception until its final disposal. As discussed in Sections 1.4 and 1.5, the Generator will be held legally responsible for personal injury or damage to the environment caused by the waste. The Generator must therefore ensure that the waste is properly managed and disposed of.

* Draft legislation to ensure the registration of generators and transporters was formulated in February 1990. This is not yet enacted.

It is the responsibility of the Generator to determine whether a waste is a General Waste or a Hazardous Waste.

2.6 Classification of Hazardous Waste

There are four steps in the classification of a Hazardous Waste (see Figure 1):

- Identification of the waste or waste stream as probably Hazardous.
- Testing and analysis to determine the hazardous properties, characteristics and components of a waste. This will confirm whether the waste is Hazardous or not.
- Classification and treatment in accordance with SABS Code 0228 "The Identification and Classification of Dangerous Substances and Goods".
- Analysis and Hazard Rating of the waste or its residue, in order to determine the Hazard Rating and the Minimum Requirements for disposal.

An additional step would be re-examination of an existing classification with the objective of possible delisting and reclassification. This would apply in cases where, because of pre-treatment, low concentration, low mobility or other applicable factors, waste can delist to a lower Hazard Rating (see Figure 1).

The approach that was used in formulating the Hazardous Waste Classification System is described in Appendix 2.

2.6.1 Identification of a probably Hazardous Waste

It is possible to identify industries and processes, which are likely to generate Hazardous Waste. The first indication that a waste stream could be Hazardous, therefore, can be the industrial activity, process or waste stream from which it arises.

Should a waste arise from any of the industries, processes or waste streams listed in Diagram I, Section 4, it is probably a Hazardous Waste.

In the future, manufacturers and institutions practising the processes, services and activities listed in Diagram I will be registered.

2.6.2 Analysis to confirm that a waste is a Hazardous Waste

If it is probable that the waste is a Hazardous Waste, it must be tested for its properties and analysed for its substances. These are then compared to the lists of characteristics, properties and substances in SABS Code 0228, the Basel Convention, and the Waste Classification Tables at the back of this document.

If the properties and substances of the waste are not listed in SABS Code 0228, but conform to the Basel Convention or one of the nine classes in the Code, the waste is probably a Hazardous Waste. The Department should then be approached for guidance.

2.6.3 SABS Code 0228

SABS Code 0228: "The Identification and Classification of Dangerous Goods and Substances" is a system for classifying hazardous substances for transport purposes. In the Code, hazardous substances are given an identification number and divided into nine classes:

Class 1	Explosives
Class 2	Gases
Class 3	Flammable liquids
Class 4	Flammable solids
Class 5	Oxidising substances and organic peroxides
Class 6	Toxic and infectious substances
Class 7	Radioactive substances
Class 8	Corrosives
Class 9	Other miscellaneous substances.

The waste must be tested against the nine classes, to see into which class it falls (it may fall into more than one class). The Minimum Requirements for that class must then be complied with.

2.6.4 Hazardous Waste treatment

In many cases, it will be a Minimum Requirement that the waste be treated to reduce its hazardousness. Exact treatment methods are not usually prescribed. These remain dependent upon the availability of facilities or on the suitability of treatment technologies.

2.6.5 Hazard Rating

The toxicity of the waste or the residue remaining after treatment must be determined before disposal. This is called Hazard Rating.

In Class 6 of SABS Code 0228, hazardous substances are given a danger rating for transport and divided into three danger groups. However, these danger groups only relate to the risk the substance poses to man during transport (mammalian toxicity or LD_{50}). Hazard Rating for disposal, on the other hand, also takes into account risk to the environment. For this reason, the LC_{50} or acute ecotoxicity of a substance is used in addition to the LD_{50}.

The LC_{50} is the concentration at which a substance would kill 50 per cent of organisms if it were disposed of directly into a body of water. If the concentration of the hazardous substance is only ten percent of the LC_{50}, it should have very little harmful effect on the aquatic organisms (refer to Appendix 8, paragraph 6).

0,1 x LC_{50} is therefore used to represent an

Acceptable Risk Level.

To determined the Hazard Rating, the Estimated Environmental Concentration or **EEC** of the substance in the waste is calculated in grams disposed of per hectare per month multiplied by a factor of 0,66.

EEC (ppb) = g/ha/month x 0,66

The EEC is compared to the Acceptable Risk Level.

If the EEC is higher than the Acceptable Risk Level, then the waste remains in the originally classified Hazard Rating.
If the EEC is lower than the Acceptable Risk Level, the waste may delist to a lower Hazard Rating.

The EEC is used to determine the amount of a substance that can safely be disposed of per hectare per month at a landfill site.

The EEC is also used to determine the total amount of a hazardous substance that may be accepted at a certain landfill site, before it must close for that substance. This is termed the **Total Load**.

2.6.6 Delisting

The fate of the waste stream is regulated by the most hazardous contaminant of which the EEC exceeds the Acceptable Risk Level (worse case scenario). But, hazardousness can be reduced, e.g., by treatment. The contaminant could be treated to a compound of which the EEC would fall within the Acceptable Risk Level.

Treatment of a contaminant from one species to another (e.g. chloride to hydroxide or oxide) affects leachability and hence mobility in the environment. The EEC can carry out tests to prove that, because of low mobility, the substance is of a less hazardous nature than that indicated. Tests used to prove this would include the "Toxicity Characteristic Leaching Procedure" or the "Acid Rain" test.

2.7 Disposal of a Hazardous Waste

The Minimum Requirements for the disposal of a Hazardous Waste are determined from the relevant SABS Code 0228 class. The Minimum Requirements for Class 6 wastes (poisonous and toxic substances) will be determined from the Hazard Rating.

It is noted that, in many cases, treatment prior to disposal by landfill will be a Minimum Requirement. This reduces the risk of future pollution, and resultant liabilities and costs.

2.8 Hazardous Waste handling and transportation

Careful handling, collection, packaging, temporary storage and transportation of Hazardous Waste are essential for the maintenance of public health and for environmental protection. For this reason, these issues are briefly discussed in Section 10. While perhaps not directly related to the subject of this document, there can be no safe disposal if these are not carried out successfully.

In the future, a manifest system will be a legal requirement for a Hazardous Waste. This is a system of control documentation that accompanies each load of Hazardous Waste from point of generation until it is responsibly and legally disposed of at a suitable, permitted facility.

Section 3

WASTE MINIMISATION

3.1 Introduction

With rapid population growth, quantities of waste generated are increasing rapidly. This places increasing pressure on waste management resources, such as landfills, collection services and the environment. It therefore makes sense to reduce the amount of waste generated, and hence disposal costs and the risk to the environment. It is the responsibility of every South African to avoid and minimise waste wherever possible.

Waste minimisation is currently a function of environmental responsibility and good housekeeping. It will, however, be emphasised in future legislation, see *White Paper on Environmental Management Policy for South Africa*, Government Gazette, Notice 1096 of 1997. In particular, an industry, which may produce a Hazardous Waste, may be compelled to demonstrate its committed policy towards waste minimisation before the industry is established*.

There are many excellent documents available that outline options for reducing the wastes that are commonly generated in homes, offices and factories. Such wastes would include glass, plastic, tin, aluminium, metal, paper, food, oil, and grease wastes. No attempt is made, therefore, to reproduce these here. For further information, however, a list of recyclable wastes and organisations involved in recycling is provided in Appendix 3.

* The Environment Conservation Act empowers the Administrator of a Province to make regulations for the reduction of waste by modification in design, marketing and manufacturing processes, and by the use of alternative products. The mandate has not yet, however, been enforced. Essentially, actions necessary for waste avoidance, reduction and recycling for waste avoidance; reduction and recycling should fall within the realms of good management, social responsibility and good housekeeping.

This section deals primarily with the prevention and minimisation of Hazardous Waste.

The objectives of Hazardous Waste prevention and minimisation are to:

- **reduce the amount of Hazardous Waste disposed of into the environment by avoiding or reducing waste generation at source;**
- **save money by reducing waste treatment and disposal costs;**
- **meet national waste minimisation goals; and**
- **protect man and the environment, and reduce potential environmental liabilities.**

3.2 Hazardous Waste prevention

In practice, it is possible to predict the quantities and the composition of a waste before it is generated, as these will depend on the processes and practices used. A professional person will therefore be able to identify substances of concern and understand the possible implications of their chemical forms, likely changes and interactions, mobility and possible persistence, and treatment. In accordance with the IWM approach (see Section 1.4), this knowledge should be used to minimise the waste at source rather than incurring the costs and risks of managing it.

In the past, products that would generate extremely hazardous and persistent wastes have been prevented by being banned for certain uses by government. This is an option, which will be used in the future, if required.

3.3 Hazardous Waste minimisation

Hazardous Waste minimisation includes any action that reduces the volume and toxicity of waste. This includes avoidance, recycling, recovery and re-use (see Figure 2). It also includes waste treatment technologies that lead to a reduction in volume and toxicity, such as incineration, chemical detoxification and biological treatment.

Experience has shown that there are two essential components for any successful waste minimisation programme:

- the technologies used must be simple;
- the production personnel must be strongly motivated to implement and maintain the necessary changes.

The Department strongly supports programmes, which have the avoidance or the minimisation of Hazardous Waste as their major aims.

3.3.1 Avoidance

Avoidance of waste generation is any activity that reduces or eliminates the generation of waste, at source, usually within a process. This can be accomplished by:

- ***Implementing good operating practices:***

  This would include management and personnel practices such as training, loss prevention, improved material handling and inventory practices, and production scheduling, (for example to reduce the frequency of cleaning of equipment).

  It is important to ensure that Hazardous Waste is kept separate from General Waste. If even a small quantity of a Hazardous Waste is mixed with and allowed to contaminate a General Waste stream, the entire stream may have to be classified as a Hazardous Waste.

- ***Changing process technologies:***

  This would include changes to process, equipment, piping, layout and operating conditions, specifically aimed at reducing Hazardous Waste generation. Examples of process changes might be as drastic as replacing a mercury cell with a diaphragm or membrane cell (Chlor-alkali industry) or as simple as replacing a chemical cleaning bath with mechanical cleaning.

- ***Making changes in the input material:***

  This would include purification and substitution. An example would be the substitution of cyanate for cyanide (electro-plating industry).

- ***Making changes in the product:***

  Examples of product changes are the use of water based explosives that minimise the need for organic solvents and substances such as nitro-glycerine, and the replacement of oils containing PCB (polychlorinated biphenyl) with other oils or converting to air cooled transformers.

3.3.2 Recycling

Recycling includes:

- Re-use: involving the return of a waste material either to the originating process as a substitute for an input material or to another process as an input material.
- Reclamation: where the waste is processed for resource recovery or as a by-product. Reclamation differs from "re-use" as the recovered material is not used in the facility but is rather sold.

Increasing disposal costs due to the implementation of Minimum Requirements and the need to avoid liabilities could make many previously discarded waste materials worth reprocessing.

3.3.3 Treatment

There are many treatment and technology options, which can lead to a reduction in the volume and toxicity of Hazardous Waste. These would include physical treatment, chemical treatment, immobilisation, solidification, encapsulation, and incineration.

As the treatment of a Hazardous Waste depends upon its classification and the relevant Minimum Requirements, these are discussed in Section 8.

3.4 Waste minimisation audit

The best approach to adopt when determining the most appropriate options for a process or facility is to do a waste minimisation audit. This audit can be implemented at four levels:

- The common sense audit, in which the most obvious areas for minimising the waste produced are attended to. This level need not cost much, is easily accomplished in a short time, and can lead to substantial savings.

- The information based audit, in which information that can lead to minimisation of the waste can be obtained cheaply from waste management companies, consultants or from relevant literature.

- The in-depth audit, where a thorough investigation of the processing and manufacturing facility is carried out.

- The research and development based audit, in which considerable funds and time are spent researching new approaches to waste minimisation.

FIGURE 2: WASTE MINIMISATION TECNIQUES

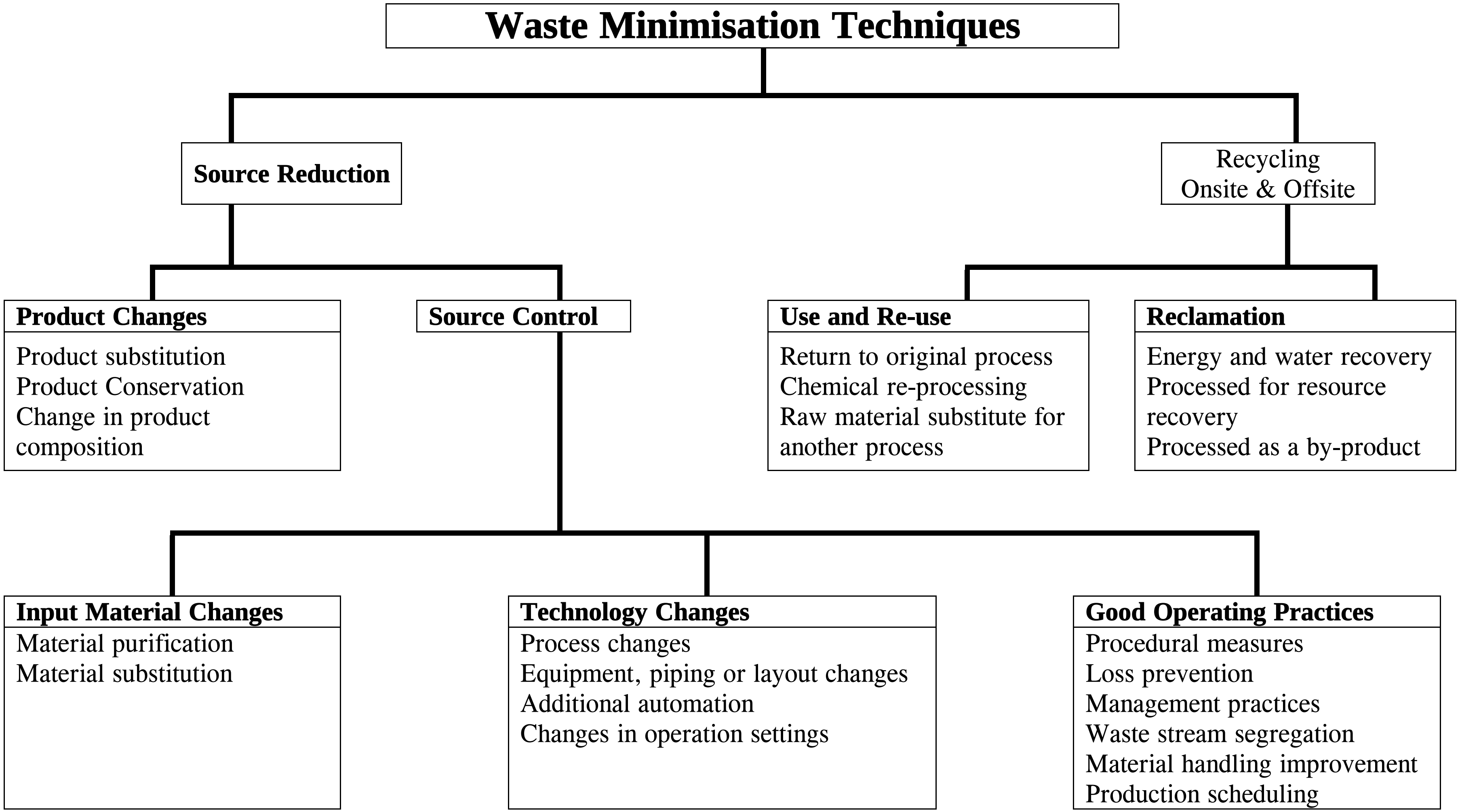


TABLE 4

MINIMUM REQUIREMENTS FOR THE IDENTIFICATION OF A PROBABLY HAZARDOUS WASTE

{PRIVATE }Subject	Minimum Requirement
Properties and sources of Hazardous Waste	Waste exhibiting the properties or arising from the sources listed in Section 4.2 must be regarded as probably Hazardous.
Industries and Processes	Waste arising from any of the industries or processes listed in Diagram I must be regarded as probably Hazardous.
Responsibility for classification	It is the responsibility of the Generator to determine whether a waste is a General Waste or a Hazardous Waste.
Doubt regarding classification	Where there is any doubt regarding the classification of a waste, it must be regarded as Hazardous.

Section 4

IDENTIFICATION OF A PROBABLY HAZARDOUS WASTE

4.1 Introduction

The identification of industries and processes which, from past experience, are known to generate Hazardous Waste is the first step in identifying and classifying a Hazardous Waste.

The objectives of this section are to:

- **identify industrial groups, processes or waste streams that are likely to produce Hazardous Waste, so that the Generator can register, when it becomes mandatory, with the appointed government institution**

- **alert the Generator, at the earliest possible opportunity, of the probable generation of Hazardous Waste, so that applicable legislation can be conformed to and possible liabilities avoided.**

Hazardous Waste can arise from manufacturing processes or from a wide variety of medical, commercial and personal services.

4.2 Properties and sources of Hazardous Waste

To identify or designate a waste material as probably Hazardous or Hazardous, the following properties and sources should be taken into account:

- The raw materials utilised in a manufacturing process.

- Intermediates and products produced in a manufacturing process.

NB: If these raw materials, intermediates or products are classified as hazardous in the SABS Code 0228, the Basel Convention or in the Waste Classification Tables at the back of this document, it is likely that waste originating from that process will be a Hazardous Waste.

- Products used in service industries that are classified as hazardous substances, e.g., solvents, grease and oil.

- The nature and properties of the waste, e.g., oily residues; sludge's from heavy metal processing, water treatment, or organic chemicals processing; or waste with flammable, toxic, reactive, corrosive or explosive properties.

- Putrescible organic waste, e.g., waste arising from production of edible oils, skins and other animal based products.

- Poisonous or toxic chemicals utilised in agriculture, forestry and related industries.

- Packaging materials contaminated with hazardous substances.

- Waste arising from hospitals, medical clinics, veterinary services and similar services.

- Pharmaceutical wastes

- Residues such as ash, slag's and leachate.

- Waste designated as Hazardous by the authorities.

4.3 Industrial groups, processes and waste streams

Processes and activities that are likely to produce Hazardous Waste have been grouped together in eleven Industrial Groups, see Diagram I.* These groups represent typical industrial processes or commercial and service activities (see Blocks 1 and 2, Diagram I).

Several waste streams are likely to originate from each identified process (see Diagram I). Some of these streams may not be Hazardous, but the majority may contain a component or components that may need special care. The nature of these streams may also vary widely in composition and physical form. To assist the decision maker in determining the appropriate handling and treatment of such waste streams, these streams have been categorised into six different waste types, each of similar health or ecological concern (see Block 3, Diagram I).

Note that Diagram I indicate that a waste or waste stream could **potentially** be classified as Hazardous. No waste can be classified as either Hazardous or General simply because it is or is not listed in Diagram I.

4.4 Registration of Hazardous Waste generators

All manufacturers and institutions practising any of the processes or services and activities listed in Diagram I, or any similar or related activity, will be required to register with a government institution and to provide all the details required in terms of the registration procedure as soon as the relevant regulations are promulgated.

The intention is that registration will initially be required for:

- Generators of Hazard Rating 1 waste;
- Generators of >10 kg/month of Hazard Rating 2 waste;
- Generators of >100 kg/month of Hazard Rating 3 waste;
- Generators of >1000 kg/month of Hazard Rating 4 waste.

It is, however, envisaged that all Generators of Hazardous Waste will ultimately be registered, regardless of the amount of waste produced.

* These groups have been selected in conformance with international practice.

DIAGRAM 1

Identification of Hazardous Waste

Select Industrial Group	
A	**Agriculture, Forestry and Food Products**
B	**Mineral Extraction and upgrading *(Excluding hydrocarbons)***
C	**Energy**
D	**Metal Manufacture**
E	**Manufacture of Non-Metal Mineral Products**
F	**Chemical and Related Industries**
G	**Metal Goods, Engineering and Vehicle Industries**
H	**Textile, Leather, Timber and Wood Industries**
J	**Manufacture of Paper and Products, Printing and Publishing**
K	**Medical, Sanitary and other Health Services**
L	**Commercial and Personal Services**

Identify Process:	***Key***
A - Agriculture, Forest Management, Fisheries	A1
- Animal and Vegetable Products from the Food Sector	A2
- Drink Industry	A3
- Manufacture of Animal Feed	A4
B: - Mining and Quarrying of Non-metallic Minerals	B1
- Mining and Quarrying of Metallic Minerals	B2
C: - Coal Industry including Gas Works and Coking	C1
- Petroleum and Gas Industry including Extraction and Refined Products	C2
- Production of Electricity	C3
D: - Ferrous Metallurgy	D1
- Non-ferrous Metallurgy	D2
- Foundry and Metal Working Operations	D3
E: - Construction Materials, Ceramics and Glass	E1
- Salt Recovery and Refining	E2
- Asbestos Goods	E3
- Abrasive Products	E4
F: - Petrochemicals	F1
- Production of Primary Chemicals and Feedstocks	F2
- Production of Fine Chemicals	F3
- Production of Inks, Varnish, Paint and Glue	F4
- Fabrication of Photographic Products	F5
- Production of Pharmaceuticals	F6
- Rubber and Plastic Materials	F7
- Production of Explosives	F8
- Production of Biocides	F9
- Waste and Water Treatment	F10
G: - Mechanical Engineering	G1
- Electronic and Electrical Engineering	G2
- Manufacture of Motor Vehicles and parts	G3
H: - Textile, Clothing and Footwear Industry	H1
- Hide and Leather Industry	H2
- Timber, Wood and Furniture Industry	H3
J: - Paper and Cardboard Industry	J1
- Printing, Publishing and Photographic Laboratories	J2
K: - Health, Hospitals, Medical Centers and Labora-tories	K1
- Veterinary Services	K2
L: - Laundries, Dyers and Dry Cleaners	L1
- Domestic Services	L2
- Cosmetic Institutions	L3

Identify Waste Stream:

A - **Inorganic Wastes**

- Acids and alkalis
- Cyanide Wastes
- Heavy metal sludges and solutions
- Asbestos wastes
- Other solid residues

B - **Oily Wastes**

- Primarily from the processing, storage and use of mineral oils

C: - **Organic Wastes**

- Halogenated solvents residues
- Non-halogenated solvent residues
- PCB wastes
- Paint and resin wastes

D - **Putrescible Organic Wastes**

- Wastes from production of edible oils, slaughter houses, tanneries and other animal based products.

E - **High Volume / Low Hazard Wastes**

- Those wastes which, based on their instrinsic properties, present relatively low hazards, but may pose problem because of their high volumes. *(e.g. drilling mud, fly-ash from power plants, mine tailings, etc.)*

F - **Miscellaneous Wastes**

- Infectious waste from diseased human/animal tissue
- Redundant chemicals
- Laboratory wastes
- Explosive wastes from manufacturing operations or redundant munitions.

TABLE 5

MINIMUM REQUIREMENTS FOR TESTS AND ANALYSES

{PRIVATE } Subject	Minimum Requirement
Tests and analyses	The properties, characteristics and composition of a Hazardous Waste must be determined by appropriate tests or analyses.
Record keeping	The Generator and the Permit Holder of a disposal facility must keep accurate records of the waste type, the volumes handled, and the individual components of a Hazardous Waste.
Laboratory	The laboratory facility used must be capable of producing accurate and precise results.
Analytical method	A recognised method applicable to the sample type must be used.
Documentation	The analytical procedure must be fully documented and available on request.
Extent of documentation	Documentation must fully describe, amongst others: sample preparation procedures, preparation of reagents and calibration standards, analysis procedure, quality control procedures, procedure for calculating the analytical result, and units of measurement.
Record Keeping	Full records of raw analytical data, including values obtained for calibration standards, check standards and blanks, must be kept for at least six months.
Responsible Person	Analytical work to be done under the supervision of a suitably trained and experienced analyst, with a recognised tertiary qualification.
Sample	The sample must have same composition as the bulk of the material.
Sampling	Sampling to be carried out as required by *Minimum Requirements for Water Monitoring at Waste Management Facilities*.

Section 5

TESTS AND ANALYSES

5.1 Introduction

A Hazardous Waste can only be effectively managed if its composition, concentration and quantity are known. In turn, this knowledge can only be acquired by means of accurate and meaningful analysis.

The correct identification of the properties and composition of a Hazardous Waste for the purposes of classification, as determined by appropriate testing or analysis, is a Minimum Requirement. If this Minimum Requirement is not met, the waste will be regarded as extremely Hazardous, Hazard Rating 1*.

The objectives of carrying out tests and analyses are to:

- **correctly identify any hazardous substance in the waste;**
- **provide the information needed for classification and Hazard Rating;**
- **assess the effectiveness of any treatment, disposal or remediation programme; and**
- **determine whether a waste generator, transporter, or treatment and disposal facility is conforming to the legislative requirements.**

Testing is carried out in order to determine qualitative or screening criteria. It is used to determine the hazardous properties of the waste, that is, whether the waste is flammable, corrosive, reactive, toxic, etc.

* It may be cheaper for the Generator to simply classify small quantities of waste as Extreme Hazard (or the most hazardous class) rather than carrying out a full analysis.

Analysis is a more in-depth investigation, to identify specific substances and concentrations. In practice, the chemical analysis of the waste stream needs to be repeated at intervals to ensure that the analyses are representative and that any fluctuations in composition are known, monitored, understood and anticipated.

The Generator and the waste disposal site Permit Holder must keep accurate records of the type, the volumes handled and the individual components of a Hazardous Waste.

Both the Generator and the Permit Holder must have access to laboratory facilities that are capable of producing results with the required accuracy and precision. Such results must be able to withstand scrutiny in a court of law.

5.2 Quality assurance and quality control

Hazardous Wastes and leachate (from both General and Hazardous Waste landfills) usually contain a very complex mixture of substances. Methods of analysis, however, have often been designed for cleaner and simpler sample types.

To ensure accuracy, therefore, close attention must be given to analytical methods and quality control procedures.

5.2.1 Laboratory accreditation

It is recommended that samples be analysed by laboratories accredited under SABS Code 0259 or an equivalent international standard.

It is noted, however, that a laboratory is accredited separately for each of the tests that it performs. The waste sample may therefore not be strictly within the laboratory's accredited range of methods. The analyst must use his ingenuity and experience to obtain a valid result using the best analytical methods available.

In addition, it is difficult to specify general standards for the finer details of Hazardous Waste analysis, although many protocols have been devised by the United States Environmental Protection Agency*.

Formal accreditation therefore must be seen only as a step in improving analytical quality control and not as a guarantee of correct analytical procedure. For this reason, periodic assessments should be made of a laboratory's quality assurance and quality control programmes.

If an accredited laboratory is not available, it must be ensured that the chosen laboratory meets the Minimum Requirements.

5.2.2 Good analytical practice

Each sample matrix type should be considered individually, and any necessary procedure should be adapted to the sample type. Four principles that must be adhered to are: the use of documented methods, correct calibration, control standards and accuracy.

Documented method

The analytical method used must be designed to handle the sample type. This implies that the sample must usually be prepared so as to minimise any mismatch and ensure that it is in the appropriate chemical and/or physical form to make correct analysis possible. The analytical method used must be documented. This must include a description of the broad principles used in sample preparation.

Correct calibration

The analytical method must be correctly calibrated. Quality control procedures should be applied to ensure that the calibration standards used are valid and have the correct concentration and that the analytical instrument has been correctly optimised to ensure correct measurement of the calibration standards. A secondary component of this principle is that a blank should always be included. The blank should be treated with the same accuracy as the other samples and must not be contaminated.

Control standards

The prepared sample must be measured under the same conditions as the calibration standards. Each group of samples must be bracketed with control standards and blanks to ensure that no change has occurred in the calibration conditions. The readings must be stable and capable of being reproduced.

Accuracy

Data processing and calculation of results must be accurate. In particular, units of measurement must be unambiguous and clearly stated in the analytical report.

5.2.3 Minimum Requirements

To meet the above principles of analysis, the following Minimum Requirements must be complied with:

- A recognised and preferably established and documented method applicable to the sample type must be used.

- The analytical procedure must be fully documented and available on request. This documentation must include:

* In terms of the Water Act, SABS standard methods should be used.

- a description of sample preparation procedures that the sample is subjected to before analysis, such as, preservation, filtration or digestion;

- a full description of the preparation of reagents and calibration standards, and the actual analysis procedure to which the sample has been subjected;

- a description of the quality control procedures used before, during and after each analysis run, such as analysis of check standards and blanks; and

- a clear description of the procedure used for calculating the analytical result. Close attention must be given to units of measurement and these must be explicitly stated.

- For all samples analysed, full records of raw analytical data, including values obtained for calibration standards, check standards and blanks, must be kept for at least six months.

- The analytical work must be done under the supervision of a suitably trained and experienced analyst, with a recognised tertiary qualification.

5.3 Samples

As it is not possible to discuss sampling methods and standards in any great depth here, the reader is referred to the *Minimum Requirements for the Monitoring of Water Quality at Waste Management Facilities* for further information. Sampling standards such as ISO 3081, ISO 1988 and BS 1017 (part 1 of 1989) are available from the South African Bureau of Standards.

5.3.1 Sampling

An analytical result can only be accurate if the portion of the material taken as a sample has the same composition as the bulk of the material. Representative sampling is therefore crucial when testing for a Hazardous Waste.

The physical and chemical diversity of Hazardous Wastes (gases, liquids, solids and sludges) and the variety of ways wastes can be stored (in lagoons, drums, piles, tanks, etc.) means that sampling can be a very complex procedure.

The sampling plan drawn up must have two objectives:

- to collect samples that allow for **accurate** measurement of the chemical properties of the waste. This emphasises the closeness of the sample value to the true value and is normally accomplished by some form of statistically correct random sampling; and

- to collect samples that allow for **precise** measurement of the chemical properties of the waste. This ensures the closeness of repeated sample values. This is normally accomplished by taking a statistically appropriate number of samples.

To obtain a statistically significant analysis, the number of samples required can be very large and hence the costs and time involved in analysing the samples can become prohibitive. One strategy is to combine the randomly collected samples into a single sample, which is then analysed for the substances of concern.

5.3.2 Sample preservation

Although some tests can be carried out on-site, e.g., pH and conductance tests, most substances have to be analysed for in a laboratory to obtain accurate data. The container used (glass or polyethylene), the method of storage and the maximum allowable time of storage are dependent on the substance that must be analysed for.

As a general rule, samples should be analysed as soon as possible and most preservation techniques should be considered as simply "buying time".

5.4 Tests

Tests are undertaken to determine:

- hazardous properties of a waste; and
- hazardous substances in a waste.

5.4.1 Tests for hazardous properties

Hazardous properties that would be tested for include:

- explosiveness
- flammability
- corrosiveness
- reactivity
- radio-activity and
- toxicity.

Methods that can be used to test for some of these properties are provided in **Appendix 5.1.**

Flammable wastes are those liquids, such as paint or varnish that give off a flammable vapour at or below 61^oC closed cup, or those solids that are readily combustible or may cause or contribute to fires.

Corrosive wastes are solids or liquids that can, in their original state, severely damage living tissue. It is important to determine the corrosiveness of the waste in order to establish equipment and safety requirements for transport, storage and handling, and, if necessary treatment, prior to disposal.

Reactive wastes are those that have one or more of the following properties:

- they readily undergo violent chemical change, e.g., nitroglycerine;
- they react violently or form potentially explosive mixtures with water, e.g., calcium carbide;
- they generate toxic fumes when mixed with water, e.g., aluminium phosphide, or, in the case of cyanide or sulphide bearing wastes, when exposed to mild acidic or basic conditions;
- they explode when subjected to a strong initiating force, e.g., mercury fulminate; or
- they explode at normal temperatures and pressures.

5.4.2 Tests for hazardous substances

Tests and analyses for hazardous substances in the waste would usually depend upon the raw products used in the manufacturing process, any intermediate products, wastes or residues, and the final product. For example, if ammonium sulphate were used in a process, the waste would be tested for ammonia.

However, often information on the waste composition may be limited or, in cases of abandoned or spilled material, no information may be available.

Rapid screening of waste is therefore often necessary both at the laboratory and in the field.

Rapid screening tests

Simple qualitative or semi-quantitative tests can be carried out to point an investigation in the right direction.

Some of the parameters that can be tested for using rapid tests are listed in Table 5.1. The tests themselves are listed in Table 5.2. Tests would include test strips and drop count tests for substances such as arsenic, cyanide, chloride, chromium (VI), and manganese.

As wastes are often complex mixtures, rapid tests may be subject to considerable interference from other components in the waste. The values measured must, therefore, be interpreted with caution and only used as a guide to choosing those substances that should be analysed for using more sophisticated techniques.

Field tests

There are many situations when results are required in the field. This is the case, for instance, when:

- samples are difficult to obtain or are subject to rapid change, e.g., pH, conductivity, redox potential and dissolved oxygen;

- unknown spilled material has to be identified;

- chemical fires or other chemical emergencies occur;

- suspected violations of regulatory standards are investigated; and

- the extent of pollution on an abandoned site, in a stream, etc., is investigated.

The rapid tests in Table 5.2 can be adapted for almost any field application.

Field parameters that are commonly measured instrumentally include pH, conductivity, redox potential and dissolved oxygen. The analysis of methane, e.g., at landfills, can be accomplished using explosimeters. Trace gases, such as paraffins (but not methane), chlorinated hydrocarbons, heterocyclics and aldehydes can be detected using photo-ionisation detectors.

Mobile laboratories capable of investigation on site with specialised equipment such as spectrophotometers, gas chromatographs and high performance liquid chromatographs, and even a mobile mass spectrometer, can be used.

TABLE 5.1

SELECTED WASTE AND EFFLUENT SCREENING TESTS

{PRIVATE }{PRIVATE } pH
Lime equivalent
Flammability
Flash Point
% Volatiles
% Solids
Density

Spot Tests	**Other Tests**
Arsenic	Cadmium
Ammonia	Copper
Chromium (VI)	Iron
Heavy Metals	Lead
Chloride	Mercury
Fluoride	Zinc
Nitrate	Phenols
Phosphate	Volatile Organics
Sulphide	
Sulphate	

TABLE 5.2

SELECTED RAPID TESTS AVAILABLE IN SOUTH AFRICA

ALKALINITY	TEST TYPE	TEST RANGE	METHOD
Alkalinity	Titration	0-40 mmo1/1	HCI to pH 4.3
Ammonium	Test Strip Colorimetric	0-400 mg/ℓ NH4+ 0-10 mg/ℓ NH4+	Nesslers Reagent
Arsenic	Test Strip	0-3 mg/ℓ As	Arsine + $HgBr_2$
Calcium	Test Strip Titration	0-250 mg/ℓ Ca 0-800 mg/ℓ Ca	With indicator, red-violet
Chloride	Drop Count Colorimetric	0-2500 mg/ℓ Cl 0-300 mg/ℓ Cl	Hg + diphenyl-carbazone
Chromium (VI)	Test Strip Colorimetric	0-100 mg/ℓ CrIV 0-0.5 mg/ℓ	Chromate + dip-henyl carbazone
Copper	Test Strip Colorimetric	0-300 mg/ℓ 0-5 mg/ℓ	Cu + 2,2' biquinoline
Cyanide	Test Strip Colorimetric	0-30 mg/ℓ 0-5 mg/ℓ	Prep of polymethinedye
Iron	Test Strip Colorimetric		Ortho phenanthro-line complex formed
Magnesium	Colorimetric	0-20 mg/l	Azodye complex
Manganese	Test Strip Colorimetric	0-500 mg/ℓ 0-10 mg/ℓ	Formaldoxime to red/brown
Nickel	Test Strip Colorimetric	0-500 mg/ℓ 0-10 mg/ℓ	Dimethylglyoxim e complex
Peroxide	Test Strip	0-100 mgℓ1	Peroxidase + redox indicator
Potassium	Test Strip	0-1500 mg/ℓ	Dipicrylamine
Sulphate	Test Strip Colorimetric	200-1600 mg/ℓ 0-300 mg/ℓ	Red Ba-thorin turns yellow
Sulphite	Test Strip Titration	0-300 mg/ℓ 0-100 mg/ℓ	Pentacyanonitros yl ferrate
Zinc	Test Strip Colorimetric	0-250 mg/ℓ 0-5 mg/ℓ	Red complex with dithizone

5.5 Analysis

Waste is analysed to identify inorganic constituents (such as Arsenic, Zinc, Lead or Mercury) and organic constituents (such as solvents, PCB's or aromatics). Analysis would also be used to determine the concentration of any hazardous constituent in the waste.

Methods that can be used to identify inorganic constituents include Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, X-ray Fluorescence, Ion Chromatography and traditional wet methods such as titrimetric, gravimetric and colorimetric analysis. These methods and their application are described in **Table 5.3 Analytical Methods.**

Methods that can be used to identify individual organic constituents include Gas Chromatography and High Performance Liquid Chromatography, see Table 5.3.

The gross organic content of a waste or leachate can be measured by methods such as the Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOC) and Dissolved Organic Carbon (DOC), see Table 5.3.

Note that, in terms of the Water Act 1956 (Act 54 of 1956) (refer to Section 1 paragraph 1.1), SABS standard methods of analysis must be used in all cases involving compliance with permit conditions or in legal cases regarding effluent quality and the pollution of rivers. As these methods have been developed for use in water analysis, correct preparation when applying them to complex waste samples is essential to minimise potential interference.

5.6 Literature search

During classification, information will be required regarding the toxicity and ecotoxicity of compounds in the waste.

It will have to be ascertained whether or not the waste contains:

- infectious material
- a teratogen (a substance with the capacity to induce birth defects);
- a carcinogen (a substance with the potential to induce cancer);
- a mutagen (a substance with the capacity to induce genetic mutations).

Some compounds regarded as teratogens, carcinogens (A class or B class) or mutagens are listed in **Appendices 5.2 & 5.3**.

If the waste does contain any of the above, the **concentration** of the compounds must be established.

In addition it will be necessary to ascertain the**:**

LD_{50}: acute mammalian toxicity of substances in waste, expressed as LD_{50} (mg/kg).

LC_{50}: acute ecotoxicity of substances in waste, expressed as LC_{50} (mg/kg) of aquatic organisms.

P_{ow}: accumulation potential of substances, expressed as the octanol/water partition coefficient, P_{ow}.

K_{oc} : persistence potential of substances, expressed as soil adsorption constant, K_{oc}.

DOC & COD: biodegradation of substances, measured as dissolved organic carbon (DOC) or chemical oxygen demand (COD), expressed as a percentage (%).

The tests and analyses undertaken to determine certain of this information could be expensive and require much time and effort. The necessary information would therefore usually be acquired from the literature.

If these figures are not available in the literature, the K_{oc} and P_{ow} may be estimated by regression models. These simplified models are:

$\text{Log } K_{oc} = 3{,}6 - (0{,}55 \times \log S)$
$\text{Log } P_{ow} = 4{,}5 - (0{,}75 \times \log S)$
Where S = solubility in parts per million (ppm)

Biodegradation can be quantified by simple laboratory tests:

DOC: Modified OEDC screening
DOC: Modified AFNOR test
COD: Closed bottle test or modified MITI test.
(standard tests, SABS 1048).

These tests do not, of course, simulate practical aerobic and anaerobic conditions in a landfill site, but they suffice as an indicator.

TABLE 5.3: ANALYTICAL METHODS

METHOD	DESCRIPTION	APPLICATIONS
A: INORGANIC SPECIES		
1. Atomic Absorption Spectroscopy (AAS)	A solution containing the element to be analysed is sucked into a flame or placed in a pyrolytic carbon furnace. At ca. 1 000 ^{0}C energy is absorbed at characteristic frequencies. Comparison with standard solutions gives the concentration of the species.	A whole variety of elements can be analysed e.g. Arsenic, Cadmium, Chromium, Lead, Mercury, Selenium, Vanadium and Zinc. The correct preparation of the sample and correction for background interference is important. The technique is widely used in South Africa and relatively cheap.
2. Atomic Emission Spectroscopy (AES)	The technique uses similar principles to AAS except a plasma is used to heat the sample to ca. 2500 ^{0}C and the emission of energy is monitored.	Similar elements can be analysed to AAS but usually with greater sensitivity and less interferences. It can also be more readily adapted for sequential analysis of many species in the same sample. The instrument van cost up to 10 times those used for AAS.
3. X-Ray Fluorescence Spectroscopy (XRF)	Measurement of the secondary X-rays or fluorescent radiation emitted after bombarding a target material with primary X-rays gives quantitative information on the composition of the material.	The rapid analysis of elements from sodium to uranium can be done routinely from 0,1% and above. Lighter elements down to Boron can be determined with the appropriate attachments. It is widely used for the rapid elemental analysis of solid wastes e.g., ash.
4. Ion Chromatography	Separation of positive ions (cations) or negative ions (anions) is achieved by passing a solution through special cation or anion exchange resins. The ions can be detected by conductivity after chemical suppression or by using special eluents and with UV/visible and electrochemical detectors.	The rapid multicomponent analysis of anions e.g., fluoride, chloride, nitrate, nitrite and sulphate or cations e.g.. sodium, potassium, calcium and magnesium can be achieved. Heavy metal ions such as Iron, Cobalt and Nickel and their complex ions plus species such as arsenate and fatty acid anions can also be analysed.
5. Wet Methods	Traditional analytical techniques such as titrimetric, gravimetric and colorimetric analysis.	Methods exist for the analysis of many elements and their compounds. These methods can be accomplished by relatively unskilled personnel and are well suited to ad-hoc analyses without the need for expensive equipment.

TABLE 5.3 (Continued): ANALYTICAL METHODS

METHOD	DESCRIPTION	APPLICATIONS
B: ORGANIC SPECIES **6. Organic Indicator Analysis**	**Chemical Oxygen Demand – COD**: total organic carbon is measured by oxidation with chromic acid. **Biological Oxygen Demand – BOD**: total biodegradable carbon and sometimes the oxidisable nitrogen. **Total Organic Carbon – TOC**: total carbon including inorganic carbon dioxide, bicarbonate and carbonate measured as carbon dioxide. **Dissolved Organic Carbon – DOC**: similar to TOC. **Total Organic Halogen** – TOX: all organic halogen compounds are converted to chloride, bromide and iodide and analysed by conventional methods. **Permanganate Value – PV**: similar to COD except that permanganate is used under less rigorous conditions.	All methods are widely used and give a gross measure of the organic content. The results must be interpreted with caution. The tests should be compared to each other for a better understanding of the nature of the organic content.
7. Gas Chromatography (GC)	The organic components of a waste are split into their individual components by vaporising and passing the resulting gas through a column of material which has a different affinity for each compound. They are detected as they come off the column and identified by comparison with a standard or by a mass spectrometer or mass selective detector.	The procedure can only be applied to those species which are volatile. Thousands of compounds can be analysed including aromatics, solvents, halogenated compounds including PCB's and dioxins, organic acids and bases and aliphatic compounds.
8. High Performance Liquid Chromatography (HPLC)	The principles are similar to IC and GC with the organic being in the liquid phase and being a neutral species. Detection of the individual components by UV/visible spectroscopy, fluorescence and electrochemical means.	A technique that lacks the general versatility of GC but is finding increasing application in the analysis of many organic compounds including polynuclear aromatic hydrocarbons and large molecules.

TABLE 6

MINIMUM REQUIREMENTS FOR WASTE CLASSIFICATION

Subject	Minimum Requirement
Classification	In accordance with its properties and characteristics, a Hazardous Waste must be placed in a SABS Code 0228 class.
Unlisted compounds	Should a Hazardous Waste contain compounds NOT listed in SABS Code 0228, the Department must be consulted before classification is attempted.
Class 1	Direct disposal of Class 1 wastes is PROHIBITED. Class 1 wastes to be pre-treated (destroyed)
Class 2	Flammable gases to be thermally destroyed. Non-flammable gases to be released to atmosphere, unless in contravention with the Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965) and the Montreal Protocol. Controlled destruction of poisonous gases.
Class 3	Landfilling of flammable liquids, flashpoint $<$ 61°C is PROHIBITED. Flammable liquids to be treated to flashpoint $>$ 61°C.
Class 4	Landfilling of flammable solids is PROHIBITED. Flammable solids to be treated to non-flammability.
Class 5	Landfill of Oxidising Substances and Organic Peroxides is PROHIBITED. Treatment to neutralize oxidation potential.
Class 6	Infectious Substances to be sterilised. Residue of Infectious Substances to be given a Hazard Rating. Toxic Substance, Hazard Rating 3 or 4, to be disposed of at **H:H** or **H:h** sites, to have EEC multiplied by Department approved factor. Toxic Substance, Hazard Rating 1 or 2, to be disposed at permitted **H:H** sites, to have EEC multiplied by Department approved factor.

Subject	**Minimum Requirement**
Classification	In accordance with its properties and characteristics, a Hazardous Waste must be placed in a SABS Code 0228 class.
Class 7	Radioactive Substance with specific activity < 74 Bq/g, total activity $< 3,7$ kBq, to be incinerated or landfilled.
	Disposal of Radioactive Substance with specific activity > 74 Bq/g, total activity $> 3,7$ kBq, is PROHIBITED. Consult Department of Health.
Class 8	Disposal of Corrosive Substance, pH < 6 and/or pH > 12, by landfill is PROHIBITED. Corrosive Substance to be treated to pH 6 - 12.
Class 9	Department to be notified if a compound contains substances listed in Class 9 and written approval must be obtained before disposal. Department to be notified if a compound contains substances <u>NOT listed</u> in Class 9.

Section 6

WASTE CLASSIFICATION

6.1 Introduction

Once the substances, compounds, properties and characteristics of a waste have been determined, usually by tests and analyses (see Section 5), it can be classified.

The objectives of the classification system are to:

- **distinguish between Hazardous Waste and General Waste;**
- **determine the single most hazardous property of the waste and, hence;**
- **determine the degree of hazard posed by the Hazardous Waste;**
- **rate Hazardous Wastes, based on the properties and degree of hazard, and set requirements for pre-treatment and disposal;**
- **provide a hierarchical approach, which ensures that unnecessary restrictive measures and expenses are avoided.**

An overview of the classification system was provided in Section 2 and the approach was described in Appendix 2.

6.2 SABS Code 0228

SABS Code 0228, *Identification and Classification of Dangerous Substances and Goods,* form the basis of the Hazardous Waste classification system.

The Code is derived from the International Maritime Dangerous Goods (IMDG) Code. This is a United Nations based system for the classification of dangerous goods to be transported by sea.

The IMDG Code was adopted by South Africa in 1986 (RSA-IMDG Code), to provide a uniform and internationally acceptable system for the identification and classification of hazardous substances. All existing and future legislation is therefore related to the Code.

The different aspects of Hazardous Waste management, such as packaging, temporary storage, transport, treatment and disposal are all based on the principles of SABS Code 0228 (see Appendix 2).

Extension of SABS Code 0228

In the Code, hazardous substances are given an identification number and are classified into nine classes (see **Table 6.1**). Hazardous substances that fall into Class 6, *Poisonous (toxic) and infectious substances* are further divided into three **danger** groups. However, these danger groups relate primarily to transportation, taking into account only the danger to man. In this document, therefore, the Code has been extended, to take into account potential hazardousness to the ecosystem, and especially groundwater.

This extension of the Code can be seen in the **Waste Classification Tables** at the back of this document. In these, the Hazard Rating, the EEC, the Total Load, and the preferred treatment and disposal methods are provided for substances listed in the Code.

Currently, some 350 of the more common Hazardous Waste substances generated in South Africa are listed in the Waste Classification Tables. With time, this information will be provided for all of the substances listed in the Code. When complete, the extended Code should provide an easy and convenient means of identifying and classifying Hazardous Waste.

The Waste Classification Tables are mentioned at this early stage because of their importance. However, it is strongly recommended that the classification system outlined in the following sections be understood before any attempt is made to use them.

6.3 Confirming that a waste is Hazardous

Once the substances and properties of a waste have been determined (see Section 5), they are compared with the Waste Classification Tables, with the Basel Convention and with SABS Code 0228.

If any of the substances or characteristics of the waste are listed in the above sources, it is confirmed that the waste is a Hazardous Waste.

Should a waste contain hazardous substances NOT listed in SABS Code 0228, the Department must be consulted before classification is attempted.

References included at the end of this document, can also be used as a source of information regarding hazardous substances.

6.4 SABS Code 0228 hazard classes

When confirming that the waste is hazardous (see 6.3), the properties of the waste are tested against the nine SABS Code 0228 classes, i.e., is the waste flammable, explosive, corrosive, radioactive, toxic, etc. See **Table 6.1 and Appendix 6.1** for class definitions.

From **Diagram II**, it can be seen that all classes of wastes, except gases or radioactive wastes, will ultimately have to be tested against Class 6, *Toxic and Infectious Substances*. This is because even though a waste may be treated or destroyed there will often be some form of residue which will require disposal. This residue will have to be analysed and its hazardousness (Hazard Rating) will have to be determined before it can be disposed of.

6.5 Determining the Minimum Requirements

Once the SABS Code 0228 class has been determined, the relevant Minimum Requirements, i.e. treatment, incineration or destruction, can be determined from **Diagram III**. The user moves from Class 1 through to Class 9 in Diagram III by reacting to the Yes and No choices, and following the arrows as indicated. It is noted that the waste must be classified **according to its most dangerous substance.**

6.6 Minimum Requirements

Class 1 (explosives)

It is a Minimum Requirement that a waste or a substance in the waste that falls into Class 1 be pretreated. Direct landfilling is prohibited and the Explosives Act must be consulted.

Examples of wastes that would fall into Class 1 would include ammonium perchlorate, ammunition, explosive articles, cyclonite, dinitrophenol, hexanitrodiphenylamine and nitrocellulose.

Class 2 (gases)

It is a Minimum Requirement that flammable gases be subjected to thermal destruction.

Non-flammable gases may be released to the atmosphere, unless in contravention with the Atmosphere Pollution Prevention Act, 1965 (Act 45 of 1965) and the Montreal Protocol. It is a Minimum Requirement, however, that poisonous gases be subjected to controlled destruction.

Class 3 (flammable liquids)

Direct landfilling of certain flammable liquids is PROHIBITED. It is a Minimum Requirement that flammable liquids with flashpoint $<61°C$ be treated to flashpoint $>61°C$. The residual product can then be regarded as non-flammable. However, the residue would then have to be evaluated for its toxicity potential (Class 6).

Examples of flammable liquid would include acetone, alcohol, ethyl ether, aviation gasoline, brake fluid or butaldehyde.

Class 4 (flammable solids)

It is a Minimum Requirement that flammable solids be treated to non-flammability before disposal, see Diagram III. Thereafter, the waste must be tested against Class 6, and given a Hazard Rating.

Class 5 (oxidising substances)

It is a Minimum Requirement that oxidising substances and organic peroxides be treated before disposal to neutralise their oxidation potential (see Diagram III). Thereafter, the waste must be tested against Class 6, and given a Hazard Rating.

Class 6 (toxic and infectious substances)

It is a Minimum Requirement that **all wastes or residues of waste pass through Class 6**. It is at this stage that the Hazard Rating are determined. This is shown in Diagram II. The methodology for determining the Hazard Rating is set out in Section 8.

It is a Minimum Requirement that infectious waste be destroyed. Thereafter, any residue must be given a Hazard Rating.

Class 7 (radioactive substances)

Radioactive materials with a specific activity $>$ 74 Bq/g and/or a total activity $>$ 3,7 kBq are too dangerous to be directly disposed of at a landfill site. Special provision for the disposal of this class of materials has therefore been made in terms of the Nuclear Energy Act, 1982 (Act 92 of 1982).

Class 8 (corrosive substances)

Disposal of corrosive substances, pH $<$ 6 or pH >12, by landfill is prohibited. Corrosive substances must be pre-treated to pH 6 to 12 and thereafter given a Hazard Rating.

Class 9 (miscellaneous dangerous substances)

Class 9 provides for substances that may be difficult to classify according to the definitions in the Code. Examples of such substances are acenapthene, acetylaminofluorene, adipic acid, aerosol dispensers and anthracene.

When wastes contain Class 9 substances or products, it is a Minimum Requirement that the Department be approached regarding the Hazard Rating. It is also a Minimum Requirement that written approval be obtained before disposal.

TABLE 6.1

SABS CODE 0228 CLASSES

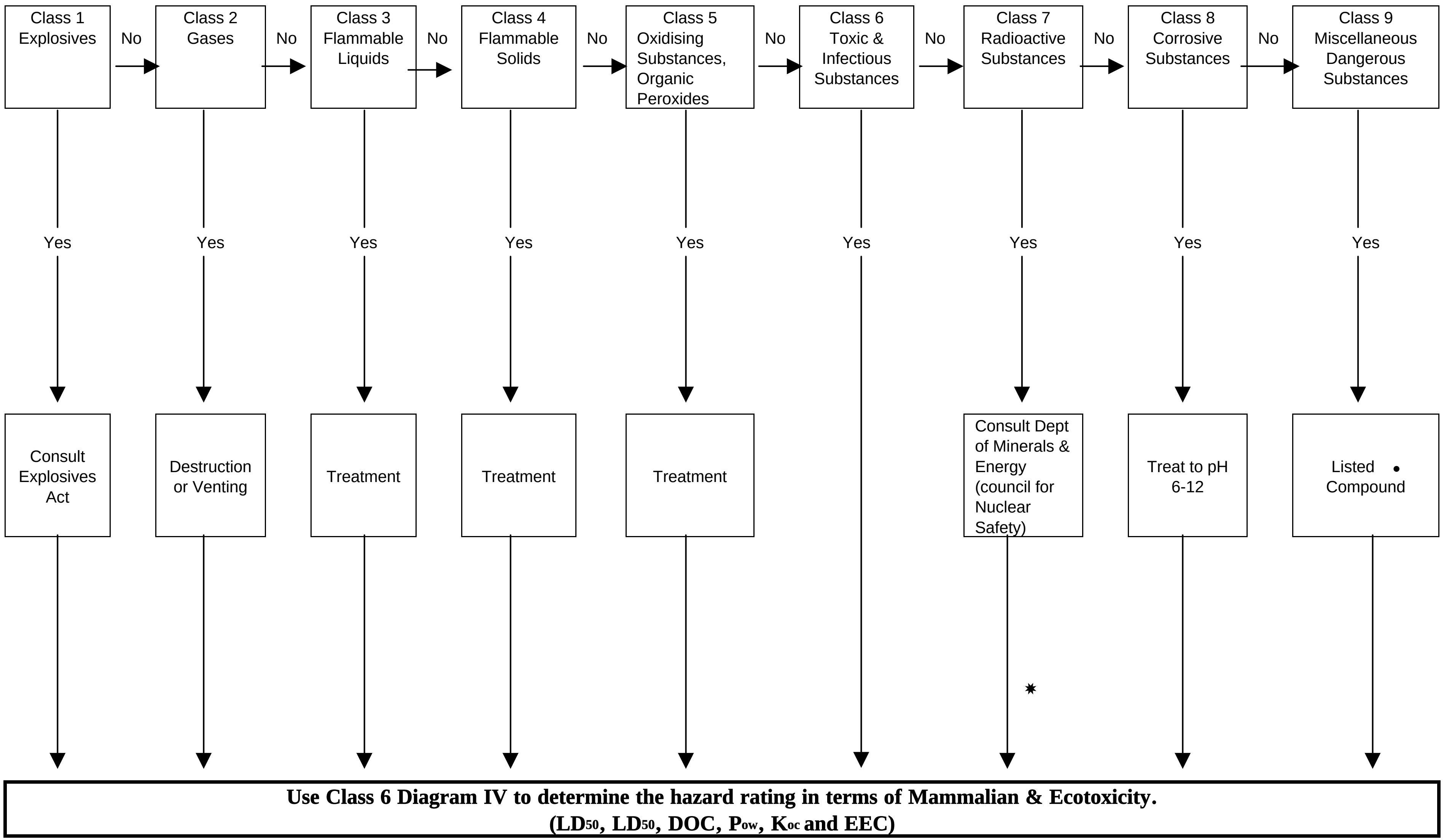
Class	Description
Class 1	Explosives
Class 2 2.1 2.2 2.3	Gases: compressed, liquefied or dissolved under pressure Flammable gases Non-flammable gases Poisonous gases
Class 3 3.1 3.2 3.3	Flammable liquids Low flashpoint group of liquids; flashpoint below – 18°C c.c*. Intermediate flashpoint group of liquids; flashpoint of –18°C up to, but not including 23°C c.c. High flashpoint group of liquids flashpoint of 23°C up to, and including, 61°C c.c
Class 4 4.1 4.2 4.3	Flammable solids or substances Flammable solids Flammable solids liable to spontaneous combustion Flammable solids which emit flammable gases when in contact with water
Class 5 5.1 5.2	Oxidising Substances Oxidising agents Organic peroxides
Class 6 6.1 6.2	Poisonous (toxic) and infectious substances Toxic substances Infectious substances
Class 7	Radioactive substances
Class 8	Corrosive substances
Class 9	Other miscellaneous substances, that is any other substance which experience has shown, or may show, to be of such dangerous character that the provisions of this Section should apply to it.

* **c.c.** = closed cup

These classes are discussed further in Appendix 6.1.

In the SABS Code 0228, the nine classes are allocated a Danger Group (Groups I - III) for transport purposes. **This should not be confused with the Hazard Rating for waste disposal described in Sections 2 and 8.**

DIAGRAM II CLASSIFICATION OF HAZARDOUS WASTE

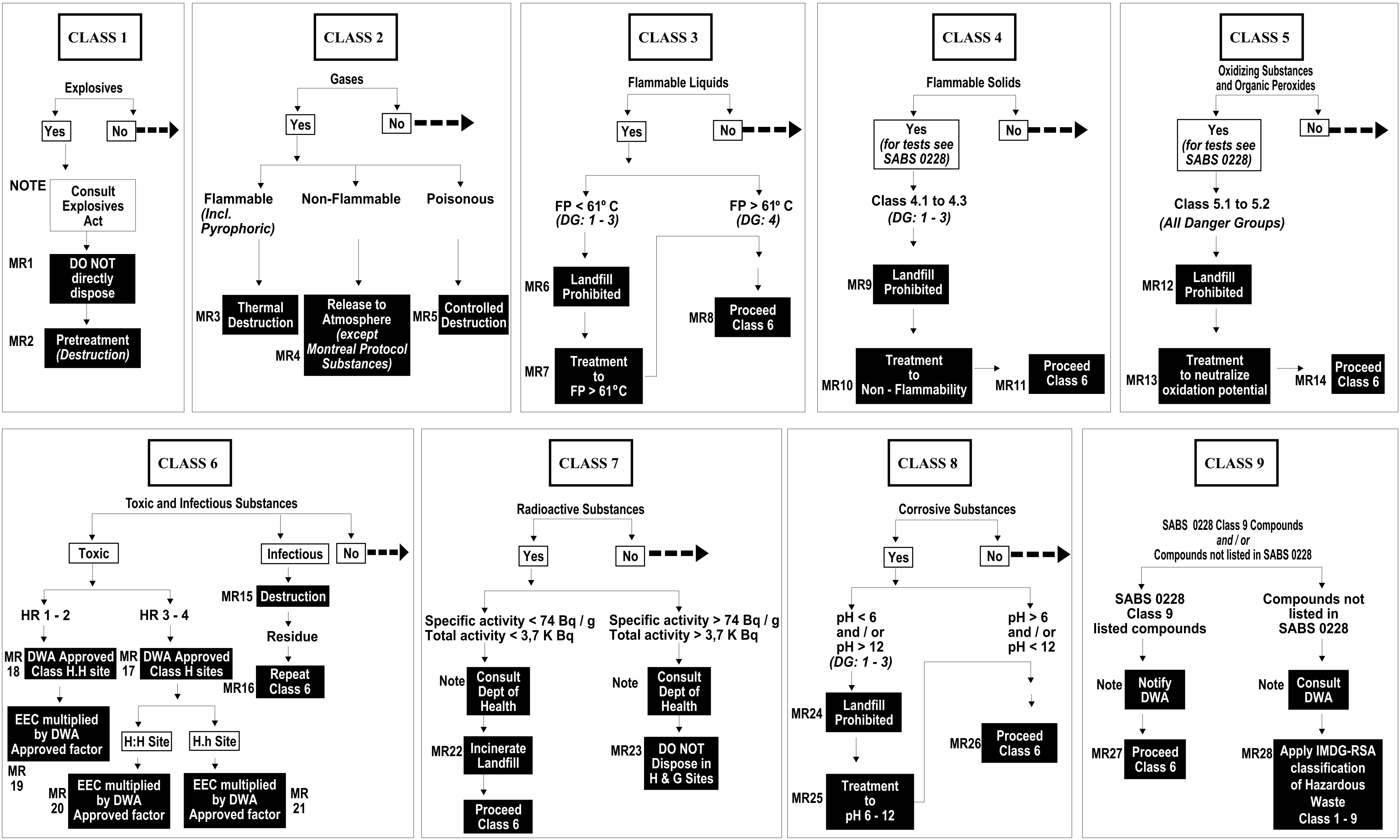


- • Compounds not listed must be classified in accordance with the waste classification system and final verification must be obtained from the Department prior to disposal and for the purposes of updating the Waste Classification Tables.

✷ Only applicable where substance possesses toxicity as well as radioactivity (Uranium, lead and cadmium).

Minimum Requirements for the Treatment and Disposal of Hazardous Wastes

DIAGRAM III



MR = Minimum Requirements
DG = Danger Group
HR = Hazard Rating (Class 6)
= Proceed to following class

Section 7

HAZARDOUS WASTE TREATMENT

7.1 Introduction

After determining the relevant Minimum Requirements from Diagram III, Section 6, it may be necessary to treat the Hazardous Waste. The exact treatment method is usually not prescribed. The choice of technology applied to the approved treatment and disposal of a particular Hazardous Waste will depend upon the nature of the waste, the availability of treatment and disposal facilities, and the cost-effectiveness of treatment and disposal options.*

The objectives of treating a Hazardous Waste or waste stream are to:

- **reduce the toxicity of the harmful components so as to minimise the impact of the waste on the environment;**

- **comply with the relevant Acts and the Minimum Requirements for treatment and disposal.**

This section provides a brief overview of possible Hazardous Waste treatment technologies. The methodologies outlined here can also often be used for the recovery of materials during waste minimisation and recycling programmes. Most treatment technologies can be readily adapted and modified to the requirements of a particular waste stream.

Once a waste has been treated, it will often have to be analysed once again for its hazardous properties and characteristics, see Section 5. The information obtained from this and previous analyses will then be used to determine the Hazard Rating of the waste, see Section 8.

* The cost of a disposal or treatment option is obviously a key issue, but it must be remembered that the cheapest option may not necessarily be the most cost effective in the long term.

7.2 Treatment technologies

The technology chosen for the treatment of a Hazardous Waste will be influenced by its physical and chemical characteristics, i.e.:

- gas, liquid, solid, sludge, in solution, a colloid etc;

- inorganic or organic;

- concentration of both hazardous and non-hazardous components ;

- other characteristics that are used in Hazard Rating, such as mobility, toxicity, accumulation potential, etc.

The available technologies for the treatment of Hazardous Waste can be grouped generally as:

- physical treatment;

- chemical treatment;

- biological treatment;

- immobilisation, solidification and encapsulation;

- incineration.

Site rehabilitation and clean-up technologies can also be regarded as forms of treatment.

7.3 Physical treatment

Physical treatment methods are used to re-move, separate and concentrate hazardous and toxic materials. For example, evaporation or filtration can be used to separate a liquid from dissolved or suspended solids.

There are many such conventional technologies that are commonly used in South Africa. The safety aspects of the processes and the environmental problems that could arise during their use are well known and many processes have been identified as Best Developed Available Technologies (BDAT).

A list of physical treatment technologies together with a brief description of each process and its typical application is provided in Appendix 7, Table A.7.1.

7.4 Chemical treatment

Chemical treatment is used:

- to assist in the application of physical treatment technologies; and
- to lower the toxicity of a Hazardous Waste by changing its chemical nature. This often yields essentially non-hazardous sub-stances, such as salts, carbon dioxide and water.

An example of chemical treatment would be the addition of acid to an alkaline waste stream to neutralise the pH.

Chemical treatment technologies are widely applicable, and many have been designated as BDAT. A list of technologies, together with a brief description of each process and its typical application is given in Appendix 7, Table A.7.2.

7.5 Biological treatment

In biological treatment, microbes are used to destroy or at least reduce the toxicity of a waste stream.

The use of selected or even engineered bacteria is making this technology one of increasing versatility and importance for the treatment of Hazardous Wastes.

The general types of transformations that can be accomplished biologically include:

- degradation of organics, e.g., phenols, to products such as carbon dioxide, methane, water and inorganic salts;
- reduction of inorganic substances, e.g., nitrate;
- complexation of heavy metals, e.g., nickel.

For convenience, contained biological waste treatment and exploitation may be divided into aerobic and anaerobic processes. The two are often used in series and in conjunction with physical and chemical treatment technologies.

7.5.1 Aerobic treatment

In aerobic processes, organic matter is removed from solution by micro-organisms, by means of biological oxidation. Aerobic decomposition involves the breakdown of organic wastes to energy and cell mass in the **presence of oxygen**.

That is Organics + oxygen + Nitrogen + Phosphates = new cells, carbon dioxide, water and non-biodegradable residue.

Of particular importance are: the rate of the process, which can be slow for many industrial organic materials, e.g., polymers and oils; the phosphorus and nitrogen requirements; and the amount of sludge produced. Aerobic treatment is increasingly being used in the treatment of leachates from landfill sites.

7.5.2 Anaerobic treatment

Anaerobic decomposition involves the breakdown of organic wastes to, mainly, gases and water in **the absence of oxygen**. Such gases would include methane and carbon dioxide.

In general, the process is slower than aerobic treatment, but a lower volume of sludge is produced and the potentially valuable resource methane gas is obtained.

Anaerobic technology is used in the treatment of food and brewery wastes and it has been shown that anaerobic methods can break down a variety of aromatic organic substances that have proven recalcitrant to aerobic treatment. Anaerobic decomposition occurs in landfills and is responsible for the generation of landfill gas.

7.6 Immobilisation, solidification and encapsulation

The prime objective of immobilisation, solidification and encapsulation techniques is to convert the Hazardous Waste into an inert, physically stable mass. This treated waste should have a very low leachability and sufficient strength to allow for landfilling or land reclamation.

Immobilisation (or chemical stabilisation) is a process in which the waste is converted to a more chemically stable or more insoluble or immobile form.

Solidification or cementation is a process in which the waste is converted to an insoluble rock-like material by being mixed with suitable materials.

Encapsulation is the coating or enclosure of waste with an inert durable material. Micro-encapsulation applies to the individual particles of a waste, while macro-encapsulation is the encapsulation of a mass of waste, which is normally in a container such as a drum.

The most common materials used are cementing agents, such as portland cements, lime, fly-ash and gypsum mixtures, although modified clay minerals that are now available on the market show considerable advantages over these more conventional materials.

Macro-encapsulation in specially designed cells of a variety of wastes contained in drums, is currently practised in South Africa. This includes both inorganic wastes, e.g., arsenic, and organic wastes, e.g., pesticides and PCBs.

7.7 Landfill-ash blend, neutralisation, precipitation

Landfill-ash blend involves the mixing or blending of a flammable waste with sufficient fly-ash, bottom ash or other material approved by the Department, so that the flash point is $>61°C$. Ash blending is considered a treatment process. The resulting product may be landfill co-disposed with General Waste in accordance with its Hazard Rating.

Neutralisation is the addition of acid or alkali to bring the pH in the region of 7. Lime is normally used to neutralise acid wastes prior to landfilling.

Precipitation is the addition of lime, sodium sulphide or other reagents that result in the formation of insoluble substances that come out of solution.

7.8 Incineration

Incineration can be regarded as both an option for treatment and for disposal, and is therefore discussed in Section 9.

7.9 Site rehabilitation and clean-up technologies

The choice of a strategy and a process for the clean-up and rehabilitation of an industrial site should be made on the basis of a detailed risk assessment that includes a hazard evaluation, exposure assessment and risk characterisation. However, the initial response should be to clean up the most obvious sources of pollution, such as old drums and stockpiles plus obviously contaminated soils and to contain potential run-off water on site in order to minimise further pollution.

Technologies that can be used to rehabilitate and clean up a site are:

- Engineering Containment
- Incineration or other thermal treatment
- Solidification/Stabilisation/Neutralisation
- Volatilisation or Soil Aeration
- Bio-treatment
- Vacuum Extraction.

The main aim of engineering containment is to limit the movement of surface or ground water into the contaminated area or to prevent contaminant migration from the site. Options include the provision of covers, as for site closure, or vertical barriers by slurry trenching or cut-off or diaphragm wall technology.

7.10 Effluent and residue quality standards

Any effluent or residue that is to be released into the environment must conform to the standards of the relevant Acts or their regulations, such as:

- Water Act (Act 54 of 1956) (refer to Section 1 paragraph 1.1);

- Atmospheric Pollution Act (Act 45 of 1965);

- Health Act (Act 63 of 1977);

- Environmental Conservation Act (Act 73 of 1989); and

- Minerals Act (Act 50 of 1991), and Article 1 and 9 of the Mines and Works Act (Act 27 of 1956).

They must also conform to any local by-laws or regulations.

TABLE 8

MINIMUM REQUIREMENTS FOR HAZARD RATING

{PRIVATE } **Subject**	**Minimum Requirement**
Class 6, Poisonous/Toxic Substances	All Hazardous Wastes or residues must be tested against Class 6, Poisonous/Toxic substances.
Hazard Rating	The waste must be Hazard Rated to determine the Hazard Rating into which it falls.
Dose (g/ha/month)	The amount of a hazardous substance in a waste that can be disposed of at a landfill per month must be determined, using the EEC.
Total Load	The capacity of a Hazardous Waste landfill to safely accept a certain substance must be determined.

Section 8

HAZARD RATING

8.1 Introduction

The Hazardous Waste has been treated to comply with the requirements for its SABS Code O228 class (see Sections 6 and 7). Now, it or its residue must be tested against Class 6, *Poisonous/Toxic Substances*. It is at this stage that it is Hazard Rated and allocated a Hazard Rating.

In Class 6 of the Code, provision is made for a hazardous substance to be classified as "toxic" and allocated a transport Danger Group (see Waste Classification Tables, Column 3). However, this Danger Group is allocated only in terms of acute mammalian toxicity (LD_{50}) or, in other words, the risk to man during storage, handling and transport.

This is inadequate for waste disposal purposes. Assessment of the risk posed to health and the environment by the **disposal** of a chemical or a mixture must also take into account all the properties that are related to exposure within the environment, such as,:

- biodegradability
- persistence
- bioaccumulation
- chronic toxicity
- concentration
- production volume
- high dispersion
- leakage to the environment.

Class 6 has therefore been extended to include ecotoxicity and environmental fate as well as chronic toxicity.

The objectives of Hazard Rating are to indicate:

- **the risk posed by a Hazardous Waste and hence the degree of care required for its disposal;**
- **the class of Hazardous Waste landfill at which the waste may be disposed;**
- **the amount of a hazardous substance or compound that can be disposed of at a particular Hazardous Waste landfill site before it begins to pose a risk.**

8.2 Hazard Ratings

As discussed in Section 2, the Hazard Rating is used to classify Hazardous Waste into four Hazard Ratings.

Hazard Rating 1: **Extreme Hazard**
Hazard Rating 2: **High Hazard**
Hazard Rating 3: **Moderate Hazard**
Hazard Rating 4: **Low Hazard**

The four Hazard Ratings are ranked according to a logarithmic progression, whereby Extreme Hazard is 10 times more toxic than High Hazard and *1000* times more toxic than Low Hazard.

Hazard Rating 1 (Extreme Hazard): is waste of first priority concern, containing significant concentrations of extremely toxic substances, including certain carcinogens, teratogens and infectious wastes.

Hazard Rating 2 (High Hazard): is waste of second priority concern with highly toxic characteristics or extremely toxic substances, which are not persistent, including certain carcinogens.

Hazard Rating 3 (Moderate Hazard): is waste of third priority concern, which is moderately toxic or which contains substances that are potentially highly harmful to human health or to the environment but are not persistent.

Hazard Rating 4 (Low Hazard): is waste that often occurs in large quantities and which contains potentially harmful substances in concentrations that in most instances would represent only a limited threat to human health or to the environment.

Hazard Rating lower than Hazard Rating 4: where the classification falls below Hazard Ratings 1 to 4. The hazard posed by a waste can be considered to be low enough to allow the waste, with the consent of the Department, to be disposed of at a General Waste landfill with a leachate collection system.

The Hazard Rating determines the class of landfill at which a waste is disposed:

Hazard Rating 1 Hazard Rating 2	} **H:H** landfill
Hazard Rating 3 Hazard Rating 4	} **H:H or H:h** landfill

The requirements for the siting, investigation, design, operation and monitoring of a Hazardous Waste landfill are more stringent than those for a General Waste landfill (see *Minimum Requirements for Waste Disposal by Landfill*). In turn, the requirements for an **H:H** landfill are more stringent than those for an **H:h** landfill.

8.3 Determining the Hazard Rating

Before attempting the Hazard Rating, the user should have obtained the necessary information from tests and analyses (see Section 5) and from the literature (see References).

To determine the Hazard Rating, the user will proceed from Phase A through to Phase H in Diagram IV.

Moving from Phase A to Phase D, does the waste contain:

- infectious material
- a teratogen
- a carcinogen
- a mutagen

Some compounds regarded as teratogens, carcinogens (A class or B class) or mutagens are listed in Appendices 5.2 & 5.3.

If it does contain any of the above, what is the **concentration** of the carcinogenic or mutagenic substance?

It should be noted that the hazardous effects of some carcinogens are not related to their concentration in the waste, and cannot be reduced with dilution.

Thereafter, what is the:

- biodegradation of the substance, measured as dissolved organic carbon (DOC) or chemical oxygen demand (COD), expressed as a percentage (%);

- accumulation potential of the substance, expressed as the octanol/water partition coefficient, P_{ow};

- persistence potential of the substance, expressed as soil adsorption constant, K_{oc}.

From Phases E to H of Diagram IV, what is the:

- acute mammalian toxicity of the substance, expressed as LD_{50} (mg/kg);

- acute ecotoxicity of the substance, expressed as LC_{50} (mg/ℓ) of aquatic organisms;

- Estimated Environmental Concentration or EEC of the substance, expressed as parts per billion.

Having moved through Diagram IV, the Hazard Rating will have been determined.

Where Diagram IV indicates that the waste is "no risk" or "non-toxic", the waste can be disposed of at a General Waste landfill with a leachate collection system, a **G:B**$^+$ landfill (see **delisting**, Section 8.4.1).

The above criteria are discussed in depth in **Appendix 8.1**. The EEC is discussed further, in Section 8.4, because it is a unique concept and because of the role that it plays in determining the Hazard Rating.

8.4 The Estimated Environmental Concentration (EEC)

The Estimated Environmental Concentration (EEC) represents **exposure** by a hazardous substance in the waste, should it enter into the environment (air, water, and soil). The pathway for the escape of a substance in waste is usually water. Therefore, in this document, EEC represents exposure in a body of water*. It is used to:

- determine the Hazard Rating of the waste;
- determine the amount of a substance in the waste, and hence the waste, that can be disposed of at a landfill per hectare per month;
- determine the total amount of a substance that can be disposed of at a landfill before the site must be closed for that substance (Total Load);
- assess whether, after treatment or tests, a waste can be reclassified to fall into a lower Hazard Rating or even be disposed of as a General Waste (delisting).

The EEC is expressed in parts per billion (ppb) and is calculated using the simplified formula*:

* The EEC represents the worst case scenario, that is, it assumes total concentration, as if all of the substance was to leach out of the waste and enter the environment.

* When wishing to optimise the concept of the EEC, in terms of site specific parameters and conditions, the procedures become compounded and complex. Therefore, within the agreed scope and context of this document, only a brief introduction to the EEC has been regarded appropriate. For more information, the Department should be consulted.

EEC (ppb) = dose (g/ha/month) x 0,66*.

Where dose represents the total amount in grams of the substance in the waste to be disposed of on one hectare of the disposal site per month.

If there is more than one hazardous substance in a waste stream, there will be more than one EEC. **The EEC of the most hazardous substance in the waste stream will determine the Hazard Rating.**

The EEC varies according to:
- the concentration of the waste in a specific media (water, soil, air)
- the actual concentration of the compound in the waste
- ability to reduce the actual concentration by, for example, recovery or treatment procedures.

8.4.1 Using the EEC to determine the Hazard Rating or to delist a Hazardous Waste

The first Yes/No replies determining the **Hazard Rating** in Diagram IV, Phases E to H, are according to acute mammalian toxicity (LD_{50}) and acute ecotoxicity (LC_{50}). See Table 8.1.

* 0,66 is derived from the ratio of the substance in a weight of underground body of water.

$$\text{EEC(ppb)} = \frac{\text{A (waste load/ha of land/month}}{\text{B (weight of underground body of water)}}$$

Where A: Waste in g/ha x size of drainage basin x percentage which may leach into the ground water.

Where B: Surface area of body of water x average depth x weight of water.

Table 8.1 Toxicity Criteria

LD_{50}(mg/kg)	**LC_{50} (mg/l)**	**Hazard Rating**
<5	<1	HR1
5 to 50	1 to 10	HR2
50 to 500	10 to 100	HR3
500 to 5 000	100 to 1 000	HR4

The LC_{50} is the concentration at which a substance would kill 50% of the aquatic animals tested.

One tenth of the LC_{50} should have a limited effect on the aquatic environment. It thus can be considered the concentration at which a substance poses an acceptable low risk to the environment.*

0,1 x LC_{50} is therefore termed the **Acceptable Risk Level**.

The EEC is always compared to the Acceptable Risk Level, to indicate whether the aquatic environment will be at risk or not.

When exposure, EEC, falls **within** the Acceptable Risk Level, the compound can be regarded as a lesser or no threat to the environment. The compound can then be **delisted**.

Delisting is when a hazardous compound in a waste moves from a specific risk group to a lower risk or 'non-risk' group. **It does not become a non-hazardous compound, but the associated risk declines to a risk, which is smaller or even acceptable.**

* The factor of 10 is calculated from a cross section of typical dose-response data, with a typical slope of dose-response curves. From an exposure 10 times lower than the LC_{50}, approximately 0,00034% or one in 300 000 of a population exposed to the contaminant, are likely to die.

Table 8.2. Delisting Criteria

RISK

Classification:	Low *f* 10	=	Moderate *f* 10	=	High *f* 10	=	Extreme
LC_{50}:	100 - 1 000		10 – 100		1 –10		<1
Acceptable Risk Level:	10 - 100		1 – 10		0,1 - 1,0		$<0{,}1$

EEC (EXPOSURE)

$>0.1 \times LC_{50}$	=	**Risk:**	**Remain** in Hazard Rating
$<0.1 \times LC_{50}$	=	**Risk:**	**HR1 remains** in **H:H** landfill site
	=	**No Risk:**	**HR2, HR3 & HR4** can **delist** to **G:B**$^+$ landfill site
$<0.01 \times LC_{50}$	=	**No Risk:**	All Hazard Ratings can **delist** to **G:B**$^+$ landfill site

NOTES:

1) Hazard Rating 2, 3 and 4 compounds delist when EEC is < Acceptable Risk Level.

2) Due to the presence of carcinogens and teratogens in Hazard Rating 1, compounds in this group will only delist when the EEC is less than 0,1 x Acceptable Risk (Precautionary Principle).

EXAMPLE 1: EEC higher than Acceptable Risk Level

The total constituent analysis of a waste stream indicates that zinc (Zn^{2+}) is present at a concentration of 120 mg/kg. If 300 000 kg of this waste is produced per month, then the site would receive 36 000 g of zinc per month.

Teratogen	:	Negative
Mutagen	:	Negative
Carcinogen	:	Negative

The EEC is calculated:

EEC (ppb) = dose (g/ha/month) x 0,66
= 36 000 x 0,66
= 23 760 ppb

The EEC must now be compared with the Acceptable Risk Level.

From the literature, it is determined that the LC_{50} (96 hours for Bluegill) is 7,0 mg/ℓ. This is in the high hazard category (see Table 8.1). The entire waste stream must therefore be classified as Hazard Rating 2 (see also Phase F of Diagram IV).

Acceptable Risk Level = 0,1 x LC_{50}
= 0,1 x 7,0 mg/ℓ
= 0,70 mg/ℓ
= 700 ppb

The EEC is compared to the Acceptable Risk Level:

23 760 ppb > 700 ppb

The EEC is greater than the Acceptable Risk Level and is therefore still classified as Hazard Rating 2. It must be disposed of at an **H:H** waste disposal facility.

Example 2: EEC less than Acceptable Risk Level

A fine ash waste stream contains Iron (Fe) at a concentration of 1,5 mg/kg; to be disposed of at a landfill with an area of 32.5 ha.

Teratogen : Negative

Carcinogen : Negative

Acute ecotoxicity (LC_{50}) = 90 mg/ℓ
= Moderately hazardous
= Hazard Rating 3

Acceptable Risk Level = 0,1 x 90 mg/ℓ
= 9,0 mg/ℓ
= **9 000 ppb**

Concentration = 1,5 mg/kg

Waste = 116 289 t/annum/32,5 ha
= 9 690 750 kg/month/32,5 ha
= 298 177 kg/month/ha

Fe in waste = 298 177 @ 1,5 mg/kg
= 447 g/ha/month

EEC = 447 g x 0,66
= **295 ppb**

295 ppb (EEC) <9 000 ppb (Acceptable Risk Level)

As the EEC for iron in the fine ash is less than the Acceptable Risk Level (0,1 x LC_{50}), the waste is 'no risk', see **Table 8.2**. It can therefore be delisted and disposed of at a General Waste site with a liner and leachate collection system.

Note: This will only be the case if there is no other hazardous substance in the waste, with an EEC > than the Acceptable Risk Level, that requires that the waste be disposed as a higher Hazard Rating.

Further examples of the use of the EEC to determine the Hazard Rating are presented in Appendix 8.3.

8.4.2 Using the EEC to determine the amount of a hazardous substance that can be disposed of in g/ha/month

The EEC is also used to determine the dose, or amount of a substance that can be disposed of in g/ha/month. Once again, as a precautionary measure, and to avert a risk situation, the EEC must not exceed the Acceptable Risk Level.

EEC = Acceptable Risk Level

dose (g/ha/month) x 0,66 = 0,1 x LC_{50}

Therefore:

$$\text{dose(g/ha/month)} = \frac{0{,}1 \times LC_{50}}{0{,}66}$$

Example:

A waste contains a Compound C at a concentration of 5 mg/kg (ppm) with the following characteristics:
LC_{50} (daphnia) = 0,25 mg/ℓ
Carcinogen, Class B
COD = 93%
K_{oc} = 40
P_{ow} = 114

Using these characteristics, Compound C is classified, using **Diagram IV**, as an extreme hazard, i.e., Hazard Rating 1.

To determine the amount of Compound C that can be disposed in g/ha/month:

Acceptable Risk Level = 0,1 x 0,25 mg/ℓ
= 0,025 mg/ℓ
= 25 ppb

The EEC must not exceed the Acceptable Risk Level of 25 ppb to avert a risk situation.

EEC = Acceptable Risk Level
dose (g/ha/month) x 0,66 = 25 ppb

$$\text{dose} = \frac{25\text{ppb}}{0{,}66} = 37{,}8 \text{ g/ha/month}$$

The amount of Compound C that can be disposed of at a landfill site is therefore 37,8 g/ha/month.

From this, it is possible to calculate the amount of the waste containing C at a concentration of 5 ppm that can be disposed of at a landfill site per month:

$$\text{Total amount of waste} = \frac{37{,}8 \text{ g/ha/month}}{5 \text{ ppm}}$$

$$= 7560 \text{ kg/ha/month.}$$

8.4.3 Using the EEC to determine the Total Load

The capacity of a Hazardous Waste landfill to safely accept a certain substance must be determined. This is termed the Total Load.

The Total Load capacity of a landfill site will be influenced by the inherent hazardousness of the waste, by the mobility (leachability) of the waste, and by the landfill design (leachate collection system).

The flow of leachate through the liner of a Hazardous Waste Landfill is estimated to be 5%, with 95% of the leachate being adsorbed permanently in the waste or captured by the leachate collection system.
The Total Load capacity is calculated by multiplying the allowed monthly volume per hectare, by a factor of 100.

Example of calculation of the Total Load:

In the example of Compound C:

LC_{50} = 0,25 mg/ℓ
Carcinogen, Group B
Biodegradable (COD) = 93%
K_{oc} = 40
P_{ow} = 114
Acceptable Risk Level = 0,1 x 0,25 mg/ℓ
= 0,025 mg/ℓ
= 25 ppb

Compound C will be classified, using Diagram IV as Extreme Hazard, i.e., Hazard Rating 1.

If it is to be disposed of in a Hazardous Waste landfill, then EEC must not exceed the Acceptable Risk Level:

EEC = Acceptable Risk Level

g/ha/month x 0,66 = 25 ppb

g/ha = 25 ppb/0,66

g/ha = 37,8 g/ha/month

Total Load Capacity = 37,8 x 100
= 3 780 g/ha

If Compound C is present in a waste stream at a concentration of 5 mg/kg (ppm) and the amount of C that can be disposed of is 3 780 g/ha, then the total amount of waste that can be disposed of is:

$$\text{Total Load} = \frac{3\ 780 \text{ g/ha}}{5\text{mg/kg}} = 756\ 000 \text{ kg/ha} = 756 \text{ tonnes/ha}$$

Thereafter, the site will have to close down with regard to Compound C.

Other Hazardous Wastes that do **not** contain Compound C can, of course, still be disposed of at the site.

8.5 Delisting a Hazardous Waste stream by means of treatment or tests

A Hazardous Waste or waste stream may consist of any number of different substances and compounds. In accordance with the Precautionary Principle, it is the most hazardous substance and its concentration that determines the class, the Hazard Rating, and hence the ultimate method of disposal of a waste or waste stream. In most cases, therefore, a single characteristic, often resulting from a single substance, will determine the classification.

Treatment

Since a single substance can determine the Hazard Rating, treatment can be used to reduce the hazardousness of the substance. Thereafter, the next most hazardous substance will determine the Hazard Rating.

Treatment can thus be used to delist a waste to a lower Hazard Rating or to allow a waste to be disposed of as a General Waste. Note, however, that the treated waste will have to be tested and analysed once more to confirm the efficacy of the treatment.

Leachability tests

The EEC is based on the **total concentration** of a hazardous substance in an aquatic environment, see Appendix 8.1. However, not all of a hazardous substance in the waste stream will necessarily leach out into the environment. There could therefore be cases where it may be considered that the Hazard Rating based on the EEC is too conservative.

In such cases, tests such as the Toxicity Characteristic Leaching Procedure (TCLP) or the Acid Rain test can be used to determine the amount of a hazardous substance that will leach out of the waste stream, (see Appendix 8.5).

The TCLP test is used where wastes are co-disposed with domestic waste or other Hazardous Wastes containing organic matter that could generate organic acids. The Acid Rain test is used when inorganic wastes are disposed of in a dedicated site (mono-disposed). No organic acids would be generated in such a site.

From the test results, the EEC can be recalculated, and the results submitted to the Department to motivate that a specific Hazardous Waste stream be 'delisted' to a lower Hazard Rating.

Example of delisting:

The TCLP test was performed on the zinc containing waste stream described in Section 8.4.1. It was found that only 0,6 mg/kg of the total amount of zinc contained in the waste stream leached out under the fairly rigorous test conditions.

The EEC for zinc can now be recalculated as:

EEC = 300 000kg @ 0,6 mg/kg
= 180g x 0,66
= 119 ppb

The EEC is compared to the Acceptable Risk Level

119 ppb $<$ 700 ppb

As the EEC for zinc is now lower than the Acceptable Risk Level, the waste stream can be delisted, with regard to zinc, from Hazard Rating 2 to General Waste Quality, see Table 8.2. If there is no other hazardous substance in the waste with a higher Hazard Rating, the waste can now be disposed of at a **G:B$^+$** landfill site.

Hazard Classification for Waste Disposal

DIAGRAM IV

Class 6 : Poisonous/Toxic Substances

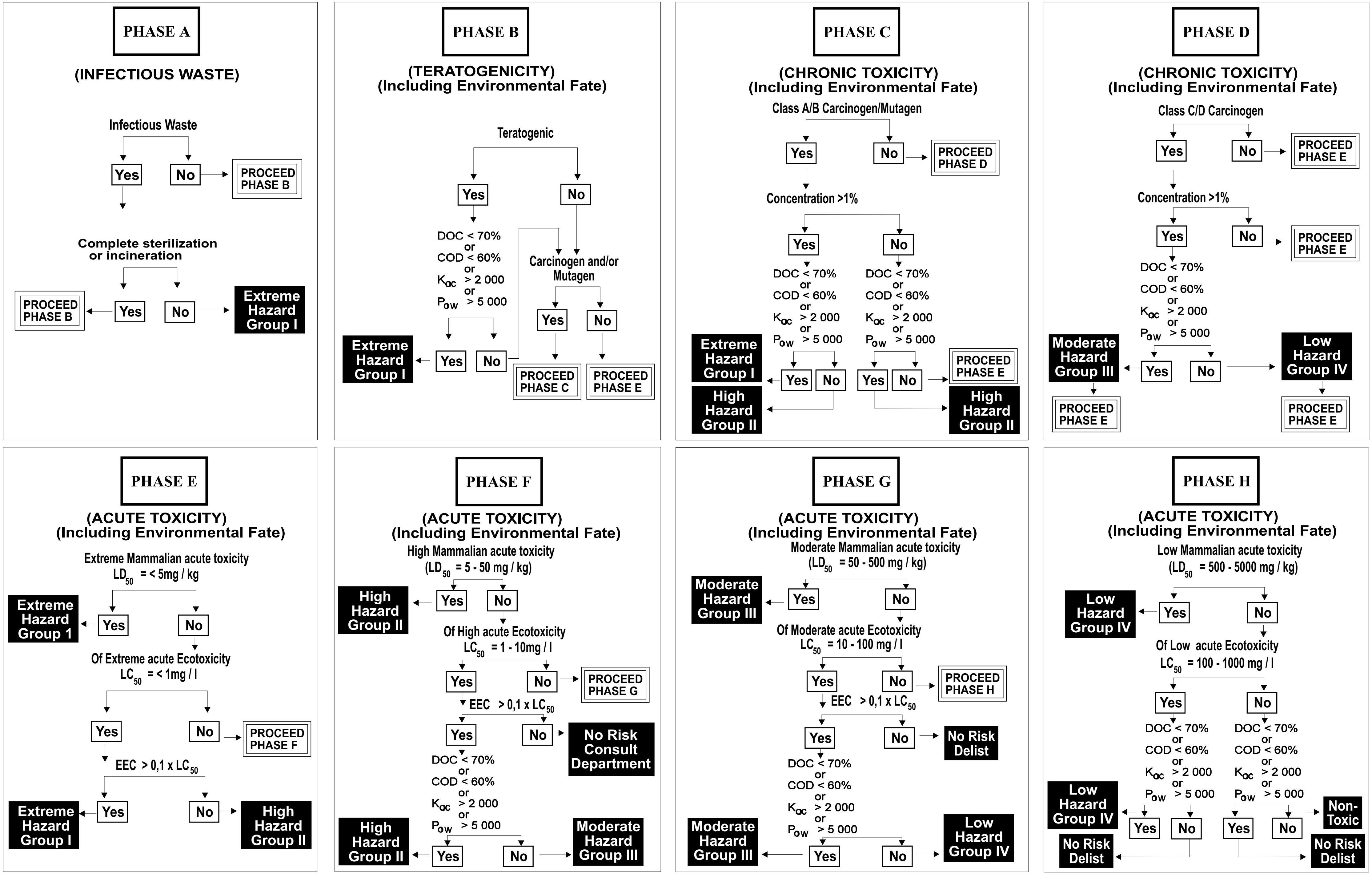


TABLE 9

MINIMUM REQUIREMENTS FOR DISPOSAL

Subject	Minimum Requirement
Landfill class	Hazard Rating 1 and 2 wastes must be disposed of at an **H:H** landfill. Hazard Rating 3 and 4 wastes must be disposed of at either an **H:H** or an **H:h** landfill.
Dose	The amount of a hazardous substance that may be disposed of per hectare per month must not be exceeded.
Total Load	The Total Load capacity of a landfill must not be exceeded.
Solvents	The landfilling of solvents listed in Appendix 9 is restricted and the given Total Load may not be exceeded.
Encapsulation	An encapsulation procedure must conform to SABS Code 1200 series and must be approved by the Department. It is the responsibility of the Generator to ensure that a waste disposal company uses an approved procedure.
Record Keeping	The Operator must keep full records for each engineered cell, its location with-in the landfill, its number and the date of completion. The contents of each drum or container and the name of the Generator or Generators of the waste in each drum or container that is stored within the cell.
Flammable Wastes	Landfilling of waste with a flash point below 61°C is PROHIBITED.
Corrosive Wastes	Landfilling of waste with a pH <6 or >12 is PROHIBITED.
Reactive Wastes	The direct disposal of wastes that react with water, air or components of the waste, or that could generate unacceptable amounts of toxic gases within the landfill is totally PROHIBITED.
Explosive Wastes	Landfilling of explosive wastes is PROHIBITED.
Gases	Landfilling of gases is PROHIBITED.
Radioactive Wastes	Class 7, Radioactive waste, is covered by the Atomic Energy Act and disposal in a landfill is PROHIBITED.
Radioactive Wastes	Only those radioactive wastes defined as "inactive", i.e., with a specific activity less than 74 becquerels per g (Bq/g) and total activity less than 3.7 kBq (0.1uCi), may be disposed as waste.
Organic Waste	Halogenated organic waste may only be disposed of by landfill in the absence of an incineration facility.
Infectious Waste	Landfilling of infectious waste is PROHIBITED unless special permission is granted by the Department (see *Minimum Requirements for Waste Disposal by Landfill*). Infectious Waste must be incinerated or sterilised.

Section 9

DISPOSAL OF A HAZARDOUS WASTE

9.1 Introduction

After being placed in a SABS Code 0228 class (see Section 6), a Hazardous Waste would have been treated in accordance with the requirements for that class (see Section 7). Subsequently it or its residue would have been given a Hazard Rating (see Section 8). The waste would possibly have been treated once more, to reduce the Hazard Rating. Now the waste must be safely disposed of.

The objectives of the Minimum Requirements for the disposal of a Hazardous Waste are to:

- **ensure that any adverse impact on the environment is minimised**
- **prevent hazardous substances leaching or moving into the environment, in particular the ground and surface waters**
- **ensure that Hazardous Waste is disposed of in accordance with the class and the Hazard Rating**
- **to act as a mechanism ensuring the disposal of Hazardous Waste in an orderly manner, thus avoiding detrimental effects both in the short- and long-term to man and to the environment.**

In general, the higher the Hazard Rating of a waste, the greater the control that should be exercised over the disposal route. For an extremely Hazardous Waste, e.g. Hazard Rating 1, the Department will prescribe, and will require to approve, the technology to be applied to its treatment and disposal.

The options available for the disposal of Hazardous Waste can be classed generally as:

- landfill
- incineration

The preferred technology for most organic wastes is incineration, since the advantage of incineration is that, apart from the residual ash which must be landfilled, the waste is destroyed and the risk posed by the waste is minimised. Because of a lack of facilities and the high cost of incineration, however, the most common method of disposal of organic and inorganic Hazardous Waste in South Africa at present is landfill.

9.2 Landfill

Hazardous Waste may only be disposed of at a landfill designed specifically for the disposal of Hazardous Waste and legally permitted by the Department, in terms of the Environment Conservation Act.

As discussed in Section 2, landfills that can accept Hazardous Waste are classified as **H:H** landfills and **H:h** landfills.

H:H landfills can accept all wastes that are allowed to be landfilled. **H:h** landfills, which are not as stringently designed, may only accept Hazard Rating 3 and 4 waste, and General Waste. Hazardous Wastes that are classified as extremely or highly toxic, i.e., Hazard Rating 1 or 2, may only be disposed of in a permitted **H:H** site, if landfill is the management option of choice.

9.2.1 Total Load

Disposal volumes must be in accordance with the calculated EEC, multiplied by a factor of 100, see Total Load, Section 8.4.3 and Appendix 8.4.

Hazardous Waste sites, H:H.

Hazardous Waste, Hazard Ratings 1, 2, 3 and 4, may be disposed in sites permitted for Hazardous Waste but may not exceed the total load per hectare as explained in the text of Appendix 8.1 (7). Also refer to section 8.4.3 for examples.

Hazardous Waste sites, H:h:

Hazardous Waste, Hazard Ratings 3 and 4, may be disposed of at landfill sites permitted as **H:h** sites but may not exceed the total load per hectare as explained in the text of Appendix 8.1 (7). Also refer to section 8.4.2 for examples.

Wastes which exceed the set criteria must either be treated until they meet the criteria or they must be destroyed (for example, by incineration) or isolated from the environment (for example, by encapsulation).

Solvents of concern

The landfilling of certain solvents is restricted because of their effects on liners, mobilisation of other wastes and the ability of treatment procedures to remove, destroy or immobilise the hazardous substances of the waste. There is also strong evidence that certain volatile chemicals can diffuse through clay and flexible membrane liners when present even in low amounts. For the solvents listed in **Appendix 9**, therefore, the total load to be disposed of per hectare of any site must not exceed the amount listed in gram/ hectare/ month.

9.2.2 Co-disposal at landfills

The objective of the co-disposal of General Waste and Hazardous Waste is to absorb, dilute and neutralise any liquids and to provide a source of biodegradable materials in order to encourage microbial activity that will assist in the degradation of hazardous substances. Co-disposal also improves trafficability within the landfill.

The ratio of Hazardous Waste to General Waste required to absorb liquids and obtain an appropriate dilution of the Hazardous Waste is discussed in Section 10.3.4. and Appendix 10.1, *Minimum Requirements for Waste Disposal by Landfill*.

The Total Load of a waste, as determined from the EEC, is not affected by co-disposal.

9.2.3 Encapsulation

Encapsulation (or macro-encapsulation) is the containment of waste in drums or other approved containers within a reinforced concrete cell that is stored in a specifically prepared and engineered area within a permitted Hazardous Waste landfill.

The Department must approve an encapsulation procedure and the Generator should ensure that a waste disposal company utilises an approved procedure.

Encapsulation procedures must conform to the SABS Code 1200 series and Standard Specifications for Civil Engineering Construction. The cell must remain integral if subsidence occurs or if there is an earthquake.

The Department requires that the operator keep full records of each encapsulation cell, its location within the landfill, its number and the date of completion, and the contents of each drum or container. The name of the Generator or Generators of the waste in each drum or container stored within each encapsulation cell must be recorded.

9.2.4 Landfill disposal restrictions

The disposal of Hazardous Wastes that exhibit the characteristics of flammability, corrosivity, or reactivity to a permitted landfill is strictly controlled (see Diagram III).

Flammable Wastes:

Landfilling of Hazardous Wastes with a flash point below 61°C, Danger Group 3, is PROHIBITED (for Class 4, Flammable solids see Reactive Wastes below).

Corrosive Wastes:

Class 8, Corrosive Substances, must be neutralised prior to disposal at a permitted landfill. Hazardous Wastes with a pH less than 6 or greater than 12 CANNOT be directly landfilled.

Reactive Wastes:

Classes 4 and 5, Reactive Substances, must be treated to reduce their reactivity prior to disposal at a permitted landfill. Direct disposal of wastes that react with water, air or components of the waste, or that could generate unacceptable amounts of toxic gases within the landfill is totally PROHIBITED.

9.2.5 Prohibition of waste disposal by landfill

It is anticipated that a few substances could pose such a high risk that the disposal of the waste by landfill should be totally disallowed. In such cases, the **total destruction** of the waste will be required.

Explosive wastes:

The direct landfilling of Class 1, Explosive wastes, is totally PROHIBITED. Explosive wastes must be incinerated, exploded or chemically treated before the residues are landfilled.

Waste compressed gases:

The direct landfilling of Class 2 waste compressed gases, is totally PROHIBITED. Flammable gases must be safely burned or incinerated, non-flammable gases can be vented safely to the atmosphere provided this procedure does not violate the Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965) and poisonous gases must be incinerated or chemically treated. Empty cylinders containing gaseous residues at atmospheric pressure may be landfilled provided this does not violate the permit conditions.

Radioactive waste:

Class 7, Radioactive wastes, are covered by the Atomic Energy Act and the Hazardous Substances Act, 1973 (Act 15 of 1973); their disposal in a landfill is PROHIBITED. Only those wastes defined as "inactive wastes", i.e., with a specific activity less than 74 becquerels per g (Bq/g) and total activity less than 3.7 kBq, may be disposed as normal waste.

9.2.6 Conditional disposal of organic waste

The disposal of halogenated organic wastes by the approved process, e.g., encapsulation or landfill, is only permitted in the absence of a proper incineration facility.

9.3 Historic pollution and accidental spills

'Land treatment' is a form of disposal. It relies upon the natural capacity of soil and the addition of micro-organisms to attenuate, disperse and biologically degrade hazardous substances. Wastes that have been successfully treated in this way include those from petroleum refineries and the textile industry. In theory, almost any organic waste can be treated by land treatment. However, our knowledge of the mechanisms of attenuation, dispersal and biological degradation is extremely limited. Land treatment may therefore NOT be used as a means of Hazardous Waste disposal except in cases of historic pollution or accidental spills.

Where waste has been disposed of directly onto land:

- exposure of any hazardous substance in the waste must be less than or equal to the Acceptable Risk Level (0,1 x LC_{50})
- if greater than the Acceptable Risk Level, it must be treated or remediated until it is less than the Acceptable Risk Level.

9.4 Incineration

Incineration is the preferred means of disposal for most organic and selected inorganic Hazardous Wastes. It is simply the controlled combustion of waste materials to reduce these to a non-combustible residue or ash and exhaust gases, i.e., carbon dioxide and water. The combustion of sulphur and chlorine containing wastes can lead to considerable quantities of acid gases, such as sulphur dioxide and hydrochloric acid, but these can be scrubbed from the gas stream prior to discharge to the atmosphere. In South Africa, as in the USA and in Europe, incineration is the preferred technology for many organic Hazardous Waste streams (see Hazardous Waste Classification Tables).

There are many different types of incineration technology, but the Rotary Kiln, Multiple Hearth and Fluidised Bed Furnaces have been shown to be the most versatile for Hazardous Waste streams. Hazardous Waste normally requires very high temperatures (up to 1 250°C) and long residence times (1 to 2 seconds) for essentially complete combustion of thermally stable materials such as PCB's and dioxins. The need for considerable atmospheric pollution control equipment, which often costs more than the combustor itself, the sophistication of the equipment required for the safe handling and analysis of highly toxic materials, and the need for highly trained staff all contribute to the high cost of incineration.

Selected Hazardous Wastes are being burned extremely successfully as fuels in more than 25 cement kilns in the USA. There are a number of advantages to cement kilns, including the high temperatures (up to 1 500°C) that are reached in order to manufacture the cement clinker. The long gas residence times (up to 6 seconds), the automatic scrubbing of noxious gases such as hydrogen chloride from the gas stream by the alkaline conditions in the kiln, and the savings in conventional fuel such as coal. Also, because they are existing facilities, there is usually less public opposition to their siting. The capital expenditure required is only about 10% of that needed to build a dedicated chemical incinerator.
There are disadvantages, however, since only limited amounts of certain hazardous substances, such as heavy metals, sulphur, and chlorine, can be added. Due to their effect on the operation of the kiln or on the quality of the clinker, and because of the increase in the cost of monitoring the stack gases, and because the waste should preferably have a reasonable calorific value and therefore pre-treatment is often necessary.

9.4.1 Disposal of infectious or medical waste

Infectious waste includes not only that from hospitals - generally termed Medical or Clinical Waste - but also waste from biological research facilities and water analysis laboratories. Medical waste includes human tissue.

Infectious waste is classified as Hazard Rating 1 or Extreme Hazard waste. Methods for its disposal are incineration or, if no incineration facility is available, pre-treatment by sterilisation, direct irradiation or micro-waving before landfilling at an **H:H** or **H:h** site.

Medical waste must be incinerated, since the Human Tissue Act requires that all human parts be incinerated.

All infectious waste must be sterilised prior to landfilling at Hazardous Waste sites or alternatively incinerated at approved incineration facilities.

TABLE 9.1

ADVANTAGES AND DISADVANTAGES OF INFECTIOUS WASTE HANDLING/DISPOSAL TECHNIQUES

{PRIVATE }SYSTEM	ADVANTAGES	DISADVANTAGES
Incineration	• maximum volume weight reduction • sterile residue when operated properly • moderate amount of space required • air emissions can be controlled	• non-combustibles not reduced in volume (ash, metal, etc) • complex operation considering environmental factors • requires trained operator • non-combustibles and ash may pose a disposal problem and auxiliary fuel may be required
Hydropulping	• reduction in volume • should provide good disinfection • substantially changes appearance of waste	• adds substantial weight to product for disposal • difficult for biomonitoring • chlorine solution discharged to POTW* may not be acceptable
Sterilisation (Autoclaving)	• low cost (capital & operating) • low maintenance	• may have increased waste handling • need thorough testing program (spore strip testing) • no volume reduction • no change in appearance of waste
Direct Irradiation	• positive disinfection, very reliable for providing good disinfection	• not demonstrated for infectious waste treatment • permitting expensive and special licences required • high capital cost • extensive monitoring required • no volume reduction
Compaction	• reduces volume of waste • relatively inexpensive	• does not reduce weight • no disinfection • may not render sharps unusable • may cause leakage problem • may cause difficulty in incineration or other treatment
Microwaving	• reduces volume of waste (because of grinding) • moderate cost	• may result in fugitive emissions of volatile organic substances (VOC) • requires strict monitoring program • biomonitoring difficult

Sterilisation/Compaction	• positive disinfection • good volume reduction • low cost • results in change in appearance of waste	• difficult to perform biomonitoring • no weight reduction
Sterilisation/Grinding	• low cost • good volume reduction • substantially changes appearance of waste • positive disinfection • not difficult to perform biomonitoring	• moderate maintenance required

* Publicly owned treatment works (municipal wastewater treatment plant)

TABLE 10

MINIMUM REQUIREMENTS FOR WASTE HANDLING, STORAGE AND TRANSPORTATION

Subject	Minimum Requirement
Qualification as disposal site	If a waste is held at a storage site for a period exceeding three months, the site automatically qualifies as a Waste Disposal Site, and must be registered as such and meet all the requirements of a disposal site.
Temporary storage area	A temporary storage area must have a firm, waterproof base and drainage system. It must be so designed and managed that there is no escape of contaminants into the environment.
Identification of waste	The transporter must be provided with accurate information about the nature and properties of the load.
Documentation	The transport operator must be provided with the relevant transportation documentation for the consignment.
Security of load	The load must be properly loaded and secured on site.
Hazchem placard	The transport operator must be supplied with the appropriate Hazchem placards.
Hazchem placard	The transport operator must ensure that the Hazchem placards are properly fitted to the vehicle.
Vehicle Roadworthiness	The Responsible Person must ensure that before the vehicle leaves the consignor's premises it is not overloaded or showing any obvious defect that would affect its safety.
Escape of hazar-dous spillage at site	The Department and the Local Authority must be advised immediately, should it prove impossible to contain spillage of a Hazardous Waste on a site.
Protection against effect of accident	The Generator - or his representative, i.e., transporter - must ensure that adequate steps are taken to minimise the effect an accident or incident may have on the public and on the environment.
Spillage on site	The Generator must initiate remedial action to clean up any spillage remaining on a site after an accident.
Notification	All road accidents must be reported to the Department of Transport on the prescribed documentation.
Notification	In case of an accident, a full report, containing all the information listed in 10.8.2 must be sent to the Department

Section 10

WASTE HANDLING, STORAGE AND TRANSPORTATION

10.1 Introduction

The handling, temporary storage and transportation of Hazardous Wastes follows the same principles and requirements as those, which relate to dangerous goods in general. South Africa accepts the United Nations Recommendations for the transport of Dangerous Goods as incorporated in the International Maritime Organisation's Dangerous Goods Code IMDG and the International Civil Aviation Organisation's Regulations as given in their Technical Notes. These are both implemented as legislation through the Department of Transport's Merchant Shipping Act (Act 57 of 1951) and Aviation Act (Act 72 of 1962).

These principles also underlie the regulations relating to the transportation of dangerous goods by rail, as incorporated in Spoornet's Supplement 6 of the Official Tariff Book. Further, they are the basis of a series of SA Bureau of Standards Codes of Practice on the Transportation of Dangerous Goods by Road currently nearing completion, as well as of forthcoming Codes on Handling and Storage. It is expected that these Codes will be made law by both the Department of Manpower and the Department of Transport in the future.

An additional requirement of the transportation of Hazardous Waste relates to the "duty of care" principle. This places responsibility for a waste on the Generator, and is supported by the "cradle-to-grave" principle, according to which a "manifest" accompanies each load of Hazardous Waste until it is responsibly and legally disposed of. This manifest is transferred from one transporter to the next along with the load, should more than one transporter be involved.

Once the waste is properly disposed of at a suitable, permitted facility, a copy of the manifest must be returned to the point of origin.

To minimise uncontrolled dumping of Hazardous Wastes, consignors and transporters must comply with the SABS Codes of Practice on Transportation of Dangerous Goods. *Inter alia*, these require an adequate level of training of all personnel involved in the handling and transportation, by both parties. The consignor must satisfy himself of the competence of the carrier and the carrier needs to satisfy himself of the *bona fides* of the consignor to ensure that materials offered for transport are honestly described and suitably contained and labelled.

The objectives of the transportation of Hazardous Waste are:

- to ensure the correct packaging, temporary storage and collection of a waste prior to transportation, so as to prevent accidental spillage into the environment and minimise the impact should a spillage occur;
- to ensure that the Hazardous Waste is never "lost": this is achieved by use of a system of documentation or a manifest system;
- to ensure that the waste arrives safely at a permitted facility;
- to ensure that emergency procedures are in place before an accident occurs, and that the Hazardous Waste is correctly marked so as to aid the emergency team.

  It should be noted that all aspects of handling explosive material, flammable material and radioactive material are covered by specific legislation. The relevant Acts are:

- the Explosives Act, 1973 (Act 16 of 1973);
- the Fire Brigade Services Act, 1987 (Act 88 of 1987); and
- the Nuclear Energy Act, 1982 (Act 92 of 1982).

10.2 Collection and storage

A Generator who treats, stores for a period exceeding 90 days, or disposes of Hazardous Waste on site is subject to section 20(1) of the Environment Conservation Act and must apply for a permit for a waste disposal facility from the Department.

10.2.1 Collection

It is essential that all waste arisings should be accumulated at the point of origin as they occur and that they should not be allowed to lie around for any length of time. Such waste material must also not be mixed with other wastes of a different nature or composition. Mixing could result in severe reactions in the case of non-compatible materials and hinder later efforts to recover or recycle the waste material. Small additions of a highly toxic or Hazardous Waste mixed with a less toxic or General Waste would render both wastes Hazardous and so place an unnecessary (and avoidable) large volume in a higher waste category.

Once the waste has accumulated in a suitable container, the waste container itself must be clearly marked before temporary storage to prevent any risk of wrong identification resulting in environmental pollution. Guidance on compatibility of materials is contained in SABS Code 0232.

10.2.2 Temporary storage

The migration of leachate or spillage into the ground and groundwater regime around all temporary storage areas must be prevented. A temporary storage site therefore requires a firm waterproof base that is protected from the ingress of storm water from surrounding areas. It must also have an effective drainage system to a waterproof spillage collection area, where any spillage can be recovered and suitably treated. This area must be clearly demarcated and should not be accessible to unauthorised persons.

Waste materials should always be stored separately from other process chemicals or products.

If non-compatible wastes are to be stored, care should be taken to adequately separate them, to prevent possible interactions in the event of fire or spillage. Flammable or combustible wastes must in any event be stored separately from other waste materials.

10.2.3 Quantities of waste that can be temporarily accumulated

A Generator may accumulate the following quantities of Hazardous Waste on site for 90 days or less without a permit for a waste disposal site:

Hazard Rating 1	=	10 kgs
Hazard Rating 2	=	100 kgs
Hazard Rating 3	=	1 000 kgs
Hazard Rating 4	=	10 000 kgs

provided that:

- the waste is stored in such a manner that no pollution of the environment occurs at any time;
- the date upon which accumulation begins is clearly marked and visible for inspection on each container;
- while being stored on site, each container and tank is labelled or marked clearly with the words "Hazardous Waste";
- the Generator fences off the storage area to prevent unauthorised access and erects a weatherproof, durable and clearly legible notice-board in official languages at every entrance of the storage area with the words "Hazardous Waste: unauthorised entry prohibited".

The Generator who accumulates more than the above specified quantities or who intends to accumulate Hazardous Wastes for more than 90 days is subject to the requirements of Section 20(1) of the Environment Conservation Act unless he has been exempted from obtaining a permit by the Minister.

10.3 Packaging and labelling

10.3.1 Packaging

Hazardous Waste must be securely contained during handling, storage and transport to prevent risk to the environment. The ways of achieving this objective depend on the nature of the material, on its physical form, on quantity and on the degree of hazard of the material.

The container must be manufactured from materials that can resist effects of the material contained and that can withstand the physical methods used for the handling and the transportation of the containers.

The type of packaging to be used is determined by a series of practical tests, related to the degree of hazard posed by the material to be contained, as categorised by the three Packaging Groups 1, 2 and 3 (Refer to SABS Code 0229 for details). This Code is applicable to moderate quantities of material, ranging up to 450 litre capacity. If the waste material can be classified as Explosive, Flammable or Radioactive, further regulations apply when the material is being stored and transported. When larger quantities of waste are involved, bulk containers should be used as specified in SABS Code 0233.

10.3.2 Labelling

Labelling of containers with the correct Name and Description of the contents is essential for three basic reasons, i.e.,

- to correctly identify the material for purpose of recycling or recovery;

- to facilitate the correct emergency action in case of an accident;

- to ensure that the appropriate treatment and disposal methods are being used by the disposal contractor.

Labelling of hazardous substances must be done according to the SABS Code 0233.

When Hazardous Waste is transported, further labelling of bulk containers and placarding of the vehicle is also required. (Refer to SABS Code 0233 for details).

10.4 Transport

10.4.1 Legislative control

The most important control measures for the transportation of Hazardous Wastes are:

Legislative:

- The National Road Traffic Act (Act 93 of 1996).

- The Hazardous Substances Act (Act 15 of 1973).

- The Occupational, Health and Safety Act (Act 85 of 1993).

If the Waste is classified as Explosive, Flammable or Radioactive, additional regulations would apply respectively under:

- The Explosives Act (Act 16 of 1973).

- The Fire Brigade Services Act (Act 99 of 1987).

- The Nuclear Energy Act (Act 92 of 1982).

Codes of Practice:

- SABS Code 0230: Vehicle Inspection Requirements
- SABS Code 0231: Operational Requirements.
- SABS Code 0232: Emergency Response Information
- SABS Code 1518: Design Requirements for Vehicles.

10.4.2 Transport groups

Waste material that, because of its composition and physical properties, falls within the general definition and technical norms for "Hazardous Substances" (SABS Code 0228), is, for the purpose of transport, just another hazardous substance and therefore subject to all the normal requirements and controls for the transport of hazardous substances. Typical examples of such waste would be spent sulphuric acid from an extraction unit or a flammable solvent residue from a scrubber unit.

These transport requirements include:

- the packaging/containerisation of the waste;
- labelling of containers;
- vehicle requirements and licensing thereof;
- driver training, licensing and responsibilities;
- loading of the vehicle and securing of the load;
- placarding of the vehicle and transport documentation, etc.

Tank containers are normally used for liquid or sludge hazardous substances and have to be specially designed to cope with such loads.

Packaged waste material is normally transported in open trucks or in large quantities on a flat bed truck. In such instances, it is of utmost importance that the compatibility of waste materials in a mixed load should be observed since even a slight leak between non-compatible waste components may result in a fire on the vehicle or in worst case even an explosion.

Hazardous Waste should be controlled in the same way as hazardous substances with regard to identification and placards for transport purposes.

10.4.3 Packaging

SABS Code 0228 gives a full description of the various types of containers which can be used for the packaging and labelling of hazardous substances for transport purposes. This must be strictly followed.

For documentation purposes the following abbreviations should be used:

DM = Metal drums, barrels, kegs
DW = Wooden drums, barrels, kegs
DF = Fibreboard or plastic drums, barrels, kegs
TP = Tanks portable
TT = Cargo tanks (tank trucks)
TC = Tank cars
DT = Dump truck
CY = Cylinders
CM = Metal boxes, cartons, cases (including roll-offs)
CW = Wooden boxes, cartons, cases
CF = Fibre or plastic boxes, cartons, cases
BA = Burlap, cloth, paper or plastic bags

10.5 Emergency and remedial action

Accidents that can cause environmental pollution may occur during the storage and accumulation stage and the transport stage of the waste handling process.

10.5.1 Temporary storage and accumulation

If there is a spillage or pollution of surface water due to flooding of a storage area during heavy rains, the Generator must take all possible steps to recover the hazardous component and prevent any polluted water from entering sewerage systems or public streams. If and when it becomes obvious that such spillage cannot be contained on site, the local authorities and the Department must be advised of the incident immediately. Full co-operation must be given to these authorities to implement emergency action so as to minimise the adverse affects of such occurrence on the public and on the environment.

10.5.2 Transport

If there is a transport accident resulting in leakage or spillage of the Hazardous Waste, two distinct actions are required, i.e.,

- Emergency action must be taken to contain the spilled material and to prevent further uncontrolled spillage or leakage. In addition immediate steps must be instituted to clear the road from any material that may delay or stop the traffic.

  These emergency actions are normally initiated by the driver of the vehicle and executed by emergency services personnel. Emergency action should follow immediately after the incident and would normally last for three to four hours thereafter.

- Remedial action must be taken to clean up and remove any spillage or residue and to ensure that no environmental pollution or contamination of water resources will take place at a later stage. The load must be properly loaded and secured on site!

Emergency Action

If a road accident causes leakage or spillage of Hazardous Waste, the driver of the vehicle must immediately notify the local emergency services of the incident, clearly stating:

- the location;
- the nature of the load being carried; and
- the status at the site of the accident itself, i.e., whether further leakage is still taking place, whether the vehicle or the load is on fire and what the traffic situation is.

Until assistance arrives, the driver will be responsible for warning and if necessary regulating traffic. Bystanders must, under all circumstances, be kept away from the vehicle and its load.

The Transport Emergency Card (Tremcard), which must accompany the load, must be recovered from the vehicle and handed to the Police and/or emer-gency personnel on their arrival. The Tremcard information on emergency action and the HAZCHEM placard on the vehicle will provide the emergency services with the initial information required for action.

Since spillages of Hazardous Waste resulting from road accidents or failure of the containers normally happen outside the Generator's premises, arrange-ments must be made beforehand for good and prompt communication between the carrying vehicle and the Generator of the waste. When such an incident is reported the Generator must promptly inform the Regional Office of the Department. In addition, the Generator must ensure that all technical information relating to the waste material is made available immediately to emergency teams on the site of the incident.

It should be noted that the Generator - or his representative, i.e., transporter - retains primary responsibility for ensuring that adequate steps are taken to minimise the effect of an accident or incident on the public and on the environment.

If there is a serious accident that results in substantial losses or consequential damage, it is advisable that the Generator should also advise its insurance company since they may wish to send an assessor to conduct an on-site inspection.

Remedial action

Remedial action to clean up any spillage remaining on site after an accident has to be initiated by the Generator.

Such remedial action may be undertaken by the Generator himself, a waste disposal contractor appointed by either the Generator or by the insurance company or, if this fails, by the State.

In such event all costs relating to the remedial action will be recovered by the State from the Generator of the waste.

The remedial action will depend on the nature and properties of the waste material, on the physical environment in which it has been spilled and on the severity of the spillage. In some instances washing away of residues with water may prove adequate but in other instances chemical treatment of the residue or even digging up of soil and removal thereof to a disposal site may be required.

The major objective of the clean-up procedure must be to minimise the risk of contaminating the environment and in particular the water sources at a later stage.

10.5.3 Reporting of road accidents and spillage

All road accidents must be reported to the Department of Transport on the prescribed documentation. In addition, an incident report must be compiled, giving full details of the nature of the incident, amounts of waste material lost and remedial action taken to prevent environmental and water pollution. Such a report should be send to the Department of Water Affairs & Forestry, Directorate of Water Quality Management, Private Bag X313, Pretoria, 0001.

LIST OF APPENDICES

Appendix 1

INTERNATIONAL WASTE MANAGEMENT

A.1 Historical development

In the past 15-20 years, increasing attention has been given to the impacts on health and to the environmental significance of chemical contaminants in wastes. This is for the most part due to an increasing awareness that improper disposal of such wastes has resulted in significant adverse health and environmental consequences. Unfortunately the awareness had to be triggered by actual or potential disasters, most of which are well documented in relevant literature. Such disasters, as well as uncontrolled dumping of hazardous waste, were subsequently addressed by International Organisations, mostly under the auspices of the United Nations:

In 1983, the United Nations Environment Program (UNEP) in conjunction with the World Health Organisation (WHO) published principles for the formulation and implementation of a hazardous waste management policy, as a code of practice.

In 1985, under the auspices of UNEP, the "Cairo Guidelines" on policies and legislation for the environmentally sound management of hazardous substances were adopted.

Also in 1985, an International Register of potentially toxic chemicals, with treatment and disposal options for hazardous waste, was published by UNEP.

In 1986, guidelines, policies and strategies for hazardous waste management in Asia and the Pacific were published by UNEP.

The UN Economic Commission for Europe started to focus particularly on low-waste and non-waste technologies in the later parts of 1980-1990.

The Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal came into force on 5 May 1992. (It should be noted that a technical co-operation trust fund was established to support developing countries in need of assistance to implement the Convention.)

Legislation in solid waste management in the USA and the European Community is being revised. In the United States, the mixture and derived-from rules that were promulgated on May 19, 1980 (45FR33066) were withdrawn on April 28, 1993. Alternatives proposed by the EPA on May 20 1992 contained three major options:

1. Concentration-based exemption criteria (CBEC) that would allow a listed hazardous waste to become non-hazardous if it does not exceed prescribed concentration limits for any of 200 constituents.

2. An expanded characteristic option (ECHO) which would add more constituents to the toxicity characteristic and would eventually establish concentration levels for all hazardous constituents.

3. A contingent management option that could be used in combination with CBEC or ECHO.

In the European Community, the EC Framework Directive, which is being revised, will set the principles of common waste management practice within the EC. Some inclusions in the draft directive are:

- export of waste is prohibited to any state, which is not a signatory of the Basel Convention. Export beyond 60° latitude and export of toxic waste to Africa, to the Caribbean Islands and to the Pacific States is also prohibited;

- the producer of waste is legally liable for damage and deterioration to the environment caused by waste, whether or not he is at fault;
- with regard to third party risk (transportation), an insurance policy or some other form of financial guarantee is compulsory;
- with regard to packaging of waste, the directive is heavily based on a dual system, i.e., the producer and retailer are obliged to take back and to recycle packaging;
- the strategy on Waste Management is based on a ladder approach, i.e.:
  - Prevent
  - Recycle
  - Incinerate
  - Landfill

In the UK, a waste management licensing system came into force in April 1993. This specifies that any residual pollution risk posed by a completed landfill is borne by the operator until the site has stabilised. Post-closure and other costs will therefore have to be paid by the operator.

New hazardous waste management plans are currently being drafted by, amongst others, Hungary, The Netherlands, Japan, Denmark and France. In addition, the Working Group on Hazardous Waste (WGHW) of the International Solid Waste Association (ISWA) has agreed to the following 10 priority work areas for fiscal years 1994-1997.

1. Household hazardous waste and small generators;
2. Contaminated sites
3. Developing countries
4. Safe or best hazardous waste practices
5. Household waste transport
6. Waste minimisation
7. Siting issues
8. Socio-economic issues;
9. Hazardous waste handling; and
10. Industrial waste

A.1.2 Current waste management approaches

In most industrialised countries, toxic waste management has only come within the ambit of government policy since the 1960's and has only really been addressed by governments during the 1970's.

Countries started slowly by developing procedures for the investigation and recording of quantities of "wastes" and toxic and/or "dangerous" waste, as well as investigating the origin and characteristics of these classes of materials. The first Act relating to public health dates from the early 20th century, whereas specific environmental protection legislation for the control of waste and more specifically of toxic waste, has only been in existence for 20 years at the most.

The main stimulus for the passing of new legislation was the increasing awareness of detrimental effects on the environment as a result of careless disposal of wastes, be it uncontrolled dumping on, and/or discharges into surface and ground water, careless storage and transportation, or inappropriate treatment. It was realised that if damage to human health and the environment was to be prevented, appropriate legislation was needed to control the separation of toxic and dangerous waste from ordinary domestic and non-hazardous industrial waste and to ensure its correct disposal.

A policy for toxic waste management must be consistent with policies developed to control the use of toxic substances, to conserve resources, to preserve health and to protect the environment. In such a policy, three objectives can be distinguished:

a. the protection of human health and the safeguarding of the environment against harmful effects caused by the collection, transportation, treatment, storage and disposal of toxic wastes;

b. the promotion of waste avoidance, the use, re-use or reclamation and treatment of waste in order to minimise its potential impact on the environment; and

c. the reduction or prevention of any dispersion of toxic waste into the environment.

The vital components of a policy with the above objectives are:

- legislation and regulations that are acceptable, implementable and affordable by all concerned;
- proper implementation and enforcement procedures;
- provision of adequate facilities for hazardous waste recycling, treatment and disposal activities.
- inclusion of Integrated Environmental Management (IEM) as part of an environmental policy.

Appendix 2

DEFINITION OF HAZARDOUS WASTE

Considerable attention has been focused on the question of what constitutes a "Hazardous Waste." National systems differ both in the methods used for defining wastes and in the type of wastes included. These differences arise partly from variations in the institutional and legal frameworks of different countries and partly from the difficulty involved in distinguishing between wastes that are "normal" and wastes that are Hazardous.

The South African definition of Hazardous Waste is based upon the UNEP definition, "Waste, other than radioactive waste, which is legally defined as hazardous in the state in which it is generated, transported or disposed of. The definition is based on chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or in contact with other waste."

Internationally, many different "legal" definitions for hazardous waste exist. In most cases the definitions are relatively vague and mostly refer to a list of compounds and/or types of wastes concerned.

Some of the main identification criteria for such lists are:

- Type of hazard involved (flammability, corrosivity, toxicity, reactivity);
- The generic category of the products involved (e.g. pesticides, solvents, medicines);
- Technological origins (e.g. oil refining, electro-plating);
- Presence of a specific substance or group of substances (e.g. PCB, dioxin, lead compounds).

These criteria and others are used alone or in combination but in very different ways, depending on regulations. In particular, the compositional characteristics of waste may or may not be quantified. Where concentration levels are set, they vary from country to country.

This may be illustrated by the fact that waste containing 50 mg of cyanide per kg would be considered as hazardous in one country, but not in another where the standard is fixed at 250 mg/kg.

In general it can be stated that the legal definitions give no better understanding of criteria covered by such definitions. Terms like "it can lead to serious pollution" and "causes an increase in mortality or illness" are difficult to interpret in a totally objective way and need to be quantified for every waste material individually. If not quantified, misinterpretation and doubt as to the classification of a waste material or stream will continue.

South Africa has therefore decided that the most practical method of identifying and classifying hazardous substances is by:

- inclusion of lists of substances;
- incorporation of a degree of hazard approach, not only to designate a waste as hazardous or not, but also to differentiate between degree of hazard regarding disposal methods and sites;

- use of concentration levels and "total loading", or the assimilation capacity of sites, to guard man and the environment against future detrimental effects;
- The use of "acceptably low risk" levels to allow for the delisting or reclassification of a Hazardous Waste as a General Waste for waste disposal, if it can be shown that the risk posed to the environment is acceptably low.

It is on this basis that the Hazardous Waste Classification System was developed.

Lists of hazardous substances

- A list of industries and processes is included (Section 3, Diagram I) to identify processes which are likely to generate Hazardous Waste. Waste from these processes will be classified as potentially Hazardous and as requiring to be controlled.
- A list of Hazardous Wastes is included in Appendix 6.1.
- SABS Code 0228 is used as an inclusive Hazardous Waste list, that is, a list explicitly identifying hazardous substances. The presence of a substance on the list automatically brings the waste into the regulatory control system. (Note: the absence of a substance from this list does not necessarily imply that the substance is not hazardous.)
- The Basel Convention also provides a list of hazardous substances.

Degree of Hazard

- The SABS Code 0228 groups substances into 9 classes, according to characteristics such as flammability, corrosivity, reactivity or toxicity. These characteristics are defined by means of limiting parameters determined by standard test protocols.
- Wastes that fall within Class 6 of SABS Code O228 are given a Hazard Rating for disposal. The Hazard Rating is derived from the inherent mammalian and ecological (acute and chronic) toxicity of compounds, including environmental fate and the Estimated Environmental Concentration (EEC) principle.

Concentration Levels

- The Estimated Environmental Concentration (EEC) is used to provide an exposure level and assimilation capacity approach. In this approach, chemical compounds are regarded as being hazardous above a threshold concentration. The EEC includes environmental fate and allows prediction of the fate of a waste contaminant.
- The SABS Code 0228 is to be expanded to include a no effect or "acceptably low risk" level. This will provide a list of substances that in certain quantities or concentrations will not pose a risk to health and/or to the environment.

Delisting by Exemption Approach

The classification system also incorporates a "delisting by exemption approach". Generators are allowed to perform tests such as the TCLP test to prove that their wastes should be regarded as non-hazardous or of a lesser hazardous nature, and should therefore be exempted from disposal on a Hazardous Waste site, in which event it may be disposed of on an approved General Waste disposal site equipped with a leachate management system.

Appendix 3

WASTE MINIMISATION

Waste avoidance, i.e., reducing waste without relying on recycling or re-use, is the most economically and environmentally beneficial waste minimisation option. Householders and businesses can contribute through 'smart shopping'; e.g., avoiding excess purchases (especially food), packaging or shopping bags. Waste avoidance could be encouraged in future by such measures as pricing, with greater charges for bigger garbage bins, and take back schemes where an industry must take back the product when it becomes a waste.

Where waste is unavoidable, the recovery of resources by re-use, recycling and other processes can reduce reliance on virgin materials and the adverse impacts of waste disposal. Currently, many private industries, community groups, schools and municipalities run recycling schemes in South Africa. However, with the improvement of waste collection services and public education, it will be possible to separate most recyclable wastes at source. There is therefore a great deal of scope for the further development of recycling industries. For example, it would be possible to collect textiles in bins, in the same way as paper and glass are collected. The Departments of Environment & Tourism and Water Affairs & Forestry strongly support the development of recycling industries and initiatives by the public sector.

Some wastes that can be recycled are listed in the paragraphs that follow.

1. Paper

Paper-fibre materials can be recycled to produce such products as tissue & toilet paper, newspaper, writing and office paper, and cardboard packaging. Predominant sources of recycled paper would include newsprint, magazines, cardboard, packaging, white office paper and liquid paperboard.

2. Glass

Recovered glass can be resold to the manufacturer. New glass bottle manufacture can contain over 90% recyclable glass (cullet), replacing virgin materials such as sand. It is also possible to use glass in the manufacture of bricks and the production of asphalt. Plate glass can be used in the production of sandblasting materials and sandpaper. Cullet must be sorted into three separate colour streams of amber, white and green. With new technology, colour sorting can be automated.

3. Plastic

A major difficulty with the recycling of plastics is the need to separate different types of plastic, as these have different melting points. Mixed plastic will not form a uniform and stable material. However, processes are being developed for the automated separation of plastics and also for fusing and subsequently laminating shredded plastics to make plastic sheets for use as wallboards and similar applications. Recycled waste plastic materials can also be used to generate electricity at Waste to Energy plants. Recyclable plastics include polypropylene, polystyrene, polyurethane, polyethylene, perspex, and polycarbonate. The most common recyclable 'household' plastics are PET and HDPE.

PET (Polyethylene terephthalate) is used in the manufacture of soft drink and fruit juice bottles, pillow and sleeping bag filling, and textile fibres. Currently, recycled PET is more expensive than the raw product and recycled PET cannot be used in food packaging. However, it is possible to manufacture a multi-layer bottle that contains 38% recycled PET and a depolymerisation process (molecular components are chemically separated and then reconstituted) allows 100% incorporation of recycled PET.

High Density Polyethylene (HDPE) is used in the manufacture of such products as milk containers, shopping bags, freezer bags, bleach bottles, buckets, milk crates, and rigid agricultural pipes. Recycling options include the manufacture of mobile garbage bins from recycled HDPE.

4. Metal

Metal recycling is already an accepted activity where metal scrap is generally sold to merchants, who in turn supply homogenous and some mixed scrap to steel mills and foundries for re-use. Tin, steel and aluminium cans, used for aerosols, food and beverages, can also be recycled.

5. Tyres

The disposal of tyres in a landfill is a problem, as they are hard to compact and tend to rise up through the waste. In many countries, therefore, a levy is placed on tyres at point of sale to support tyre recycling technology and infrastructure.

Current recycling and re-use options include retreading of tyres and the use of tyres as fuel in cement kilns. Processes are also available for separating the steel from the rubber. The steel is then recycled and the rubber turned into rubber crumb. The rubber crumb can be used for retreading tyres, acoustic materials, roofing, runways, road base, oil spill absorbers, aggregate, asphalt, speed bumps, road barriers, mud flaps, floor mats, packaging, toys, watering systems, animal bedding and fences.

6. Oil

Oil from commercial and industrial premises can be filtered and used for fuel applications. A recently developed technology, Interline, enables used oil to be refined sufficiently to be re-used as a primary oil product.

Used car oil from households and commercial organisations in South Africa is collected by some garages.

7. Textiles

Re-usable wastes in the form of fabric, fibre or flock can be put to many uses. These include cleaning clothes, padding, toy filling, upholstery, mattresses, carpets, and insulation.

Old clothes, suitable for use, can be recycled via welfare organisations, second hand shops. Clothing not suitable for use can be sold as rags for industry. Carpets can also be cleaned and resold.

8. Recyclable Organic Materials

Recyclable organic materials, including timber, garden, food and abattoir wastes, are a major contributor to the volume and toxicity of landfills. If this waste can be diverted from landfill, it can be used in the manufacture of compost and mulch.

Options for the recycling of waste foods from canteens, restaurants and stores includes their use by pig farmers. Householders can make compost or have 'earth worm farms'. Recycled timber that is suitable can be used for furniture, building material or firewood.

9. Construction and Demolition Waste

The main material that can be recovered from heavy construction and development activities is rubble (concrete, soil, rock, gravel, etc). This can be used for road construction. Separated concrete can be recycled into low strength concrete or road base. Other recyclable materials emanating from construction and development activities would include wood, asphalt, bitumen, plate glass, roofing materials, plasterboard and bricks.

10. Other waste

With ingenuity and the right collection systems, almost all waste can be recycled. Examples would include white goods, spectacles, cork, toys, etc. Workshops for repairing goods could also be set up.

Appendix 5.1

TESTS FOR HAZARDOUS PROPERTIES

Ignitability

The ignitability or flash point is determined using a closed cup tester. The sample is heated at a slow constant rate with continual stirring. At intervals a small flame is directed into the cup, with simultaneous interruption of the stirring. The flashpoint is the lowest temperature at which application of the flame ignites the vapour above the sample.

Corrosivity

The corrosivity of a waste is determined by measuring the degree to which a coupon of a standard steel has been dissolved. The coupon is immersed in the waste, which is stirred at a sufficient rate to ensure that the liquid is kept well mixed and homogeneous. The test is carried out at a constant temperature of 55°C for a period of 24 hours, which is ample time to determine whether the corrosion rate is greater than 6,35 mm per year and therefore regarded as corrosive.

Reactivity

There are no general tests for reactivity, although the EPA recommends that the specific release of hydrogen cyanide or hydrogen sulphide must be determined for cyanide and sulphide wastes. This is achieved by subjecting the wastes to 0,005M sulphuric acid (pH 2), under controlled conditions. The released gases are trapped in an absorber containing 1,25M sodium hydroxide and analysed by the standard methods.

Toxicity using the Toxicity Characteristic Leaching Procedure

As discussed in Section 2, the classification system devised for South Africa includes the Estimated Environmental Concentration (EEC) as an essential component. Where it is considered that mobility is overestimated, using the EEC approach, the Toxicity Characteristic Leaching Procedure and/or the Acid Rain extraction procedure where appropriate can be used to evaluate the mobility of a hazardous element or compound. The methodologies for these tests are set out in Appendix 8.

APPENDIX 5.2

LIST OF TERATOGENS

Ammonia Bromotrifluoromethane Caprolactam Carbon disulfide Carbon monocide Chlorinated bipbhenyls Chlorine Chlorobenzene Chlorodifluoromethane 2-Chloroethanol Chloroform Cyclohexanone Diazinon 1,2-Dichlorobenzene 1,4-Dichlorobenzene Dichlorodifluoromethane Dichlorvos (DDVP) Diethylene glycol monobutyl ether Di(2-ethylhexyl)phthalate N,N-dimethyl acetamide Dimethylformamide Ethylene glycol Ethylene glycol monobutyl ether Ethylene glycol monobutyl ether acetate Ethylene glycol monoethyl ether Ethylene glycol monoethyl ether acetate Ethylene glycol monomethyl ether Ethylene glycol monomethyl ether acetate Formaldehyde Halothane Hexane (*n*-Hexane) Hydrogen chloride Isoamyl alcohol Isobutyl alcohol 2-Isopropoxyethanol Lead	Maleic anhydride Methacrylic acid methyl ester Mehyl chloride Methyl mercury 4-Nitroaniline Propylene glycol 1-methyl ether Propylene glycol 2-methyl ether Propylene glycol 1-methyl ether-2-acetate Propylene glycol 2-methyl ether-1-acetate Styrene Tetrachloroethylene Tetrahydrofuran Toluene Tri-*n*-butyltin compounds 1,1,1-Trichloroethane Trichloroethylene Trichlorofluoromethane Vinylidene chloride

APPENDIX 5.3

LIST OF MUTAGENS AND CARCINOGENS

CLASS A

Aflatoxins, naturally occurring [1402-68-2]
4-Aminobiphenyl [92-67-1]
Arsenic [7440-38-2] and arsenic compounds
Asbestos [1332-21-4]
Azathioprine [446-86-6]
Benzene [71-43-2]
Benzidine [92-87-5]
Beryllium [7440-41-7] and beryllium compounds
Bis(chloromethyl)ether [542-88-1]
1,4-Butanediol dimethanesulfonate [55-98-1]
Cadmium [7440-43-9] and cadmium compounds
Chlorambucil [305-03-3]
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea [13909-09-6]
Chlornaphazine [494-03-1]
Chloromethyl methyl ether [107-30-2]
Chromium[vi] compounds
Ciclosporin [79217-60-0]
Coal-tar pitches [65996-93-2]
Coal-tars [8007-45-2]
Cyclophosphamide [50-18-0] [6055-19-2]
Diethylstilboestrol [56-53-1]
Erionite [66733-21-9]
Ethylene oxide [75-21-8]
Melphalan [148-82-3]
8-Methoxypsoralen [298-81-7]
Mustard gas (Sulfur mustard) [505-60-2]
2-Naphthylamine [91-59-8]
Nickel compounds [7440-02-0]
Radon [10043-92-2] and its decay products
Tamoxifen [10540-29-1]
Thiotepa [52-24-4]
Treosulfan [299-75-2]
Vinyl chloride [75-01-4]

CLASS B

A-α-C (2-Amino-9*H*-pyridol[2,3-*b*]indole [26148-68-5]
Acetaldehyde [75-07-0]
Acetamide [60-35-5]
Acrylamide [79-06-1]
Acrylonitrile [107-13-1]
Adriamycin [23214-92-8]
AF-2 [2-(2-Furyl)-3-(5-nitro-2-furyl)acrylamide [3688-53-7]
Aflotoxin M_1 [6795-23-9]
para-Aminoazobenzene [60-09-3]
ortho-Aminoazotoluene [97-56-3]
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole [712-68-5]
Amitrole [61-82-5]
ortho-Anisidine [90-04-0]
Antimony trioxide [1309-64-4]
Aramite [140-57-8]
Atrazine [1912-24-9]
Auramine [492-80-8]
Azacitidine [320-67-2]
Azaserine [115-02-6]
Benz[*a*]anthracene [56-55-3]
Benzidine-based dyes [ ]
Benzo[*a*]pyrene [50-32-8]
Benzo[*b*]fluoranthene [205-99-2]
Benzo(*j*]fluoranthene [205-82-3]
Benzo-[*k*]fluoranthene [207-08-9]
Benzofuran [271-89-6]
Benzyl violet 4B [1694-09-3]
Bischloroethyl nitrosourea (BCNU) [154-93-8]
Bleomycins [11056-06-7]
Bromodichloromethane [75-27-4]
1,3-Butadiene [106-99-0]
Butylated hydroxyanisole (BHA) [25013-16-5]
β-Butyrolactone [3068-88-0]
Caffeic acid [331-39-5]
Captafol [2425-06-1]
Carbon black [1333-86-4]
Carbon tetrachloride [56-23-5]
Ceramic fibres [ ]
Chloramphenicol [56-75-7]
Chlordane [57-74-9]
Chlordecone (Kepone) [143-50-0]
Chlorendic acid [115-28-6]
α-Chlorinated toluenes (benzyl chloride, benzal chloride, benzotrichloride)
para-Chloroaniline [106-47-8]
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) [13010-47-4]
Chloroform [67-66-3]
1-Chloro-2-methylpropene [513-37-1]
Chlorophenols
Chlorophenoxy herbicides
4-Chloro-*ortho*-phenylenediamine [95-83-0]

para-Chloro-*ortho*-toluidine [95-69-2] and its strong acid salts
Chlorozotocin [54749-90-5]
CI Acid Red 114 [6459-94-5]
CI Basic Red 9 [569-61-9]
CI Direct Blue 15 [2429-74-5]
Cisplatin [15663-27-1]
Citrus Red No. 2 [6358-53-8]
Cobalt [7440-48-4] and cobalt compounds
para-Cresidine [120-71-8]
Cycasin [14901-08-7]
Dacarbazine [4342-03-4]
Dantron (Chrysazin; 1,8-Dihyfroxyanthraquinone) [117-10-2]
Daunomycin [20830-81-3]
DDT [*p*,*p*'-DDT, 50-29-3]
N,N'-Diacetylbenzidine [613-35-4]
2,4-Diaminoanisole [615-05-4]
4,4'-Diaminodiphenyl ether [101-80-4]
2,4-Diaminotoluene [95-80-7]
Dibenz[*a,h*]acridine [226-36-8]
Dibenz[*a,j*]acridine [224-42-0]
Dibenz[*a,h*]anthracene [53-70-3]
7H-Dibenzo[*c,g*]carbazole [194-59-2]
Dibenzo[*a,e*]pyrene [192-65-4]
Dibenzo[*a,h*]pyrene [189-64-0]
Dibenzo[*a,i*]pyrene [189-55-9]
Dibenzo[*a,l*]pyrene [191-30-0]
1,2-Dibromo-3-chloropropane [96-12-8]
para-Dichlorobenzene [106-46-7]
3,3'-Dichlorobenzidine [91-94-1]
3,3'-Dichloro-4,4'-diaminodiphenyl ether [28434-86-8]
1,2-Dichloroethane [107-06-2]
Dichloromethane (methylene chloride) [75-09-2]
1,3-Dichloropropene [542-75-6]
Dichlorvos [62-73-7]
Diepoxybutane [1464-53-5]
Di(2-ethylhexyl)phthalate [117-81-7]
1,2-Diethylhydrazine [1615-80-1]
Diethyl sulfate [64-67-5]
Diglycidyl resorcinol ether [101-90-6]
Dihydrosafrole [94-58-6]
Diisopropyl sulfate [2973-10-6]
3,3'-Dimethoxybenzidine (*ortho*-Dianisidine) [119-90-4]
para-Dimethylaminoazobenzene [60-11-7]
trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)-vinyl]-1,3,4-oxadiazole [25962-77-0]
2,6-Dimethylaniline (2,6-Xylidine) [87-62-7]
3,3'-Dimethylbenzidine (*ortho*-Tolidine) [119-93-7]
Dimethylcarbamoyl chloride [79-44-7]
Dimethylformamide [68-12-2]
1,1-Dimethylhydrazine [57-14-7]
1,2-Dimethylhydrazine [540-73-8]

Dimethyl sulfate [77-78-1]
3,7-Dinitrofluoranthene [105735-71-5]
3,9-Dinitrofluoranthene [22506-53-2]
1,6-Dinitropyrene [42397-64-8]
1,8-Dinitropyrene [42397-65-9]
2,4-Dinitrotoluene [121-14-2]
2,6-Dinitrotoluene [606-20-2]
1,4-Dioxane [123-91-1]
Disperse Blue 1 [2475-45-8]
Epichlorohydrin [106-89-8]
Ethyl acrylate [140-88-5]
Ethylene dibromide [106-93-4]
Ethylene thiourea [96-45-7]
Ethyl methanesulfonate [62-50-0]
N-Ethyl-*N*-nitrosourea [759-73-9]
Formaldehyde [50-00-0]
2-(2-Formylhydrazino)-4-(nitro-2-furyl)thiazole [3570-75-0]
Furan [110-00-9]
Glu-P-1 (2-Amino-6-methyldipyridol [1,2-*a*: 3',2'-*d*]
imidazole) [67730-11-4]
Glu-P-2 (2-Aminodipyrido[1,2-a:3',2'-d]imidazole) [67730-10-3]
Glycidaldehyde [765-34-4]
Griseofulvin [126-07-8]
HC Blue No. 1 [2784-94-3]
Heptachlor [76-44-8]
Hexachlorobenzene [118-74-1]
Hexachlorocyclohexanes [ ]
Hexamethylphosphoramide [680-31-9]
Hydrazine [302-01-2]
Indeno [1,2,3-*cd*]pyrene [193-39-5]
Iron-dextran complex [9004-66-4]
Isoprene [78-79-5]
IQ (2-Amino-3-methylimidazol[4,5-f]quinoline) [76180-96-6]
Lasiocarpine [303-34-4]
Lead [7439-92-1] and lead compounds, inorganic
MeA-α-C (2-Amino-3-methyl-9H-pyrido[2,3-b]indole) [68006-83-7]
MelQ (2-Amino-3,4-dimethylimidazo[4,5-f]quinoline) [77094-11-2]
MelQx (2-Amino-3,8-dimethylimidazo[4,5-*f*]quinoxaline)
Merphalan [531-76-0]
5-Methoxypsoralen [484-20-8]
2-Methylaziridine (Propyleneimine) [75-55-8]
Methylazoxymethanol acetate [592-62-1]
5-Methylchrysene [3697-24-3]
4,4'-Methylene bis (2-chloroaniline) (MOCA) [101-14-4]
4,4'-Methylene bis(2-methylaniline) [838-88-0]
4,4'-Methylenedianiline [101-77-9]
Methylmercury compounds
Methyl methanesulfonate [66-27-3]
2-Methyl-1-nitroanthraquinone [129-15-7]
N-Methyl-*N*'-nitro-*N*-nitrosoguanidine (MNNG) [70-25-7]
N-Methyl-*N*-nitrosourethane [615-53-2]

N-Methyl-*N*-nitrosourea [684-93-5]
Methylthiouracil [56-04-2]
Metronidazole [443-48-1]
Mirex [2385-85-5]
Mitomycin C [50-07-7]
Monocrotaline [315-22-0]
5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-2-oxazolidinone [3795-88-8]
Nafenopin [3771-19-5]
Nickel, metallic [7440-02-0] and alloys
Niridazole [61-57-4]
Nitrilotriacetic acid [139-13-9] and its salts
5-Nitroacenaphthene [602-87-9]
2-Nitroanisole [91-23-6]
Nitrobenzene [98-95-3]
6-Nitrochrysene [7496-02-8]
Nitrofen [1836-75-5]
2-Nitrofluorene [607-57-8]
1-[(5-Nitrofurfurylidene)amino]-2-imidazolidinone [555-84-0]
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide [531-82-8]
Nitrogen mustard [51-75-2]
Nitrogen mustard *N*-oxide [126-85-2]
2-Nitropropane [79-46-9]
1-Nitropyrene [5522-43-0]
4-Nitropyrene [57835-92-4]
N-Nitrosodi-*n*-butylamine [924-16-3]
N-Nitrosodiethyllamine [55-18-5]
N-Nitrosodimethylamine [62-75-9]
N-Nitrosodiethanolamine [1116-54-7]
N-Nitrosodi-n-propylamine [621-64-7]
3-(N-Nitrosomethylamino)propionitrile [60153-49-3]
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK) [64091-91-4]
N-Nitrosomethylethylamine [10595-95-6]
N-Nitrosomethylvinylamine [4549-40-0]
N-Nitrosomorpholine [59-89-2]
N'-Nitrosonornicotine [16543-55-8]
N-Nitrosopyrrolidine [930-55-2]
N-Nitrososarcosine [13256-22-9]
Ochratoxin A [303-47-9]
Oil Orange SS [2646-17-5]
Oxazepam [604-75-1]
Panfuran S (containing dihydroxymethylfuratrizine [794-93-4]
Pentachlorophenol [87-86-5]
Phenacetin [62-44-2]
Phenazopyridine hydrochloride [136-40-3]
Phenobarbital [50-06-6]
Phenoxybenzamine hydrochloride [63-92-3]
Phenyl glycidyl ether [122-60-1]
Phenytoin [57-41-0]
PhIP (2-Amino-1-methyl-6-phenylimidazo[4,5-*b*]pyridine)
Ponceau MX [3761-53-3]

Ponceau 3R [3564-09-8]
Potassium bromate [7758-01-2]
Procarbazine hydrochloride [366-70-1]
1,3-Propane sultone [1120-71-4]
β-Propiolactone [57-57-8]
Propylene oxide [75-56-9]
Propylthiouracil [51-52-5]
Saccharin [81-07-2]
Safrole [94-59-7]
Silica [14808-60-7], crystalline
Sodium *ortho*-phenylphenate [132-27-4]
Styrene [100-42-5]
Styrene-7,8-oxide [96-09-3]
Sulfallate [95-06-7]
2,3,7,8-Tetrachlorodibenzo-*para*-dioxin (TCDD) [1746-01-6]
Tetrachloroethylene [127-18-4]
Tetranitromethane [509-14-8]
Thioacetamide [62-55-5]
4,4'-Thiodianiline [139-65-1]
Thiorea [62-56-6]
Toluene diisocyanates [26471-62-5]
ortho-Toluidine [95-53-4]
Trichlormethine (Trimustine hydrochloride) [817-09-4]
Trichloroethylene [79-01-6]
1,2,3-Trichloropropane [96-18-4]
Tris(2,3-dibromopropyl)phosphate [126-72-7]
Trp-P-1 (3-Amino-1,4-dimethyl-*5H*-pyrido[4,3-*b*]indole) [62450-06-0]
Trp-P-2 (3-Amino-1-methyl-*5H*-pyrido[4,3-*b*]indole) [62450-07-1]
Trypan blue [72-57-1]
Uracil mustard [66-75-1]
Urethane [51-79-6]
Vinyl acetate [108-05-4]
Vinyl bromide [593-60-2]
4-Vinylcyclohexene [100-40-3]
4-Vinylcyclohexene diepoxide [107-87-6]
Vinyl fluoride [75-02-5]

CLASS C & D

Acridine orange [494-38-2]
Acriflavinium chloride [8018-07-3]
Acrolein [107-02-8]
Acrylic acid [79-10-7]
Acrylic fibres
Acrylonitrile-butadiene-styrene copolymers
Actinomycin D [50-76-0]
Agaritine [2757-90-6]
Aldicarb [116-06-3]
Aldrin [309-00-2]
Allyl chloride [107-05-1]
Allyl isothiocyanate [57-06-7]
Allyl isovalerate [2835-39-4]
Amaranth [915-67-3]
5-Aminoacenaphthene [4657-93-6]
2-Aminoanthraquinone [117-79-3]
para-Aminobenzoic acid [150-13-0]
1-Amino-2-methylanthraquinone [82-28-0]
2-Amino-4-nitrophenol [99-57-0]
2-Amino-5-nitrophenol [121-88-0]
4-Amino-2-nitrophenol [119-34-6]
2-Amino-5-nitrothiazole [121-66-4]
11-Aminoundecanoic acid [2432-99-7]
Ampicillin [69-53-4]
Angelicin [523-50-2]
Aniline [62-53-3]
para-Anisidine [104-94-9]
Anthanthrene [191-26-4]
Anthracene [120-12-7]
Anthranilic acid [118-92-3]
Antimony trisulfide [1345-04-6]
Apholate [52-46-0]
Attapulgite [12174-11-7]
Aurothioglucose [12192-57-3]
Aziridine [151-56-4]
2-(1-Aziridinyl)ethanol [1072-52-2]
Aziridyl benzoquinone [800-24-8]
Azobenzene [103-33-3]
Benz[*a*]acridine [225-11-6]
Benz[*c*]acridine [225-51-4]
Benzo[*ghi*]fluoranthene [203-12-3]
Benzo[*a*]fluorene [238-84-6]
Benzo[*b*]fluorene [243-17-4]
Benzo[*c*]fluorene [205-12-9]
Benzo[*ghi*]perylene [191-24-2]
Benzo[*c*]phenanthrene [195-19-7]
Benzo[*e*]pyrene [192-97-2]
para-Benzoquinone dioxime [105-11-3]
Benzoyl chloride [98-88-4]
Benzoyl peroxide [94-36-0]

Benzyl acetate [140-11-4]
Bis(1-aziridinyl)morpholinophosphine sulfide [2168-68-5]
Bis(2-chloroethyl)ether [111-44-4]
1,2-Bis(chloromethoxy)ethane [13483-18-6]
1,4-Bis(chloromethoxymethyl)benzene [56894-91-8]
Bis(2-chloro-1-methylethyl)ether [108-60-1]
Bis(2,3-epoxycyclopentyl)ether [2386-90-5]
Bisphenol A diglycidyl ether [1675-54-3]
Blue VRS [129-17-9]
Brilliant Blue FCF, disodium salt [3844-45-9]
Bromochloroacetonitrile [83463-62-1]
Bromoethane [74-96-4]
Bromoform [75-25-2]
n-Butyl acrylate [141-32-2]
Butylated hydroxytoluene (BHT) [128-37-0]
Butyl benzyl phthalate [85-68-7]
γ-Butyrolactone [96-48-0]
Cantharidin [56-25-7]
Captan [133-06-2]
Carbaryl [63-25-2]
Carbazole [86-74-8]
3-Carbethoxypsoralen [20073-24-9]
Carmoisine [3567-69-9]
Carrageenan [9000-07-1]
Catechol [120-80-9]
Chloral [75-87-6]
Chloral hydrate [302-17-0]
Chlordimeform [6164-98-3]
Chlorinated dibenzodioxins (other than TCDD)
Chloroacetonitrile [107-14-2]
Chlorobenzilate [510-15-6]
Chlorodibromomethane [124-48-1]
Chlorodifluoromethane [75-45-6]
Chloroethane [75-00-3]
Chlorofluoromethane [593-70-4]
3-Chloro-2-methylpropene [563-47-3]
4-Chloro-*meta*-phenylenediamine [5131-60-2]
Chloronitrobenzenes [88-73-3; 121-73-3; 100-00-5]
Chloroprene [126-99-8]
Chloropropham [101-21-3]
Chloroquine [54-05-7]
Chlorothalonil [1897-45-6]
2-Chloro-1,1,1-trifluoroethane [75-88-7]
Chromium [7440-47-3]
Chrysene [218-01-9]
Chrysoidine [532-82-1]
CI Acid Orange 3 [6373-74-6]
Cimetidine [51481-61-9]
Cinnamyl anthranilate [87-29-6]
CI Pigment Red 3 [2425-85-6]
Citrinin [518-75-2]
Clofibrate [637-07-0]

Clomiphene citrate [50-41-9]
Copper 8-hydroxyquinoline [10380-28-6]
Coronene [191-07-1]
Coumarin [91-64-5]
meta-Cresidine [102-50-1]
Crotonaldehyde [4170-30-3]
Cyclamates [sodium cyclamate, 139-05-9]
Cyclochlorotine [12663-46-6]
Cyclohexanone [108-94-1]
Cyclopenta[*cd*]pyrene [27208-37-3]
D & C Red No. 9 [5160-02-1]
Dapsone [80-08-0]
Decabromodiphenyl oxide [1163-19-5]
Deltamethrin [52918-63-5]
Diacetylaminoazotoluene [83-63-6]
Diallate [2303-16-4]
1,2-Diamino-4-nitrobenzene [99-56-9]
1,4-Diamino-2-nitrobenzene [5307-14-2]
2,5-Diaminotoluene [95-70-5]
Diazepam [439-14-5]
Diazomethane [334-88-3]
Dibenz[*a,c*]anthracene [215-58-7]
Dibenz[*a,j*]anthracene [224-41-9]
Dibenzo[*a,e*]fluoranthene [5385-75-1]
Dibenzo[*h,rst*]pentaphene [192-47-2]
Dibromoacetonitrile [3252-43-5]
Dichloroacetic acid [79-43-6]
Dichloroacetonitrile [3018-12-0]
Dichloroacetylene [7572-29-4]
ortho-Dichlorobenzene [95-50-1]
trans-1,4-Dichlorobutene [110-57-6]
2,6-Dichloro-*para*-phenylenediamine [609-20-1]
1,2-Dichloropropane [78-87-5]
Dicofol [115-32-2]
Dieldrin [60-57-1]
Di(2-ethylhexyl)adipate [103-23-1]
Dihydroxymethylfuratrizine [794-93-4]
Dimethoxane [828-00-2]
3,3'-Dimetoxybenzidine-4,4'-diisocyanate [91-93-0]
para-Dimethylaminoazobenzenediazo sodium sulfonate [140-56-7]
4,4'-Dimethylangelicin [22975-76-4]
4,5'-Dimethylangelicin [4063-41-6]
N,N-Dimethylaniline [121-69-7]
Dimethyl hydrogen phoshite [868-85-9]
1,4-Dimethylphenanthrene [22349-59-3]
1,3-Dinitropyrene [75321-20-9]
3,5-Dinitrotoluene [618-85-9]
Dinitrosopentamethylenetetramine [101-25-7]
2,4'-Diphenyldiamine [492-17-1]
Disperse Yellow 3 [2832-40-8]
Disulfiram [97-77-8]

Dithranol [1143-38-0]
Doxefazepam [40762-15-0]
Droloxifene [82413-20-5]
Dulcin [150-69-6]
Endrin [72-20-8]
Eosin [15086-94-9]
1,2-Epoxybutane [106-88-7]
cis-9,10-Epoxystearic acid [2443-39-2]
Estazolam [29975-16-4]
Ethionamide [536-33-4]
Ethylene [74-85-1]
Ethylene sulfide [420-12-2]
2-Ethylhexyl acrylate [103-11-7]
Ethyl selenac [5456-28-0]
Ethyl tellurac [20941-65-5]
Eugenol [97-53-0]
Evans blue [314-13-6]
Fast Green FCF [2353-45-9]
Fenvalerate [51630-58-1]
Ferbam [14484-64-1]
Ferric oxide [1309-37-1]
Fluometuron [2164-17-2]
Fluoranthene [206-44-0]
Fluorene [86-73-7]
5-Fluorouracil [51-21-8]
Furazolidone [67-45-8]
Furfural [98-01-1]
Furosemide (Frusemide) [54-31-9]
Gemfibrozil [25812-30-0]
Glycidyl oleate [5431-33-4]
Glycidyl stearate [7460-84-6]
Guinea Green B [4680-78-8]
Gyromitrin [16568-02-8]
Haematite [1317-60-8]
HC Blue No. 2 [33229-34-4]
HC Red No. 3 [2871-01-4]
HC Yellow No. 4 [59820-43-8]
Hexachlorobutadiene [87-68-3]
Hexachloroethane [67-72-1]
Hexachlorophene [70-30-4]
Hycanthone mesylate [23255-93-8]
Hydralazine [86-54-4]
Hydrochloric acid [7647-01-0]
Hydrochlorothiazide [58-93-5]
Hydrogen peroxide [7722-84-1]
Hydroquinone [123-31-9]
4-Hydroxyazobenzene [1689-82-3]
8-Hydroxyquinoline [148-24-3]
Hydroxysenkirkine [26782-43-4]
Hypochlorite salts
Iron-dextrin complex [9004-51-7]
Iron sorbitol-citric acid complex [1338-16-5]

Isatidine [15503-86-3]
Isonicotinic acid hydrazide (isoniazid) [54-85-3]
Isophosphamide [3778-73-2]
Isopropanol [67-63-0]
Isopropyl oils
Isosafrole [120-58-1]
Jacobine [6870-67-3]
Kaempferol [520-18-3]
Lauroyl peroxide [105-74-8]
Lead, organo [75-74-1], [78-00-2]
Light Green SF [5141-20-8]
d-Limonene [5989-27-5]
Luteoskyrin [21884-44-6]
Malathion [121-75-5]
Maleic hydrazine [123-33-1]
Malonaldehyde [542-78-9]
Maneb [12427-38-2]
Mannomustine dihydrochloride [551-74-6]
Medphalan [13045-94-8]
Melamine [108-78-1]
6-Mercaptopurine [50-44-2]
Mercury [7439-97-6] and inorganic mercury compounds
Metabisulfites
Methotrexate [59-05-2]
Methoxychlor [72-43-5]
Methyl acrylate [96-33-3]
Methyl bromide [74-83-9]
Methyl carbamate [598-55-0]
Methyl chloride [74-87-3]
1-Methylchrysene [3351-28-8]
2-Methylchrysene [3351-32-4]
3-Methylchrysene [3351-31-3]
4-Methylchrysene [3351-30-2]
6-Methylchrysene [1705-85-7]
N-Methyl-*N*,4-dinitrosoaniline [99-80-9]
4,4'-Methylene bis (*N*,*N*-dimethyl)benzenamine [101-61-1]
4,4'-Methylenediphenyl diisocyanate [101-68-8]
2-Methylfluoranthene [33543-31-6]
3-Methylfluoranthene [1706-01-0]
Methylglyoxal [78-98-8]
Methyl iodide [74-88-4]
Methyl methacrylate [80-62-6]
N-Methylolacrylamide [90456-67-0]
Methyl parathion [298-00-0]
1-Methylphenanthrene [832-69-9]
7-Methylpyrido[3,4-*c*]psoralen [85878-62-2]
Methyl red [493-52-7]
Methyl selenac [144-34-3]
Modacrylic fibres
Monuron [150-68-5]
Morpholine [110-91-8]
Musk ambrette [83-66-9]

Musk xylene [81-15-2]
1,5-Naphthalenediamine [2243-62-1]
1,5-Naphthalene diisocyanate [3173-72-6]
1-Naphthylamine [134-32-7]
1-Naphthylthiourea (ANTU) [86-88-4]
Nithiazide [139-94-6]
5-Nitro-*ortho*-anisidine [99-59-2]
9-Nitroanthracene [602-60-8]
7-Nitrobenz[*a*]anthracene [20268-51-3]
6-Nitrobenzo[*a*]pyrene [63041-90-7]
4-Nitrobiphenyl [92-93-3]
3-Nitrofluoranthene [892-21-7]
Nitrofural (Nitrofurazone) [59-87-0]
Nitrofurantoin [67-20-9]
1-Nitronaphthalene [86-57-7]
2-Nitronaphthalene [581-89-5]
3-Nitroperylene [20589-63-3]
2-Nitropyrene [789-07-1]
N’-Nitrosoanabasine [37620-20-5]
N’-Nitrosoanatabine [71267-22-6]
N-Nitrosodiphenylamine [86-30-6]
para-Nitrosodiphenylamine [156-10-5]
N-Nitrosofolic acid [29291-35-8]
N-Nitrosoguvacine [55557-01-2]
N-Nitrosoguvacoline [55557-02-3]
N-Nitrosohydroxyproline [30310-80-6]
3-(*N*-Nitrosomethylamino)propionaldehyde [85502-23-4]
4-(*N*-Nitrosomethylamino)-4-(3-pyridyl)-1-butanal (NNA) [64091-90-3]
N-Nitrosoproline [7519-36-0]
Nitrotoluenes [88-72-2; 99-08-1; 99-99-0]
5-Nitro-*ortho*-toluidine [99-55-8]
Nitrovin [804-36-4]
Nylon 6 [25038-54-4]
Orange I [523-44-4]
Orange G [1936-15-8]
Oxyphenbutazone [129-20-4]
Paracetamol (Acetaminophen) [103-90-2]
Parasorbic acid [10048-32-5]
Parathion [56-38-2]
Patulin [149-29-1]
Penicillic acid [90-65-3]
Pentachloroethane [76-01-7]
Permethrin [52645-53-1]
Perylene [198-55-0]
Petasitenine [60102-37-6]
Phenanthrene [85-01-8]
Phenelzine sulfate [156-51-4]
Phenicarbazide [103-03-7]
Phenol [108-95-2]
Phenylbutazone [50-33-9]
meta-Phenylenediamine [108-45-2]

para-Phenylenediamine [106-50-3]
N-Phenyl-2-naphthylamine [135-88-6]
ortho-Phenylphenol [90-43-7]
Picloram [1918-02-1]
Piperonyl butoxide [51-03-6]
Polyacrylic acid [9003-01-4]
Polychloroprene [9010-98-4]
Polyethylene [9002-88-4]
Polymethylene polyphenyl isocyanate [9016-87-9]
Polymethyl methacrylate [9011-14-7]
Polypropylene [9003-07-0]
Polystyrene [9003-53-6]
Polytetrafluoroethylene [9002-84-0]
Polyurethane foams [9009-54-5]
Polyvinyl acetate [9003-20-7]
Polyvinyl alcohol [9002-89-5]
Polyvinyl chloride [9002-86-2]
Polyvinyl pyrrolidone [9003-39-8]
Ponceau SX [4548-53-2]
Potassium bis(2-hydroxyethyl)dithiocarbamate [23746-34-1]
Prazepam [2955-38-6]
Prednimustine [29069-24-7]
Prednisone [53-03-2]
Proflavine salts
Pronetalol hydrochloride [51-02-5]
Proham [122-42-9]
n-Propyl carbamate [627-12-3]
Propylene [115-07-1]
Ptaquiloside [87625-62-5]
Pyrene [129-00-0]
Pyrido [3,4-c]pspralen [85878-62-2]
Pyrimethamine [58-14-0]
Quercetin [117-39-5]
para-Quinone [106-51-4]
Quintozene (Pentachloronitrobenzene) [82-68-8]
Reserpine [50-55-5]
Resorcinol [108-46-3]
Retrorsine [480-54-6]
Rhodamine B [81-88-9]
Rhodamine 6G [989-38-8]
Riddelliine [23246-96-0]
Rifampicin [13292-46-1]
Rifazepam [26308-28-1]
Rugulosin [23537-16-8]
Saccharated iron oxide [8047-67-4]
Scarlet Red [85-83-6]
Selenium [7782-49-2] and selenium compounds
Semicarbazide hydrochloride [563-41-7]
Seneciphylline [480-81-9]
Senkirkine [2318-18-5]
Sepiolite [15501-74-3]

Shikimic acid [138-59-0]
Silica [7631-86-9]
Simazine [122-34-9]
Sodium chlorite [7758-19-2]
Sodium diethyldithiocarbamate [148-18-5]
Spironolactone [52-01-7]
Styrene-acrylonitrile copolymers [9003-54-7]
Styrene-butadiene copolymers [9003-55-8]
Succinic anhydride [108-30-5]
Sudan I [842-07-9]
Sudan II [3118-97-6]
Sudan III [85-86-9]
Sudan Brown RR [6416-57-5]
Sudan Red 7B [6368-72-5]
Sulfafurazole (Sulfisoxazole) [127-69-5]
Sulfamethoxazole [723-46-6]
Sunset yellow FCF [2783-94-0]
Symphytine [22571-95-5]
Tannic acid [1401-55-4]
Temazepam [846-50-4]
2,2',5,5'-Tetrachlorobenzidine [15721-02-5]
1,1,1,2-Tetrachloroethane [630-20-6]
1,1,2,2-Tetrachloroethane [79-34-5]
Tetrachlorvinphos [22248-79-9]
Tetrafluoroethylene [116-14-3]
Theobromine [83-67-0]
Theophylline [58-55-9]
Thiouracil [141-90-2]
Thiram [137-26-8]
Titanium dioxide [13463-67-7]
Toluene [108-88-3]
Toremifene [89778-26-7]
Trichlorfon [52-68-6]
Trichloroacetic acid [76-03-9]
Trichloroacetonitrile [545-06-2]
1,1,1-Trichloroethane [71-55-6]
1,1,2-Trichloroethane [79-00-5]
Triethylene glycol diglycidyl ether [1954-28-5]
Trifluralin [1582-09-8]
4,4',6-Trimethylangelicin [90370-29-9]
2,4,5-Trimethylaniline [137-17-7]
2,4,6-Trimethylaniline [88-05-1]
4,5',8-Trimethylpsoralen [3902-71-4]
2,4,6-Trinitrotoluene [118-96-7]
Triphenylene [217-59-4]
Tris(aziridinyl)-*para*-benzoquinone (Triaziquone) [68-76-8]
Tris(1-aziridinyl)phosphine oxide [545-55-1]
2,4,6-Tris(1-aziridinyl)-s-triazine [51-18-3]
Tris(2-chloroethyl)phosphate [115-96-8]
1,2,3-Tris(chloromethoxy)propane [38571-73-2]

Tris(2-methyl-1-aziridinyl)phosphine oxide [57-39-6]
Vat yellow 4 [128-66-5]
Vinblastine sulfate [143-67-9]
Vincristine sulfate [2068-78-2]
Vinylidene chloride [75-35-4]
Vinylidene chloride-vinyl chloride copolymers [9011-06-7]
Vinylidene fluoride [75-38-7]
N-Vinyl-2-pyrrolidone [88-12-0]
Vinyl toluene [25013-15-4]
Wollastonite [13983-17-0]
Xylene [1330-20-7]
2,4-Xylidine [95-68-1]
2,5-Xylidine [95-78-3]
Yellow AB [85-84-7]
Yellow OB [131-79-3]
Zectran [315-18-4]
Zineb [12122-67-7]
Ziram [137-30-4]

Appendix 6.1

SABS CODE 0228 "*The Identification and Classification of Dangerous Substances and Goods*": CLASS DEFINITIONS

Class 1 - Explosives

Class 1 comprises:

a) explosive substances except those which are too dangerous to transport or those where the predominant hazard is one appropriate to another class;

b) explosive articles, except devices containing explosive substances in such quantity or of such a character that their inadvertent or accidental ignition during transport shall not result in any action external to the device either by projection, fire, smoke, heat or loud noise; and

c) substances and articles not mentioned under a) and b) above which are manufactured with a view to producing a practical, explosive or pyrotechnic effect.

For the purpose of this Code, the following definitions apply:

a) An explosive substance is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Included in this category are pyrotechnic substances even when they do not evolve gases.

b) A pyrotechnic substance is a substance or a mixture of substances designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as a result of non-detonative self-sustaining exothermic chemical reactions.

c) An explosive article is an article containing one or more explosive substances.

Class 1 is divided into five divisions:

Division 1.1 - Substances and articles which have a mass explosion hazard.

Division 1.2 - Substances and articles which have a projection hazard, but not a mass explosion hazard.

Division 1.3 - Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.

This division comprises substances and articles:

- which give rise to considerable radiant heat; or
- which burn one after another, producing minor blast or projection effects or both.

Division 1.4 - Substances and articles which present no significant hazard

This division comprises substances and articles which present only a small hazard in the event of ignition or initiation during transport. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire must not cause practically instantaneous explosion of the entire contents of the package.

NOTE: Substances and articles in this division can be so packaged or designed that any hazardous effects arising from accidental functioning are confined within the package (unless the package has been degraded by fire). In this case, where all blast or projection effects are limited to the extent that they do not significantly hinder fire fighting or other emergency response efforts in the immediate vicinity of the package, the substances can be considered as part of Compactability Group S.

Division 1.5 - Very insensitive substances which have a mass explosion hazard

This division comprises explosive substances which are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport. As a Minimum Requirement they must not explode in the external fire test.

NOTE: The probability of transition from burning to detonation is greater when large quantities are carried by ship.

Class 1 is unique in that the type of packaging frequently has a decisive effect on the Hazard rating and therefore on the assignment to a particular division. Where multiple hazard classifications have been assigned, they are listed on the individual schedule. The correct division is determined by use of the method outlined in the United Nations recommendation on Transport of Dangerous Goods.

Class 2 - Gases: compressed, liquified or dissolved under pressure

Because of the difficulty in reconciling the various main systems of regulation, definitions in this class are of a general nature to cover all such systems. Moreover, since it has not been found possible to reconcile two main systems of regulation in respect of the differentiation between a liquified gas exerting a low pressure at a certain temperature and a flammable liquid, this criterion has been omitted; both methods of differentiation are recognised.

Class 2 comprises:

a) **Permanent gases**

Gases which cannot be liquified at ambient temperatures.

b) **Liquified gases**

Gases which can become liquid under pressure at ambient temperatures.

c) **Dissolved gases**

Gases dissolved under pressure in a solvent, which may be absorbed in a porous material.

d) **Deeply refrigerated permanent gases - e.g. liquid air, oxygen, etc.**

These gases are normally under pressure varying from high pressure in the case of compressed gases to low pressure in the case of deeply refrigerated gases.

In this code, Class 2 is subdivided further, namely:

Class 2.1 - Flammable gases

Class 2.2 - Non-flammable gases

Class 2.3 - Poisonous gases

Some gases are chemically any physiologically inert. Such gases as well as others, normally accepted in toxic concentrations, will nevertheless be suffocating in high concentrations.

Many gases of this class have marked narcotic effects which may occur at comparatively low concentrations, or may evolve highly poisonous gases when involved in a fire.

All gases which are heavier than air will present danger if allowed to accumulate in the bottom of the holds.

Class 3 - Flammable liquids

Class 3 comprises:

Liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (e.g. paints, varnishes, lacquers, etc., but not including substances which, on account of their dangerous characteristics, have been included in other classes) which give off a flammable vapour at or below 61°C (141°F) closed cup test (corresponding to 65,6°C (150°F) open cup test).

In this Code, Class 3 is subdivided further, namely:

Class 3.1 - Low flashpoint group of liquids; flashpoint below –18°C c.c

Class 3.2 - Intermediate flashpoint group of liquids; flashpoint of –18°C up to 23 °C

Class 3.3 - High flashpoint group of liquids; flashpoint of 23°C up to, and including, 61°C c.c.

Substances which have a flashpoint above 61°C (141°F), closed cup test, are not considered to be dangerous by virtue of their fire hazard. Where the flashpoint is indicated for a volatile liquid, it may be followed by the symbol "c.c.", representing determination by a closed cup test, or by the symbol "o.c.", representing an open cup test.

Class 4 - Flammable solids or substances

Class 4 deals with substances other than those classed as explosives, which, under conditions of transportation, are readily combustible, or may cause or contribute to fires.

Class 4 is subdivided further into:

Class 4.1 - Flammable Solids

The substances in this Class are solids possessing the properties of being easily ignited by external sources, such as sparks and flames, and of being readily combustible, or of being liable to cause or to contribute to fire through friction.

Some of these substances may evolve toxic and flammable gases when heated or when on fire.

Class 4.2 - Substances liable to spontaneous combustion

The substances in this Class are either solids or liquids possessing the common property of being liable spontaneously to heat and to ignite.

Some of these substances are more liable to spontaneous ignition when wetted by water, or when in contact with moist air.

Some may also give off toxic gases when they are involved in a fire.

Class 4.3 - Substances emitting flammable gases when wet

The substances in this Class are either solids or liquids possessing the common property, when in contact with water, of evolving flammable gases. In some cases these gases are liable to spontaneous ignition.

In some cases these gases are liable to spontaneous ignition due to the heat liberated by the reaction.

Some of these substances also evolve toxic gases when in contact with moisture, water or acids.

Class 5 - Oxidising substances (agents) and organic peroxides

Class 5 deals with oxidising substances (agents) and organic peroxides.

Class 5 is subdivided further into:

Class 5.1 - Oxidising substances (agents)

These are substances which, although in themselves not necessarily combustible, may, either by yielding oxygen or by similar processes, increase the risk and intensity of fire in other materials with which they come in contact.

Depending on the amount and nature of combustible impurities they may contain, some substances in this Class are sensitive to impact, friction or to a rise in temperature. In addition, certain substances react vigorously with moisture, so increasing the risk of fire.
Mixtures of these substances with combustible material are readily ignited, in some cases even by friction or impact. Such a mixture may burn with explosive force.

There will be a violent reaction between most oxidising substances and strong liquid acids evolving highly toxic gases. Such gases may also be evolved when certain oxidising substances are involved in a fire.

Class 5.2 - Organic peroxides

Organic substances which contain the bivalent -0-0- structure and may be considered derivatives of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. Organic peroxides are thermally unstable substances which may undergo exothermic self-accelerating decomposition.

Most organic peroxides will burn rapidly and are sensitive to heat. Some may also be sensitive to friction or impact.

In liquid, paste or solid from many organic peroxides may react dangerously with other substances. Violent decomposition may be caused by traces of impurities such as acids, metallic oxides or amines.

Decomposition may give rise to the evolution of toxic and flammable gases.

Class 6 - Poisonous (toxic) and infectious substances

Class 6 is subdivided as follows:

Class 6.1 - Poisonous (toxic) substances

These are substances liable either to cause death or serious injury or to endanger human health if swallowed or inhaled, or by skin contact.

The technical basis used for classification into hazard ratings is:*

Hazard Rating	Oral toxicity LD50 (mg/kg)	Dermal toxicity LD_{50} (mg/kg)	Inhalation toxicity LC_{50}	
			Vapours (ml/m^3)	Dusts and mists (mg/ml)
1	Up to 5	Up to 40	Up to 50	Up to 0,5
2	More than 5	More than 40	More than 50 Up to 200	More than 0,5 Up to 2
3	Solids: More than 50 Up to 200 Liquids: More than 50 up to 2 000	More than 200 Up to 1 000	More than 200 Up to 1 000	More than 2 Up to 10

For practical reasons Class 6.1 has been further subdivided into two subsidiary groups, namely:

* This basis holds for the SABS Code 0228 for transport purposes and was changed and adapted in the SABS Code 0228 for waste disposal purposes.

Class 6.1(a): This category comprises all poisonous (toxic) substances including pesticides in Hazard Ratings 1 and 2.

Class 6.1(b): This category comprises all poisonous (toxic) substances including pesticides in Hazard Rating 3.

The dangers of poisoning which are inherent in these substances depend upon contact with the human body: Unsuspecting persons at some distance from the substance can inhale vapours and the immediate dangers of physical contact with the substance must also be considered.

Nearly all toxic substances evolve toxic gases when involved in a fire or when heated to decomposition.

Some toxic substances also possess other hazards, such as flammability.

Class 6.2 - Infectious substances

These are substances containing viable micro-organisms or their toxins which are known, or suspected, to cause disease in animals or humans.

NOTE: "Biological products" and Diagnostic specimens" are not considered to be dangerous goods provided they do not contain, or are reasonably believed not to contain, an infectious substance, and do not contain other dangerous goods.

Class 7 - Radioactive substances

Radioactive materials are too dangerous to allow direct disposal on a landfill site. Special provision has been made for Class 7 materials in terms of the Nuclear Energy Act, 1982 (Act 92 of 1982) and the Hazardous Substances Act, 1973 (Act 15 of 1973).

Class 7 comprises substances which spontaneously emit a significant radiation and of which the specific activity is greater than 74 Bq per gram.

All radioactive substances are dangerous to a greater or a lesser degree because they emit invisible radiation which may damage body tissue. This damage arises either from external irradiation or from internal irradiation following the intake of radioactive material into the body. Two other properties of radioactive substances are heat emission and liability to criticality. The former is significant only with very large quantities of the radioactive substance whereas the latter is peculiar to fissile radioactive substances.

These provisions are based upon the principles of the International Atomic Energy Agency's (IAEA) Regulations for the Safe Transport of Radioactive Materials, 1973, revised edition.

The Atomic Energy Corporation and the Department of Health are the responsible authorities for all aspects of radioactive substances and must be consulted for specific information.

Class 8 - Corrosive substances

Class 8 comprises substances which are solids or liquids possessing, in their original state, the common property of being able more or less severely damage living tissue.

Many substances in this Class are sufficiently volatile to evolve vapour irritating to the nose and eyes.

A few substances may produce toxic gases when decomposed by very high temperatures.

In addition to a direct destructive action in contact with skin or mucous membranes, some substances in this Class are toxic. Poisoning may result if they are swallowed, or if their vapour is inhaled, some of them may even penetrate the skin.

All substances in this Class have a more or less destructive effect on materials such as metals and textiles.

Many substances in this Class only become corrosive after having reacted with water, or with moisture in the air.

The reaction of water with many substances is accompanied by the liberation of irritating and corrosive gases. Such gases usually become visible as fumes in the air.

Class 9 - Miscellaneous dangerous substances

Substances of this Class present a danger not covered by other classes.

Class 9 provides for compounds that may be difficult to classify according to the definitions in SABS Code 0228. Examples of such compounds are acenapthene, acetylaminofluorene, adipic acid, aerosol dispensers and anthracene. When wastes contain such compounds or products and the compounds are listed in SABS Code 0228, the Department has to be explicitly notified before classification according to Class 6 Toxic and Infectious Substances.

Appendix 7

HAZARDOUS WASTE TREATMENT TECHNOLOGIES

Table A. 7.1 : PHYSICAL TREATMENT TECHNOLOGIES

	PROCESS DISCRIPTION	APPLICATIONS
Air Stripping	Air is passed countercurrent to a normally aqueous waste stream and the volatile wastes are removed from solution Cooling or scrubbing of the air removes the wastes from the gas.	Removal of low concentrations of ammonla or volatile fatty acids e.g. acetic acid from water.
Electrodialysis	A membrane that selectively retains or permits the passage of specific ions is used. Separation of the ions is induced by the application of an electric current.	Recovery of developer in the photographic industry and hydrogen or ammonium fluoride from glass etching solutions.
Evaporation	A liquid is vaporised e.g. by heating in order to separate it from dissolved or suspended solids. Unlike distillation no attempt is made to separate the components of the vapour.	Solar evaporation ponds abound in South Africa for volume reduction of the large amounts of inorganic solutions from the Chemical and Mining Industries.
Filtration	Solids are removed from a solution by passing it through a filter medium.	Solids are often removed prior to discharge to receiving waters.
Flocculation	Small suspended particies are increased in size by the addition of chemicals such as alum, lime, ferrous sulphate, ferric chloride or organic polyelectrolytes. The particles can then be removed more readily by sedimentation or filtration.	Used with hydroxide precipitates in the metal finishing industry, in phosphate removal processes and for wastes from spray paint booths.
Flotation	Air is passed through water containing suspended solids, the bubbles stick to the surface of the required particles and they float to the surface where they are skimmed off. In Dissolved Air Flotation (DAF) the water is pressurised and on removal of the pressure bubbles are formed.	Flotation is widely used in the Mining Industry but only DAF has so far found wide application in water treatment e.g. in the recovery of oily wastes and paint wastes from water.

Table A. 7.1 (Continued) : PHYSICAL TREATMENT TECHNOLOGIES

	PROCESS DESCRIPTION	APPLICATIONS
Ion Exchange	An organic resin that has cationic (positive) or anionic (negative) groups can exchange ions with those dissolved in a waste water.	Deionisation of water to produce high grade water is the most common application but the recovery of valuable materials such as silver or toxic materials such as mercury and Cr(VI) find wide use.
Reverse Osmosis	A semi-permeable membrane that only allows passage of certain components of a solution is used. Pressure applied to one side of the membrane concentrates the dissolved components on that side.	The preparation of pure water, the removal of heavy metals such as Nickel(II) or Cr(VI) or organic components such as sugars has found wide use.
Solvent Extraction	A waste solution is contracted with a solvent such as kerosene or chloroform, that has a high affinity for certain of the dissolved components. Stripping of the solvent results in a product with a high concentration of desired waste.	Extraction of phenols from water and de-oiling of water in the petroleum industry. Recovery of valuable metals from water or sludges is likely to gain wider acceptance in the future.
Waste Blending	A waste (solution, sludge or solid) is blended with an inert solid waste such as flyash or bottom ash prior to co-disposal to a landfill.	A common produce is to ash-blend flammable wastes in order to raise the flash point above 61°C. Ash with a reasonable free lime content is often used to neutralise acidic wastes.
Ultrafiltration	Ultrafiltration is similar to reverse osmosis except that the semi-permeable membranes have larger pores so that only required molecules of high molecular mass are retained. Lower pressures are also used.	A versatile technology that can be used for recovery of materials as diverse as paint, protein from cheese whey and oil from metal machining wastes.

Table A. 7.2 : CHEMICAL TREATMENT TECHNOLOGIES

	PROCESS DESCRIPTION	EXAMPLE APPLICATIONS
Dechlorination	Reaction of organochlorine compounds with alkali metals such as sodium, alkali metal hydroxides or with hydrogen and a catalyst. This removes the chlorine and makes the compounds less environmentally hazardous.	Detoxification of PCB's and Dioxins.
Electrolysis	An electric current is passed through a solution and the positive ions (cations) go to cathode where they are reduced and the negative ions (anions) go to the anode where they are oxidised.	Selective removal of metal ions from waste solutions e.g. silver, copper, cadmium and nickel. The electrochemical oxidation of cyanide is a BDAT technology for concentrations $>300 mg/\ell$.
Hydrolysis	Hydrolysis is a process where the elements of water are added to an organic compound. The process is usually carried out in strong acid or base at elevated temperatures.	Hydrolysis of the organics in waste waters increases their biodegradability. Acid oil sludge from the recovery of used lubrication oils has been successfully treated by this technique.
Neutralisation	The pH of an acidic or alkaline waste stream is brought to near neutrality by the addition of base or acid respectively.	Neutralisation of metal containing acid wastes with lime leads to precipitation of the metal hydroxides. Reaction of acid oil sludge with fly ash.
Oxidation	Oxidation occurs when one or more electrons are added to a molecule. Common oxidising agents include chlorine, oxygen, ozone and hydrogen peroxide.	Oxidation of cyanide with chlorine to the less toxic cyanate. Ozone and hydrogen peroxide with or without U/V treatment are finding wide application in removal of toxic organics such as phenols from water.
Precipitation	Some or all of a substance is a solution comes out of the solution as a solid. Common precipitating agents include alkali's, e.g. lime, and alkali metal sulphides.	Removal of heavy metals from solutions as their insoluble hydroxides or sulphides.
Reduction	Reduction occurs when one or more electrons are removed from a molecule. Common reducing agents include ferrous sulphate and sodium sulphite.	Reduction of Cr(VI) to Cr(III) with ferrous sulphate followed by precipitation of the Chromium(III) hydroxide.

Appendix 8.1

TOXICITY CRITERIA (LD_{50}, LC_{50}, K_{oc}, P_{ow}, DOC, COD, EEC)

1. Acute mammalian toxicity (LD_{50})

Acute mammalian toxicity is expressed as LD_{50} (mg/kg). This indicates the dosage that statistically will kill 50% of the test organisms concerned. LD_{50} values are expressed per kg body mass.

Toxicity category	LD_{50} (Oral) mg/kg	LD_{50} (Dermal) mg/kg	LC_{50} (Inhalation) mg/ℓ
Extreme	< 5	< 40	< 0,5
High	5 to < 50	40 to < 200	0,5 – 2
Moderate	50 to < 500	200 to < 2 000	2 – 10
Low	500 to < 5 000	> 2 000	> 10

2. Acute ecotoxicity (LC_{50})

Ecotoxicity is the potential to harm animals and plants, but more specifically ecosytems, being constitutes by a community with its habitat. It is based on the LC_{50} of specific warm and cold water fish or aquatic invertebrate species.

Toxicity category	LC_{50} (96 hr) mg/ℓ
Extreme	< 1
High	1 to <10
Moderate	10 to < 100
Low	100 to < 1 000

3. Persistence Potential (K_{oc})

Soil adsorption (K_{oc}) is an important phenomenon which tends to restrict the movement of both organic and inorganic chemicals from the landfill site. In addition, the process of adsorption may be an important factor in retarding the migration of soil waste. The soil adsorption coefficient of a chemical describes its potential for chemically binding with soil particles. A compound with a low soil adsorption coefficient will generally tend to migrate from the landfill site. For example, phenol is not only highly water soluble, but also has a low soil adsorption coefficient. These characteristics are reflected by rapid leaching of phenol in many landfill sites.

K_{oc} is therefore related to mobility:

A	B	C
slightly adsorbed	**moderately adsorbed**	**strongly adsorbed**
= high leachability	= moderate leachability	= slight leachability
= $K_{oc} < 50$	= K_{oc} 50-200	= $K_{oc} > 200$

4. Accumulation Potential (P_{ow})

The octanol/water partition coefficient (P_{ow}) is often used as an index of the bio-accumulation potential for a chemical in the aquatic environment. It is environmentally of extreme importance in that it indicates migration into biota. As such, accumulation is not only an integral component describing exposure, but also describes a potential for being persistent in the environment. It normally correlates to soil sorption, making it possible to estimate soil sorption from accumulation potential.

The K_{oc} and the P_{ow} may be estimated by regression models, if these figures are not available. These simplified models are:

$\text{Log } K_{oc} = 3{,}6 - (0{,}55 \times \log S)$
$\text{Log } P_{ow} = 4{,}50 - (0{,}75 \times \log S)$

Where S = solubility in parts per million (ppm)

5. Biodegradation of compounds (COD and DOC)

Biodegradation is quantified by simple laboratory tests which, of course, do not simulate practical aerobic and anaerobic conditions in a landfill site, but which suffice as an indicator.

	Test	**Parameter measured**	**Duration of test**	**Readily bio-degradable**
BIO-DEGRADATION	Modified OEDC Screening (EEC = C3) (OECD = 301E)	Dissolved Organic Carbon (DOC)	28 days	70% loss of DOC
	Modified AFNOR test (EEC = C4) (OECD = 301A)	DOC	28 days	70% loss of DOC
	Closed bottle test (EEC = C6) (OECD = 301D)	Oxygen con-sumption (COD)	28 days	60% of COD
	Modified MITI test (EEC = C&) (OECD = 301C)	COD	28 days	60% of COD

6. Estimated Environmental Concentration (EEC)

The mere presence of a chemical substance does not *ipso facto* imply a detrimental effect. When safety to any form of life is the objective, the only rational approach is through the nature of the toxicity in question, and the application of benefits *versus* potential hazards under the condition of intended use of a compound. Thus, nothing is totally safe or hazardous *per se*. It is the quantity involved, the manner and conditions of use, and the susceptibility of the organism which determine degree of hazard or safety.

Unreasonable adverse effects to the environment mean any unreasonable risk to man and/or the environment. Risk is a measure of the probability and severity of adverse effects and is thus a function of **hazard** and **exposure**. Toxicological **hazard** is the intrinsic property of a chemical to cause an **adverse effect**, normally under a particular set of circumstances. Exposure on the other hand is the amount of a chemical available to man or any living matter. When the level of an adverse effect, and the amount of chemical available (exposure) is known, the likelihood of an adverse effect can be determined. The level of risk acceptable to a community is however also a management function, and not only a scientific judgement. This is due to the fact that "no risk" situations do not exist - no matter how remote or small the risk may be - and that an **acceptable risk** has therefore to be decided on.

Many pathways of exposure exist, which may cause an effect. The end-point will be some or other kind of living matter, whether man, plant, or animal. With regard to the environment and waste disposal in the environment, extensive groundwater contamination is a well known documented fact world-wide. Not only is the contamination or pollution of waters a pathway ultimately reaching man, animals or plants, but is it firstly of consequence to the aquatic environment, the sensitivity of which is not under dispute. Risk to the aquatic environment is defined as the likelihood that the aquatic environment will suffer harm, directly or indirectly, from the introduction of chemicals as a result of human activity, the key to aquatic hazard analysis being the determination of environmental concentrations (exposure) of contaminants, and the effect they produce.

For all chemicals, except certain carcinogens, a concentration in the dose-response relationship exists, which will represent a 'no-effect' or no-observable-effect level. This, in short, is due to defence mechanisms and the ability of an organ (e.g. the liver) to 'decontaminate' the body of the effects of the specific contaminant. (Carcinogens are somewhat different due to their different mechanisms, being either genotoxic or epigenetic). This implies that, given a concentration or exposure small or low enough, the contaminant will theoretically have a no-effect on the specific organism over its entire life-span.

The aim in hazardous waste disposal should not be to 'ban' chemicals or waste streams from accepting such streams for disposal in the environment. It should be to exert subtle and reasonable controls to make disposal acceptable. Acceptable should then imply that disposal should conform to acceptable risk.

From the above rationale is it clear that three actions have to be performed in order to dispose of a contaminant in the environment:

1. acceptance of a concentration or level of exposure in the environment as an acceptable risk, according to sound toxicological principles;

2. estimation and quantification of an environmental concentration resulting from a compound being introduced to the environment; and

3. application of 1 and 2 to ensure that individuals and communities will not be 'exposed' to an unacceptable risk.

The pathway of exposure, which was decided on by the Department to quantify risk to man and the environment, is the aquatic environment. Although mammalian acute toxicity information on a chemical compound is the most abundant in the scientific literature, it has also to be regarded as being extremely inaccurate for the purpose of risk modelling (quantification).

Due to the aquatic environment being extremely sensitive to contamination and pollution, it is possible to prove that if the aquatic environment is not at risk (being within acceptable risk), that man and other mammals, avian and plant-life, should also not be exposed or compromised to unacceptable risk. It can statistically be proven that one tenth of the LC_{50} of all chemicals with similar dose/response slopes will result in a mortality incidence of one in three hundred thousand in the aquatic environment. Such a risk, being extremely low, is believed to be an acceptable risk, although it can be argued to be somewhat liberal with regard to very endangered species.

The Estimated Environmental Concentration (EEC) can be based upon the risk posed by a volume/mass of a waste, if disposed of directly into a body of water. The resultant concentration (exposure) can be compared to one tenth of the LC_{50} of the specific contaminant in question in the aquatic environment, to indicate the possibility of an acceptable or unacceptable risk.

The 'safest' method of calculation of the EEC would be using a model in which an amount of a contaminant or pollutant is introduced in total into a body of water. The resultant concentration, being smaller or larger than the acceptable risk concentration (derived from toxicological characteristics) would indicate whether a risk situation is possible.

In waste disposal by landfill, it would imply calculation of the total amount of a contaminant in a waste stream which would be disposed of on a specific unit area of site (one hectare); followed by a calculation of the resultant concentration in a body of water should the total amount of contaminant leach to groundwater over an indefinite period of time.

Such a model would be a ***worst case scenario***, in which it is theoretically impossible to exceed the acceptable risk concentration when abiding to the mass of the specific contaminant per unit area which confirms to acceptable risk. It is calculated using the simplified formula:

EEC, parts per billion (ppb) = dose (g/ha) x 0,66

The dose, in grams per hectare, represents the amount in grams of the substance in the waste to be disposed of on one hectare of landfill site. The factor of 0,66 is derived from the ratio of the substance in a weight of an underground body of water as explained in Footnote on **page 8 - 4**of this document.

Appendix 8.2

DELISTING OF A HAZARDOUS WASTE

In discussion of the EEC (see Appendix 8.1), the concepts of dose/response relationships, exposure/effect, no-observable effect (NOEC) and acceptable risk were discussed. The implication was that, for almost all contaminants/pollutants, a dose exists below which the effect on a specific organism will be that of a NOEC. This dose in turn could be used to derive an acceptable risk to man and/or the environment (Acceptable Risk Level).

It was also pointed out that in the primary classification of a compound, toxicological parameters such as acute toxicity (LD_{50}, LC_{50}), chronic toxicity (carcinogenicity, teratogenicity) and environmental fate (degradation, adsorption, bio-accumulation) are used to rank a compound from extreme to low hazard (Hazard Ratings 1 - 4).

Finally, it was indicated that an acceptable risk had to be derived at, taking the above parameters in consideration and the fact that absolute safety does not exist.

From the above, it is obvious that at a certain concentration in the environment, i.e. aquatic environment, any compound (excluding certain carcinogens and teratogens) classified in any one of the four Hazard Ratings, would be within an acceptable risk, if the concentration and hence, total amount is low enough. This means that a compound must be able to 'move out', i.e. **delist** from its primary classification rating to a lower rating, or to a situation where it can be regarded as 'non-hazardous'. The important factors which play a role in delisting are, *inter alia*, concentration, total amount, speciation of compound (Cr^{6+} or Cr^{3+}), salt (Cl, NO_3, SO_4, etc.) and leachability (solubility, K_{oc}, K_{ow}, etc.). Should these factors designate a compound in a waste stream to be within acceptable risk, then delisting will be appropriate. An example of delisting was given in paragraph 8.5 (P 8 - 9) of Section 8.

Appendix 8.3

EXAMPLES OF CALCULATION OF THE EEC

1. Manganese in ash (2,0 mg/kg)

Teratogenicity	:	Negative
Carcinogenicity	:	Negative
Acute toxicity	:	LC_{50}
		= 3,0 mg/ℓ
		= Highly hazardous
		= Hazard Rating 2
Acceptable Risk Level	:	0,1 x LC_{50}
		= 0,1 x 3,0 mg/ℓ
		= 0,30 mg/ℓ
		= 300 ppb
Concentration of Mn in stream		= 2 mg/kg
Annual fine ash waste stream		= 116 289 tonnes
		= 9 691 tonnes/month
		= 9,691 x 10^6 kg/month
Area of disposal site	:	32,5 ha
Disposal stream/month/ha	:	$\frac{9{,}691 \times 10^6}{32{,}5}$
		= 2,98 x 10^5 kg/month/ha
Manganese in stream	:	2,98 x 10^5 x 2 mg/kg
		= 596 g/ha/month
EEC		= 0,66 x 596 ppb
		= 393 ppb

393 ppb (EEC) > 300 ppb (Acceptable Risk Level)

As the EEC is higher than the Acceptable Risk Level, the Manganese, and therefore the ash, cannot be delisted and must therefore be disposed of at an **H:H** landfill.

2. Example 2

Compound B in a waste stream has an LC_{50} of 0,9 mg/ℓ (i.e. $<$ 1 mg/ℓ). From Table 8.1 it can be seen that it therefore poses an extreme hazard. The waste is therefore classified as Hazard Rating 1.

The Acceptable Risk Level is calculated:

Acceptable Risk Level	=	0,1 x LC_{50} ppb (0,9 mg/ℓ = 900 ppb)
	=	0,1 x 900 ppb
	=	90 ppb

The EEC must not exceed the Acceptable Risk Level of 90 ppb.

If the concentration of Compound B is 0,5 ppm in a waste stream of 20 000 kg, then there are 10 grams of B in the waste stream. If disposal occurs on a one hectare site in the period of one month then:

EEC	=	10 g/ha/month x 0,66
	=	6,6 ppb.

The EEC is now compared to the Acceptable Risk Level.

6,6 ppb $<$ 90 ppb

AND

6,6 ppb $<$ 9 ppb

As the EEC for this **HG1** substance is less than 0,1 x 0,1 x LC_{50}, the waste can be delisted for disposal in a **G:B$^+$** landfill.

Appendix 8.4

MULTIPLICATION FACTOR (CALCULATION OF TOTAL LOAD)

The process that occurs in a landfill can be described as follows:

1. A hazardous substance will be co-disposed with domestic refuse so that the ratio of the total mass of hazardous waste (including a dose A of a hazardous substance X) to the mass of dry domestic refuse does not exceed a certain permissible value.

2. Initially the various hazardous substances will not necessarily be uniformly distributed throughout the waste body, but as they migrate downward towards the base of the landfill, lateral dispersion of each substance will occur. This will result in a particular substance, e.g. X reaching the base of the landfill at a concentration that is much closer to being uniform. This is the justification for averaging the monthly dose by dividing the total mass disposed by the base area of the landfill cell where disposal has taken place. The approach is conservative, as observations have shown that many substances are strongly adsorbed by the refuse and never move far from the place where they are disposed.

3. The downward migration process also pre-supposes that the landfill is generating leachate to transport the hazardous substance downwards and disperse it as it migrates. If no leachate is produced, the hazardous substance will not migrate. **However, most H:h and H:H landfills are co-disposal landfills and will generate leachate**. Suppose that the calculated average rate of production of leachate for the landfill is V_ℓ m^3/m^2/month i.e. V_ℓ m/month as calculated from the water balance. (The calculation process is described in section 10.3.5 of "Minimum Requirements for Waste Disposal by Landfill"). The concentration of A in g/ha/month in the leachate will be a maximum of

$$10^{-4}\,\frac{A}{V_\ell}\ \mathrm{g/m^3} \quad = \quad 0.1\,\frac{A}{V_\ell}\ \mathrm{ppb.}$$

   This assumes that the unit weight of the hazardous substance is equal to that of the leachate.

4. The dispersed hazardous substance, in the case of any landfill in a B^+ climate on which hazardous waste disposal is allowed, will eventually reach the leachate collection layer, and the bulk of the leachate, including the dissolved or liquid hazardous substance X, **will drain to the leachate collection sumps where it will be removed and treated**. Hence a large proportion of the total dosage will be removed from the landfill and will never enter the liner. **A small proportion of leachate will, however, remain to enter and seep through the liner**.

5. As percolation and dispersion occurs downward through the refuse and cover layers and through the liner, the hazardous substances will be attenuated by adsorption onto the waste as well as onto the soil minerals. The concentration of the substance will thus be reduced in its passage through the landfill by a factor K_A with a value depending on the properties of the waste and cover soils and of the particular substance being considered.

6. Because of the action of the leachate collection layer, no appreciable head of leachate should ever build up over the liner. Hence the flow gradient through the liner will be unity, and the Darcy flow velocity will be numerically equal to the liner permeability.

Leachate carrying the balance of the attenuated substance with it will thus seep through the liner at a velocity V_L = K(liner) where K(liner) is the Darcy permeability of the liner. It will then seep through the unsaturated zone and enter the groundwater at a concentration of

$$\frac{0.1A}{V_\ell \; K_A} \text{ ppb}$$

Where K_A is the attenuation factor

In the absence of present knowledge of suitable values for K_A, a conservative assumption will be made that no attenuation occurs and thus $K_A = 1$.

7. The leachate outflow from the liner of the landfill will be diluted by the regional flow of groundwater. Suppose that the aquifer under the landfill has a regional Darcy (i.e. superficial) velocity V_A, and that the outflow from the landfill mixes into the upper layer of groundwater to a depth d below the phreatic surface. The downward velocity of the leachate flow will be denoted V_L. The concentration factor for the leachate (CF) will be given by:

$$\text{CF} = \frac{\text{Volume of leachate entering flow tube in time t}}{\text{Volume of groundwater and leachate passing through flow tube in time t}}$$

$$= \frac{\text{Volume of leachate in t}}{\text{Volume of groundwater + volume of leachate + sum of volumes of groundwater flow entering and leaving in time t}}$$

$$\text{CF} = \frac{V_L \, Dt}{n\,Dd + V_L \, Dt + 2V_A \, dt} = \frac{1}{1 + \frac{d}{V_L}\left[\frac{n}{t} + \frac{2V_A}{D}\right]} \quad \text{.......(1)}$$

where n = porosity of strata underlying landfill

Note that if the groundwater is stagnant, i.e. $V_A = 0$, CF becomes

$$\text{CF} = \frac{1}{1 + \frac{dn}{V_L \, t}} \quad \text{.......(1a)}$$

In this case, the larger V_L is and the larger t becomes, the closer CF approaches unity, i.e. no dilution occurs, and the groundwater composition will approach that of the leachate. Similarly, if V_L is zero.

$$\text{CF} = \frac{0}{n\,Dd + 2V_A \, dt} = 0 \quad \text{.......(1b)}$$

There is no contamination in this case.

The concentration of substance X in the groundwater as it exists from under the landfill will thus be given by:

$$EEC = CF \quad \frac{0.1A}{V_\ell \, K_A}$$

$$EEC = CF \quad \frac{0.1A}{V_\ell K_A} \quad \frac{1}{1+\frac{d}{V_L}\left[\frac{n}{t}+\frac{2V_A}{D}\right]} \quad \text{......(2)}$$

Note that in equation (2), the EEC is directly proportional to the dosage A. The dispersion and concentration factors are dependent on the site characteristics.

Examples:

A hazardous substance is to be disposed of at a dosage of 100 g/ha/month
LC_{50} = 0,25 mg/ℓ = 250 ppb
Hence EEC must not exceed 25 ppb
V_ℓ = 0.05 m/month
K_L = 0.03 m/y = V_L
V_A = 10 m/y

In the absence of better knowledge, the precautionary principle is adopted and K_A set equal to unity, i.e. attenuation in the waste and cover soil is ignored.

The flow path under the landfill is 50 m long, i.e. = 50 m and d will be taken as 1 m, and n as 0.3. The time period for the calculation will be taken as 30 y.

$$EEC = \frac{0.1 \times 100}{0.05 \times 1} \times \frac{1}{1+\frac{1}{0.03}\left(\frac{0.3}{30}+\frac{2 \times 10}{50}\right)} = 14\,\text{ppb}$$

Hence the required EEC can be achieved. In fact in this case, if the EEC were to be set exactly to 25 ppb, the dosage, A, could be increased to -

$$100 \times \frac{25}{14} = 178 \text{ g/ha/month}$$

which exceeds the amount allowed by the current EEC model by a factor of 5.

However, due to the fact that some leachate will penetrate the liner system, and variations in time is needed for biodegradation (organics) and adsorption (inorganics) to take place, the precautionary principle remains, hence the factor of 0,66 for calculation of the EEC also remains.

The controlling element is the flow through the liner which is -

$$\frac{0.03}{0.05 \times 12} = 0.05 \text{ or } 5\%$$

of the total leachate flow. Thus, at least 95% of the hazardous substance should either remains absorbed permanently in the waste, **or is removed in the leachate collected by the leachate management system**. The **total load** is therefore to be calculated by incorporation of the two factors 5 and 20, resulting in a multiplication factor of 100.

Appendix 8.5

TOXICITY CHARACTERISTIC AND ACID RAIN LEACHING PROCEDURES

1. The Toxicity Characteristic Leaching Procedure

The Toxicity Characteristic Leaching Procedure (TCLP) was developed in the USA by the Environmental Protection Agency to measure a waste's leachability and hence the risk it poses to groundwater. It plays a major part in determining the Concentration Based Exemption Criteria used in the USA for the classification of wastes. In preference to this, South Africa has adopted the EEC, which is a method whereby the exposure of fauna to compounds of concern in the waste is estimated and quantified. The two approaches to waste classification, EEC and Concentration Based Exemption Criteria, have a number of important fundamental differences. In general, however, they lead to comparable values for the hazardousness of various wastes and waste streams. The TCLP can therefore be used to support or affirm the EEC.

The TCLP would be used when a waste is to be landfilled in a site that receives a variety of organic and inorganic wastes. The procedure simulates the dissolving action of the organic acid leachate formed in a landfill where Hazardous Waste has been co-disposed with General Waste. It can be used to determine the mobility of organics and inorganics in liquid, solid and multiphase wastes.

A sample of waste is extracted with either dilute acetic acid or an acetic acid and sodium acetate buffer over a period of 20 hours. The extraction fluid used will depend on the *in situ* alkalinity of the specific waste stream [*Toxicity Characteristic Leaching Procedure*, Federal Register and *Toxicity Characteristic Rule*, ibid, (1990), 55, 11826, 1986]. The extract (simulated leachate) is analysed for the components of concern. If the components of concern are not known, a compositional analysis of the waste stream will be required before the procedure is performed.

The procedure is based on the fact that different hazardous elements or compounds exhibit different solubilities under landfill conditions; for example, a waste containing mercuric chloride will exhibit a considerably different extraction result from one containing mercuric sulphide, which is extremely insoluble under normal conditions. It is important to note that the mobility of a particular identified hazardous element or compound will depend on its nature and composition. The procedure is therefore also particularly useful for evaluating the residues or products of wastes after solidification or other waste treatment technologies.

2. Acid Rain Test

The TCLP test was developed for cases where Hazardous Waste is co-disposed with organic waste, which could then generate organic acids. The organic acids could then mobilise pollutants, which would be of concern to the environment.

In many cases, however, Hazardous Wastes are mono-disposed in "dedicated" landfill sites in which only that waste is disposed. Typical examples of such wastes would be the slags and sludges from mineral extraction and metal manufacturing industries. Leaching in such sites would more probably be due to "Acid Rain" than organic acids, and therefore the Acid Rain extraction method is preferred to the TCLP method.

The Acid Rain procedure is based on the fact that carbon dioxide dissolves in rain water, to form carbonic acid. The carbonic acid could mobilise organics and/or inorganics in the waste.

The method thus entails the extraction of a sample of waste with a saturated solution of carbonic acid.

The two extraction methods for leachability are as follows:

LEACHABILITY TESTS FOR INORGANICS AND ORGANICS IN SOLID WASTES BY ORGANIC ACID EXTRACTIONS (TCLP) AND INORGANIC ACID EXTRACTIONS (ACID RAIN)	
APPARATUS:	
1.	Agitation apparatus capable of rotating the extraction vessel in an end-over-end fashion at 30 ± 2 r.p.m.
2.	Extraction bottles for inorganics. These may be constructed from various materials. Borosilicate glass bottles are highly recommended. Polytetrafluoroethylene (PTFE), high density polyethylene (HDPE), polypropylene (PP), Polyvinyl chloride (PVC) and stainless steel bottles may also be used.
TCLP SOLUTION NO 1.	
	Add 5,7 ml glacial Acetic Acid to 500 ml of reagent quality water (double distilled water). Add 64,3 ml of IN NaOH. Dilute to a volume of **1 litre.** When correctly prepared, the pH of this solution will be **4,93 ± 0,05**.
TCLP SOLUTION NO 2.	
	Dilute 5,7 ml glacial acetic acid with double distilled water to a volume of **1 litre** When correctly prepared, the pH of this solution will be **2,88 ± 0,05**
ACID RAIN SOLUTION	
	Prepare 4ℓ carbonic acid solution (4ℓ of carbonated double distilled water). Dilute to 10ℓ with double distilled water. Acidify to pH 3,6 - 3,8 with atomic absorption quality HNO_3. **Notes:** All chemicals (and water) must be of the highest purity possible. In this regard, atomic absorption quality chemicals are recommended. It should be noted that AA measurements will be in the 10-20 ppb (0,010 - 0,020 ppm) range. Blanks from reagents used will have to be run with all measurements. The purity of reagents and possible contamination of reaction vessels (bottles) is therefore of paramount importance.

SAMPLES

1.	The sample must be a minimum of 100 grams.
2.	The sample must be a **dry** solid.
3.	The sample must be able to pass through a 9,5 mm sieve, i.e. particle size of the solid sample must be smaller than 10 mm.

Notes:

The sample must be dry. If not, then it should be filtered (pressure filtration). Filters should be Borosilicate glass fibre with a pore size of 0,5 - 0,8 μm. Filters must be acid washed with IN Nitric acid followed by three consecutive rinses with double distilled water - a minimum of 1ℓ per rinse is recommended. **Remember:** filtration devices must be of inert material (see apparatus) which will not leach or adsorb any of the inorganic components in the waste. The same principles apply should dry waste be crushed to pass through a sieve with a 10 mm pore size.

TCLP EXTRACTIONS

A. Preliminary evaluation:

This part of the extraction procedure must be performed to **determine which TCLP** (No. 1 or 2) solution should be used (see extraction solutions).

1. Weigh out 5,0 grams of the dry waste into a 500 ml beaker or Erlenmeyer flask. (In this exercise the particle size of the 5 grams should be 1 mm or less).
2. Add 96,5 ml of double distilled water, cover with a watchglass and stir vigorously for 5 minutes with a magnetic stirrer.
3. Measure the pH.
4. **If** the pH is **smaller than 5,0**, then use **TCLP solution - No 1**.
5. **If** the pH is **larger than 5,0**, then proceed as follows:
6. Add 3,5 ml IN HCL and stir briefly.
7. Cover with a watchglass, heat to 50°C and hold at 50°C for ten minutes.
8. Let cool to room temperature and record the pH.
9. **If** the pH is **smaller than 5,0**, then use **TCLP solution** - **No 1**.
10. **If** the pH is **larger than 5,0**, then use **TCLP solution - No 2**.

B. Extraction for analysis of contaminants:

1. Weigh out 100 gram of the dry waste which passes through a 9,5 mm sieve and quantitatively transfer it to the extraction bottle.
2. Add **two litres** (2ℓ) of the appropriate TCLP solution (No. 1 or 2 as determined by preliminary evaluation) and close bottle tightly.
3. Rotate in agitation apparatus at **30 r.p.m.** for **20 hours**. Temperature of room in which extraction takes place should be maintained at 23 $\pm$ 2°C.
4. Filter through a glass fibre filter and collect filtrate. Record pH of filtrate.

	5. Take aliquot samples from the filtrate for determination of metal concentrations. 6. Immediately acidify each aliquot sample with nitric acid to a **pH just smaller than 2**. 7. Analyse by AA or the other sensitive and appropriate techniques for different metals. 8. If analysis cannot be performed immediately after extraction, then store the acidified aliquots at 4°C, until analysis (as soon as possible).
ACID RAIN EXTRACTION	
	Repeat 1 - 8 of **B**: Extraction for analysis of contaminants, as above, except For point 2 which must read: 2. Add **two litres** (2ℓ) of the **Acid Rain Solution**, as prepared, and close bottle tightly.

Appendix 9.1

SOLVENTS OF CONCERN

Certain solvents should be restricted to landfill because of their effect on liners, mobilisation of other wastes and the ability of treatment procedures to remove, destroy or immobilise the hazardous constituents of the waste. There is also strong evidence that certain volatile chemicals can diffuse through clay and flexible membrane liners when present even in low amounts. For the solvents listed, **total load** to be disposed of per hectare of any site, must not exceed the amount listed as gram/hectare/month.

Table A. 9: Solvents of Concern

Compound	SIN	SABS Hazard Class	Toxic Hazard Rating	Acceptable Envorn. Risk ppm	Amount g/ha/m
Acetone	1090	3.1(II)	4	610	924242
n-Butyl Alcohol	1120	3.3(III)	4	430	651515
Carbon disulphide	1131	3.1(I)	4	13.5	20454
Carbon Tetrachloride	1846	6.1(II)	2	0.1	151
Chlorobenzene	1134	3.3(III)	4	4.5	6818
Cresols	2076	6.1(II)	3	0.4	606
Cyclohexanone	1915	3.3(III)	4	52.7	79848
1,2-Dichlorobenzene	1591	6.1(III)	4	1.7	2575
Ethylacetate	1173	3.2(II)	3	21.2	32121
Ethylbenzene	1175	3.2(II)	3	1.2	1818
Ethyl ether	1155	3.1(I)	4	260	393939
Methanol	1230	3.2(II)	4	800	1212121
Methyl ethyl ketone	1193	3.2(II)	4	322	487878
Nitrobenzene	1662	6.1(II)	3	4.3	6515
Pyridine	1282	3.2(II)	4	65	98484
Tetrachloroethylene	1897	6.1(III)	1	0.1	151
Toluene	1294	3.2(II)	3	1.3	1969
1,1,1-Trichloroethane	2831	6.1(III)	3	5.3	8030
Trichloroethylene	1710	6.1(III)	1	0.1	151
Xylene	1307	3.2(II)	3	1.1	1667

APPENDIX 9.2

HAZARDOUS WASTE CLASSIFICATION TABLES

The Hazardous Waste Classification Tables is derived from SABS Code 0228. The substances listed here have been identified as being of particular concern in South Africa. The list is not yet complete and will have to be periodically updated.

Column 1, **SIN**, Substance identification number

Column 2, **Compound or Waste Stream**, lists the hazardous substance. The compound or waste stream that occurs in the Code is listed alphabetically. Here, however, it is listed under the working group. **(S)** indicates that the compound is a "solvent of concern". **(M)** indicates a Montreal Protocol Substance, United Nations Ozone Secretariat, 1993. Some of the solvents of concern are listed in Appendix 9, Table A.9. The Chemical Abstracts Service (CAS) number of the compound or waste stream is also given in order to have easy reference to international data banks.

Column 3, **Example Industrial Group**, gives a typical industrial group that generates a Hazardous Waste. The industrial groups are listed in the Hazardous Waste Classification table, together with the key to the abbreviations used. The example group was chosen, if possible, to indicate an industry which is expected to generate the largest quantity of the material or, if no data on this was available, an industry that illustrated the widespread use of the compound. References used to select the Example Industrial Group include the Merck Index, 11th Edition (1989); the Kirk-Othemer Encyclopaedia of Science and Technology, the US EPA's Hazardous Substances Data Base (HSDB); Ullman's Encyclopaedia and Chemical Abstracts.

Column 4, **SABS 0228 Class/Danger Group**, indicates the SABS Class and also the Danger Group (i.e., the hazard classification) for **transport purposes**. The Danger Group is indicated in brackets. This listing is derived from SABS Code 0228 (1990), Appendix B, Alphabetical List of Dangerous Substances and Goods and Appendix D, Alphabetical List of Pesticides for Packaging and Transport.

Column 5, **Hazard Rating**, indicates the hazard classification for **waste disposal purposes.**

Column 6, **Acceptable Environmental Risk**, indicates the LC_{50} x 0,1. This is compared to the EEC.

Column 7, **Disposal Allowed g/ha/m**, gives the amount of the hazardous substance that can be safely disposed of per hectare per month.

Column 8, **Preferred Technology**, lists appropriate technologies for waste streams that might arise from an identified process or for individual chemicals that may occur in a waste. Assessment of the risks or costs associated with the recommended technology has not been considered. Waste generators are therefore advised to carry out an Environmental Impact Assessment for each possible approach to the handling, treatment and disposal of their waste. Technologies such as recycling, treatment, and incineration are listed. It is not stated, but it is understood that the best approach to management of any waste stream is waste avoidance, that is, not to produce the waste at all if possible. See the table that follows for a brief description of each technology and abbreviations used.

Column 9, **Allowed Technology**. Technologies which in practice have appeared to the scientifically and technically sound.

Column 10, **Unacceptable Technology**. For wastes that pose an extreme or high hazard to the environment (**HR1** and **HR2**), these will be strictly applied. For **HR3** and **HR4** wastes, the listings can be taken simply as guidelines and any technology that is capable of attaining the appropriate standards will be acceptable.

The recommended or required treatment technologies given in the Hazardous Waste Tables include the Minimum Requirements set in this document. The treatment of a waste stream may, however, significantly change its nature and hence the Minimum Requirements for its disposal.

Key to Example Industrial Group

Industrial Group	Industrial Process	Key
A: Agriculture, Forestry & Food Production	Agriculture, Forest Management, Fisheries	A1
	Animal & Vegetable Products from Food Sector	A2
	Drink Industry	A3
	Manufacture of Animal Feed	A4
B: Mineral Extraction & Upgrading	Mining & Quarrying of Non-metallic Minerals	B1
	Mining & Quarrying of Metallic Minerals	B2
C: Energy	Coal Industry including Gas Works & Coking	C1
	Petroleum & Gas Industry including Extraction & Refined Products	C2
	Production of Electricity	C3
D: Metal Manufacture	Ferrous Metallurgy	D1
	Non-ferrous Metallurgy	D2
	Foundry & Metal Working Operations	D3
	Metal Finishing and Electroplating	D4
E: Manufacture of Non-Metal Mineral Products	Construction Materials, Ceramics & Glass	E1
	Salt Recovery & Refining	E2
	Asbestos Goods	E3
	Abrasive Products	E4
F: Chemical & Related Industries	Petrochemicals	F1
	Production of Primary Chemicals & Feedstocks	F2
	Production of Fine Chemicals	F3
	Production of Inks, Varnish, Paint & Glue	F4
	Fabrication of Photographic Products	F5
	Production of Pharmaceuticals and Cosmetics	F6
	Rubber & Plastic Materials	F7
	Production of Explosives and Propellants	F8
	Production of Biocides	F9
	Waste & Water Treatment	F10
	Analytical, Biochemical & Chemical Laboratories	F11

G: Metal Goods, Engineering & Vehicle Industries	Mechanical Engineering Electronic & Electrical Engineering Manufacture of Motor Vehicles & Parts	G1 G2 G3
H: Textile, Leather & Wood Industries	Textile, Clothing & Footwear Industry Hide & Leather Industry Timber, Wood & Furniture Industry	H1 H2 H3
J: Manufacture of Paper Products, Printing & Publishing	Paper & Cardboard Industry Printing, Publishing & Photographic Laboratories	J1 J2
K: Medical, Sanitary & other Health Services	Health, Hospitals, Medical Centres & Laboratories Veterinary Services	K1 K2
L: Commercial & Personal Services	Laundries, Dyers & Dry Cleaners Domestic Services Cosmetic Institutions	L1 L2 L3

Abbreviations used for Technologies listed in Waste Classification Tables

Abbreviation	Technology	Description
CTR	Chemical Treatment then landfill codispose residues	A chemical treatment procedure (unspecified), that can meet the requirements must be used prior to codisposal to landfill.
DBI	Detonation, Burning or Incineration	Destruction by detonation, by burning or by controlled incineration as approved by the Chief Inspector of Explosives or the Government Mining Engineer.
ENC	Encapsulation	The containment of waste in drums or other approved containers in a reinforced concrete cell within a permitted hazardous waste landfill. Encapsulation of organic materials is permitted only in the absence of an appropriate and cost effective incineration facility.
HNR	Hydrolyse & Neutralise then landfill codispose residues	Hydrolysis of a compound, organic or inorganic, using acid or base followed by neutralisation prior to codisposal to landfill.
IML	Immobilisation then landfill	This term includes all immobilisation techniques such as microencapsulation, vitrification and solidification but not macroencapsulation.
INC	Incineration	The controlled thermal destruction of the waste in a facility permitted for that type of waste. For chemical waste, appropriate pollution control equipment, e.g. for the scrubbing of acid gases, may be required.
LFL	Landfilling not allowed	Disposal of this waste to a landfill is not allowed.
LFC	Landfill codispose	Mixing or blending of a Hazardous Waste with General Waste within a permitted landfill with a recommended minimum ratio of 1 to 9 v/v.
LWT	Landfilling without treatment	Landfilling of the waste is not allowed without appropriate pre-treatment.
LFB	Landfill-ash blend	Mixing or blending of a flammable waste with sufficient fly ash, bottom ash or other material approved by the Department, so that the flash point is $>61^{o}C$. Ash blending is considered a treatment process and therefore the resulting product must be landfill-codisposed with municipal or commercial waste.
NCR	Neutralise then landfill codispose residues	Addition acid or alkali to bring the pH in the region of 7. Lime is normally used to neutralise acid wastes prior to codisposal to landfill.
OCR	Oxidation then landfill codispose residues	Oxidise, e.g. by using chlorine or another oxidising agent, prior to codisposal to landfill.
PRN	Precipitation then landfill codispose residues	Addition of lime, sodium sulphide or other reagent that results in the formation of insoluble compounds that come out of solution. Usually the solids are separated from the liquids prior to codisposal to landfill.
RCY	Recovery	This term includes all recycling, reuse and utilisation techniques.
RCR	Reduction then landfill codispose residues	Reduce by using, e.g.,ferrous sulphate, sodium sulphite or another reducing agent prior to codisposal to landfill.
RTA	Release to Atmosphere	Small amounts of gas may be released to the atmosphere with appropriate health and safety precautions. The Department of Health should, however, be consulted about the requirements of the Atmospheric Pollution Act.
WTL	Weather then landfill codispose residues	Exposure of the waste to the elements, e.g. the sun, in order to decompose the hazardous substance prior to codisposal to landfill.

HAZARDOUS WASTE CLASSIFICATION TABLES

S.I.N.	WASTE STREAM/ CAS NUMBER		EXAMPLE INDUSTRIAL GROUP	SABS 0228 CLASS/ DANGER GROUP	HAZARD RATING	ACCEPTABLE ENVIRON. RISK ppm	DISPOSAL ALLOWED g/ha/m	PREFERRED TECHNOLOGY	ALLOWED TECH-NOLOGY	UNACCEPTABLE TECHNOLOGY
1088	**Acetal**	[105-57-7]	F2	3.1(II)	3/4	0.1	151	RCY, INC	LFB	LWT
1089	**Acetaldehyde**	[75-07-0]	F2	3.1(I)	3/4	5.3	8030	RCY, INC	LFB	LWT
2790	**Acetic Acid Solution**	[64-19-7]	F2	8(II/III)	3/4	8.8	13333	RCY, INC	NCR	LWT, pH<6
1090	**Acetone (S)**	[67-64-1]	F6	3.1(II)	4/NT	610	924242	RCY, INC	LFB	LWT
1648	**Acetonitrile**	[75-05-8]	F3	3.2(II)	4/NT	100	151515	RCY, INC	LFB	LWT
2310	**Acetylacetone**	[123-54-6]	F4	3.3(III)	3/4	2.9	4393	RCY, INC	LFB	LWT
1717	**Acetyl Chloride**	[75-36-5]	F2	3.2(II)	3	4.2	6363	RCY, INC	HNR	LWT
1092	**Acrolein**	[107-02-8]	F7	6.1(I)	1	0.008	12	RCY, INC	ENC, LFB, CTR	LWT
2607	**Acrolein Dimer**	[100-73-2]	F7	3.3(III)	3/4	1.0	1515	RCY, INC	LFB, CTR	LWT
2074	**Acrylamide**	[79-06-1]	F7	6.1(III)	2	0.1	151	RCY, INC	LFC	-
2218	**Acrylic Acid**	[79-10-7]	F7	8(II)	4/NT	13	19696	RCY, INC	NCR, LFB	LWT, pH<6
1093	**Acrylonitrile**	[107-13-1]	F7	3.2(I)	2	1.4	2121	RCY, INC	ENC, LFB	LWT
-	**Alachlor**	[15972-60-8]	A1	-	2	0.18	273	RCY, INC	ENC, LFC	-
1170	**Alcohol**	[64-17-5]	C2	3.2(II)	4/NT	700	1060606	RCY, INC	LFB	LWT
2761	**Aldrin**	[309-00-2]	A1	6.1(II/III)	1	0.0004	0.606	RCY, INC	ENC, LFC	-
-	**Aluminium**	[7429-90-5]	B2	-	2	0.39	591	RCY, IML	ENC, PRN	LWT

S.I.N.	WASTE STREAM/ CAS NUMBER	EXAMPLE INDUSTRIAL GROUP	SABS 0228 CLASS/ DANGER GROUP	HAZARD RATING	ACCEPTABLE ENVIRON. RISK ppm	DISPOSAL ALLOWED g/ha/m	PREFERRED TECHNOLOGY	ALLOWED TECH-NOLOGY	UNACCEPTABLE TECHNOLOGY
1726	**Aluminium Chloride** [7446-70-0]	F7	8(II)	3/4	10	15151	RCY, IML	HNR	LWT, pH<6
1397	**Aluminium Phosphide** [20859-73-8]	A1	4.3(I)	1	0.1	<151	INC	CTR (toxic gas)	LWT
1711	**Aminodimethylbenzenes** [1300-73-8]	F3	6.1(II)	3/4	1	151	RCY, INC	LFC, LFB	-
1841	**1-Aminoethanol** [75-39-8]	F3	9(III)	-	-	-	RCY, INC	NCR, LFB	LWT
2512	**Aminophenols** [27598-85-2]	F3	6.1(III)	2/3	0.2	303	RCY, INC	NCR, LFB	LWT
2672	**Ammonia Solutions** [1336-21-6]	F2	8(III)	1	0.0024	3,63	RCY	NCR	LWT
8214	**Ammonium Chloride** [12125-02-9]	G3	9(III)	4	10.9	16515	RCY	LFC, LFB	-
2859	**Ammonium metavanadate** [7803-55-6]	D2	6.1(II)	2/3	0.15	227	RCY, IML	ENC, LFC	-
2590	**Amosite** [12172-73-5]	E3	9(III)	1	-	-	IML	LFC (bagged wet)	-
1104	**Amyl acetate** [628-63-7]	F2	3.3(III)	3/4	6.5	9848	RCY, INC	LFB	LWT
1105	**Amyl Alcohol** [71-41-0]	F1	3.2(II)	4/NT	47	71212	RCY, INC	LFB	LWT
1547	**Aniline** [142-04-1]	F7	6.1(II)	4	13.4	20303	RCY, INC	LFC, LFB	-
1548	**Aniline Hydrochloride** [62-53-3]	F7	6.1(III)	2	0.55	833	RCY, INC	LFC	-
2222	**Anisole** [100-66-3]	F3	3.3(III)	3/4	1.0	1515	RCY, INC	LFB	LWT
1549	**Antimony** [7440-36-0]	B2	6.1(II)	2	0.07	106	RCY, IML	ENC, PRN	LWT
1733	**Antimony Chloride** [10025-91-9]	F1	8(II)	3	1.0	1515	RCY, IML	HNR	LWT
1558	**Arsenic** [7440-38-2]	G2	6.1(II)	2	0,43	651	RCY, IML	ENC, LFC	-

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1553	**Arsenic Acid**	[7778-39-4]	G2	6.1(I)	2	0.43	651	RCY, IML	ENC, PRN	LWT
1561	**Arsenic Trioxide**	[1327-53-3]	B2	6.1(II)	2	0.43	651	RCY, IML	ENC, PRN	LWT
2212	**Asbestos blue**	[1332-21-4]	E3	9(II)	1	-	-	IML	LFC (bagged wet)	-
2590	**Asbestos white**	[12001-29-5]	E3	9(III)	1	-	-	IML	LFC (bagged wet)	-
1564	**Barium**	[7440-39-3]	E1	-	3	7.8	11818	RCY, IML	PRN	LWT
1446	**Barium nitrate**	[10022-31-8]	F8	5.1(II)	2/3	0.1	151	RCY, IML	ENC, PRN	LWT
-	**Benzaldehyde**	[100-52-7]	F2	3.4(IV)	2/3	0.11	166	RCY, INC	ENC, LFB	LWT
1114	**Benzene**	[71-43-2]	F2	3.2(II)	3	2.2	3333	RCY, INC	ENC, LFB	LWT
2225	**Benzenesulphonyl Chloride**	[98-09-9]	F3	8(III)	2	0.3	454	RCY, INC	CTR, HNR	LWT
2337	**Benzenethiol**	[108-98-5]	F9	6.1(I)	1/2	<0.5	<757	RCY, INC	ENC, LFC, OCR	-
1885	**Benzidine**	[92-87-5]	F3	6.1(II)	2	0.1	151	RCY, INC	ENC, LFC	-
1993	**Benzine**	[8030-30-6]	F1	3.1(II)	2	0.22	334	RCY, INC	LFB	LWT
8240	**Benzo(a)pyrene**	[50-32-8]	F1	9	1	0.005	7.57	RCY, INC	ENC, LFC	-
2224	**Benzonitrile**	[100-47-0]	F7	6.1(II)	3/4	7.8	11818	RCY, INC	LFC, LFB	-
2587	**Benzoquinone**	[106-51-4]	H1	6.1(II)	1	0.0045	6.818	RCY, INC	ENC, LFC	-
3102	**Benzoyl Peroxide**	[94-36-0]	F6	5.2(II)	3	1.0	1515	RCY, INC	RCR, LFB	LWT
1738	**Benzyl Chloride**	[100-44-7]	F3	6.1(II)	2	0.6	909	RCY, INC	LFC, LFB	-

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2208	**Bleaching Powder** [7778-54-3]	F10	5.1(III)	2	0.18	272	RCY	RCR	LWT
2514	**Bromobenzene** [100-86-1]	F2	3.3(III)	2/3	0.946	1433	RCY, INC	LFB	LWT
2783	**Bromophos-ethyl** [4824-78-6]	F9	6.1(III)	1	0.014	21	RCY, INC	ENC, LFC	-
2588	**Bromoxynil** [1689-84-5]	F9	6.1(III)	1	0.015	22,7	RCY, INC	ENC, LFC	-
1570	**Brucine** [357-57-3]	K2	6.1(I)	3/4	2	3030	RCY, INC	ENC, LFC	-
2346	**Butanedione** [431-03-8]	F3	3.2(II)	3	1	1515	RCY, INC	LFB	LWT
1120	**Butanols (S)** [71-36-3, 78-92-2, 75-65-0]	F2	3.2(II)	4/NT	430	651515	RCY, INC	LFB	LWT
1193	**2-Butanone (S)** [78-93-3]	F2	3.2(II)	4/NT	322	487878	RCY, INC	LFB	LWT
1129	**n-Butyl Aldehyde** [123-72-8]	F3	3.2(II)	3/4	2.58	3909	RCY, INC	LFB	LWT
1127	**Butyl Chlorides** [109-69-3, 78-86-4, 507-20-0]	F7	3.2(II)	3/4	9.7	14696	RCY, INC	LFB	LWT
1149	**Butyl Ethers** [142-96-1, 6863-58-4]	C2	3.3(III)	3/4	5.2	7878	RCY, INC	LFB	LWT
2347	**Butyl Mercaptans** [109-79-5, 13-53-1, 75-66-1]	F2	3.1(II)	2/3	0.55	833	RCY, INC	OCR	LWT
2352	**Butyl Vinyl Ether** [111-34-2]	F3	3.2(II)	3	1.0	1515	RCY, INC	LFB	LWT
2820	**n-Butyric Acid** [107-92-6]	H2	8(III)	4/NT	20	30303	RCY, INC	NCR	LWT, pH<6
2411	**Butyronitrile** [109-74-0]	F3	3.2(II)	2/3	0.1	151	RCY, INC	ENC, LFB	LWT
1572	**Cacodylic Acid** [75-60-5]	F9	6.1(II)	4NT	100	15115	RCY, INC	NCR	LWT, pH<6
2570	**Cadmium** [7440-43-9]	D4	6.1(I)	1	0.031	47	RCY, IML	PRN	LWT

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-	**Cadmium Chloride** [10108-64-2]	D4	-	1	0.031	47	RCY, IML	PRN	LWT
1544	**Caffeine** [58-08-2]	F6	6.1(III)	2/3	0.1	151	RCY, INC	ENC, LFC	-
1573	**Calcium Arsenate** [7778-44-1]	F9	6.1(II)			-	RCY, INC	ENC, LFC	-
1403	**Calcium Cyanamide** [156-62-7]	D1	4.3(III)	2	0.1	151	RCY, INC	CTR (flam. gas)	LWT
1575	**Calcium Cyanide** [592-01-8]	D2	6.1(I)	1	0.05	76	RCY, INC	OCR	LWT
-	**Calcium Fluoride** [7789-75-5]	D1	-	3	1.0	1515	RCY	LFC	-
1748	**Calcium Hypochlorite** [7778-54-3]	F10	5.1(II)	2	0.18	272	RCY	RCR	LWT
2717	**Camphor** [76-22-2]	F6	4.1(III)	4/NT	11	16666	RCY, INC	LFC, LFB	-
8035	**Captab/Captan** [133-06-2]	F9	9	1	0.03	45	RCY, INC	ENC, LFC	-
2757	**Carbaryl** [63-25-2]	L2	6.1(III)	1	0.06	90	RCY, INC	ENC, LFC	-
2757	**Carbofuran** [1563-66-2]	L2	6.1(III)	1	0.028	42	RCY, INC	HNR, LFC	LWT
1311	**Carbon Disulphide (S)** [75-15-0]	F3	3.1(I)	4	13.5	20454	RCY, INC	LFB	LWT
1707	**Carbonic Acid, Dithallium salt** [6533-73-9]	D2	6.1(II)	1	0.1	<151	RCY, IML	ENC, LFC	-
1846	**Carbon Tetrachloride (S,M)** [56-23-5]	F2	6.1(II)	2	0.1	151	RCY, INC	LFC, LFB	-
1824	**Caustic Soda Solution** [1310-73-2]	A3	8(II)	3	3.3	5000	RCY	NCR	LWT, pH>12
2996	**Chlordane** [57-74-9]	A1	6.1(III)	1	0.007	10.6	RCY, INC	ENC, LFC	-
2996	**Chlordimeform** [6164-98-3]	A1	6.1(III)	3/4	1.17	1772	RCY, INC	LFC	-
1750	**Chloroacetic acid** [79-11-8]	F3	8(II)	2	0.1	151	RCY, INC	NCR	LWT, pH<6

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2019	**2- and 3-Chloroanilines** [95-51-2, 108-42-9]	F3	6.1(II)	2/3	0.1	151	RCY, INC	ENC, LFC, LFB	-
2018	**4-Chloroaniline** [106-47-8]	F3	6.1(II)	2	1.2	1818	RCY, INC	LFC, LFB	-
1134	**Chlorobenzene (S)** [108-90-7]	F4	3.3(III)	3/4	4.5	6818	RCY, INC	LFB	LWT
2669	**Chlorocresols solid/liquid** [59-50-7]	F6	6.1(II)	1	0.001	1.5	RCY, INC	ENC, LFC, LFB	-
1135	**2-Chloroethanol** [107-07-3]	F9	6.1(II)	2	0.1	0.04	RCY, INC	ENC, LFB	LWT
1888	**Chloroform** [67-66-3]	F6	6.1(II)	1	0.1	0.04	RCY, INC	LFC	-
2237	**Chloronitroanilines** [121-87-9, 89-63-4, 6283-25-6, 635-22-3]	H1	6.1(III)	2	1	7.04	RCY, INC	ENC, LFC	-
1578	**Chloronitrobenzene** [88-73-3]	H1	6.1(II)	2/3	0.12	0.845	RCY, INC	ENC, LFC, LFB	-
2020	**4-Chlorophenol** [106-48-9]	F6	6.1(III)	3	0.19	287	RCY, INC	ENC, LFC, LFB	-
2238	**Chlorotoluenes** [25168-05-2]	F3	3.3(III)	1	0.59	893	RCY, INC	ENC, LFB	LWT
2239	**Chlorotoluidines** [95-74-9, 616-65-6]	F6	6.1(III)	1	1	1515	RCY, INC	ENC, LFC	-
2783	**Chlorpyrifos** [2921-88-2]	A1	6.1(III)	1	0.0003	0.45	RCY, INC	ENC, LFC	-
-	**Chromium (III)** [7440-47-3]	B2	-	3	4.7	7121	RCY	CTR	LWT
1755	**Chromium (VI)** [7738-94-5]	D4	8(II)	1	0.02	30	RCY	RCR	LWT, pH<6
-	**Cobalt** [7440-48-4]	B2	-	2	6.9	10454	RCY	CTR	LWT
2775	**Copper** [7440-50-8]	D4	6.1(III)	2	0.1	151	RCY, IML	ENC, PRN	LWT

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1585	**Copper Acetoarsenite** [12002-03-8]	H3	6.1(II)	1	0.1	<151	RCY, IML	ENC, PRN	LWT
2775	**Copper Oxychloride** [1332-40-7]	F9	6.1(III)	2	0.22	333	RCY, IML	PRN	LWT
2811	**Copper Sulphate** [7758-99-8]	F9	6.1(III)	1	0.01	15	RCY, IML	PRN	LWT, pH<6
2076	**Cresols solid/liquid (S)** [1319-77-3]	K1	6.1(II)	2/3	0.4	606	RCY, INC	LFC, LFB	-
2022	**Cresylic Acid** [1319-77-3]	F2	6.1(II)	2/3	0.4	606	RCY, INC	ENC, NCR, LFB	LWT, pH<6
1143	**Crotonaldehyde** [4170-30-3]	C2	3.2(II)	2/3	0.13	196	RCY, INC	ENC, LFB	LWT
1403	**Cyanamide** [420-04-2]	D1	4.3(III)	2	0.1	151	RCY, INC	CTR (flam. gas)	LWT
1588	**Cyanide** [151-50-8, 143-33-9]	D4	6.1(I)	1	0.0053	8.0	RCY, CTR	OCR	INC
2670	**Cyanuric Chloride** [108-77-0]	F10	8(III)	2	0.1	151	RCY, INC	RCR	LWT
1145	**Cyclohexane** [110-82-7]	F1	3.1(II)	3/4	9.3	14090	RCY, INC	LFB	LWT
-	**Cyclohexanol** [108-93-0]	F7	3.4(IV)	4/NT	72	109090	RCY, INC	LFC, LFB	-
1915	**Cyclohexanone (S)** [108-94-1]	F7	3.3(III)	4/NT	52.7	79848	RCY, INC	LFC, LFB	-
2046	**Cymenes** [99-87-6]	F2	3.3(III)	3	1	1515	RCY, INC	LFB	LWT
2761	**DDT** [50-29-3]	A1	6.1(III)	1	0.0007	1.06	RCY, INC	ENC, LFC	-
-	**Decanol** [112-30-1]	F6	-	3	2.3	3485	INC	LFC	-
1147	**Decalin** [91-17-8]	F4	3.3(III)	3	1	1515	RCY, INC	LFB	LWT
2783	**Demeton** [8065-48-3]	A1	6.1(III)	1	0.01	15	RCY, INC	ENC, LFC	-

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1673	**Diaminobenzenes** [95-54-5, 108-45-2, 106-50-3]	H2	6.1(III)	2/3	0.574	869	RCY, INC	ENC, LFC	-
1148	**Diacetone Alcohol** [123-42-2]	F7	3.3(III)	4	42	63636	RCY, INC	LFB	LWT
3082	**Di-n-butylphthalate** [84-74-2]	F8	9(III)	2	1	1515	RCY, INC	ENC, LFC, LFB	-
3018	**Dichlofenthion** [97-17-6]	F9	6.1(III)	2	0.1	151	RCY, INC	ENC, LFC, LFB	-
1764	**Dichloroacetic Acid** [79-43-6]	F9	8(II)	3/4	1	1515	RCY, INC	NCR	LWT, pH<6
1590	**Dichloroanilines** [608-27-5, 554-00-7, 95-82-9, 95-76-1, 626-43-7]	F2	6.1(II)	2	0.7	1060	RCY, INC	ENC, LFC, LFB	-
1591	**1,2-Dichlorobenzene (S)** [95-50-1]	F3	6.1(III)	4	1.7	2575	RCY, INC	LFC, LFB	-
-	**1,3-Dichlorobenzene** [541-73-1]	F3	6.1(III)	4	0.78	1181	RCY, INC	LFC, LFB	-
1592	**1,4-Dichlorobenzene** [106-46-7]	F3	6.1(III)	4	3.37	5106	RCY, INC	LFC	-
2362	**1,1-Dichloroethane** [75-34-3]	F3	3.2(II)	4	48	72727	RCY, INC	LFB	LWT
1184	**1,2-Dichloroethane** [107-06-2]	F3	3.2(II)	3	6.5	20454	RCY, INC	ENC, LFB	LWT
2465	**Dichloroisocyanuric Acid Salts** [2782-57-2]	F10	5.1(II)	3/4	1	1515	RCY, INC	RCR	LWT
1593	**Dichloromethane (S)** [75-09-2]	D3	6.1(III)	4/NT	14	21210	RCY, INC	LFC, LFB	-
2020	**Dichlorophenols** [576-24-0, 120-83-2, 583-78-8]	F9	6.1(III)	2/3	0.5	757	RCY, INC	ENC, LFC, LFB	-
1886	**Dichlorotoluene** [98-87-3]	F3	6.1(II)	2	0.58	878	RCY, INC	ENC, LFC, LFB	-
2783	**Dichlorvos** [62-73-7]	F9	6.1(II)	1	0.09	136	RCY, INC	ENC, LFC	-

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2783	**Dicrotophos** [141-66-2]	F9	6.1(II)	2	20	30300	RCY, INC	ENC, LFC	-
2761	**Dieldrin** [60-57-1]	A1	6.1(II)	1	0.0006	0.9	RCY, INC	ENC, LFC	-
2686	**Diethylaminoethanol** [100-37-8]	F3	3.3(III)	3/4	1	1515	RCY, INC	NCR, LFB	LWT
2432	**N,N-Diethylaniline** [91-66-7]	F3	6.1(III)	3/4	1	1515	RCY, INC	LFC, LFB	-
-	**Diethylene glycol monoethyl ether** [111-77-3]	H1	3.4(IV)	4/NT	750	1136363	RCY, INC	LFC, LFB	-
1155	**Diethyl ether (S)** [60-29-7]	K1	3.1(I)	4/NT	260	393939	RCY, INC	LFB	LWT
1156	**Diethyl ketone** [96-22-0]	F3	3.2(II)	4/NT	154	233333	RCY, INC	LFB	LWT
8233	**Diethyl phthalate** [84-66-2]	F7	9(III)	3/4	3	4545	RCY, INC	LFC, LFB	-
2991	**Dimetan** [122-15-6]	F9	6.1(III)	2/3	0.1	151	RCY, INC	ENC, LFC	-
1160	**Dimethylamine solution** [124-40-3]	F2	3.1(II)	3/4	4	6060	RCY, INC	NCR	LWT
2253	**N,N-Dimethylaniline** [121-69-7]	F7	6.1(II)	3/4	1	1515	RCY, INC	LFC, LFB	-
1163	**1,1-Dimethylhydrazine** [57-14-7]	C2	6.1(I)	2	2.65	3939	RCY, INC	OCR, NCR, LFB	LWT
2382	**1,2-Dimethylhydrazine** [540-73-8]	C2	3.2(II)	1	0.1	<151	RCY, INC	CTR, LFB (Care!)	LWT
8081	**Dimethyl Nitrosamine** [62-75-9]	F7	9(II)	1	8,8	8.8	RCY, INC	LFC, CTR	-
-	**Dimethyl Sulfoxide** [67-68-5]	F3	3.4(IV)	4/NT	10	15151	RCY, INC	LFC, LFB	-
2991	**Dimetilan** [644-64-4]	A1	6.1(II)	1	0.1	<151	RCY, INC	ENC, LFC, HNR	-
1596	**2,4-Dinitroaniline** [97-02-9]	F3	6.1(II)	3	1.42	2151	RCY, INC	LFC	-

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2779	**Dinoseb**	[88-85-7]	A1	6.1(II)	1	0.0032	4.8	RCY, INC	ENC, NCR	LWT, pH<6
2779	**Dinoseb Acetate**	[2813-95-8]	A1	6.1(III)	2/3	0.1	151	RCY, INC	ENC, LFC	-
2779	**Dinoterb**	[1420-07-1]	A1	6.1(III)	1	0.00034	0.51	RCY, INC	ENC, NCR	LWT, pH<6
2779	**Dinoterb Acetate**	[3204-27-1]	A1	6.1(III)	1	0.0039	5.9	RCY, INC	ENC, LFC	-
1165	**1,4-Dioxane**	[123-91-1]	F7	3.2(II)	4/NT	670	101515	RCY, INC	LFB	LWT
2489	**Diphenylmethane-4,4-diisocyanate**	[101-68-8]	F7	6.1(III)	3	10	15151	RCY, INC	CTR, LFB, HNR	-
3016	**Diquat**	[85-00-7]	A1	6.1(III)	3/4	2.1	3181	RCY, INC	LFB	-
2761	**Endosulfan**	[115-29-7]	A1	6.1(III)	1	0.0003	0.45	RCY, INC	ENC, HNR, LFC	-
2761	**Endrin**	[72-20-8]	A1	6.1(I)	1	0.00007	0.106	RCY, INC	ENC, LFC, LFB	-
2023	**Epichlorohydrin**	[106-89-8]	F3	6.1(II)	2	1.8	2728	RCY, INC	LFC, LFL	LWT
2363	**Ethanethiol**	[75-08-1]	F3	3.1(I)	3/4	1	1515	RCY, INC	OCR, (Care!)	LWT
2491	**Ethanolamine**	[141-43-5]	F3	8(III)	4/NT	17	25757	RCY, INC	LFB, NCR	LWT
1173	**Ethyl Acetate (S)**	[141-78-6]	F3	3.2(II)	2/3	21.2	32121	RCY, INC	LFB	LWT
1917	**Ethyl Acrylate**	[140-88-5]	F4	3.2(II)	3/4	2	3030	RCY, INC	LFB	-
2270	**Ethylamine aqueous**	[75-04-7]	F2	3.1(II)	3/4	4	6060	RCY, INC	NCR, LFB	LWT
2273	**2-Ethylaniline**	[578-54-1]	F3	6.1(III)	3/4	7.5	11363	RCY, INC	LFC, LFB	-
2272	**N-Ethylaniline**	[103-69-5]	F3	6.1(III)	3/4	3.1	4696	RCY, INC	LFB, LFC	-

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1175	**Ethylbenzene (S)** [100-41-4]	F7	3.2(II)	3	1.2	1818	INC	LFC	-
2404	**Ethyl cyanide** [107-12-0]	F3	3.2(II)	1/2	0.1	<151	RCY, INC	LFB	LWT
1184	**Ethylene chloride** [107-06-2]	F3	3.2(II)	4/NT	13.5	20454	RCY, INC	LFB	LWT
1604	**Ethylenediamine** [107-15-3]	F2	8(II)	3/4	23	34848	RCY, INC	LFB, NCR	LWT
8293	**Ethylenediamine-tetraacetic Acid (EDTA)** [60-00-4]	F10	9(>III)	4/NT	12.9	19545	RCY, INC	NCR	LWT, pH<6
1171	**Ethyleneglycol monomethyl ether** [109-86-4]	C2	3.3(III)	4/NT	1552	2351515	RCY, INC	LFB	LWT
1190	**Ethyl Formate** [109-94-4]	A2	3.1(II)	3/4	1	1515	RCY, INC	LFB	LWT
1191	**2-Ethylhexanol** [104-76-7]	F7	3.3(III)	3	3.2	4848	INC	LFC	-
2525	**Ethyl Oxalate** [95-92-1]	F6	6.1(III)	2	0.1	151	RCY, INC	ENC, LFC, LFB	-
1195	**Ethyl Propionate** [105-37-3]	F4	3.2(II)	3/4	5.6	8484	RCY, INC	LFB	LWT
1196	**Ethyltrichlorosilane** [115-21-9]	F7	3.2(II)	3	1	1515	RCY, INC	HNR (flam. gas)	LWT
2783	**Fenthion** [55-38-9]	A1	6.1(III)	1	0.07	106	RCY, INC	ENC, LFC	-
1773	**Ferric Chloride** [7705-08-0]	F10	8(III)	3	9	13636	RCY, IML	PRN	LWT, pH<6
1466	**Ferric Nitrate** [10421-48-4]	H1	5.1(III)	3	9	13636	RCY, IML	PRN	LWT, pH<6
8102	**Ferrous Chloride** [7758-94-3]	F10	9	3	9	13636	RCY, IML	PRN	LWT, pH<6
2941	**Fluoroanilines** [348-54-9, 371-40-4]	F3	6.1(III)	2/3	0.25	378	RCY, INC	ENC, LFC, LFB	-
1198	**Formaldehyde solutions** [50-00-0]	F7	3.3(III)	2	0.9	1364	RCY, INC	LFB	-

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1199	**Furfural** [98-01-1]	F3	3.3(III)	3/4	3.2	4848	RCY, INC	LFB	LWT
2761	**Heptachlor** [76-44-8]	F9	6.1(II)	1	0.0007	1.06	RCY, INC	ENC, LFC	-
1206	**Heptanes** [142-82-5]	F3	3.2(II)	4	37,5	56818	RCY, INC	LFB	LWT
2729	**Hexachlorobenzene** [118-74-1]	F3	6.1(III)	2	0.032	48	RCY, INC	ENC, LFC	-
2279	**Hexachlorobutadiene** [87-68-3]	F3	6.1(III)	1	0.009	13.6	RCY, INC	ENC, LFC	-
8092	**Hexachloroethane** [67-72-1]	F8	9(>III)	2	0.14	212	RCY, INC	ENC, LFC	-
2875	**Hexachlorophene** [70-30-4]	F6	6.1(III)	1	0.01	15	RCY, INC	ENC, LFC	-
2280	**Hexamethylenediamine** [124-09-4]	F7	8(III)	3	1	1515	RCY, INC	LFC, NCR	-
1208	**Hexanes** [110-54-3]	A2	3.1(II)	1	0.4	606	RCY, INC	LFB	LWT
-	**2-Hexanone** [591-78-6]	F3	-	4	43.0	65152	RCY, INC	LFB	LWT
2030	**Hydrazine hydrate** [7803-57-8]	F9	8(II)	2	0,1	151	RCY, INC	OCR (Care!)	LWT
1787	**Hydriodic Acid solution** [10034-85-2]	F3	8(II)	-	-	-	RCY	NCR	LWT, pH<6
1788	**Hydrobromic Acid solution** [10035-10-6]	F3	8(II)	-	-	-	RCY	NCR	LWT, pH<6
1789	**Hydrochloric Acid solution** [7647-01-0]	D4	8(II)	3	1	1515	RCY	NCR	LWT, pH<6
1051	**Hydrocyanic Acid solution** [74-90-8]	D4	6.1(I)	1	0,0057	8.6	RCY, INC	OCR	LWT
1790	**Hydrofluoric Acid solution** [7664-39-3]	F3	8(I/II)	-	-	-	RCY	NCR, PRN	LWT, pH<6
2014	**Hydrogen peroxide, aqueous** [7722-84-1]	H3	5.1(II)	3	4.2	6363	RCY	RCR	LWT
2662	**Hydroquinone** [123-31-9]	F5	6.1(III)	1	0,0097	14.6	RCY, INC	ENC, LFC	-

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2865	**Hydroxylamine Sulphate** [10039-54-0]	F5	8(III)	2	0,72	1090	RCY, INC	OCR	LWT
2644	**Iodomethane** [74-88-4]	F3	6.1(II)	2/3	0,1	151	RCY, INC	ENC, LFC, LFB	-
-	**Iron** [7439-89-6]	D1	-	3	9	13636	RCY, IML	PRN	-
2757	**Isolan** [119-38-0]	A1	6.1(II)	1	0,1	<151	RCY, INC	LFC, LFB	-
1219	**Isopropanol** [67-63-0]	F2	3.2(II)	4/NT	1040	1575757	RCY, INC	LFB	LWT
1918	**Isopropylbenzene** [98-82-8]	F3	3.3(III)	3	5.0	7576	RCY, INC	LFB	LWT
-	**Lead** [7439-92-1]	G2	-	2	0.1	151	RCY	ENC, IML	LWT
1616	**Lead acetate** [301-04-2]	H1	6.1(III)	3/4	40	60606	RCY, IML	PRN	LWT
1617	**Lead arsenates** [7784-40-9]	A1	6.1(II)	1	10	15151	RCY, IML	ENC,LFC	-
1872	**Lead dioxide** [1309-60-0]	G3	5.1(III)	2	0.1	151	RCY, IML	ENC, LFC	-
1794	**Lead Sulphate** [7446-14-2]	G3	8(II)	2	0.1	151	RCY, IML	ENC, NCR	LWT,pH<6
2761	**Lindane** [58-89-9]	A1	6.1(III)	1	0,0027	4.09	RCY, INC	ENC, LFC	-
2723	**Magnesium Chlorate** [10326-21-3]	A1	5.1(II)	4	10	15151	RCY	LFC (Wet)	-
3082	**Malathion** [121-75-5]	A1	9(III)	1	0,01	15	RCY, INC	ENC, LFC	-
2215	**Maleic Anhydride** [108-31-6]	F7	8(III)	3	15	22727	RCY, INC	HNR	LWT
2647	**Malononitrile** [109-77-3]	F3	6.1(II)	2	0,1	242	RCY,INC	ENC, LFC, LFB	-
2210	**Maneb** [12427-38-2]	A1	4.2(III)	2	0,18	272	RCY, INC	ENC, LFC	-

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-	**Manganese**	[7439-96-5]	D2	-	2	0.3	454	RCY, IML	ENC, PRN	LWT
-	**Manganese Chloride**	[7773-01-5]	H1	-	2	0.3	454	RCY, IML	ENC, PRN	LWT
-	**Manganese Dioxide**	[1313-13-9]	C3	-	2	0.3	454	RCY, IML	LFC	-
1940	**Mercaptoacetic Acid**	[68-11-1]	F3	8(II)	2	0,1	151	RCY, INC	ENC, OCR, NCR	LWT, pH<6
1629	**Mercuric Acetate**	[1600-27-7]	F9	6.1(II)	1	0,0009	1.36	RCY, IML	ENC, PRN	LWT
1624	**Mercuric Chloride**	[7487-94-7]	F7	6.1(II)	1	0,0009	1.36	RCY, IML	ENC, PRN	LWT
1641	**Mercuric Oxide**	[21908-53-2]	F7	6.1(II)	1	0,0009	1.36	RCY, IML	ENC, PRN	LWT
3077	**Mercurous Chloride**	[7546-30-7]	F6	9(III)	1	0,0009	1.36	RCY, IML	ENC, LFC	-
2809	**Mercury metal**	[7439-97-6]	G2	8(III)	1	0.022	24	RCY, IML	ENC, OCR	LWT
1229	**Mesityl Oxide**	[141-79-7]	F4	3.3(III)	4/NT	54	81818	RCY, INC	LFB	LWT
1332	**Metaldehyde**	[9002-91-9]	F9	4.1(III)	4/NT	10	15151	RCY, INC	LFC	-
2823	**Methacrylic Acid**	[79-41-4]	F3	8(III)	2/3	0.1	151	RCY, INC	NCR	LWT, pH<6
1230	**Methanol (S)**	[67-56-1]	F3	3.2(II)	NT	800	1212121	RCY, INC	LFB	LWT
2757	**Methomyl**	[16752-77-5]	A1	6.1(II)	2	0.34	515	RCY, INC	ENC, LFC	LWT
8095	**Methoxychlor**	[72-43-5]	A1	9	1	0.0007	1.06	RCY, INC	ENC, LFC	-
1919	**Methylacrylate**	[96-33-3]	F7	3.2(II)	2/3	0.1	151	RCY, INC	ENC, LFB	LWT
1235	**Methylamine aqueous**	[74-89-5]	F2	3.2(II)	3/4	2	3030	RCY, INC	NCR, LFB	LWT
2938	**Methyl Benzoate**	[93-58-3]	F6	6.1(III)	2/3	0.461	698	RCY, INC	ENC, LFC,	-

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								LFB	
2295	**Methyl Chloroacetate** [96-34-4]	F3	6.1(II)	2	0.1	151	RCY, INC	ENC, LFB	LWT
1193	**Methyl Ethyl Ketone (S)** [78-93-3]	F2	3.2(II)	4/NT	322	487878	RCY, INC	LFB	LWT
1244	**Methylhydrazine** [60-34-4]	F3	6.1(I)	2	0.258	390	RCY, INC	OCR	LWT
1247	**Methyl Methacrylate** [80-62-6]	F9	3.2(II)	4/NT	15.9	24090	RCY, INC	LFB, CTR	LWT
3082	**Methyl Salicylate** [119-36-8]	F6	9(III)	2/3	1	<1515	RCY, INC	LFC, LFB	-
2618	**Methylstyrenes** [98-83-9]	F7	3.3(III)	3	1	1515	RCY, INC	LFB, CTR	LWT
1251	**Methyl Vinyl Ketone** [78-94-4]	F3	3.2(II)	2/3	1	<1515	RCY, INC	ENC, LFB	LWT
2783	**Mevinphos** [7786-34-7]	A1	6.1(I)	1	0.0034	5.15	RCY, INC	ENC, LFC	-
1300	**Mineral Turpentine** [8030-30-6]	F4	3.2(II)	3	1.1	1666	RCY, INC	LFB	LWT
2996	**Mirex** [2385-85-5]	A2	6.1(III)	1	0.02	30	RCY, INC	ENC, LFC, LFB	-
1134	**Monochlorobenzene** [108-90-7]	F4	6.1(III)	3	2.4	3636	RCY, INC	LFC	-
1334	**Naphthalene** [91-20-3]	F3	4.1(III)	2/3	0.38	575	RCY, INC	LFC	-
1256	**Naphtha solvent** [8030-30-6]	F4	3.2(II)	2	0.2	1666	RCY, INC	LFB	LWT
-	**Nickel** [7440-02-0]	D4	-	2	1.14	1727	RCY, IML	ENC, PRN	LWT
8323	**Nickel Chloride** [7718-54-9]	D4	9(III)	2/3	1.2	1818	RCY, IML	PRN	LWT, pH<6
1654	**Nicotine** [54-11-5]	A2	6.1(II)	2	0.4	606	RCY, INC	ENC, LFC	-
1662	**Nitrobenzene (S)** [98-95-3]	F3	6.1(II)	3/4	4.3	6515	RCY, INC	LFC, LFB	-

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2446	**Nitrocresols** [4920-77-8]	F3	6.1(III)	3/4	4.61	6984	RCY, INC	LFC, LFB	-
2842	**Nitroethane** [79-24-3]	F7	3.3(III)	3/4	1	1515	RCY, INC	LFB	-
0143	**Nitroglycerine** [55-63-0]	F8	1.1D	2/3	0.1	151	DBI	-	LFL
1261	**Nitromethane** [75-52-5]	C2	3.3(II)	2/3	0.5	>757	RCY, INC	ENC, LFB	LWT
1663	**Nitrophenols** [25154-55-6]	F3	6.1(III)	3/4	4.6	6969	RCY, INC	LFC, LFB	-
1664	**Nitrotoluenes** [99-08-1, 1321-12-6]	F3	6.1(II)	3/4	3.0	4545	RCY, INC	LFC, LFB	-
3082	**Nonylphenol** [25154-52-3]	F2	9(III)	1	0.014	21.2	RCY, INC	ENC, LFC, LFB	-
-	**1-Octanol** [111-87-5]	F6	3.4	3	2.3	3485	RCY, INC	LFB	-
2271	**2-Octanone** [111-13-7]	A2	3.3(III)	3	3.59	5439	RCY, INC	LFB	-
-	**Octanoic Acid** [124-07-2]	F6	-	3	4.7	7121	RCY, INC	LFB	-
1805	**Orthophosphoric Acid** [7664-38-2]	F2	8(III)	3	1	1515	RCY	NCR	LWT, pH<6
2471	**Osmium Tetroxide** [20816-12-0]	F11	6.1(I)	2	0.1	151	RCY	RCR	LWT
1040	**Oxirane** [75-21-8]	F2	2(2.3)	3/4	9	1363	RCY, INC	HNR	LFL
2213	**Paraformaldehyde** [30525-89-4]	A2	4.1	3	3.1	4696	RCY, INC	LFC	-
3016	**Paraquat** [4685-14-7]	A2	6.1(II)	3/4	3.2	4848	RCY, INC	LFC, HNR	-
3018	**Parathion** [56-38-2]	A2	6.1(II)	1	0.019	28	RCY, INC	ENC, LFC, HNR	-
1265	**Pentane** [109-66-0]	F3	3.1(I/II)	3/4	10	15151	RCY, INC	LFB	LWT

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1897	**Perchloroethylene** [127-18-4]	L1	6.1(III)	1	0.1	151	RCY, INC	ENC, LFB	LWT
1873	**Perchloric Acid** [7601-90-3]	D4	5.1(I)	4	200	303030	RCY	NCR	LWT, pH<6
2902	**Permethrin** [52645-53-1]	F9	6.1(I)	1	0.0006	0.909	RCY, INC	ENC, LFC, LFR	-
1271	**Petroleum Ether** [8030-30-6]	F4	3.1(I/II)	3	1.1	1666	RCY, INC	LFB	LWT
1300	**Petroleum Thinners** [8006-64-2]	F4	3.2(II)	4	10	15151	RCY, INC	LFB	LWT
1671	**Phenol** [108-95-2]	F3	6.1(II)	3	2.3	3485	RCY, INC	LFC, LFB	-
1338	**Phosphorus-red** [7723-14-0]	F8	4.1(III)	1	0.1	<151	RCY, INC	OCR	LWT
1381	**Phosphorus-white/yellow** [7723-14-0]	F8	4.2(I)	1	0.1	<151	RCY, INC	OCR (Care!)	LWT
2214	**Phthalic Anhydride** [85-44-9]	F7	8(III)	3/4	1	1515	RCY, INC	HNR	LWT
2313	**Picolines •,ß,γ** [1333-41-1]	F3	3.3(III)	3/4	1	1515	RCY, INC	LFB	LWT
2579	**Piperazine** [110-85-0]	F6	8(III)	3	1	1515	RCY, INC	LFB, NCR	LWT
2401	**Piperidine** [110-89-4]	F7	3.2(II)	2/3	0.1	151	RCY, INC	ENC, LFB, NCR	LWT
2315	**Polychlorinated biphenyls** [1336-36-3]	C3	9(II)	1	0.002	3.0	RCY, INC	ENC, CTR, LFC	-
1680	**Potassium Cyanide** [151-50-8]	D2	6.1(I)	1	0.009	13.6	RCY	ENC, OCR	LWT
2811	**Potassium Dichromate** [7778-50-9]	H2	6.1(III)	3/4	2.5	3787	RCY, IML	ENC, RCR	LWT
1812	**Potassium Fluoride** [7789-23-3]	E1	6.1(III)	2/3	0.1	151	RCY, IML	ENC, PRN	LWT
1811	**Potassium Hydrogen Fluoride** [7789-29-9]	E1	8(II)	2/3	0.1	151	RCY	ENC, NCR,	LWT, pH<6

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								PRN	
2509	**Potassium Hydrogen Sulphate** [7646-93-7]	F3	8(II)	3	1	1515	RCY	NCR	LWT, pH<6
1814	**Potassium Hydroxide** [1310-58-3]	F2	8(II)	3	8.0	12121	RCY	NCR	LWT, pH>12
1486	**Potassium Nitrate** [7757-79-1]	A1	5.1(III)	3/4	1	1515	RCY	LFC (Care!)	-
1490	**Potassium Permanganate** [7722-64-7]	F10	5.1(II)	2	0.15	227	RCY	ENC, RCR	LWT
2757	**Promecarb** [2631-37-0]	A1	6.1(III)	1	0.031	46	RCY, INC	ENC, LFC	-
1274	**1-Propanol** [71-23-8]	F2	3.2(II)	4/NT	320	484848	RCY, INC	LFB	LWT
1991	**Propargyl Alcohol** [107-19-7]	F3	3.3(III)	2/3	0.153	231	RCY,INC	ENC, LFB	LWT
1848	**Propionic Acid** [79-09-4]	F3	8(III)	4/NT	18.8	28484	RCY, INC	NCR	LWT, pH<6
-	**Propoxur** [114-26-1]	A1	6.1	2	0.37	561	RCY, INC	HNR, LFL	LWT
1282	**Pyridine (S)** [110-86-1]	F9	3.2(II)	4/NT	65	98484	RCY, INC	LFB	LWT
1922	**Pyrrolidine** [123-75-1]	F9	3.2(II)	2/3	0.5	<757	RCY, INC	ENC, NCR, LFB	LWT
2656	**Quinoline** [91-22-5]	F3	6.1(III)	2/3	1.15	1742	RCY, INC	ENC, LFC	-
2876	**Resorcinol** [108-46-3]	F7	6.1(III)	3/4	5.7	8636	RCY, INC	LFC	-
2588	**Rotenone** [83-79-4]	F9	6.1(III)	1	0.0021	3.18	RCY, INC	ENC, LFC	-
8020	**Saccharin** [81-07-2]	A3	9	NT	1830	2772727	RCY, INC	LFC	-
2658	**Selenium** [7782-49-2]	F3	6.1(III)	2	0.26	394	RCY, IML	LFC	-
8338	**Selenium Dioxide** [7446-08-4]	F3	9	2	0.26	394	RCY	NCR	LWT

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8340	**Silver** [7740-22-4]	D3	9	3	2	3030	RCY, IML	ENC, PRN	LWT
1493	**Silver Nitrate** [7761-88-8]	F5	5.1(II)	1	0.0007	1.06	RCY, IML	ENC, PRN	LWT
1687	**Sodium Azide** [26628-22-8]	G3	6.1(II)	2	0.5	>757	RCY	LFC (Aqueous sol.)	-
1688	**Sodium Cacodylate** [124-65-2]	F9	6.1(II)	3/4	1	1515	RCY	LFC	-
1495	**Sodium Chlorate** [7775-09-9]	F8	5.1(II)	3/4	1	1515	RCY	LFC (Wet)	-
1689	**Sodium Cyanide** [143-33-9]	B2	6.1(I)	1	0,0053	8.0	RCY, CTR	ENC, OCR	LWT, INC
2811	**Sodium Dichromate** [10588-01-9]	H2	6.1(III)	2/3	1.5	2272	RCY, IML	ENC, RCR	LWT
1690	**Sodium Fluoride** [7681-49-4]	E1	6.1(III)	3/4	4.3	6515	RCY, IML	PRN	LWT
2674	**Sodium Fluorosilicate** [16893-85-9]	F10	6.1(III)	2/3	0.1	151	RCY, IML	ENC, PRN	LWT
1823	**Sodium Hydroxide** [1310-73-2]	F2	8(II)	3	3.3	5000	RCY	NCR	LWT, pH>12
1791	**Sodium Hypochlorite** [7681-52-9]	F10	8(II/III)	1	0.007	10.6	RCY	RCR	LWT
1498	**Sodium Nitrate** [7631-99-4]	A1	5.1(III)	3/4	1	1515	RCY	LFC (Wet)	-
1500	**Sodium Nitrite** [7632-00-0]	D4	5.1(III)	3	6.4	9696	RCY	LFC(Wet)	LWT
8167	**Sodium Phosphate dibasic** [7558-79-4]	A2	9	4	10	15151	RCY, IML	PRN	LWT
8168	**Sodium Phosphate tribasic** [7601-54-9]	F10	9	4	10	15151	RCY, IML	PRN	LWT, pH>12
1507	**Strontium Nitrate** [10042-76-9]	F8	5.1(III)	3/4	1	1515	RCY, IML	LFC	-
1692	**Strychnine** [57-24-9]	A1	6.1(I)	1	0.087	131	RCY, INC	ENC, LFC	-
2055	**Styrene monomer** [100-42-5]	F7	3.3(III)	3/4	2.5	3787	RCY, INC	CTR, LFB	LWT

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1830	**Sulphuric Acid** [7664-93-9]	F2	8(II)	4	10	15151	RCY	NCR	LWT, pH<6
2783	**Systox** [8065-48-3]	A1	6.1(I)	1	0.01	15	RCY, INC	ENC, LFC	-
3000	**2,4,5-T** [93-76-5]	A1	6.1(III)	3/4	35	53030	RCY, INC	LFC	-
3020	**TBTO (Tributyltin oxide)** [56-35-9]	F4	6.1	1	0.0003	0.464	RCY, INC	ENC, LFC, LFB	-
-	**Tebuthiuron** [34014-18-1]	A1	6.1	4	11.2	16970	RCY, INC	ENC, LFC	-
2783	**Terbufos** [13071-79-9]	A1	6.1(I)	1	0.0004	0.606	RCY, INC	ENC, LFC, LFB	-
1702	**Tetrachloroethane** [79-34-5]	F4	6.1(II)	3/4	3.7	5606	RCY, INC	LFB, LFC	-
1897	**Tetrachloroethylene (S)** [127-18-4]	H1	6.1(III)	1	0.1	151	RCY, INC	LFB, LFC	-
1649	**Tetraethyl Lead** [78-00-2]	C2	6.1(I)	1	0.002	3.03	RCY, INC	WTL, LFB	LWT
2056	**Tetrahydrofuran** [109-99-9]	F4	3.2(II)	3	5	7576	RCY, INC	LFB	LWT
1649	**Tetramethyl Lead** [75-74-1]	C2	6.1(I)	3/4	1.35	2045	RCY, INC	WTL, LFB	LWT
2727	**Thallium Nitrate** [10102-45-1]	F11	6.1(II)	1/2	0.1	151	RCY, IML	ENC, LFC	-
1940	**Thioglycolic Acid** [68-11-1]	F6	8(II)	2	0.5	>757	RCY, INC	OCR, NCR	LWT, pH<6
2811	**Thiosemicarbazide** [79-19-6]	F3	9(III)	3	2.5	3788	RCY, INC	LFC	-
1838	**Titanium Tetrachloride** [7550-45-0]	F7	8(II)	2	0.73	1106	RCY	HNR	LWT
1294	**Toluene (S)** [108-88-3]	F2	3.2(II)	3	1.3	1969	RCY, INC	LFB	LWT
2078	**Toluene Diisocyanate** [584-84-9]	F7	6.1(II)	2	0.1	151	RCY, INC	CTR, LFB, HNR	LWT

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2783	**Triazophos** [24017-47-8]	A1	6.1(III)	2/3	0.56	848	RCY, INC	ENC, LFC, LFB	-
1839	**Trichloroacetic acid** [76-03-9]	F6	8(II)	4/NT	200	303030	RCY, INC	NCR	LWT, pH<6
2321	**1,2,3-Trichlorobenzene** [87-61-6]	C3	6.1(III)	2	0.28	424	RCY, INC	LFB	LWT
2831	**1,1,1-Trichloroethane (S)** [71-55-6]	L1	6.1(III)	3/4	5.3	8030	RCY, INC	LFC, LFB	-
3082	**1,1,2-Trichloroethane** [79-00-5]	F4	9(III)	3/4	8.2	12424	RCY, INC	LFC, LFB	-
1710	**Trichloroethylene (S)** [79-01-6]	D4	6.1(III)	1	0.1	151	RCY, INC	LFC, LFB	-
2468	**Trichloroisocyanuric Acid** [87-90-1]	F10	5.1(II)	2	0.1	151	RCY, INC	RCR	LWT
8143	**2,4,5-Trichlorophenol** [95-95-4]	F9	9(III)	1	0.045	68	RCY, INC	ENC, LFC	-
1296	**Triethylamine** [121-44-8]	F7	3.2(II)	3	8	12121	RCY, INC	CTR, LFL	LWT
2259	**Triethylenetetramine** [112-24-3]	F6	8(II)	3	1.0	1515	RCY, INC	NCR, LFB	LWT
-	**Trifluralin** [1582-09-8]	A1	6.1	1	0.021	32	RCY, INC	ENC, LFC	LWT
1297	**Trimethylamine-aqueous** [75-50-3]	F3	3.1(I)	3	8	12121	RCY, INC	NCR, LFB	LWT
2325	**1,3,5-Trimethylbenzene** [106-67-8]	F6	3.3(III)	N/T	360	545455	RCY, INC	NCR	LWT
1354	**Trinitrobenzene-wetted** [99-35-4]	F8	4.1(I)	2	0.103	156	DBI	-	LFL
1356	**Trinitrotoluene-wetted** [118-96-7]	F8	4.1(I)	2/3	0.16	242	DBI	-	LFL
-	**Urea** [57-13-6]	A1	6.1	4	29	43939	LFL, LFC	LFL, LFC	-
-	**Vanadium** [7440-62-2]	D1	-	3	1.3	1970	RCY, IML	PRN	LWT
2862	**Vanadium Pentoxide** [1314-62-1]	F2	6.1(II)	1	0.1	<151	RCY, IML	PRN	LWT

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1301	**Vinyl Acetate** [108-05-4]	F7	3.2(II)	3/4	1.8	2727	RCY, INC	LFB	LWT
1085	**Vinyl Bromide** [593-60-2]	F7	2(2.1)	3	1	1515	RCY, INC	-	LFL
1086	**Vinyl Chloride** [75-01-4]	F7	2(2.1)	2	0.1	151	RCY, INC	-	LFL
3026	**Warfarin** [81-81-2]	A1	6.1(I)	1	1.2	1818	RCY, INC	LFC	-
1307	**Xylenes (S)** [1330-20-7, 95-47-6, 106-42-3, 108-38-3]	C2	3.2(II)	3	1.1	1667	RCY, INC	LFB	LWT
-	**Zinc** [7440-66-4]	D1	-	2	0.7	1061	RCY, IML	PRN	LWT
1840	**Zinc Chloride** [7646-85-7]	F3	8(III)	3	1	1515	RCY, IML	PRN	LWT
-	**Zirconium** [7440-67-2]	F8	-	3	2	3030	RCY, IML	PRN	LWT

GLOSSARY OF TERMINOLOGY

Since the meaning of terms may vary in different contexts, the following list defines, in colloquial English, certain terminology as it is used in the context of this document.

Acceptable Risk Level : The concentration of a substance that will have a minimal effect on the environment. This is represented by the LC_{50} multiplied by a chosen safety factor of 10% (0,1 x LC_{50}).

Accumulation Potential (P_{ow}) : The octanol/water partition coefficient (P_{ow}) is used as an index of the bio-accumulation potential for a chemical in the food chain. This coefficient correlates approximately with a compound's molecular weight and water solubility.

Analysis : An investigation to ascertain the constituents of a waste.

Assimilation Capacity : This represents the ability of a landfill to accept a substance without risk.

Attenuation : In this context, attenuation is the process of reducing the concentration of a substance by means of natural physical, chemical and biochemical processes such as dilution, oxidation and cell synthesis. Natural systems have an attenuation capacity, which may render small volumes of contaminants insignificant. However, when this capacity is exceeded, pollution results.

Basel Convention : South Africa become a signatory to the Basel Convention in 1994. The Convention controls the transboundary movement of hazardous wastes and their disposal.

Bio-Accumulation : The combined intake of pollutants from food and water by organisms.

Biodegradable : Capable of being decomposed by living matter, especially bacteria.

BPEO : Best Practicable Environmental Option. BPEO is the outcome of a systematic consultative and decision-making procedure that emphasises the protection of the environment across land, air and water. It establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole at acceptable cost in the long term and as well as the short term.

Carcinogens : A substance or agent producing or inciting cancer. These substances can be grouped as: Group A - Clinically and epidemiologically proven in humans, Group B - Proven without doubt in laboratory animals, Group C - limited evidence in animals, Group D - Inadequate and doubtful data.

Chronic Toxicity : The effects of prolonged exposure of organisms or of man to a chemical substance.

Co-Disposal (General Waste with Hazardous Waste) : The mixing and joint disposal of Hazardous (H) and General (G) waste in the same landfill. The co-disposal of General Waste with Hazardous Waste as a means of facilitating disposal on an H site is acceptable, whereas the co-disposal of any significant quantity of Hazardous Waste with General Waste on a General Waste disposal site is unacceptable.

Co-Disposal (liquid with dry waste) : The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a Hazardous Waste site, but is only acceptable on a General Waste site equipped with leachate management measures.

Contaminate : The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.

Corrosive : Solids or liquids that can, in their original state, severely damage living tissue. Corrosivity can be measured by determining the degree to which a standard coupon of steel dissolves.

Cradle-to-grave : A policy of controlling a Hazardous Waste from its inception to its ultimate disposal.

Danger Group : For **transport purposes**, hazardous substances that are listed in SABS Code 0228 are placed in a Danger Group.

Delisting : If the EEC is less than the Acceptable Risk Level (0,1 x LC_{50}), the waste can be delisted, i.e., be moved to a lower Hazard Rating or even disposed of at a General Waste landfill with a leachate collection system (**G:B+** landfill).

Destruction : To neutralise or get rid of a waste by incineration or other physical or chemical means.

Dispersion : The movement of a substance from a landfill into the surrounding environment.

Domestic waste : Waste emanating, typically, from homes and offices. Although classified as a General Waste, this waste contains organic substances and small volumes of hazardous substances.

Dose : The amount of a substance in g/ha that is to be landfilled.

Duty of Care : This requires that any person who generates, transports, treats or disposes of waste must ensure that there is no unauthorised transfer or escape of waste from his control. Such a person must retain documentation describing both the waste and any related transactions. In this way, he retains responsibility for the waste generated or handled.

Ecotoxicity : Ecotoxicity is the potential to harm animals, plants, ecosystems or environmental processes.

Effluent : A stream flowing from a larger stream, lake, sewerage tank, industrial process.

Encapsulation : The coating or enclosure of waste within an inert durable material. Micro-Encapsulation: the coating of individual particles of a waste. Macro-Encapsulation: the isolation of the wastes in sealed, reinforced concrete cells or capsules. The capsules are then located in a demarcated area of an H landfill site.

Engineered Cell : A cell that is lined so as to contain Hazardous Waste and prevent leachate from the waste escaping from the cell.

Environment : Associated cultural, social, soil, biotic, atmospheric, surface and ground water aspects associated with the landfill that are, or could potentially be, impacted upon by the landfill.

Environmental Impact Assessment (EIA) : An investigation to determine the potential detrimental or beneficial impact on the surrounding communities, *fauna*, *flora*, water, soil and air arising from the development or presence of a waste disposal site.

Estimated Environmental Concentration (EEC) : The Estimated Environmental Concentration represents the concentration of a substance in the aquatic environment when introduced under worst case scenario conditions, i.e., directly into a body of water. It is used to indicate possible risk, by comparison with the minimum concentration estimated to adversely affect aquatic organisms or to produce unacceptable concentrations in biota, water or sediment.

Exposure : The amount of a hazardous substance available to man or living matter.

Feasible : Acceptable, capable of being used or implemented successfully, without unacceptably damaging the environment.

Flammable Liquids : Liquids which give off a flammable vapour at or below 61*0*C using the closed cup test.

Flammable Solids : Substances, other than those classed as explosives, which are readily combustible or may cause or contribute to fires.

Flocculation : The intentional grouping of very small particles or colloids in a suspension in water or other liquids, the purpose being to increase the settlement rate of the solids.

General Waste Landfill : A landfill that can accept General Waste. Hazardous Waste may not be disposed of at a General Waste Landfill.

General Waste : Waste that does not pose an immediate threat to man or to the environment, i.e., household waste, builders' rubble, garden waste, dry industrial and commercial waste. It may, however, with decomposition, infiltration and percolation, produce leachate with an unacceptable pollution potential. (See Waste.)

Generator : The Generator is an industry or other party whose activities result in the production of waste. The responsibility for a Hazardous Waste remains from cradle-to-grave with the Generator of that waste and the Generator is held liable for any damage that the waste may cause to humans or to the environment.

Hazard Rating : The rating into which a Hazardous Waste falls when it has been Hazard Rated, see below.

Hazard Rating : A system for classifying and ranking Hazardous waste according to the degree of hazard they present. This is based on Mammalian Acute and Chronic Toxicity, Ecotoxicity, and Environmental Fate. Based on this, Hazardous waste is classified as: Extreme Hazard, Hazard Rating 1; High Hazard, Hazard Rating 2; Moderate Hazard, Hazard Rating 3; and Low Hazard, Hazard Rating 4.

Hazardous Waste : Waste, other than radioactive waste, which is legally defined as Hazardous in the state in which it is generated, transported or disposed of. The definition is based on the chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or when in contact with other waste. *After UNEP definition.* (See Waste.)

Hazardous Waste (alternative definition) : Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill-health or increase mortality in humans, *fauna* and *flora*, or adversely affect the environment when improperly treated, stored, transported or disposed of. (See Waste.)

Hazardous Waste Landfill (H) : A containment landfill, designed specifically for the disposal or co-disposal of Hazardous Waste.

IMDG-RSA Code = SABS Code 0228 : A code in which over 4 000 hazardous substances are listed and assigned a danger group for transport purposes. The Code forms the basis of the present system for classifying Hazardous Waste and is being upgraded for waste disposal purposes. In future hazardous substances will be assigned a hazard rating for waste disposal in the SABS Code 0228.

Immobilisation : Immobilisation (or chemical stabilisation) is a process in which the waste is converted to a more chemically stable or more insoluble or more immobile form.

Incineration : Incineration is both a form of treatment and a form of disposal. It is simply the controlled combustion of waste materials to a non-combustible residue or ash and exhaust gases, such as carbon dioxide and water.

Industrial Groups : Industries or activities, which are likely to produce a Hazardous Waste.

Infectious Substances	:	Micro-organisms including those which have been genetically modified, pathogens, cells, cell cultures and human endoparasites which have the potential to provoke infection, allergy or toxic effects.
Infectious Waste	:	Any waste which is generated during the diagnosis, treatment or immunisation of humans or animals; in the research pertaining to this; in the manufacturing or testing of biological agents - including blood, blood products and contaminated blood products, cultures, pathological wastes, sharps, human and animal anatomical wastes and isolation wastes that contain or may contain infectious substances.
Integrated Environmental Management (IEM)	:	A management approach designed to ensure that the environmental consequences of development proposals are understood and adequately considered in the planning process.
Interested and Affected Parties (IAP's)	:	Interested and Affected Parties are those people who will be affected in some way by the Hazardous Waste disposal process. They may be represented by residents or farmers, a whole residential community, or the public at large.
Landfill (v)	:	To dispose of waste on land, whether by use of waste to fill in excavations or by creation of a landform above grade, where the term "fill" is used in the engineering sense.
Landfill (n)	:	The waste body created by landfilling. This may be above or below grade, or both.
LC_{50}	:	The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of aquatic organisms under standard control conditions. The LC_{50} is expressed in mg/ℓ. There are many source documents available for determining the LC_{50}. A recent and reliable source is "The Dictionary of Substances and their Effects" (see list of references). In cases where toxilogical data are not available or doubtful, models should be used to derive a defensible hazardousness, in which case a qualified toxicologist should be approached.
LD_{50}	:	The median lethal dose is a statistical estimate of the amount of chemical which will kill 50% of a given population of animals (e.g., rats) under standard control conditions.
Leachate	:	An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste. It contains final and intermediate products of decomposition, various solutes and waste residues.
Leachate Management	:	The collection and drainage of leachate to a point where it can be extracted for treatment. This requires a system of under-drains and liners and, in certain instances, is synonymous with containment.

Liner	:	A layer of low permeability placed beneath a landfill and designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural materials, synthetic materials, or a combination thereof. (See also FML and Geomembrane.)
Manifest System	:	A system for documenting and controlling the fate of a Hazardous Waste from cradle-to-grave.
Medical Waste	:	Waste generated from such places as hospitals, clinics, doctors' rooms, laboratories, pharmacies, and research facilities.
Minimum Requirement	:	A standard by means of which environmentally acceptable waste disposal practices can be distinguished from environmentally unacceptable waste disposal practices.
Mutagens	:	Agents causing genetic mutations. A substance is considered mutagenic when it is significantly positive in at least 3 different *in vitro/in vivo* assays.
Neutralisation	:	To render harmless or less hazardous by the addition of acid or alkali to bring the pH in the region of 7.
Oxidising Substances	:	Substances, which may increase the risk and intensity of fire in other materials with which they come in contact.
Permeability (Primary)	:	The rate at which fluid will pass through a porous material under a unit flow gradient. The constant of proportionality K in Darcy's Law is measured in m^3/year, m^2/year or m/year.
Permeability (Secondary)	:	The rate at which fluid will pass through macro features of a soil, such as paleo-root canals, termite tunnels and rodent burrows, under unit flow gradient.
Permit	:	The permit issued by the Department of Water Affairs & Forestry for the operation or closure of a landfill, in terms of Regulation 1549, promulgated under the Environment Conservation Act (Act 73 of 1989). (See Concept Permit.)
Permitting		The act of issuing a permit.
Permit Holder		The person who, having obtained a permit to operate a waste disposal site, in terms of Section 20(1) of the Environmental Conservation Act, is legally responsible for the site, both during operation and after closure.
Persistence		The tendency to remain instead of falling away in the normal manner. (In this case, the tendency to remain in the environment, instead of degrading.)
Persistence Potential (K_{oc})	:	The potential for a substance to bind with soil particles. Compounds with a low K_{oc} will tend to migrate or leach from the landfill site into the environment, thus placing the environment at risk.

Precautionary Principle : Where a risk is unknown; the assumption of the worst case situation and the making of provision for such a situation.

Precipitation : Precipitation is the addition of lime, sodium sulphide or other reagents that result in the formation of insoluble compounds that come out of solution.

Radioactive Substances : Substances, which emit or exhibit radioactivity. These substances must be disposed of in terms of the Nuclear Energy Act (Act 92 of 1982) and the Hazardous Substances Act (Act 15 of 1973). In particular Section 3A, Hazardous Substances Act (Act 15 of 1973) regulates radioactive substances used for medical, scientific and industrial purposes.

Recycle : The use, re-use, or reclamation of a material so that it re-enters the industrial process rather than becoming a waste.

Residue : A substance that is left over after a waste has been treated or destroyed.

Responsible Person : A person(s) who takes professional responsibility for ensuring that all or some of the facets of the handling and disposal of Hazardous Waste are properly directed, guided and executed, in a professionally justifiable manner.

Risk : The scientific judgement of probability of harm.

Significant : Factors or considerations are termed significant when they are important, because they are of consequence. For example, they will have a detectable influence on a process, the environment, or the end result.

Significant leachate generation : Seasonal or continuous leachate generation resulting mainly from climate and/or waste moisture content. In the case of existing landfills, significant leachate generation may also result from poor site selection and/or design. It is essential that significant leachate generation be managed by means of leachate collection and treatment if water pollution is to be avoided.

Solidification : Solidification or cementation is a process in which the waste is converted to an insoluble rock-like material by mixing with suitable materials.

Standard : A criteria/measure by which the accuracy or quality of others is judged or a model for imitation, or the degree of excellence required.

Sterilise : Make free from micro-organisms.

Teratogens : These are substances, which have the capacity to cause birth defects.

Total Load Capacity : The capacity of a landfill site to accept a certain substance or the amount of a substance, which can be safely disposed of at a certain site. The total load capacity is influenced by the concentration levels and mobility of the waste, and by the landfill practice and design.

Toxic : Poisonous.

Toxicity Characteristic Leaching Procedure (TCLP) : A test developed by the USA Environmental Protection Agency to measure the ability of a substance to leach from the waste into the environment. It thus measures the risk posed by a substance to groundwater.

Transporter : A person, organisation, industry or enterprise engaged in or offering to engage in the transportation of waste.

Treatment : Treatment is used to remove, separate, concentrate or recover a hazardous or toxic component of a waste or to destroy or, at least, to reduce its toxicity in order to minimise its impact on the environment.

Waste : An undesirable or superfluous by-product, emission, or residue of any process or activity which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area. This definition excludes industrial waste water, sewage, radioactive substances, mining, metallurgical and power generation waste. *After definition in Government Gazette No. 12703, August 1990.* (See General Waste and Hazardous Waste.)

Waste Body : This refers to the body of waste (and cover) that is contained in the landfill. Because it is subject to decomposition, it has the potential to generate leachate and must therefore be adequately separated from the water regime.

Waste Disposal (v) The act of disposing of waste.

Waste Disposal Site Any place at which more than 100 kg of a Hazardous Waste is stored for more than 90 days or a place at which a dedicated incinerator is located is termed a Waste Disposal Site. It must be registered as such in terms of the Environment Conservation Act (Act 73 of 1989).

Waste Load Allocations This term refers to volumes of Hazardous Waste permitted on certain landfills. Such allocations are calculated taking both the nature of the waste and the specific site characteristics into account.

Waste Stream A continuous flow of waste from an industry, activity, process or group.

LIST OF REFERENCES AND SUGGESTED FURTHER READING

It is noted that certain data provided in these references may vary in accordance with the criteria used and therefore may not be suitable for classification purposes.

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