Environmental Management Guidelines for Solid Waste Landfills

Draft

NSW


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ISBN 0 7310 3714 6
EPA 94/122
December 1994

Printed on recycled paper

CONTENTS

1 INTRODUCING THE LANDFILL GUIDELINES

The NSW waste management policy embodies a hierarchy of objectives:

i) to avoid the production of waste by individuals and the community

ii) to reduce the waste going to landfill by reusing/recycling/reprocessing it

iii) to dispose of the remaining waste in an environmentally responsible way

This hierarchy reflects the community's concern that we preserve our finite natural resources to the fullest extent possible and that where we do unavoidably produce waste that we acknowledge the potential impact on the environment and manage this effectively.

There are already substantial waste reduction policies in place. Household recycling levels are up with world standards, the manufacturing industry and government are working together to reduce the raw materials used in production and to promote reuse and recycling and new initiatives in green waste and demolition waste management are emerging. The formal 50% waste reduction target provides a focus for these efforts.

To help fulfil the objective that relates to disposal the NSW Government waste policy requires the establishment and implementation of "world best" practice guidelines for landfills in NSW. The purpose of these guidelines is to protect the environment by:

i) promoting a clear understanding of those environmental impacts which need to be managed when establishing a landfill; and

ii) ensuring adoption of the most appropriate and effective means of managing these impacts.

This document is not an engineering or operations manual. It does not prescribe fixed solutions to the environmental management challenges of landfills. It is designed to provide industry, local councils and the community with clear information as to world best practice in landfill establishment and management and to provide industry with the opportunity to meet performance requirements either by implementing world best practice or by developing alternative environmental management tools which achieve the same or a better level of protection.

2 SCOPE

2.1 Waste Definitions and Landfill Classification

These guidelines relate to both old and new landfill facilities which receive or propose to receive solid waste and require Pollution Control Approval and Pollution Control licenses by the EPA.

Solid waste (SW) - means any biodegradable (putrescible), green or inert wastes generated at domestic, commercial, industrial or construction sites including night soil or spadeable (contain less than 70-75% moisture) bio-solids.

Liquid waste, non-sterilised medical waste and hazardous waste are not included in the Solid Waste Classification, but are separately classified.

Hazardous waste - means any waste containing significant quantities of a substance which may present danger:

* to the life or health of living organisms when released into the environment; or
* to the safety of humans or equipment if incorrectly handled; and is specified in the "Major Groups of Hazardous Wastes" below:

  - cyanides, surface treatment and heat treatment wastes
  - acids
  - alkalis
  - inorganic chemicals
  - reactive chemicals
  - paints, lacquers, varnish, resins, inks, dyes, pigments, adhesives
  - organic solvents, solvent residues
  - pesticides
  - oils, hydrocarbons, emulsions
  - industrial washwaters, effluents
  - organic chemicals
  - solid/sludge waste requiring special handling
  - clinical and pharmaceutical wastes
  - declared chemical wastes under the Environmentally Hazardous Chemicals Act, 1985.

This classification includes industrial waste with leachate contaminant concentrations greater than those outlined in the EPA guidelines for leachate testing procedures.

The assumption in the guidelines is that more stringent controls are likely to be required for landfills receiving hazardous wastes, depending on the nature and condition of wastes received. At a minimum, sites receiving hazardous wastes will need to adhere to these guidelines for solid waste landfills but additional considerations and requirements are also set down in the hazardous waste landfill guidelines.

A further assumption in these guidelines is that if there is a "prohibition" on hazardous and biodegradable waste disposal at a landfill and this prohibition is effectively and demonstrably enforced, then there is substantially less risk posed by the landfill.

The guidelines therefore have differential application to those facilities receiving inert waste.

> **Inert waste** - wastes which do not undergo physical, chemical or biological transformations. This class of waste includes building, demolition, gravel, stone, soil wastes. Inert waste is distinct from and does not include any biodegradable waste, hazardous waste and green waste (foodstuffs, grass and wood).

On this basis fewer design and construction and monitoring requirements might apply to inert landfills, but strict adherence to management disciplines such as waste acceptance and screening programs become vital to maintaining acceptable levels of environmental protection.

2.2 Application of the Guidelines

In essence, the EPA has developed a waste definition and associated site classification scheme which requires differential application of these guidelines, as set down in Table 1.

Table 1. Landfill Classification System

Waste Type	Landfill classification	Performance requirement
Solid Waste including: - domestic waste - industrial waste - commercial waste - construction waste	Solid Waste Landfill	These guidelines in their entirety
Hazardous wastes	Hazardous Waste Landfill	All sections of these guidelines plus existing of subsequently issued hazardous waste landfill guidelines
Inert waste (only)	Inert waste landfill	Assessment Processes for Landfill Licensing, Surface Water Controls, Surface Water Monitoring Program, Burning of Wastes, Construction Quality Assurance, Weighbridge, Compaction Program, Waste Acceptance and Screening Program, Recycling Facilities, Waste Reception Records, Capping and Revegetation, Post Closure Care, Financial Guarantees, Filling Plan/Contours, Site Security, Wheel Washing Facilities, Dust Control, Noise Control, Litter Control, Fire Fighting Capacity, Staffing and Training Requirements, Small Vehicle Access & Dust Gauges

3 THE PERFORMANCE BASED APPROACH

3.1 The Statutory Framework

From the EPA's perspective these guidelines will be implemented through statutory planning and environmental regulation and management systems. They are intended to complement the locational guidelines for landfills produced by the NSW Department of Planning and are part of the government's waste management reform package as set down in *No Time to Waste* (June 1994).

As noted in the Department of Planning locational guidelines, landfills generally require a full Environmental Impact Statement to the extent that they are designated developments under the Environmental Planning and Assessment Act 1979. These guidelines serve to put industry on notice as to the issues which will need to be addressed via the pollution control requirements and provide an incentive to considering the issues at the early environmental assessment process. There is a need to recognise that it is at the planning stage where there will be the greatest opportunity to achieve the most appropriate and effective and efficient balance between siting, design, technology, management and monitoring measures for addressing environmental impacts.

Clearly, to the extent that judicious choice of location can lead to avoidance of environmentally sensitive locations and selection of locations with high geomorphic stability, the environmental impacts will be minimised up front rather than leaving them to be handled via facility design and management solutions.

In addition to any approvals that a facility may require or achieve via the planning system, landfills may require a Certificate of Registration under the Waste Disposal Act, equipment approvals and licenses under the Clean Waters Act (and regulations).

In the case of the Clean Waters Act, an approval is required if the project contemplates the discharge of pollutants into waters. Certain means of storage, treatment and disposal which create a risk of seepage or percolation also require written approval where they involve liquid waste arsing from certain activities (mining operations, industry and sewage treatment) (CWA s. 19(1)(a)(iii) and Clean Waters Regulations 1972, cl 11A). A licence is required wherever the activity is likely to result in water pollution.

Further, if activities carried out on the landfill site render the premises "scheduled" under the Clean Air Act or Noise Control Act then pollution control approval will also be required to alter any methods of operation or types of material used on the premises.

These guidelines will be the basis for EPA decision making on licences and approvals. The system assigns to the EPA responsibility for initial approval and/or ongoing licensing for waste disposal facilities. The EPA has the option of

approving or refusing a licence application or placing conditions on a licence. The same options apply in relation to applications for approval under the Pollution Control Act. These decisions must be made on the basis of the assessed impact on the environment.

3.2 Environmental Issues

In the case of landfills the issues and impacts of major concern to the community and the EPA are:

Preventing discharges to water

Leachate can be saline, acidic and have high organic and metal concentrations and is too polluted to be discharged directly to surface waters without careful management and treatment. Leachate, if not managed, can also result in pollutant plume in local groundwater.

Surface water from bare areas of a landfill can produce unacceptable sediment load in receiving streams. Additionally, any water that contacts the waste and is permitted to flow to receiving waters has a potential for contamination.

Preventing emissions to the atmosphere

Landfills produce gases, primarily methane and carbon dioxide, but the gas can also contain a variety of odorous, toxic or corrosive trace components. Methane presents an explosion risk which may occur on-site or off-site due to gas migration on the sub-surface environment. On the other hand, landfill gas also represents a potentially valuable fuel source.

Promoting responsible land management and conservation

All land is valuable and the impact of its use as landfill needs to be sustainable.

Proper care of a landfill as a valuable asset can ensure most efficient possible rehabilitation and that some other appropriate use is possible following closure. Land management and conservation goals include diverting waste from landfills to minimise the loss of capacity and disposal of materials that should reasonably be reused or recycled. They also include ensuring proper management of the site to ensure that unsuitable wastes are not received and that the nature of waste received is well known.

Protecting amenity and preventing hazards

The potential hazards and amenity impacts from landfills include fire, birds, noise, dust, odour, pest and vermin and litter. All of these problems, particularly odour and litter, have potential impacts both on and off-site.

3.3 Environmental Protection Measures in a Performance-Based System

The guidelines are based on the four (4) primary mechanisms which need to be selectively employed to effectively address each of the environmental concerns once the most suitable site has been selected:

- design and construction
- site operations management
- environmental monitoring
- rehabilitation

The general intention of these guidelines is to ensure the best environmental outcome by providing the flexibility to adopt the best mix of approaches to address environmental concerns, given the location of a proposed facility and the nature of the waste that has been, or is to be, received.

The guidelines recognise that there are world best design, monitoring, management and rehabilitation practices in use to deal with many of the concerns identified and the real question asked in formulating these guidelines was whether and how these best practice techniques ought to be applied to NSW.

Of the environmental protection measures in question, by far the most complex to address in regard to best practice are the design and construction and monitoring mechanisms. International practices vary considerably in these areas and as knowledge increases there is substantial potential for technology to advance accordingly. In many instances a minimum design standard is set and applies across the board. The associated tendency is for operators to stick to the lowest common denominator approach. Questions such as the mitigating effect of the siting of the facility and emerging views on options for containing environmental impacts tend to be obscured in the interests of meeting strict technical design requirements.

Innovation in dealing with the issues that are traditionally handled via fixed "engineering" solutions flows from this. The need to provide for innovation particularly in the design and construction area stems from a recognition of the substantial debates on design and construction options for landfills which largely stem from differing views about whether a landfill is a construction job, a processing operation or something in between. This debate has been summarised in the recent study by Rudolph & Krol (1994) for CRC, Waste Management & Pollution Control, who argue that there are three (3) developing strategies for solid waste disposal by landfill:

i) the regulatory driven containment approach adopted by the US and to a lesser extent in Europe;
ii) the semi-aerobic method favoured in Japan and some Asian areas influenced by them; and
iii) enhanced stabilisation, a processing route which seeks to stabilise the waste as quickly as possible.

The international (and Australian) current emphasis on "state of the art" containment landfills is increasingly being recognised as a relatively short term measure, for which long term integrity cannot be guaranteed.

The general conclusion on the semi-aerobic approach is that it has merit for application in rural and other areas requiring "low-maintenance" operations, but is less suited to large, urban and managed sites.

The third approach seeks to design and operate the landfill (including any pre-processing operations) to maximise the rate and extent of waste degradation, and hence achieve more rapidly a state where there is no on-going polluting potential. This allows landfills to recycle energy and material from wastes; to diminish the volume of material going to permanent disposal, reduces establishment costs and makes best use of precious sites. Enhanced rates can be achieved in practice through optimising the conditions for each step in the sequence of SW stabilisation processes. Closely controlled laboratory systems show stabilisation rates orders of magnitude greater than most full scale conventional facilities - so very large accelerations of the degradation rate are clearly possible.

There are other design philosophies which also merit a brief note in this discussion on design strategies. These include the so called "dilute and disperse" strategy which essentially relies on the natural bio-degradation and attenuation processes to protect the local groundwater regime. This approach relies on the intrinsic ability of the environment to deal with some low level of pollution without significant effect.

The controlled attenuation approach is similar to the dilute and disperse management except that the site is selected and engineered to release contaminants in a controlled fashion. The methods used to achieve controlled release have included attenuation zones around the landfill or adsorption layers of peat or coal washery residue at the base of the landfill. Controlled release has the inherent liability that once a site's control mechanism has been established there is limited ability to intervene should the contaminant contents be higher than expected or the media adsorptive capacity exceeded thus causing a contaminant breakthrough.

The concept of a final quality landfill was developed by the Swiss, who required organic waste to be incinerated and the ash residues landfilled. This strategy is based on complete waste stabilisation prior to disposal thereby eliminating the potential for site contamination. This activity ensures that today's waste problems are solved now rather than passed on to the next generation to address. This philosophy has been augmented to include composting as a suitable oxidising process and has been adopted by the governments of Germany, Belgium, France, Italy and Luxembourg.

Given the level of debate, and the vast array of hydro-geological and environmental parameters that will exist in different locations, there is a strong concern about the merits of a regulatory approach which delves into technical debates in order to "pick a winning solution for all". **It is with a view to promoting and achieving**

best environmental performance which draws on international practice but does not simply assume that "design cloning" will deliver the best performance at sustainable cost that the EPA has selected a performance based approach rather than prescription of actions/design standards for these guidelines.

The objective is to establish a framework which provides solutions based on the necessary degree of certainty for protecting the environment in which landfill is located. Questions relating to the nature, intensity and life span of wastes can then become the subject of management by for the operator. The options will need to be considered in the context of their risks.

A balance will need to be struck with the key determinants being:

(a) Improved environmental performance and certainty - short and long term.

(b) Cost and affordability to the community and industry - short and long term.

This does not mean that world best technology is not relevant. It means that the costs and benefits of world best technology is one issue to be considered when determining where to establish a landfill and how to construct and run it.

Within this broad goal there is a need to consider performance in relation to both new and existing facilities.

In relation to new facilities, it is most desirable to establish mechanisms which encourage industry to develop innovative approaches to meeting broad environmental objectives and to recognise the potential for achieving better results through an integrated approach to land use and environmental planning. In other words, a first order priority is the need for proponents to realise that environmental protection is achieved through a combination of good planning and a judicious approach to design, operation and management.

Special issues arise in relation to existing landfills. The overarching concern is to ensure that existing landfills are operated as to minimise environmental impacts and to achieve effective site rehabilitation. It is recognised that retrospective prescription of design requirements for existing facilities could place an undue burden of cost on the industry (which would in turn be passed on to the community via waste disposal prices) and that such costs may, in some cases, be disproportionate to the environmental benefit received. For instance, the location of a facility, the wastes it receives and/or its remaining life span may be such that it poses a negligible threat to the environment or there are minor changes that might achieve the desired level of protection. In such cases overriding concern must be to ensure that the environmental solutions are appropriate to deal with the real problems at hand.

These issues lead to a facility by facility approach to the assessment and implementation of environmental management needs via the licensing system.

3.4 Economic Instruments

The guidelines should also be read with a clear appreciation that the EPA uses economic and educative tools as well as regulatory measures to achieve the desired environmental outcome.

In the case of landfills, it is relevant to note that, via the licensing process, the EPA may require different levels of licence fees and financial assurances depending on the nature of the facility and its established or proposed location. In the future, licence fees and assurances required may be lower if there is a greater the degree of certainty that the facility will not harm the environment.

The broad goal of promoting waste reduction and the need to discourage the disposal of waste will be recognised through the retention of the existing levy on waste disposal in areas controlled by the Waste Disposal Act. For every tonne of waste disposed of at a waste depot, a levy will continue to be charged. It is envisaged that rebates and exemptions will apply where recycling and waste recovery initiatives are introduced.

4 ASSESSMENT PROCESS FOR LANDFILL LICENSING

4.1 Assessment Criteria

As indicated in Section 3, these guidelines will be the basis for decisions and conditions for licensing decisions for landfills under the Waste Disposal Act and other pollution control statutes where appropriate.

The prevailing principles will be:

(i) that best practice **management, monitoring and rehabilitation requirements** set down in Section 5 will apply to all landfills

(ii) that best practice **design and construction** approaches set down in Section 5 of these guidelines will apply in all cases unless the EPA is satisfied:

1 In the case of existing landfills that the location, prevailing design, monitoring and management techniques indicate that the facility does not pose a significant threat to the environment and that effective operational monitoring and management processes are in place.

2 In the case of new landfills that proposed alternative protection measures will provide at least equal or better environmental performance than world best practice and that this performance can be demonstrated to the EPA.

4.2 Documentation Required

The processes for assessing landfill licence applications is et out in Section 4.3. This section specifies the documentation required by the EPA to assess applications against the criteria set down in Section 4.1

4.2.1 **Every application for a new landfill licence or for a substantial extension to an existing license** will need to be accompanied by a Landfill Establishment and Management Plan which systematically covers the following points.

(i) **Site Overview** - To cover broad locational and environmental characteristics of site.

(ii) **Landfill Structure & Operations Overview** - To outline the landfill design/construction concepts and specifications and the nature and volume of wastes to be received over the life of the facility.

(iii) **Leachate & Surface Water Run-off Control** - To describe in detail mechanisms for preventing groundwater and surface water

contamination. This must include a detailed groundwater monitoring plan and surface water monitoring program.

(iv) **Gas Control** - To describe in detail mechanisms for controlling gaseous emissions.

(v) **Land Management & Conservation** - To describe in detail the measures to be adopted to assist in meeting waste reduction goals, the degree of control over waste taken into the site and the proposed approach to site closure and rehabilitation (including post-closure monitoring, final site contouring, proposed future uses etc).

(vi) **Amenity Protection & Hazard Prevention** - To identify mechanisms for managing dust, birds, litter, noise, pest and vermin, odour, traffic, fire.

It is anticipated that in many cases the majority of these matters will have already been documented in the EIS phase. In these cases such documentation can be reproduced for the Landfill Establishment & Management Plan with necessary supplementation.

4.2.2 **Every established landfill** will need to provide a Landfill Management Plan to accompany an application for the next license renewal or by 31 December.

The Landfill Management Plan must:

i) describe the existing site characteristics, landfill design and management for all existing and future stages through to final closure,
ii) set down a plan for implementing specified best practice as set out in Section 5, and
iii) explicitly identify aspects of best practice that will <u>not</u> be adopted.

4.2.3 **Proposals for exemptions from best practice** for new or existing sites will need to highlight the areas of departure from world best practice, offer justification for this deviation and be accompanied by an independent risk assessment.

The risk assessment will need to follow a professional and recognised risk assessment technique to systematically analyse:

- site conditions
- contaminant sources
- exposure pathways
- receptor characteristics

related to the proposed or established site in order to estimate the risks to the natural environment.

The assessment should quantitatively demonstrate that the potential for environmental degradation is no greater than the nominated best practice technique. The uncertainty in this assessment should be characterised and the person performing this analysis must present a clear and explicit explanation of their findings.

4.2.4 **Where an exemption from nominated best practice is sought and an alternative design and construction approach is proposed**, the applicant will also need to provide documentation which does one of the following:

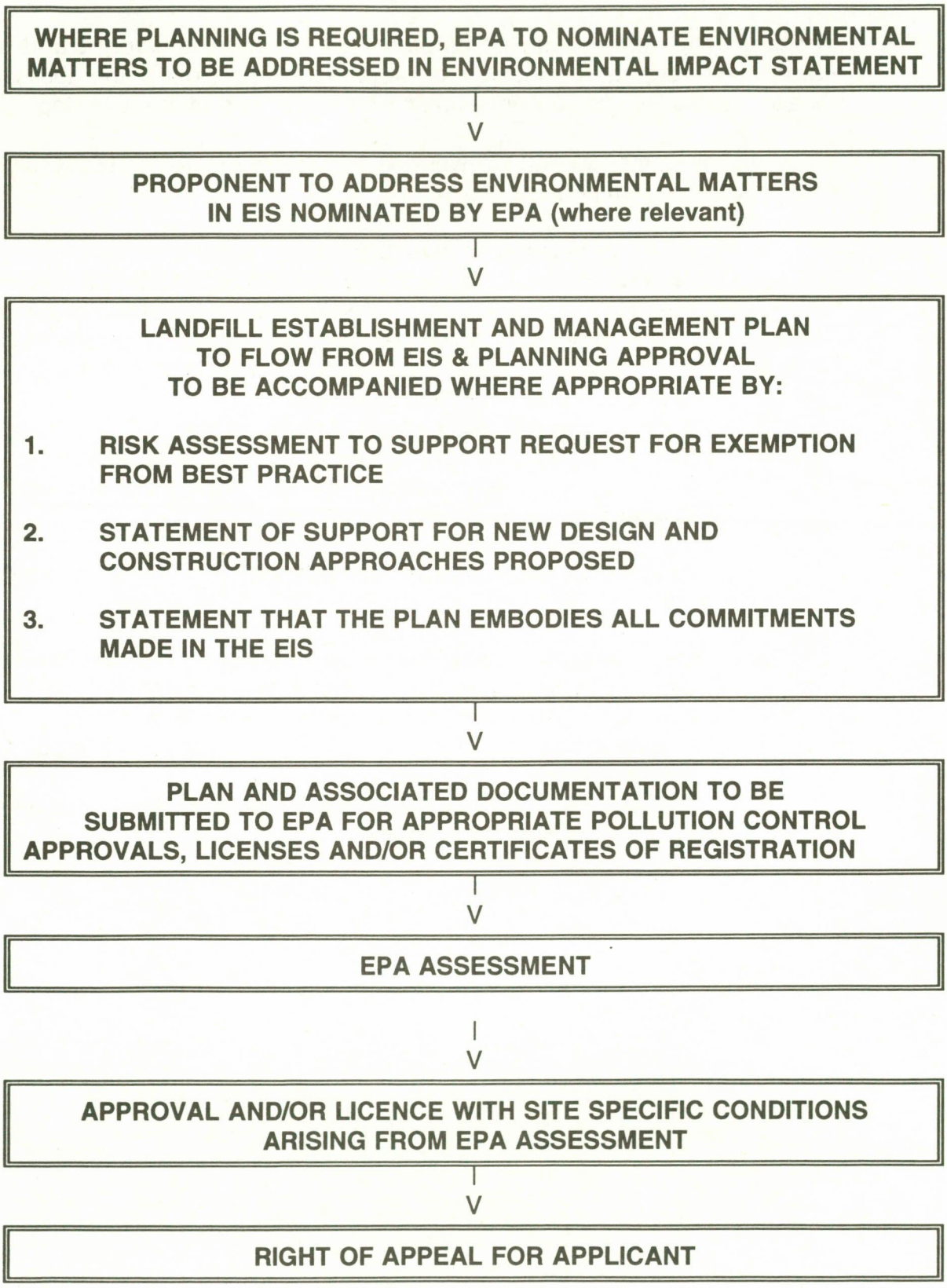
1 Identifies the extent to which the system is used successfully elsewhere and certifies that:

a. the conditions are comparable;
b. the system has been operating long enough to be sure of the possible consequences. (In other words, if a liner might fail after twenty years, a five year demonstration is unsatisfactory);
c. the prospective operator can duplicate the system that is used; ie not just make an inferior copy of it;
d. it can be demonstrated *why* the system works;
e. there is no or insufficient countervailing evidence; and
f. the proposal is compatible with other aspects of the landfill operation.

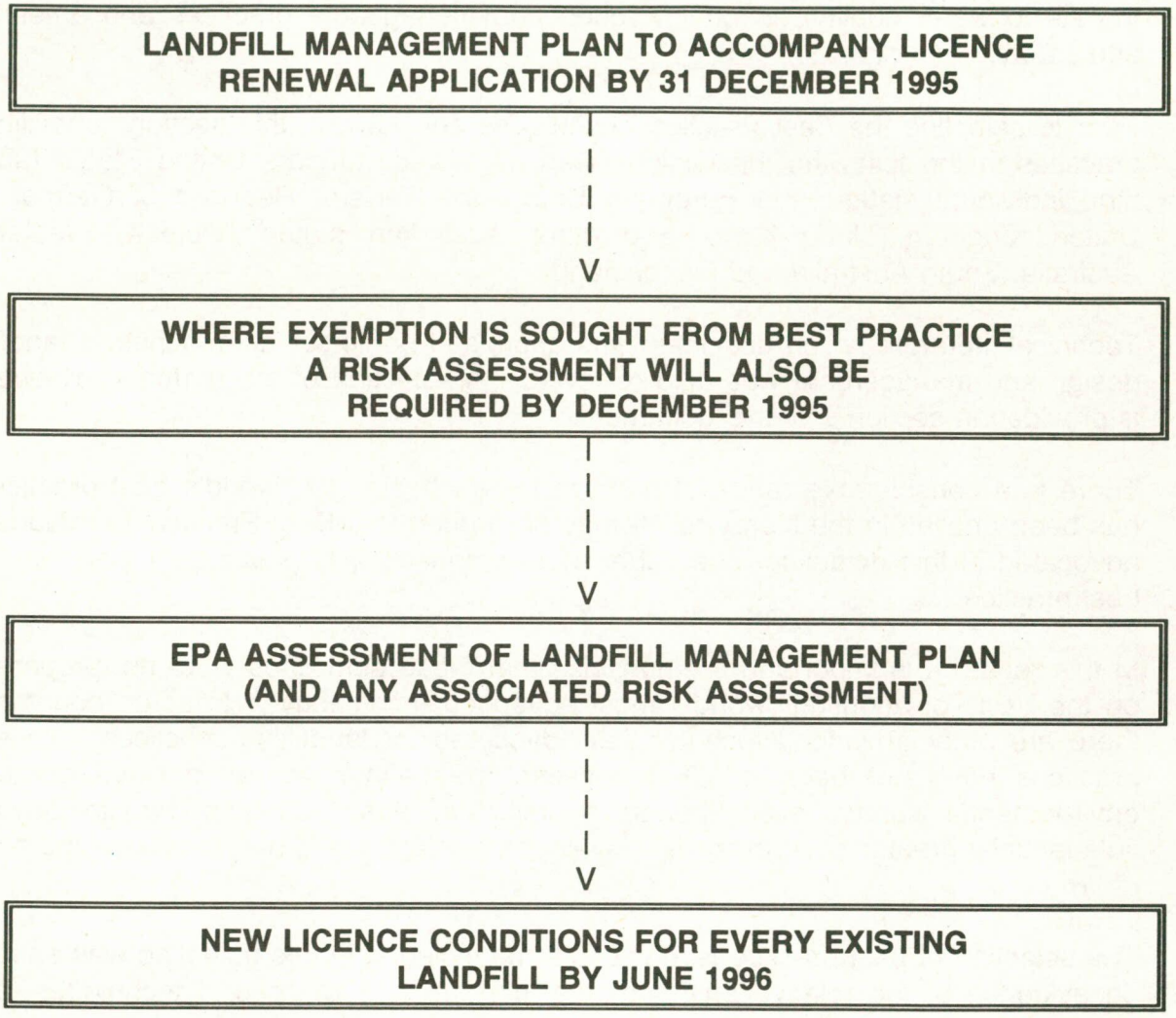
2 Demonstrates the soundness of the proposal in field or laboratory tests and:

a. the conditions simulate the proper operating conditions; and/or
b. it is demonstrated *why* the system works; and/or
c. that there is little or no countervailing evidence; and/or
d. describes how the EPA can replicate the test results produced by the proponent, if desired; and/or
e. also ensures the proposal is compatible with other aspects of the proposed landfill operation.

4.3 LANDFILL LICENSING ASSESSMENT PROCESS NEW LANDFILLS AND SUBSTANTIAL VARIATIONS TO EXISTING LANDFILLS



4.4 **LANDFILL LICENSING ASSESSMENT PROCESS**
EXISTING LANDFILLS



5 BEST PRACTICE PROVISIONS

As indicated in Section 4, best practice approaches are the starting point for a performance based environmental management system. Best practice provisions provide a guide as to the minimum level of certainty required to deal effectively with threats to water quality, air quality, good and manageable practices and amenity and safety.

Prior to selecting the Best Practice Techniques set down in this section, landfilling practices in the following jurisdictions were reviewed: Japan, United States (and nine individual states), the European Union, the Federal Republic of Germany, United Kingdom, Hong Kong, and other Australian states (Victoria, Western Australia, South Australia and Queensland).

Technical literature which described and appraised particular approaches to landfill design and management was also reviewed. A selection of the material reviewed is provided in section 7 of this document.

There is a considerable range of practice to which the title "world's best practice" has been applied in the literature. It may be argued that Best Practice Techniques advocated in this guidelines are either more stringent or less stringent than "world best practice".

In this regard it is important to emphasise that these guidelines were not prepared on the basis of adopting "world's most advanced technology". In some countries there are other advanced technologies advocated for landfilling practices. These practices have not been adopted because they either do not achieve greater environmental surety, even though adoption of this technology would be at substantially greater cost, or are in development stages and may not pass the test of time.

The selection of best practice techniques to be included in this guideline was based on evidence of the relative environmental performance of specific techniques, as documented in the literature, and appraisal of the applicability of particular approaches to Australian conditions.

The section should be considered in the light of 2 key points:

i) Design and construction are generally the most costly provisions in establishing a landfill. Bearing in mind that the same or better environmental result may be achieved via locational decisions, decisions about types of wastes to be received and management of those wastes, or different design and construction techniques, the best practice design and construction requirements are used primarily to set the benchmark level of confidence.

ii) A combination of design and construction, operations management, monitoring and rehabilitation measures will likely be required to deal with the

range of potential impacts under a best practice framework. A summary matrix of the range of best practice actions to address each environmental issue is at Appendix A.

This section outlines in detail the best practice provisions which relate to acceptable levels of performance to address each of the key environmental protection criteria.

5.1 PREVENTING DISCHARGES TO WATER

5.1.1 DESIGN AND CONSTRUCTION

The section deals with current best practice design and construction techniques aimed at protecting groundwater and surface waters.

As indicated previously, there are a number of methods to achieve the level of protection necessary to meet individual performance requirements without following the best practice techniques nominated in this guideline.

The design of each containment system should be based on the geologic formation, hydrology, style of landfill operation, anticipated nature and quantity of wastes to be received, meteorology, elevation and quality of groundwater and leachate detection and controls. Each one of these factors will influence the need for, and type, of leachate containment system for individual facilities.

Intelligent site selection is crucial in reducing the stringency of the technique employed to meet performance requirements. Locating a landfill in an area where there is a significant distance to groundwater and a uniform, thick sub-base with low permeability will minimise the likelihood of any threat to groundwater. The need to meet the performance requirement becomes superfluous if, wherever possible, the management technique employed to protect groundwater is to locate the landfill where groundwater is absent. In this case, the landfill proponent could perform an assessment of the risk to groundwater and demonstrate that installation of the nominated containment system is not warranted or that an alternative containment system is acceptable for environmental protection.

Landfill operations and management will also influence the design of containment systems. Pre-treatment (composting or incineration) of wastes to a more inert form prior to landfill disposal will minimise leachate production and thus stringency in control technology would become less important. Pre-treated wastes have a lower potential for the creation of a contaminating leachate and other measures of attenuation can be considered. If wastes are pre-treated prior to disposal, a risk assessment approach may be used to demonstrate that the best practice design and construction technique is unnecessary.

The use of a mineral liner (clay or sand washings) system which meets the retentive characteristics of the nominated technique can be employed. These materials may be suitable in certain geologic formations once consideration is given to thickness and procedures for maximising retentive characteristics of these mineral constituents.

The use of a unique management option to meet the performance requirement will not cause a reduction in certainty with regard to environmental protection. The use of alternate designs may necessitate additional requirements in order to achieve the surety provided by the nominated technique. This extra support may take the form of additional monitoring infrastructure with higher financial assurances.

A. Liner - Landfill Waste Containment System

Performance Goal

To protect groundwater quality and the subsurface environment it is necessary to establish a containment system, or approved alternate option, which is designed to contain any leachate over the period of time that this material poses a potential for environmental degradation. The attenuation properties and overall permeability of any alternative containment system would need to produce a performance result similar to the best practice waste containment system, that is outlined below.

Best Practice Techniques

The best practice technique waste containment system for new landfills and lateral expansions of operating landfills is a composite liner system that forms a barrier between groundwater and waste. Suitable liner specifications include:

(a) The liner will consist of at least 60 centimetres of compacted clay with an *in-situ* coefficient of permeability of less than 10^{-9} ms^{-1}.

(b) Successive clay layers will be of compatible material and each underlying layer will be scoured to prevent excessive permeability due to laminations. The side must have a slope not exceeding 1 vertical :3 horizontal in order to allow suitable compaction of the clay and to facilitate subsequent testing.

(c) The clay liner will be overlain with a flexible membrane liner (FML) of minimum co-efficient of permeability of 10^{-14} ms^{-1}. The FML will have a minimum thickness of 1.5 mm and must be laid following procedures in an approved construction quality assurance program. All joins and repairs must be fully tested to ensure liner integrity is not breached at these locations.

(d) The FML must be protected by an overlay of soil with low abrasive properties or synthetic nonwoven geotextile of sufficient depth to protect FML against load-induced damage.

(e) The surface of the liner is to be formed in the manner of a roof profile. Once the liner bearing surface has finished settling, the surface of the liner must exhibit a transverse gradient of greater than 3 percent and a longitudinal gradient of greater than 1 percent.

(f) The drainage layer must have a thickness of greater than 30 cm. The drainage material must exhibit a co-efficient of permeability $K > 1 \times 10^{-3}$ ms^{-1}.

Perforated pipes (collectors), capable of being rinsed and monitored, must be provided for the collection and discharge of leachate.

(g) The FML seams must be heat welded, wherever possible, and pressure tested. Extruded seams are appropriate for patches and attaching to old FML. These welds must be vacuum tested to demonstrate that the integrity of the FML is maintained. The seams must be running parallel to the direction of the leachate flux.

Figure 1 shows a schematic of an acceptable landfill waste containment system.

Once the leachate is contained, there is then a need to focus on the collection of the excessive leachate.

B. Leachate Collection System

Performance Goal

To ensure that leachate in excess of the capacity for the waste material to retain moisture is to be collected and to prevent it from escaping from the landfill into the groundwater.

Best Practice Technique

The leachate collection system will be designed and installed in accordance to the quality requirements specified in Construction Quality Assurance Requirements.

Acceptable design includes:

(a) The drainage layer must be designed and installed so that the depth of leachate over the base liner can be no more than 30 cm.

(b) The drainage media must be selected to have sufficiently large pore space to prevent encrustation during the landfill's early acidic phase.

The gravel selected ideally should be:-

i rounded
ii of grain size greater than 20 mm
iii smooth surfaced
iv non reactive in mildly acidic conditions
v relatively uniform in grain size

Geotextiles must not be used where their low porosity and consequent encrustation could result in blockage of the drainage system.

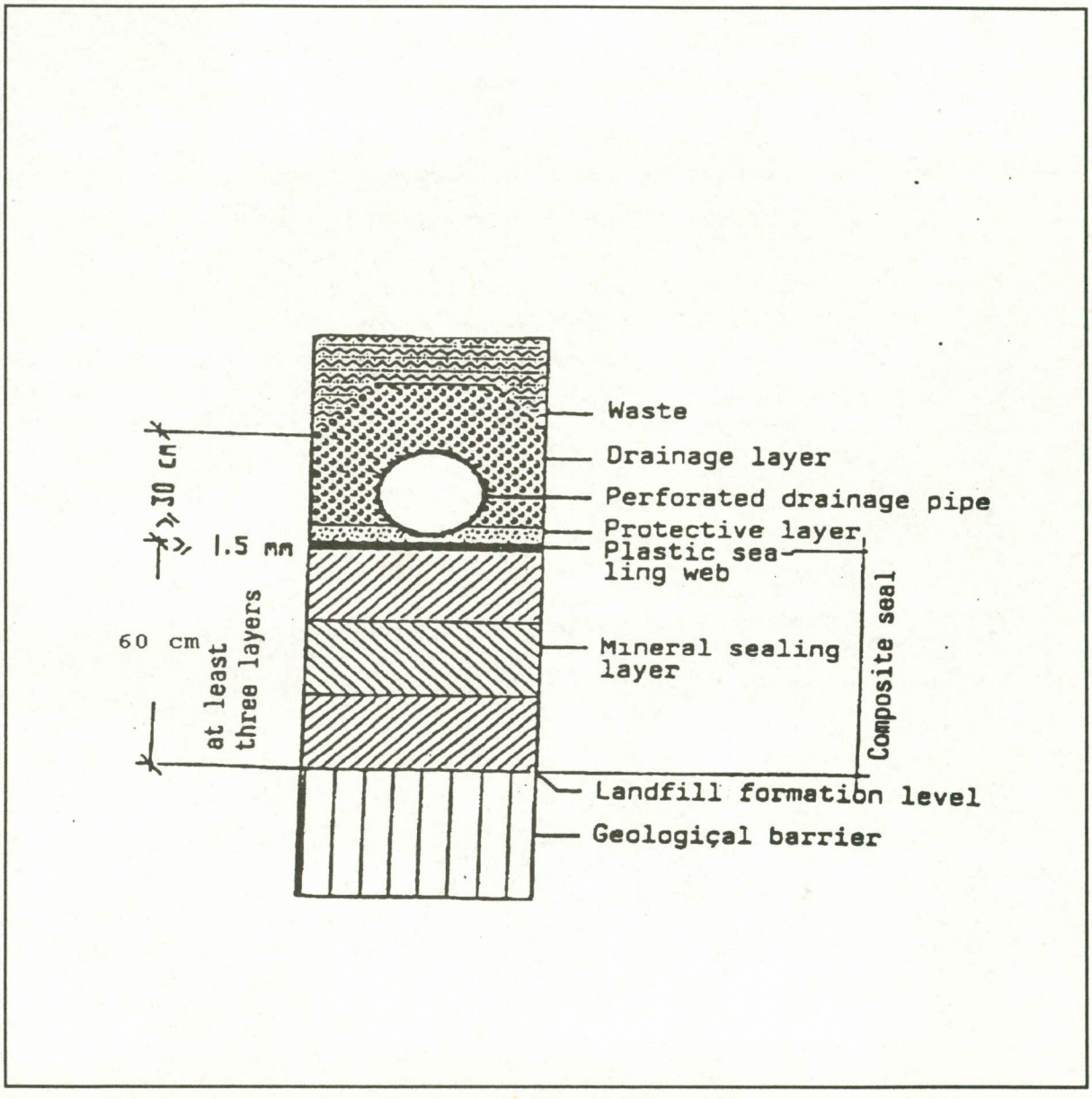


Figure 1. Schematic of an acceptable landfill composite liner (adopted from Federal Ministry of Environment, 1993).

(c) In order to facilitate predictable movement of leachate and prevent the creation of perched water tables, previously applied daily or intermediate cover will be punctured prior to further filling.

(d) Leachate is to be collected and tested prior to its release to sewer in accordance with the waste water authority requirements. Alternatively, it is to be tested prior to spraying over completed areas of the landfill or injection back into the landfill. The analysis is conducted in accordance with the requirements set down in Section 5.3.3.B. (There will be individual requirements in relation to the concentration of pollutants dependent on site soil chemistry and specific operating conditions). In instances where disposal to sewage treatment plants and spray irrigation are not viable options, landfill operators will be required to perform on-site treatment.

C. Surface Water Controls

Performance Goal

To avoid the generation of excessive leachate and washout of waste from the landfill, surface water must be prevented from mixing with waste and prevented from carrying sediment or contaminants off exposed surfaces.

Best Practice Technique

Distance to surface waters can be considered as a possible attenuation measure.

The following design may also be used, in addition or as alternatives to distance from surface waters:

(a) Surface water interceptor diversion drains must be constructed to prevent stormwater from entering areas that have been filled or are actively being filled. The design of these drains should be such that they have the capacity to divert, at a non-erosive rate, all the surface water received during 24 hours of a 1 in 25 year storm.

(b) All surface water that has flowed over cleaned or non vegetated surfaces to be channelled to a sediment pond. These ponds should be engineered to contain 150 m^3ha^{-1}. Suitable efforts must be made to minimise the erosion of sediment from disturbed surfaces.

(c) All water that has entered waste filled areas and water that has been contaminated by leachate must be treated in the same manner as leachate.

(d) All completed sections shall have a final or intermediate cover applied with a minimum slope of 3 percent in order to prevent ponding or excessive infiltration.

D. Design of Groundwater Monitoring Wells and Lysimeters

Performance Goal

To establish monitoring structures that demonstrate groundwater is not contaminated and to ensure early detection of any contamination through representative samples from the groundwater and the vadose zone.

Best Practice Technique

The requirements for establishing a groundwater monitoring network must include:

(a) Monitoring bores will be:
- i nest of bores, slotted over different intervals; *or*
- ii a multi port bore: *or*
- iii an appropriate combination of both.

Single, fully slotted bores are not regarded as sufficiently reliable for this use due to patterns of movement of contaminants. Figure 2 exemplifies an acceptable well design.

(b) Monitoring bores must have a minimum internal diameter of 100 mm in order to allow adequate sampling.

(c) The selected monitoring bore design should include suitable strength PVC pipe with slotted sections gravel packed and cement/bentonite sealed sections. The standpipe must be adequately sealed near ground level using cement based grout and the top of the standpipe covered with a security cover. Additionally, the standpipe must be constructed to prevent the ingress of surface water ant to prevent extraneous material (*ie* insects) from getting into the well.

(d) The porous media surrounding the monitoring bores and the lysimeter cup must be selected to ensure that they do not effect the sample's accuracy.

(e) Installation and well maintenance should be undertaken following standard references on this subject such as the USEPA *Handbook: Groundwater. Volume II: Methodology* (1991) or Hirschberg's *Guidelines for Groundwater Monitoring at Municipal Landfill Sites* (1993). It is important that drilling method, number of wells, material used in well design and construction, procedures for well development and security are clearly identified in the Landfill Management Plan. The quality standards established in the landfill quality control program (see Section 5.3.1) will be applied to the establishment and operation of the groundwater monitoring system.

(f) The Groundwater Detection Monitoring may include installation of suction lysimeters to monitor the vadose zone beneath the landfill and at suitable locations surrounding the landfill liner when there is no evidence of

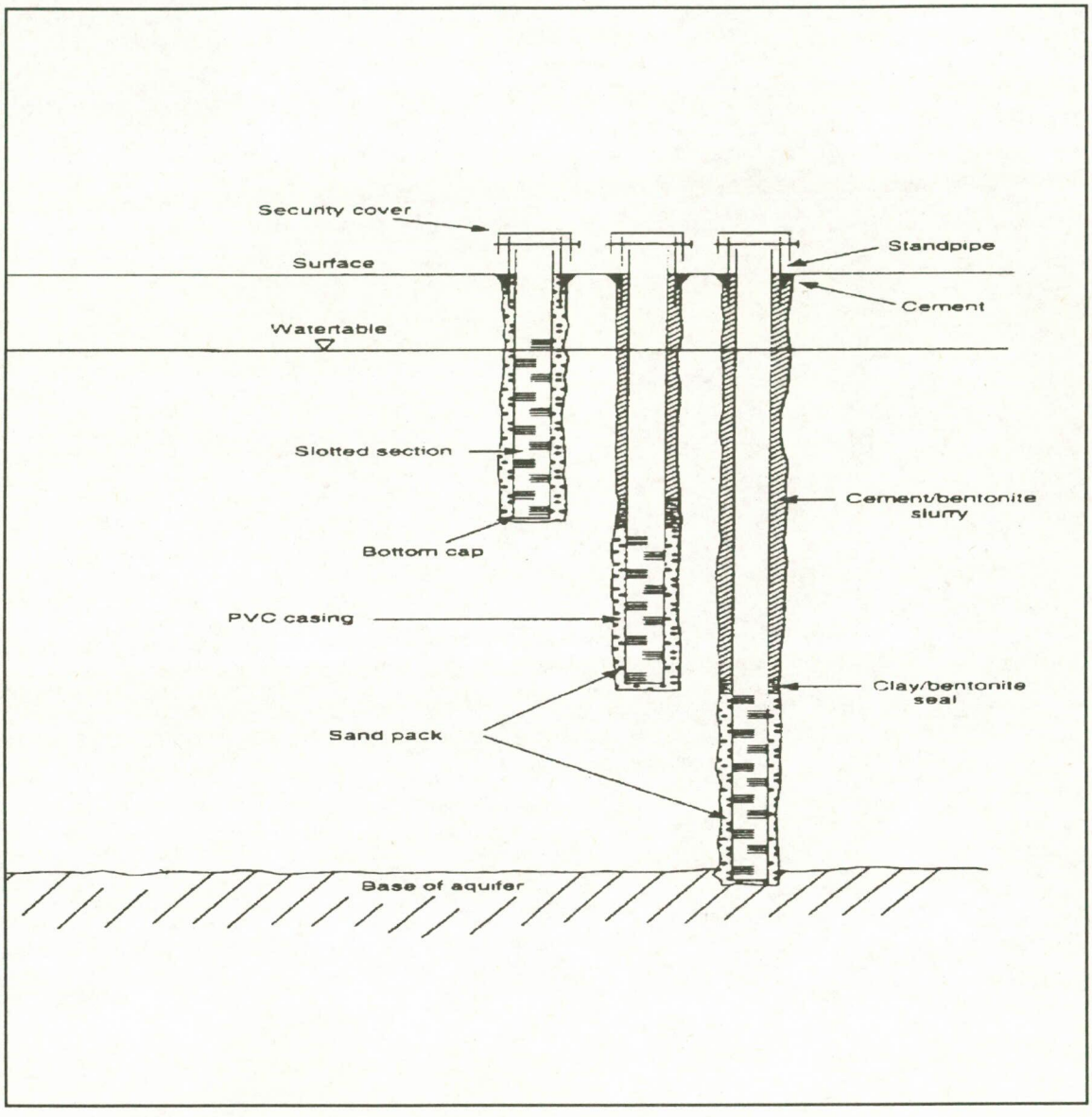


Figure 2. Example of an acceptable multiple depth groundwater monitoring well installation (from Hirschberg, 1993).

groundwater. A suction lysimeter is used to extract pore water when groundwater is absent. These devices will indicate the presence and quality of leachate in the geologic formation.

5.1.2 MONITORING

A. Groundwater Detection Monitoring Program

Performance Goal

To demonstrate that groundwater protection measures are effective in preventing pollution of groundwater.

Best Practice Technique

A comprehensive hydrological investigation of both the site and the surrounding groundwater regime will have been conducted prior to site establishment. (The technique employed must take into consideration the Department of Planning *Landfill, Practice Guideline*, 1994). The groundwater flow and flow pathways for all aquifers on site must be identified with a high degree of certainty, via a groundwater monitoring program.

(a) The groundwater monitoring program must be set down in the Landfill Management Plan (see Section 4.2.1 - Assessment Process for landfill Licensing).

(b) A plan of the proposed location and depth of the hydraulically up gradient and down gradient wells for all aquifers at risk due to landfilling activities will be included in the Landfill Management Plan. This plan is to be supported by adequate documentation outlining groundwater hydraulics. When it is not possible to locate hydraulically upgradient wells, landfill proponents will need to have sufficient number of samples taken to characterise background groundwater characteristics prior to landfilling activities at compliance point wells.

(c) Groundwater indicator parameters and required detection limits are listed in Table 2. Changes in concentration for these indicators will provide evidence that leachate has been in contact with groundwater. The specific indicator adopted must be able to provide an indication of the possible types of pollution that will occur.

(d) **All groundwater detection monitoring wells and lysimeters must be sampled on quarterly frequency by NATA or equivalently accredited individuals.** This frequency can be relaxed if a proponent can demonstrate that there are not any seasonal effects after data have been collected for five consecutive years.

(e) Water samples shall be taken in accordance with procedures outlined in

Water Quality Investigations Manual, Preferred Methods for Sampling and Analysis-Draft (EPA, 1994b) or *Handbook: Groundwater. Volume II: Methodology* (USEPA. 1991). Appropriate sampling procedures are summarised below:

i Hydrologic measurement to establish the standing water level with an accuracy of ± 0.3 cm.

ii Well purging to remove stagnant water from well casing. Wells must be purged until successive pH readings agree by 0.1 pH unit or redox potential is ± 10 percent previous reading. These readings must be taken after two well volumes have been purged.

iii Samples must be taken with a positive displacement pump or dual valve bailer. When taking the organic samples the flow rate should be reduce to ≈ 100 ml/minute to reduce the loss of volatile components.

iv Filtration/preservation of samples should be performed in the field. Trace metals, anions, cations and alkalinity samples are to be taken from filtered samples. All other samples must not be filtered.

v Field analysis of samples shall be performed for alkalinity and pH, unless it can be documented that less than six hours have passed prior to laboratory analysis.

vi Sample containers and preservation shall follow the procedures outlined in the present edition of *Standard Methods for the Examination of Water and Wastewater* (APHA, 1992).

(f) The minimum field quality control requirement would be:

i Testing of field blanks (these must represent 5 percent or at least one blank where less than 20 samples are analysed in a batch) with documented investigation report required if blanks exceed the required detection limits.

ii Testing of field spikes, (these must represent 5 percent or at least one spike where less than 20 samples are analysed in a batch) with documented investigation report required if spike recovery is outside the 80 to 120 percent range. The *Handbook: Groundwater. Volume II:* (USEPA, 1991) provides detailed instruction on the preparation and use of field spikes.

iii Testing of duplicate field samples (these must represent 5 percent or at least one duplicate where less than 20 samples are analysed in a batch) with a requirement of documented investigation report if variation between duplicates exceed 20 % relative percent difference

(RPD).

iv Statistical procedures are to be used for all analytical results to determine if there has been a significant change in concentration for the indicator parameters. Analysis of variance or other approved statistical technique, as outlined in the LMP, can be used to perform this assessment. A simplified discussion on groundwater data can be found in *Statistical Analysis of Groundwater Monitoring Data* (USEPA, 1989).

Table 2 Indicator Parameters for Groundwater Detection Monitoring Program

Chemical or Property	Required Detection Level (RDL) in µg\L
Absorbable Organic Halogens (AOX)	10
Alkalinity	1,000
Ammonia	50
Calcium	5,000
Chloride	5,000
Fluoride	500
Magnesium	5,000
Nitrate	100
pH	0.1 pH unit
Total Phenolics*	50
Potassium	5,000
Sodium	5,000
Sulfate	5,000
Total Organic Carbon (TOC)	50

* Total Phenolics or summation of 17 individual phenol containing compounds identified by USEPA Method 8040 (USEPA, 1992).

B. Groundwater Assessment Program

Performance Goal

To establish a reliable mechanism for determining the extent of failure of a leachate containment system.

Best Practice Technique

The proponent must prepare a Ground Water Assessment Plan which identifies the specific contaminants and extent of the pollution to the groundwater wherever a statistical change is detected through the groundwater monitoring program. An assessment plan is to be prepared whenever a statistically significant difference over background analytes has been detected for one or more of the constituents listed in Table 2 in Section 5.1.2 A.

The program includes:-

(a) Advising the EPA in writing within 14 days of detecting a significant increase in groundwater contaminants.

(b) Within 28 days of the notification, preparation and submission to the EPA of a list of proposed analytes for evaluation and of a monitoring program to sample groundwater wells and lysimeters. The list of analytes will be based on the detection of monitoring variations and the contaminant content of the leachate. To assist in the selection of these proposed analytes Appendix B contains a non exclusive list of substances potentially contained in groundwater.

The proposal would need to be supported by justification for the selection of analytes.

The information obtained during this assessment will be used to prepare the Groundwater Contamination Remediation Plan (Section 5.1.4).

C. Surface Water Monitoring Program

Performance Goal

To provide a mechanism that reliably demonstrates that surface water is not contaminated by landfill run-off.

Best Practice Technique

A surveyed monitoring point at all site discharge locations, upstream and downstream, of the landfill in the receiving waters, must be established. Procedures for obtaining the representative sample must be outlined in the Landfill Management Plan.

Quarterly sampling (when there is flow) and testing of a representative sample for all contaminants from Table 2 *and* arsenic, cadmium, chromium, lead, zinc & total suspended solids. This sampling and analysis program shall utilise the same quality control program as nominated in Ground Water Detection Monitoring Program.

In addition to quarterly sampling, the operator is required to capture and analyse the first flush from rainfall events at all sample locations. First flush run-off will

have the greatest environmental effects on receiving waters.

5.1.3 SITE MANAGEMENT

A. Covering Waste

Performance Goal

To minimise the generation of leachate by limiting the amount of water percolating through the waste. The use of cover material is a procedure which is relevant to such water emissions.

Best Practice Technique

The use of cover material has other benefits in relation to meeting overall environmental objectives. Therefore, detailed discussion on the use of cover material is reserved until the Land Management and Conservation (Section 5.3.2(B)).

5.1.4 REHABILITATION

A. Groundwater Contamination Remediation Plan

Site closure includes capping and revegetation which will have the net effect of minimising run-off to surface waters that may cause erosion. Additionally, final capping will prevent the infiltration of rainwater and run-on through the waste which will limit the generation of leachate that may potentially contaminate groundwater. Closure and capping are covered in significant detail in the section of Land Management and Conservation of this guideline.

Performance Goal

To ensure that all releases of contaminants into the groundwater are removed and to maintain the quality of the groundwater resource.

Best Practice Technique

Where contamination is detected via the groundwater assessment program a groundwater remediation plan is prepared that describes the process to protect the groundwater resource from further contamination and nominate a means to return the groundwater to the original quality down hydraulic gradient from the landfill.

Landfill owners should be aware that the costs associated with groundwater rehabilitation is immense and may take several years.

Appendix C contains a flow chart that graphically depicts the relationship between the various monitoring programs and associated plans in this guideline.

5.2 PREVENTING ATMOSPHERIC IMPACTS

5.2.1 DESIGN AND CONSTRUCTION

This section deals with traditional individual design and construction techniques aimed at minimising emissions to atmosphere.

A. Landfill Gas Monitoring Device

Performance Goal

To demonstrate that landfill gas is not migrating off site, and toxic air emissions are not a threat to the community. Off site sub-surface migration of landfill gas must be below 5 percent methane (v/v) .

Best Practice Technique

Perimeter monitoring wells will need to be installed around the periphery of the site. These wells need to be place at intervals sufficiently small to detect off site migration. As a rule of thumb, if there is any other activity or development within 300 metres of property line wells should be placed 50 metres apart. If adjacent land is unoccupied wells can be placed 300 metres apart.

Perimeter monitoring wells will need to be placed at a depth to the minium groundwater level, greatest depth of refuse or 10 metres below underground utilities or manholes within 50 metres. A separate probe should be installed for every 3 metres of depth to 9 metres and every 5 metres thereafter.

Approved well construction consist of a concrete well head, protected by steel casing. Individual probes should be slotted with a bentonite seal between monitoring zones. The hole is to be back filled with pea gravel to facilitate movement of gas. An example of this design can be found in Figure 3.

B. Gas Extraction System

Performance Goal

To establish a system for managing landfill gas such that:

(a) that methane does not create an explosion hazard,
(b) contribution to greenhouse gases is minimised,
(c) the gas becomes a valuable resource,
(d) odorous emissions are avoided, and
(e) air toxics do not pose a threat to the community.

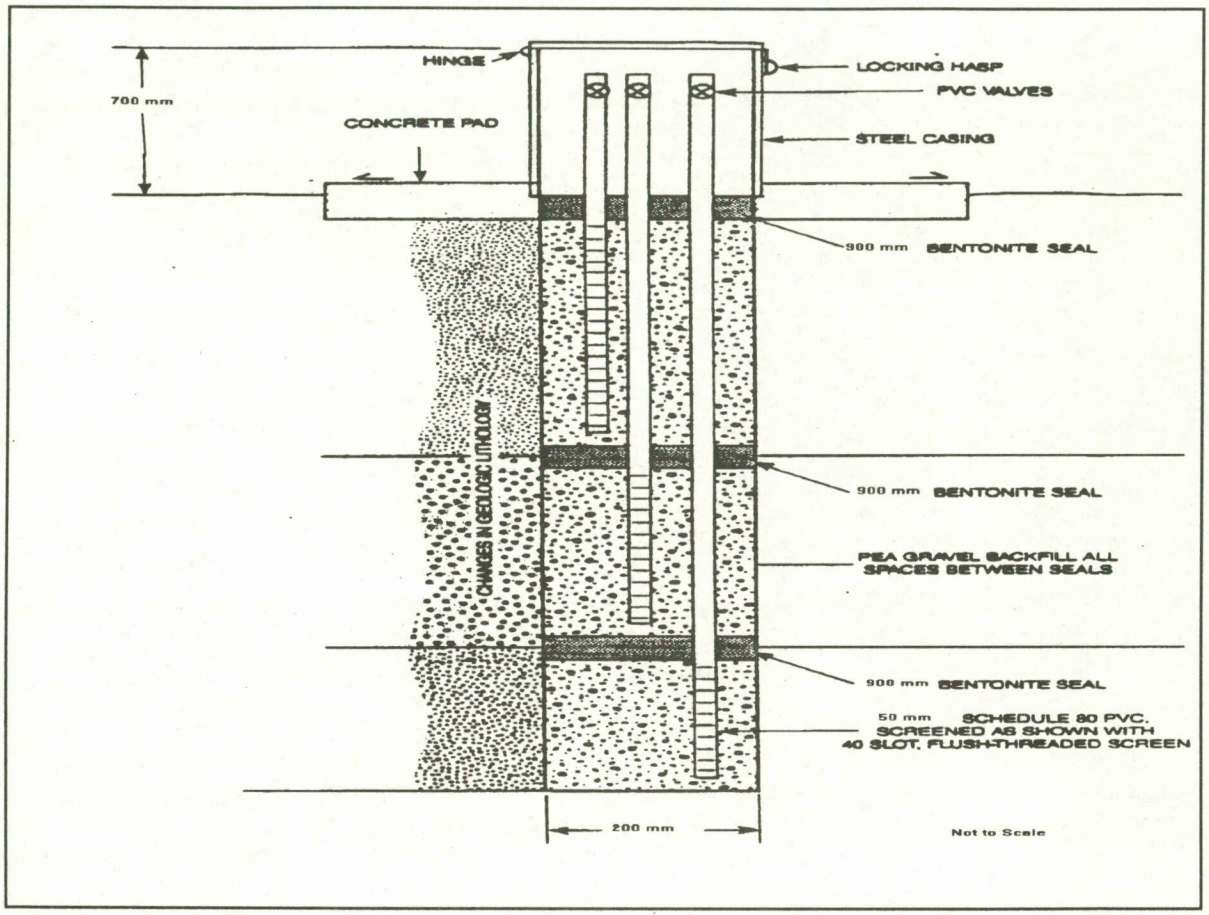


Figure 3. Acceptable design for perimeter gas monitoring wells (adopted from Parametrix, 1987)

Best Practice Technique

A gas extraction system is a device used to extract and combust landfill gases. This system reduces risk of explosion and fire, lowers the level of toxic organic compounds emitted from landfills and reduces the contribution to green house gases (methane is 20 to 30 times more potent than carbon dioxide). In conformance with the EPA's commitment to the utilisation of a the landfill as a resource, proponents should evaluate co-generation of electricity as an option when designing the extraction system.

An active gas extraction/control system is required for:

(a) All landfills that will or do receive more than 500 tonnes per week (26,000 tonnes per annum) of Solid Waste or will contain a total of over 250,000 tonnes during their operating life must install an active gas extraction and oxidation system. Gas extraction and oxidation must commence while the landfill is in operation.

(b) Landfills with approved monitoring programs where the building and or perimeter well testing shows methane concentrations exceeding 1.25 percent methane or 25 percent of the lower explosive limit.

(c) Where odour emissions are a problem and the methane emissions do not exceed the limits stated in (b), examination for sulfur compounds or organic compounds may be required in order to assess the necessity for an active gas extraction system.

Electricity generating equipment should be designed in a manner that ensures the following air quality goals are not exceeded:

(a) 1 hour maximum NO_2 concentration 320 $\mu g/m^3$
(b) Annual average NO_2 concentration 103 $\mu g/m^3$

5.2.2 MONITORING

A. Sub-Surface Gas Migration Monitoring

Performance Goal

To demonstrate that gas is not migrating off-site through the use of a subsurface gas monitoring program.

Best Practice Technique

Monitoring would be conducted on a quarterly frequency unless frequent detections above 5 percent v/v methane required a greater frequency. Procedures for sampling should be nominated in the Landfill Management Plan and should which include the flushing one probe casing volume prior to taking the reading.

The testing is to be conducted *in situ* using a properly zeroed and calibrated field instrument. A catalytic oxidation instrument or flame ionisation detector (FID) is suitable for samples below 5 percent v/v methane, while a thermal conductivity detector or FID is necessary above 5 percent.

Tabular monitoring results are to be submitted as part of an annual report unless subsurface methane is detected above 5 percent. In this case, the EPA is to be notified in writing within 14 days.

B. Surface Gas Emission Monitoring

Performance Goal

To demonstrate that the cover material and extraction system is controlling the emission of landfill gas.

Best Practise Technique

The landfill operator is required to test the atmosphere 5 cm above the ground surface in areas with intermediate or final cover where wastes have been placed. A field technician would start at a point 5 metres from the waste perimeter. The technician is to walk parallel to the boundary until reaching the opposite side and than repeat this procedure every 25 metres inward from the perimeter to the centre of the site. This monitoring is to be performed on calm days (winds below 10 k/hr).

The operator is expected to instruct the technician on the need for due diligence following this procedure. Depressions in the cover material or surface fissures away from the sampling grid nominated above will also be investigated for methane emissions.

This monitoring is to be conducted on a monthly frequency using a zeroed and calibrated FID, unless there is a case for variation of frequency of monitoring based on site assessment and/or stable in available monitoring reports.

The threshold concentration for closer investigation and potential action is 500 ppm (v/v) as methane at any point on the landfill surface. Corrective action is necessary if the threshold is exceeded. This action can take the form of repairing or replacing cover material and/or of adjusting/installing gas extraction equipment.

Reports on monitoring and corrective action will form part of the annual report.

C. Analysis of Landfill Gas Oxidation Emissions

Performance Goal

To demonstrate the non-methane organic compounds (NMOC) are reduced by a landfill gas oxidation system (flares or engines).

Best Practice Technique

Landfill gas contains a large number of non-methane organic compounds (NMOC). Many of these compounds are toxic air contaminants that occur in parts per million by volume (ppmv) concentration range. Gas extraction has the net effect of moving these compounds from within the landfill to the atmosphere which requires the use oxidation systems.

Landfill operators are required to characterise and quantify NMOC emissions prior to and following thermal oxidation. Thermal oxidation in this context may mean flaring or electricity generation.

The sampling and analysis would need to be undertaken in accordance with the site specific requirements issued by EPA's Air, Noise and Transport Branch. It is a world best practice to have greater than a 98 percent destruction efficiency for NMOC prior to atmospheric emission.

5.2.3 SITE MANAGEMENT

A. Cover Materials

The use of cover material is a control procedure which is relevant to air emissions in that it will control the movement of gas, limit atmospheric emissions, and reduce the opportunity for fire and explosions. The use of cover material has other benefits in relation to meeting overall environmental objectives. Therefore, detailed discussion on the use of cover material is reserved until the Land Management and Conservation (Section 5.3.2(B)).

B. Fire Prevention

Performance Goal

To prevent fires, this is a integral control procedure aimed at minimising emissions to the atmosphere.

Best Practice Techniques

(a) The operator will have clear signs on display to the public advising that flammable liquids are not permitted on the site. This will be reinforced by advice to customers at the gatehouse and inspection of loads at the tip face.

(b) The stockpiling of approved amounts of combustibles for recycling and composting (such as tyres, wood or vegetation) is undertaken in a manner so that they are divided into small piles or in windrow form in order that any burning material can be kept away from additional fuel.

(c) Cell construction, compaction and use of cover material will need to be undertaken in a manner conducive to the prevention of a landfill fire.

(d) All sealed drums are banned from landfill unless they are delivered as a special waste whose contents are clearly identified and suitable for acceptance.

(e) All fuels or flammable solvents for operational use shall be stored in an appropriately ventilated and secure store. This store must be located on unfilled land and bunded so that any release of raw or burning fuel could not cause a fire in the filled waste or impact on stormwater.

C. Burning of Wastes

Performance Goal

To prevent the release of pollutants into the atmosphere as a result of burning of waste at landfills. The increases in particulate emissions and decreases in site safety arising from landfill fires outweigh any perceived benefit in waste reduction. Waste reduction strategies (*ie* composting, mulching) and materials reuse are the approved methods for waste reduction.

Burning of waste is to remain forbidden in the Sydney metropolitan area. In rural areas, the operator cannot burn any waste materials without the written permission of the EPA. This consent will set specific conditions regarding the materials that can be burned, the way they are burned and the person responsible for setting and controlling the fire. The EPA permission does not remove the operator's obligation to ensure that permission is granted by other control bodies such as the Fire Brigade or National Parks and Wildlife Service where appropriate.

Best Practice Techniques

(a) The following materials banned from burning at <u>all</u> landfills are:

i hazardous wastes
ii chemical containers
iii domestic garbage
iv food wastes
v paint or paint containers
vi petroleum, oil or bitumen
vii plastics or rubber (including tyres)
viii wet materials
ix chemically treated timbers
x clinical wastes.

(b) Vegetation, timber, paper and cardboard are the only waste materials suitable for burning at a landfill.

(c) Where the clearing of on-site vegetation or preparation of fire breaks is to involve burning, approval needs to be obtained from the local fire authority.

(d) A person, authorised by the operator, shall be in attendance at all times of burning and shall be solely responsible for lighting and control of fires.

(e) Waste materials for burning shall be arranged in windrows, trenches or pits.

(f) A fire shall not be located within 50 metres of any site perimeter or working face of the landfill.

(g) A fire shall not be located over a previously filled area of the landfill or in a location that is likely to have landfill gas that has been generated within the fill area.

i A fire shall not be located such that it is offensive or potentially harmful to any person at or beyond the landfill boundary.

ii Burning shall be restricted to daylight hours.

5.2.4 REHABILITATION

Site closure includes capping and revegetation which will have the net effect of decreasing the emission of landfill gas through the surface of the landfill. This measure would improve the potential for extracting landfill gas. Landfill operators should be aware that there is a potential for greater lateral movement of gas as escape through the surface becomes more difficult. Closure and capping are covered in significant detail in the section of Land Management and Conservation of this guideline.

5.3 PROMOTING RESPONSIBLE LAND MANAGEMENT AND CONSERVATION

5.3.1 DESIGN AND CONSTRUCTION

A. Construction Quality Assurance

Performance Goal

To ensure that all site construction activities are performed at a standard that minimises the likelihood that the landfill will have deleterious effects on the surrounding environment. Construction Quality Assurance (CQA) refers to the establishment of a quality management program that explicitly states the methods and phases for site construction activities through to final closure.

Best Practice Technique

(a) All design, construction and installation work must be undertaken in compliance to the requirements of Australian Standard AS 2990 1987 *Quality Systems for Engineering and Construction Projects.*

(b) A fully documented Quality Assurance System is to be developed in accordance with AS 2990.

i All the materials and processes associated with site development, landfill liner and leachate drainage system will be in accordance to Category A - excluding design assurance where the standard liner design outlined in this guide is used. Where an alternative design is chosen design assurance would also be required for these components.

ii A suitable level of quality assurance may be selected for other materials or processes on the site (*ie* slurry wall construction) in accordance with the environmental implications posed by failure.

B. Weighbridge

Performance Goal

To ensure that landfill operators are able to make accurate records of wastes received for disposal or re-processing in order to allow all wastes in a region to be professionally managed.

Best Practice Technique

A weighbridge is used to document the mass of material going to landfill, as such it will:

a. provide useful quantitative data for waste planners
b. reduce opportunity for fraud
c. allow for accurate comparisons of capacity and waste received between sites.

(a) All landfill operations accepting in excess of 100 Tonnes/week (5000 tonnes/annum) of waste that will be operating after 30 June 1996 must install a weighbridge. Landfills which accept fewer than 100 Tonnes/week (5000 Tonnes/annum) of waste will be required to submit waste mass recording plan for approval by EPA.

(b) The weighbridge will be calibrated once every 12 months by a NATA accredited, or equivalently accredited, engineer/technician.

(c) The weighbridge should be operational at all times of landfill activity. Should the weighbridge be inoperative for 48 hours or more, operators would be required to hire a portable weighbridge until all faults are rectified.

5.3.2 SITE MANAGEMENT

A. Compaction Program

Performance Goal

To ensure that landfill space is conserved as a resource and minimise the area of land degraded by the disposal of waste. Landfills are part of a community's resource, they are to be operated to obtain greatest possible longevity.

Waste compaction plays an integral role in optimising longevity by compressing a greater mass of material into a smaller volume. Compaction also ensures the landfill's long term landform stability and minimises voids that would encourage vermin, fires or excess generation of leachate.

Best Practice Technique

(a) Unless it is contrary to the design philosophy (ie. bio-reactor design) landfill operators are expected to ensure that maximum compaction is achieved for the capacity of the machines used. Purpose built compacters should provide 850 kg/m^3 and multi-purpose vehicles should provide 650 Kg/m^3 . Purpose built compactors are required for landfills with a capacity over 500 Tonnes/week (25,000 Tonnes/annum).

(b) Compaction at the active face should not be undertaken at slopes of greater

than 1:3.

(c) Wherever possible waste brought onto the site will be mixed together to facilitate filling of voids in bulkier items.

B. Covering of Waste

Performance Goal

To control the penetration of rainwater in a fashion that is consistent with landfill design, and to ensure that wastes will not be exposed in such a fashion as to harbour vermin, permit the rapid spread of fire, emit odours off site or expose waste to wind which may result in wind blown litter.

Best Practice Technique

Use of cover material helps to protect the full range of environmental management objectives by limiting in-flow of water, controlling fire propagation, minimising emission of landfill gas, suppressing site odour, reducing fly propagation and rodent attraction, decreasing blowing paper and minimising the risk of fire.

Cover material is classified as daily, intermediate or final, depending on operation phase and function. Intermediate cover is used to close off a cell that will not receive additional lifts of refuse or final cover for some time. Final cover forms a low permeable barrier to control water entering the site and gas emissions to promote revegetation.

Landfill operators are free to specify any alternate cover material (foams, mulch, etc) provided that they can demonstrate compliance with the performance goals.

To ensure that there will always be sufficient cover material available to meet the performance requirement, landfill operators will be expected to maintain a stockpile in anticipation of need.

I) Daily Cover

(a) Daily soil cover will be applied to a depth of 15 cm over wastes. The frequency of application of cover is shown below:

i Landfills receiving 2,500 Tonnes/Week (130,000 tonnes/annum) or more, continuous application of cover to completed sections with coverage of all waste prior to ceasing operations at the end of each day and more frequently if windy.

ii Landfills receiving less than 2,500 (130,000) and more over 100 (5,000) Tonnes/week (Tonnes/annum), coverage of all waste prior to ceasing operations at the end of each day.

iii Landfills receiving less than 100 Tonne/week (5,000 Tonnes/ annum) minimum coverage is weekly.

(b) Daily cover material should have permeability not exceeding k = 10^{-6} ms^{-1} (after compaction) unless the design specifications require the use of more permeable material as part of an EPA approved landfill design.

II) Intermediate Cover

(a) Suitably selected intermediate cover will be applied to a depth of 30 cm over surfaces which will be exposed for more than 90 days. The approach taken will be decided by the design philosophy and removable cover will be considered where the environmental issues are addressed.

(b) Intermediate cover material should have permeability not exceeding k = 10^{-6} ms^{-1}.

(c) Unless it conflicts with the design requirements of the landfilling operation daily and intermediate cover will be penetrated by earthmoving equipment immediately before further waste is to be placed over this covering layer. The intention of this condition is to prevent formation of perched water tables, saturated sections, and to allow predictable movement of leachate towards the leachate collection system below.

III) Final Cover

The practice of applying final cover is related most strongly to surface rehabilitation, and is therefore addressed in detail in the Section on Rehabilitation.

IV) Cover Material Stockpile

(a) The cover stockpile should be maintained in accordance with the landfill management plan.

(b) Where all the cover material must be provided from a stockpile, a two week supply shall be maintained. As a guide, this is estimated to be 1 m^3 of cover for each 6 Tonnes of waste received.

C. Waste Acceptance and Screening Program

Performance Goal

To ensure that the landfill accepts only those wastes that it is licensed and designed to receive.

Best Practice Technique

Waste acceptance and screening refers to the procedures employed by the landfill

operator to ensure that wastes not acceptable to the site are prohibited from entry and that there is optimal opportunity for recovery of recyclables prior to landfilling. The complexity of an approved program is inversely proportional to the dangers posed by the wastes. That is, an inert landfill may require an extensive screening procedure while a hazardous waste facility with sophisticated design controls in place would require a less detailed program.

Generally, the following practices will be applied:

(a) The landfill operator shall ensure that signs clearly indicating the types of wastes that are to be accepted and are not to be accepted are prominently displayed at the point of receival.

(b) The landfill operator shall nominate a program of sampling inspection for incoming waste loads. This may involve directing selected loads to a separate section to dump the load and have it closely examined.

(c) The landfill operator shall have a process to document that soil and other inert material received is not contaminated.

(d) The landfill operator shall ensure that records of all inspections are maintained for four years.

(e) The Waste Regulation Section of the EPA is to be notified if unauthorised hazardous wastes have been found on site and of the identity of any party responsible for dumping hazardous waste with other waste types.

(f) Supervision of tipping activity at the tip face will be maintained when wastes are received at every landfill to ensure accountability of those depositing unacceptable wastes at the site. Where depots receive in excess of 500 Tonnes/week (25,000 Tonnes/annum) this should be undertaken by someone other than the compactor driver.

(g) All landfill operators will ensure adequate training of landfill staff to recognise hazardous wastes.

D. Recycling Facilities

Performance Goal

NSW government waste policy includes a plan for reducing, by the year 2000, the amount of waste material disposed to 50 percent of the mass discarded in 1990 on a per capita basis. By virtue of the being the location which wastes are delivered, landfills are ideally suited to incorporate recycling facilities as part of an overall waste management strategy. Requiring on-site recycling facilities will assist land conservation measures by reducing the amount of waste buried and extending the lifetime of a landfill.

Best Practice Technique

Landfills which receive more than 100 Tonnes/week (5000 Tonnes/annum) are required to maximise the reuse of delivered waste.

Landfills shall include the general extraction of recyclables as integral component to site operations. Landfill operators should:

(a) nominate amounts and areas to receive and store recyclable/reusable materials, and

(b) submit a plan for the processing and/or marketing of all recyclable materials separated and for disposal of those materials separated but not suitable for recycling.

5.3.3 ENVIRONMENTAL MONITORING

A. Waste Reception Records

Performance Goal

To ensure that landfill operators have accurate records of wastes received for disposal or re-processing in order to allow all wastes in a region to be professionally managed.

Best Practice Technique

(a) Waste data must be provided by landfill operators to the EPA on the amount, type and source of waste according to the National Waste Classification System on a monthly frequency. This requirement extends to all clean fill materials accepted on site. A copy of the reporting form can be found in Appendix D.

(b) The landfill operator will have an independent registered surveyor undertake a survey of the site on an annual basis to confirm the volume of landfill space consumed in the past 12 months.

(c) The landfill survey specified, above, will form part of the landfill's annual report to the EPA reconciling these quantities with the monthly waste acceptance reports.

(d) Controls should be established to prevent vehicle ingress and egress to the site without the generating a permanent record.

B. Leachate Monitoring Program

Performance Goal

To determine the potential for contaminating landfill surfaces or catchment area due to the application, treatment or storage of leachate.

Best Practice Technique

A leachate monitoring program is necessary to assess the effect leachate may have if it is recirculated in a landfill, irrigated on the surface of a landfill, stored in a pond or treated on site. Off site disposal of untreated leachate is limited to discharge to an approved sewage treatment facility.

Initial and annual characterisation testing is conducted for aromatics, volatiles, halocarbons and the base, neutral and acid extractable organic contaminants that could be detected by Methods 8260 and 8270 (USEPA, 1992). Additionally, quarterly or batch testing (whichever is most frequent) of a representative sample for all contaminants from Table 2, excluding AOX and including arsenic, cadmium, chromium, lead & zinc. This sampling and analysis program shall utilise the same quality control program as nominated in the Ground Water Detection Monitoring Program.

5.3.4 REHABILITATION

A. Capping and Revegetation

Performance Goal

To ensure that the land surface provides a barrier to the migration of water to the waste.

One aspect of site closure is the placement of final capping which will have the net effect of controlling emissions to water and atmosphere; promoting sound land management and conservation; and protecting amenity.

Best Practice Technique

(a) The operator will commence capping the completed filling areas within 30 days of completion of landfilling in that area.

(b) Acceptable conditions for the sealing bearing surface include:

i a compressed equalising layer of homogeneous, non-cohesive material (thickness must be greater than 50 cm).

ii a gas drainage layer, with minimum thickness of 30 cm, must be provided above the equalising layer. The calcium carbonate content of this degassing layer must not exceed 10 percent by weight.

(c) Suitable conditions for a composite seal are:

i a mineral sealing layer at least 50 cm thick and having a permeability less than $k = 10^{-9}$ ms^{-1}

ii This is to be covered with a Flexible Membrane Liner (FML) of thickness not less than 1.5 mm and possessing a permeability not exceeding 10^{-14} ms^{-1}

(d) The final settlement of the seal bearing surface must leave a gradient of greater than 5 percent to defined drainage points.

(e) Should the capping layer be left for a period exceeding 7 days before coverage by the revegetation layer then it must be covered by a FML protection layer.

(f) A drainage layer, of permeability not less than $k = 10^{-5}$ ms^{-1} shall be placed over the FML. The drainage layer will be of depth not less than 30 cm. Where a protective barrier is not provided over the FML the lowest layer of drainage media should be selected to be rounded gravel of diameter greater than 20 mm.

(g) A revegetation layer of depth not less than 100 cm will be placed over the drainage layer. Plants selected for revegetation shall have root systems which will not penetrate the cultivation layer and either block the drainage layer or damage the FML.

B. Post Closure Care

Performance Goal

To ensure that the landfill continues to be non-polluting and does not cause environmental harm following site closure.

Post closure care is necessary to ensure that the long term integrity of the landfill is maintained. As with many other activities, post closure care will control multiple environmental objectives including emissions to water, emissions to the atmosphere, protection of both land use and local amenity. This care must be provided until the owner can demonstrate that the landfill does not pose a threat to the environment as outlined in the Certificate of Completeness.

Best Practice Technique

Post closure care includes:

(a) The operator or landowner will ensure that all leachate collection, gas collection and stormwater sediment controls, monitoring and reporting practices, are continued at a standard equivalent to that employed during the operational life of the landfill.

(b) The operator or landowner will ensure that neighbouring residents are advised of contact persons to discuss any problems (*ie* odour emissions). Records of these complaints must be kept in the same manner as approved during operation.

(c) The landfill operator or landowner will ensure that waste materials are not received for disposal by the facility after landfill operations cease. Waste materials that are intended for use in the rehabilitation must be strictly documented and reported in the same fashion as for an operating depot.

C. Certificate of Completeness

Performance Goal

To ensure that there is sufficient evidence that the landfill is stable and non polluting prior to stopping post closure monitoring and care.

Best Practice Technique

The owner or landowner must submit a Certificate of completeness to satisfy the EPA that the following inert condition has been reached:

(a) Gas concentration levels have fallen to less than 1 percent methane and less than 1.5 percent carbon dioxide for a period of 24 months.

(b) Waste stabilisation has been completed. This would be documented by the composition of the leachate changing to a low level of contamination (*ie* ammonia less than 1000 µg/L and pH above 7.0) and posing no hazard to the environment.

(c) Groundwater monitoring has indicated no failure of the liner so the landfill poses no threat to the groundwater quality.

(d) The surface has been assessed over some years and found to be stable with acceptable surface water drainage.

(e) Documentation that all functions in the approved closure plan have been completed.

(f) Site has been placed on Unhealthy Building Land register.

D. Financial Guarantees

Performance Requirement

To ensure that funds are available for closure, post closure obligations and remediation action.

Best Practice Technique

Financial guarantees are a means of ensuring that landfill owners adequately plan for closure, post-closure care and for site rehabilitation by providing a specific mechanism to accumulate requisite funding during the life of the landfill. This mechanism encourages development of the necessary long term financial planning to protect all environmental objectives

(a) The Landfill Management Plan should include a well documented assessment of the potential cost prepared by an independent consultant for an separate contractor to undertake each of the following:

   i Close down the current operation and rehabilitate the site to a standard acceptable for its planned future use.

   ii Continue post closure after-care and monitoring, (bearing in mind that the period of after-care is significantly influenced by the design philosophy).

   iii Complete the required remediation of environmental impacts that may be identified.

(b) The Financial Guarantee will need to be provided, and may be provided in one or more of the following forms:

   i Insurance Policy
   ii Bank Guarantee of Funds or Letter of Credit
   iii Bonds
   iv Shared Assurance
   v Third Party Guarantee

   For whichever mechanism is selected, the EPA shall have access to the funds within 14 days of request. In order to ensure that an institution will not contest payment of the funds, all instruments shall be free of liability provisions. This requirement ensures that the funds are accessible even if the owner was at fault.

(c) The estimate for the level of financial protection shall be revised in the annual report to the EPA.

E. Filling Plan/Contours

Performance Goal

To ensure that the landfill contours are engineered managed in a systematic manner as outlined in the Landfill Management Plan.

Best Practice Technique

Regular filling plan surveys that document the process by which land is filled allows the owner to demonstrate that site operations are under control and to estimate volume of waste landfilled. These surveys assist in updating calculations in relation to remaining capacity.

(a) The landfill operator will update the filling plan section of the Landfill Management Plan when each cell is completed.

(b) The filling plan identifies the type of waste in each cell and the location of any special burials such as asbestos or contaminated soil.

(c) A registered surveyor shall establish a sufficient number of permanent survey benchmarks to ensure that contour recording meets professional standards.

5.4 PROTECTION OF AMENITY AND AVOIDING HAZARDS

This section of the guideline covers two functions: to identify issues related to protecting local amenity and to provide guidance on avoiding environmental hazards. These two functions are related in that most control options are simply the result of good house keeping practises and diligent site management.

5.4.1 DESIGN AND CONSTRUCTION

A. Site Security

Performance Goal

To ensure that access to the landfill is controlled so that environmental controls and public safety can be maintained. Landfills can pose health and safety hazards to people and animals. Unrestricted access to landfills may result in disposal of material for which the landfill has not been engineered to accept. Therefore, control of site access is an essential environmental protection program.

Best Practice Techniques

(a) All landfills shall install and maintain lockable security gates.

(b) Landfills in urban areas, those located on extractive industry sites and all those receiving more than 500 Tonnes of SW per week (26,000 Tonnes/annum) shall install and maintain a 1.8 metre high wire mesh fence topped with three strands of barbed wire around the perimeter of the site.

(c) Landfills in rural areas receiving less than 500 Tonnes of SW per week (26 Tonnes/annum) must install perimeter stock fences and 1.8 metre high wire mesh fences around the active tipping area and all flammable stores areas.

B. Wheel Washing Facilities

Performance Goal

To remove mud and waste materials on the underside of vehicles that leave the site, and minimise effects on both local amenity and quality of stormwater run-off. Vehicles using landfill sites will inadvertently collect mud and litter on their wheels as they proceed to and return from the active face. Unless site design has included a mechanism to remove this material, vehicles using waste disposal facilities will create a loss of local amenity by transporting mud and litter to adjacent roads.

Best Practice Technique

(a) The site operator must provide for use by customers a form of wheel washing or wheel cleaning facility. The site operator is responsible for deciding what cleaning method is appropriate, considering site traffic. Items such as hand held pressure washing hoses, drive through immersion bunds and vibration grids are all options which may suit different operations.

(b) The landfill operator should display signs advising customers that it is the vehicle operator's responsibility to ensure that the remnants of their load or the material stuck to the underside of the vehicle or the wheels does not litter public roads.

C. Dust Control

Performance Goal

To minimise pollutants leaving the site as airborne dust, reduce stormwater sediment load and protect the local amenity. The criteria level for dust deposition is 4 g/m^2∘ month as an annual mean for total solids. The deposition rate from the landfill shall note be exceeded outside the site boundary.

Best Practice Techniques

The following measures are necessary to minimise generation of dust.

(a) Engineered roads will be constructed from the public roadway to the reception section of the landfill.

(b) All weather access roads will be constructed to the tipping area.

(c) Dust suppression methods additional to water spraying may be required in areas of clay soils and windy conditions.

(d) Completed landfill sections should be rehabilitated as soon as possible in order to prevent both erosion and dust emissions.

(e) Dust gauges are to be installed in accordance with Australian Standard 2724.1-1984. The absolute number of gauges and locations nominated by landfill operator and approved by the EPA.

5.4.2 SITE MANAGEMENT

A. Noise Control

Performance Goal

To ensure that noise emissions from the landfill operation do not detract from the local amenity.

Best Practice Techniques

The noise generated during the operation of the landfill depot must be managed so that the following criteria can be met:

(a) The landfill operator must ensure that the noise emanating from the site must not exceed a $L_{A,10T}$ sound pressure level of 50 dB(A) (daytime) or 40 dB(A) (night time) when measured or computed at any point within one metre of any residential boundary or other noise sensitive areas such as schools, hospitals, etc in the vicinity of the premises.

(b) The landfill operator must ensure that the noise emanating from the site must not exceed a $L_{A,10T}$ sound pressure level of 70 dB(A) when measured or computed at any point within one metre of any boundary of the premises.

For the above criteria, the $L_{A,\ 10T}$ is taken as the dB(A) level measured using a sound level meter set on the "FAST" response over a period between 10 and 15 minutes. 5 dB(A) must be added to the measured or computed level of noise if the noise is substantially tonal or impulsive in nature. Daytime is defined as between 7:00 am and 10:00 pm on Monday to Saturday, and between 8:00 am and 10:00 pm on Sunday and Public Holidays, and night time as between 10:00 pm and 7:00 am on Monday to Saturday, and between 10:00 pm and 8:00 am on Sunday and Public Holidays.

Acceptable noise attenuation measures include buffer zones, acoustical barriers, and acoustical treatment of equipment. Particular attention must be the design of items such as speed humps and vibration grids to prevent noise generation.

B. Litter Control

Performance Goal

To ensure that the local amenity is not degraded by litter and the site itself is managed in a professional manner. Wind blown litter is a nuisance to the community in the vicinity of landfill sites.

Best Practice Techniques

(a) The operator will introduce procedures that prevent the unnecessary

proliferation of litter such as continuous compaction and use of litter fences, and will be responsible for ensuring that all wind blown litter that leaves the site is retrieved.

(b) All litter fences, perimeter fences and gates should be cleared of litter on a daily basis.

(c) Exit signs need to advise transport operators that they are responsible for any litter on public roads resulting from the transport of waste.

(d) All litter that leaves the site shall be retrieved on a daily basis.

C. Pest and Vermin Controls

Performance Goal

To ensure that vermin and other pests are not present at the site in sufficient numbers to pose a health hazard to those working at, visiting or neighbouring the site. Improperly operated sites can be locations for the attraction and breeding of vermin (domestic rodents {house mouse, *Rattus* spp.}, flies and feral animals). The presence of vermin leads to amenity loss and increases potential for spreading diseases. The measures chosen for the pest and vermin control may be site specific but good house-keeping methods will contribute considerably to the achievement of the objective

Best Practice Technique

(a) Waste is to be compacted and covered keeping the amount of exposed waste to a minimum. Additional effort may be required for loads containing large amounts of highly biodegradable wastes.

(b) The landfill operator will take steps to ensure that surfaces are adequately drained to prevent ponds of stagnant water forming on the site.

(c) If alternate cover materials or systems (see Section the Covering of Waste) are used proponents shall specify the method by which they will quantitatively monitor changes in vermin population as a result of the new cover.

D. Odour Controls

Performance Goal

To ensure that landfills do not have no odour impacts, in accordance with the Clean Air Act.

Best Practice Technique

Acceptance of wastes that are highly biodegradable and improper gas management can lead to odour problems. Landfill proponents are encouraged to consider the use of a separation distance/buffer zone as a technique for controlling the off site movement of landfill odours at the planning stage. The use of sufficient distance between the landfill and sensitive receptors (*ie* residential zones) will minimise the requirement for other stringent odour controls.

The following measures will apply:

(a) The landfill operator needs to take appropriate good housekeeping steps to prevent the production of odours. The use of daily cover and immediate attention to odours waste loads will minimise the transmission of odours off site.

(b) The operator of any landfill which is identified by an odour dispersion modelling investigation (as required by Department of Planning siting criteria) as having a potential odour impact on neighbours must install and operate a meteorological station that monitors wind speed, wind direction, sigma theta (standard deviation of the horizontal fluctuation in the wind direction) and temperature.

(c) The landfill operator will maintain a record of complaints regarding odours. This should be correlated with weather conditions and deliveries of peculiar wastes.

E. Fire Fighting Capacity

Performance Goal

To have the capacity to adequately fight fires at any part of the landfill site.

Best Practice Technique

Landfills are required to demonstrate sufficient fire fighting capacity through development of a site specific fire management plan to minimise the incidence and impact of fire.

(a) Where a reticulated water supply is available pipes shall be provided from it to standpipes located so that with hose attachments water could be directed onto any part of the site.

(b) All standpipe fittings and hoses shall be selected after consultation with the local fire authority.

(c) Where a reticulated water supply is not available a stored water supply of not less than 50,000 litres with distribution capacity to reach all parts of the site shall be provided.

(d) All fire fighting facilities must be visually checked for damage on a weekly basis and test operated on a three monthly basis.

(e) Suitable additional fire fighting equipment should be installed at the flammable store and at site buildings.

(f) All fire fighting equipment should be clearly signposted and access ensured at all times.

(g) Where appropriate fire breaks should be constructed and maintained around all filled areas, stockpiles of combustibles, gas extraction equipment and site buildings.

(h) Landfill staff should be trained in fire fighting techniques.

F. Staffing and Training Requirements

Performance Goals

To ensure that the level and nature of staffing is adequate for environmentally responsible and occupationally safe management of a landfill.

Best Practice Techniques

Manpower requirements will vary as a function of size, type of wastes, diversity and complexity of site operations.

(a) Landfill operators are to provide adequate staff to ensure that during operating hours all continuous tasks; including waste reception and security, compaction and covering, are completed in compliance with an approved Landfill Management Plan.

(b) At a minimum staff training is to ensure that:

i all operators of compaction or earthworks equipment are skilled at undertaking all tasks required of them,

ii all those that operate gas testing, water sampling or water testing apparatus are familiar with required testing and sample retention protocols

iii all those that are to inspect incoming wastes are skilled at identifying wastes that are unacceptable and accurately recording data .

G. Small Vehicle Access

Performance Goal

To ensure safe and convenient access for small vehicles delivering waste to the landfill and allow efficient resource recovery.

Best Practice Technique

Small vehicles, as used by households and small businesses, can create safety and traffic management problems if allowed near the active face. Therefore:

(a) Landfill depots receiving more than 500 Tonnes/week (25,000 Tonnes/annum) of waste must segregate vehicles that are unloaded manually from vehicles which are emptied mechanically. Smaller depots may be required to separate the smaller and larger groups depending upon site design.

(b) Due to their relative instability on soft ground tri-axle tipping trailers should not be permitted to tip at the tip face except at isolated locations or where they are isolated from other traffic during their tipping activity.

(c) All landfill depots that accept small vehicle delivered waste must provide facilities for recycling deliveries and quantify recyclables from small vehicles (see Section on Recycling).

(d) All landfill depots must provide a wet weather tipping area that is accessible to all small vehicles that regularly use the landfill.

H. Bird Control

Performance Goals

To ensure that air traffic is not exposed to bird hazard. Landfills with putrescible material may attract a large number of birds, particularly gulls and ibises. Large numbers of birds near airports will increase the potential for accidents through collision with aeroplanes.

Best Practice Techniques

New SW landfills and lateral expansions of operating landfills are not to be located within 3,000 metres of an airport runway used by turbojet aircraft or within 1,500 metres of a runway used by only piston-type aircraft.

Proponent may demonstrate to the Federal Airport Commission or the Civil Aviation Authority that a site bird management program will adequately control the possibility of aeroplane-bird strikes.

5.4.3 MONITORING

A. Dust Gauges

Performance Goal

To monitor that the dust protection measures (See Section on Dust Control) are effective.

Best Practice Technique

Monitoring of dust movement off-site will be required for all sites with development within 1 kilometre of the site boundary. Sampling and testing shall be done by NATA or equivalently accredited person or laboratory.

B. Gas Accumulation Monitoring

Performance Goal

To ensure that landfill gas does not accumulate in buildings and pose a danger of explosion.

Best Practice Technique

All buildings within 250 meters of deposited waste will be tested on a monthly frequency with a catalytic oxidation instrument or flame ionisation detector (FID).

Buildings are not to have gas concentrations exceeding 1 percent (v/v) methane. If methane is detected above this threshold, ventilation is required. It is suggested that continuous methane monitors be installed in buildings equipped with ventilation that routinely exceed the threshold value.

Reports on building monitoring are to be retained on site for 4 years. These records will need to be available for inspection upon demand from an authorised EPA officer.

6 PERFORMANCE REPORTING REQUIREMENTS

To ensure compliance with the specific licence conditions placed on each facility and to enable the EPA to fulfil its State of the Environment reporting obligations, the following reporting requirements will apply to all landfills and may be set down as a separate licence condition.

6.1 Incident Reporting

Any incidents that represent a threat to the environment and which may lead to a breach of licence conditions should be communicated to the EPA immediately. Initial contact can be through the telephone with written notice following. A non-exhaustive list of these events includes:

a) identification of non-domestic quantities of hazardous wastes amongst mixed solid waste,
b) fires at the landfill,
c) accidental release of leachate into stormwater,
d) identification of any failure of an environmental protection system such as the liner,
e) identification of significant difference in groundwater indicator parameter (written notice within 14 days),
f) detection of subsurface gas migration in perimeter gas well at greater than 5 percent (v\v) methane (written notice within 14 days),
g) any other incident or observation that could potentially pose an immediate environmental hazard, and
h) proposed change in the landfill's ownership or operator.

6.2 Monthly Reports

Each month the operator will be required to send to the EPA the total tonnage of waste received and tonnages of specific source separated wastes. This report is due by the 14th day of the following month in a format specified by the EPA.

6.3 Annual Report

Each year the following information shall be provided in support of the annual license renewal application:

a) Summary Report of the total wastes received (including cover), its composition and its eventual fate (including recycling markets). In order to satisfy a mass balance calculation of wastes received and disposals it may be necessary to identify mass losses in composting or other process.

b) An independent surveyors report of the volume of landfill space consumed in the period for which the report is prepared and the estimate of compaction that this volume represents.

c) An estimate of remaining landfill capacity.

d) A hydrogeological report that assesses the groundwater changes over the past, updated for the last 12 months.Any changes in hydraulic gradient or statistically significant variations in contaminant concentrations should be highlighted and explained.

e) A leachate collection report that identifies the quantity and composition of the leachate generated over the past 12 months. The trends that can be demonstrated should be highlighted and explained in terms of the biological activity within the landfill.

f) A landfill gas emissions report to demonstrate achievement of the appropriate environmental objectives. Perimeter well monitoring results shall be presented in graphical and tabular format. Where extraction is occurring the composition of the raw gas and the stack gases should be identified and any changes over time explained.

g) The record of odour, litter or other complaints that have been received by the depot in the past 12 months and their correlation with prevailing weather conditions or waste reception circumstances commented upon.

h) A summary report of surface water monitoring updated over the past 12 months and including all previous years data.

i) A summary of any dust monitoring results gathered over the past 12 months.

j) A summary of important incidents (drawn from incident reports) for the 12 month period.

APPENDIX A

SUMMARY MATRIX INDICATING THE RANGE OF BEST PRACTICE ACTIONS TO ADDRESS EACH ENVIRONMENTAL CONCERN

Summary Matrix Indicating the Range of Best Practice Actions to Address Each Environmental Concern

	Environmental Objectives			
TOOLS	**Preventing Emissions to Water**	**Preventing Atmospheric Impacts**	**Promoting Responsible Land Management & Conservation**	**Protection of Amenity & Avoiding Hazards**
Design & Construction	Liner, Leachate Collection System, Surface Water Controls, Design of Monitoring Wells & Lysimeters	Landfill Gas Monitoring Device, Gas Extraction System, Liner	Construction Quality Assurance, Weighbridge	Site security, Wheel Washing Facilities, Dust Control
Site Management	Covering of Wastes, Buffer Zones, Leachate Management Plan	Active Gas Extraction, Covering of Wastes, Fire Prevention, Landfill Gas Management Plan, Burning of Waste	Waste Acceptance and Screening Program, Landfill Management Plan, Covering of Wastes, Recycling Facilities	Covering of Wastes, Noise Control, Litter Control, Pest and Vermin Control, Odour Control, Small Vehicle Access, Separation Distances, Staffing and Training Requirements, Fire Fighting Capacity, Bird Control
Monitoring	Groundwater Detection Monitoring Program, Groundwater Assessment Program, Surface Water Monitoring Program, Groundwater Detection Monitoring Reports, Surface Water Report	Sub-surface Gas Migration Monitoring, Surface Gas Emission Monitoring, Analysis of Landfill Gas Oxidation Emissions, Landfill Gas Emissions Report	Waste Reception Records, Leachate Monitoring Program, Leachate Collection Report	Dust Gauges, Explosion Protection, Immediate Reporting, Monthly Report, Annual Report
Rehabilitation	Groundwater Contamination Remediation Plan, Closure - Capping and Revegetation, Post Closure Care, Certificate of Completeness, Financial Guarantees	Closure - Capping and Revegetation, Post Closure Care, Certificate of Completeness, Financial Guarantees	Filling Plans and Contours, Closure - Capping and Revegetation, Post Closure Care, Certificate of Completeness, Financial Guarantees	Certificate of Completeness, Financial Guarantee

APPENDIX B

LIST OF ANALYTES FOR GROUNDWATER ASSESSMENT MONITORING PROGRAM

Groundwater Assessment Program Analytes

Acenaphthene
Acenaphthylene
Acetone
Acetonitrile
Acetephenone
2-Acetylaminofluorene
1-Acetyl-2-thiourea
Acrolein (propenal)
Acrylonitrile
Aldrin
Allyl alcohol
Allyl chloride
4-Aminobiphenyl
2-Aminoanthraquinone
Aminoazbenzene
Aniline
Anilazine
o-Anisidine
Anthracene
Aramite
Aroclor-1016 (PCB- 1016)
Aroclor-1221 (PCB- 1221)
Aroclor-1232 (PCB- 1232)
Aroclor-1242 (PCB- 1242)
Aroclor-1248 (PCB- 1248)
Aroclor-1254 (PCB- 1254)
Aroclor-1060 (PCB- 1060)
Azinphos-ethyl
Azinphos-methyl
Barban
Benzal chloride
Benz(a) anthracene
Benzene
Benzidine
Benzoic acid
Benzo (b) fluoranthene
Benzo(j) fluoranthene
Benzo(k) fluoranthene
Benzo (g,h,i) perylene
Benzo pyrene
p-Benzoquinone
Benzyl alcohol
Benzyl chloride
BHC (Hexachlorocyclohexane)
gamma BHC (Lindane)
alpha BHC
beta-BHC
delta-BHC
Bis (2-chloroethoxy) methane
Bis (2-chloroethyl) ether
Bis (2-chloroisopropyl) ether
Bis (2-ethylhexyl) phthalate
Bolstar (Sulprofos)
Bromoacetone
Bromobenzene
Bromochloromethane
Bromodichloromethane
4-Bromofluorobenzene
Bromoform
Bromomethane
4-Bromphenyl phenyl ether
Bromoxynil
2-Butanone (Methyl ethyl ketone, MEK)
2-sec-Butyl-4,6-dinitrophenol(DNBP)
n-Butylbenzene
sec-Butylbenzene
tert-Butylbenzene
Butyl Benzyl Phthalate
Captafol
Captan
Carbaryl
Carbofuran
Carbofenthion (Carbophenthion)
Carbon disulfide
Carbon tetrachloride
Chlordane
chlorfenvinphos
chlorinated dibenzodioxins
4-Chloro-3-methylphenol
5-Chloro-2-methylaniline
4-Chloroaniline
Chlorobenzene
Chlorobenzilate
Chlorodibromomethane
Chloroethane
2-Chloroethanol

2-Chloroethyl vinyl ether
Chloroform
Chloromethane
1-Chloronaphthalene
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl phenyl ether
Chloroprene
3-Chloropropionitrile
2-Chlorotoluene
4-Chlorotoluene
5-Chloro-o-toluidine
3-(Chloromethyl) pyridine hydrochloride
Chlorpyrifos
Chrysene
Coumaphos
Creosote
p-Cresidine
Cresols (Methyl Phenols, Cresylic acids)
o-Cresols (2-Methylphenol)
m-Cresol (3-Methylphenol)
p-Cresol (4-Methylphenol)
Cresote
Crotoxphos
2-Cyclohexyl-4, 6-dinitrophenol
Cyanide
2,4-D
Dalapon
2,4-DB
4,4'-DDD
4,4'-DDE
4,4'-DDT
Demeton-O, and-S
Diallate (cis or trans)
2,4-Diaminotoluene
Diazinon
Dibenz(a,h) acridine
Dibenz(a,j) acridine
Dibenz(a,h) anthracene
7H-Dibenzo(c,g)carbazole
Dibenzo(a,e)pyrene
Dibenzo(a,h)pyrene
Dibenzo(a,i)pyrene
Dibenzofuran
Dibromochloromethane
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
Dibromomethane
Di-n-butyl phthalate
Dicamba
Dichlone
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Dichlorobenzene(s)
3,3'-Dichlorobenzidine
1,4-Dichloro-2-butene
1,3-Dichloro-2-propanol
Dichlorodifluoromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene (Vinylidene chloride)
cis-1,2-Dichloroethene
trans-1,1-Dichloroethene
Dichloromethane (Methylene chloride)
2,4-Dichlorophenol
2,6-Dichlorophenol
Dichlorophenoxyacetic acid
Dichloroprop
1,2-Dichloropropane
1,3-Dichloropropane
2,2-Dichloropropane
1,1-Dichloropropene
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Dichlorovos
Dicrotophos
Dieldrin
1,2,3,4-Diepoxybutane
Diethyl ether
Diethylstilbestrol
Diethyl sulfate
Diethyl phthalate
1,4-Difluorobenzene
Dimethoate
3,3'-Dimethoxybenzidine
3,3'-Dimethylbenzidine
Dimethyl phthalate
p-Dimethylaminoazobenzene
7,12-Dimethylbenz (a) anthracene
a,a-Dimethylphenethylamine
2,4-Dimethylphenol
4,6-Dinitro-2-methylphenol
Dinitrobenzene

1,2-Dinitrobenzene
1,3-Dinitrobenzene
1,4-Dinitrobenzene
4,6-Dinitro-o-cresol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Dinocap
Dinoseb
Di-n-octyl- phthalate
1,4-Dioxane
Dioxathion
Diphenylamine
5,5-Diphenylhydantoin
1,2-Diphenylhydrazine
Disulfoton
Endosulfan I
Endosulfan I
Endosulfan sulfate
Endrin
Endrin aldehyde
Endrin ketone
Epichlorohydrin
EPN
Ethanol
Ethion
Ethoprop
Ethylbenzene
Ethyl carbamate
Ethyl methacrylate
Ethyl methanesulfonate
Ethylene oxide
Famphur
Fensulfothion
Fenthion
Fluchloralin
Fluoranthene
Fluorene
2-Fluorobiphenyl
2-Fluorophenol
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclohexane
Hexachlorocyclopentadiene
Hexachloroethane
Hexachlorophene
Hexachlorpropene
Hexamethyl Phosphoramide(HMPA)
2-Hexanone
HMPA (Hexamethyl phosphoramide)
1,2,3,4,6,7,8-HpCDD
1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF
1,2,3,4,,7,8-HxCDD
1,2,3,4,7,8-HxCDF
Hydoquinone
2-Hydroxypropionitrile
Ideno(1,2,3-cd) pyrene
Iodomethane
Isobutyl alcohol
Isodrin
Isophorone
Isopropylbenzene
p-Isopropyltoluene
Isosafrole
Kepone
Leptophos
Malathion
Maleic anhydride
Malononitrile
MCPA
MCPP
Merphos
Mestranol
Methacrylonitrile
Methapyrilene
Methoxychlor
3-Methylcholanthrene
2-Methyl-4,6-dinitrophenol
4,4'-Methylenebis (2-chloroaniline)
Methylene chloride (Dichloromethane)
Methyl ethyl ketone (MEK, 2-Butanone)
Methyl Iodide
Methyl Isobutyl ketone (MIBK)
Methyl methacrylate
Methyl methanesulfonate
2-Methylnaphthalene
Methyl Parathion
4-Methyl-2-pentanone (MIBK)
2-Methylphenol (o-Cresol)
3-Methylphenol (m-Cresol)
4-Methylphenol (p-Cresol)

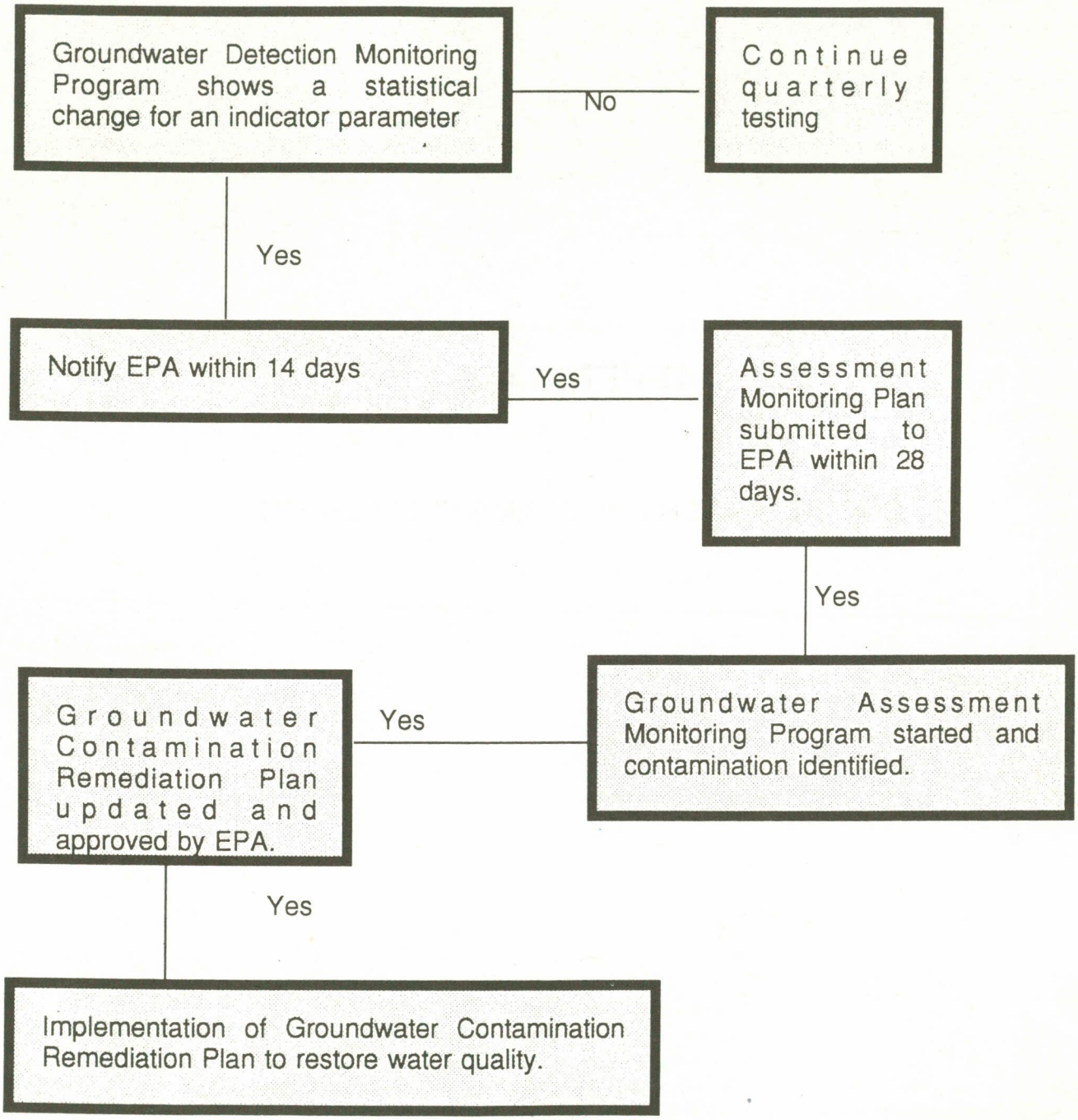
Mevinphos
Mexacarbate
Mirex
Naled
Naphthalene
1,4-Naphthoquinone
1-Naphthylamine
2-Naphthylamine
5-Nitroacenaphthene
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
5-Nitro-o-anisidine
Nitrobenzene
4-Nitrobiphenyl
Nitrofen
2-Nitrophenol
4-Nitrophenol
4-Nitroquinoline-1-oxide
N-Nitrosodibutylamine
N-Nitrosodiethylamine
N-Nitrosodimethlamine
N-Nitrosodiphenylamine
N-Nitrosodi-n-propylamine
N-Nitrosomethylethylamine
N-Nitrosomorpholine
N-Nitrosopiperidine
N-Nitrosopyrrolidine
5-Nitro-o-toluidine
OCDD
OCDF
Octamethyl pryophosphoramide
4,4'-Oxydianiline
Parathion
Parathion ethyl
Parathion methyl
PCB-1016 (Aroclor-1016)
PCB-1221 (Aroclor-1221)
PCB-1232 (Aroclor-1232)
PCB-1242 (Aroclor-1242)
PCB-1248 (Aroclor-1248)
PCB-1254 (Aroclor-1254)
PCB-1260 (Aroclor-1260)
1,2,3,4,7-PeCDD
1,2,3,7,8-PeCDD
1,2,3,7,8-PeCDF
Pentachlorobenzene
Pentachloroethane
Pentachlorohexane
Pentachloronitrobenzene
Pentachlorophenol
Phenacetin
Phenanthrene
Phenobarbital
Phenol
1,4-Phenylenediamine
Phorate
Phosalone
Phosmet
Phosphamidion
Phthalic anhydride
2-Picoline
Piperonyl sulfoxide
beta-Propiolactone
Pronamide
Propargyl alcohol
Propionitrile
n-Propylamine
n-Propylbenzene
Propylthiouracil
Pyrene
Pyridine
Resorcinol
Ronnel
Safrole
Stirophos
Strychnine
Styrene
Sulfallate
Sulfide
Sulfotep
2,4,5-T
2,3,7,8-TCDD
1,2,3,4-TCDD
1,3,6,8-TCDD
1,3,7,9-TCDD
1,3,7,8-TCDD
1,2,7,8-TCDD
1,2,8,9-TCDD
2,3,7,8-TCDF
1,2,7,8-TCDF
TEPP
Terbuphos
1,2,4,5-Tetrachlorobenzene

Tetrachlorobenzene(s)
1,1,2,2 -Tetrachloroethane
1,1,1,2 -Tetrachloroethane
Tetrachloroethene
2,3,4,6-Tetrachlorophenol
Tetrachlorophenol(s)
Tetrachlorvinphos (Stirophos)
Tetraethyl pyrophosphate
Thionazine
Thiophenol (Benzenethiol)
TOCP
Tokuthion (Prothiofos)
Toluene
Toluene diisocyanate
o-Toluidine
Toxaphene
2,4,5-TP (Silvex)
2,4,6-Tribromophenol
1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethane
Trichlorofluoromethane
Trichloronate
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Trichlorophenol(s)
1,2,3-Trichloropropane
Trifluralin
2,4,5-Trimethylaniline
1,2,4-Trimethylbenzene
1,2,5-Trimethylbenzene
Trimethyl phosphate
1,3,5-Trinitrobenzene
Tris(2,3-dibromopropyl) phosphate
Tri-p-tolyl phosphate
O,O,O-Triethyl phosphorothioate
Vinyl acetate
Vinyl chloride
o-Xylene
m-Xylene
p-Xylene
Xylenes (total)

APPENDIX C

GROUNDWATER PROGRAMS FLOW CHART

Groundwater Monitoring Flow Chart - Actions Required



APPENDIX D

DRAFT MONTHLY DEPOT REPORTING FORM

MONTHLY DEPOT RETURNS

Depot ID ☐
(As per licence registration)

Date Return Lodged ___ / ___ / ___

This return covers the month of ☐ **in the year** ☐

1. Municipal Waste received during the specified month. (All unit in Tonnes)

Enter name of LGA

LOCAL GOVERNMENT AREA (LGA)	GREEN/ VEGETATION RECYCLED	ORGANIC WASTE FOR COMPOSTING	DOMESTIC WASTE DISPOSED(A1)	OTHER DOMESTIC WASTE DISPOSED(A2)	OTHER COUNCIL WASTE DISPOSED(A3)
Total					

Total Municipal Waste Disposed (A1+A2+A3) ☐ **A**

2. Other Waste received during the specified month (All unit in Tonnes)

See glossary of terms

MATERIAL TYPES	WASTE DISPOSED
Commercial/Industrial (Mixed Waste)	
Building/Demolition (Mixed Waste)	
Tyres	
Grease Trap Waste	
Sludges	
Clinical / Pharmaceutical	
Contaminated Soils	
Asbestos	
Special Waste(specify)	
Special Waste(specify)	
Special Waste(specify)	

Total Other Waste Disposed ☐ **B**

3. Small Vehicles

	Number of		Weight Factor		Tonnes
Cars and Station Wagons	☐	times	☐	=	☐
Utes, can and Trailers	☐	times	☐	=	☐

Total small vehicle waste disposed ☐ **C**

4. Transfer Waste

(To be filled in by Transfer Station) *(Landfills accepting Waste from transfer Stations)*

WASTE TRANSFERRED OUT To Depot ID *(Use Depot Tables)*	Tonnes	WASTE TRANSFERRED IN From Depot ID *(Use Depot Tables)*	Tonnes
Total Transferred Out		**Total Transferred Waste Disposed**	

D

5. Recyclable And Compostable Materials

	OPENING STOCK	TONNES RECIEVED	TONNES OUT	TONNES DISPOSED	CLOSING STOCK
Organic Compostable					
Green/Vegetation					
Brick / Concrete					
Building Materials(Seperated)					
Paper / Cardboard					
Glass					
Ferrous / Carbody					
Non - Ferrous / Aluminion					
Plastics / PET					
Other (Specify)					
Other (Specify)					
Other (Specify)					
Other (Specify)					

Total Recyclable / Compostable Materials Disposed **E**

6. Operational Materials

	OPENING STOCK	TONNES IN	TONNES OUT	TONNES DISPOSED	CLOSING STOCK
Clean Fill					
Cover & Construction Materials					
Capping Materials					

Total Operational Materials Disposed **F**

Total Tonnage Received At Landfill **(A+B+C+D+E+F)**

Vehicle Types and Weight Factors

Vehicle type	Description	Weight Factor		
Small Vehicle		All mixed wastes		
A	Car/Station Wagon	0.06		
B	Van/Ute/Trailer	0.03		
Open Truck		Municipal & Commercial	Demolition	Clean Fill
C&D 1	Single rear axle with two rear wheels or four small rear wheels	0.62	0.98	2.47
D 2	Single rear axle with four normal size wheels	1.16	2.76	5.58
E	Tandem rear axle (bogie drive)	3.74	7.14	10.97
F	Twin steer/twin rear axles	5.57	7.61	10.97
G	Tipping semi-trailer	5.79	15.00	15.00
Enclosed Truck and Compactor		All mixed wastes		
H	Single steer/single rear axle	2.72		
I	Single steer/ tandem rear axle	6.38		
J	Twin steer/tandem rear axle	7.96		
K	Waste transfer truck	19.89		

Waste Description

A. MUNICIPAL WASTE

1. DOMESTIC WASTE: household waste put out by residents for kerbside collection by council or council's contractors.

2. OTHER DOMESTIC WASTE: clean-up waste, garden waste, disused furniture, discarded household items etc, collected by council or council's contractors.

3. OTHER COUNCIL WASTE: street sweepings, litter bins, parks and gardens, street tree loppings and other council materials.

B. COMMERCIAL / INDUSTRIAL WASTE

Waste arising from institutional, commercial, industrial activities which are non-hazardous and being disposed of at facilities owned by local authorities and/or the private sector.

C. DEMOLITION / BUILDING WASTE

Waste arising from demolition and building activities which include council's building and road works.

D. CLEAN FILL

Natural excavated soil imported for use as cover materials

SELECTED REFERENCES

American Public Health Association, American Water Works Association and Water Environment Federation. 1992. *Standard Methods for the Examination of Water and Wastewater (18th Edition).* APHA, Washington.

ANZECC. 1992a, *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australia and New Zealand Environment and Conservation Council, Canberra.

ANZECC, 1992b, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.* Australia and New Zealand Environment and Conservation Council, Canberra.

Akgün, H. and R. B. Wallace. 1993. *Solid Waste Containment in Double Lined Systems.* Journal of Resource Management and Technology, Vol. 21, No. 6, 137-141.

California Code of Regulations, Title 14-Natural Resources, Division 7 - California Integrated Waste Management Board. *California Solid Waste Management Regulations*, Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1121:0501

Carra, J and R Cossu, eds. 1990. *International Perspective on Municipal Solid Wastes and Sanitary Landfilling A report from the International Solid Wastes and Public Cleansing Association Working Group on Sanitary Landfilling.* Academic Press, London.

Codes, Rules and Regulations of the State of New York, Title 6, Chapter IV -Quality Services, *SubChapter B - Solid Wastes, Part 360 - Solid Waste Management Facilities*; Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1261:0501

Conservation Commission of the Northern Territory. 1993. *Draft Guidelines for Siting, Design and Management of a Community Landfill Facility.* CCNT, Palmerston.

Department of Environment and Natural Resources. 1994. *Draft Code of Practise for Solid Waste Disposal Depots.* SA Waste Management Commission, Adelaide.

Department of Environment and Planning. 1992. *Tasmanian Solid Waste Management Policy, Position Paper.* Division of Environmental Management. Hobart.

Department of Environment (UK). 1986. *Landfill Practises, Waste Management Paper No 26.* Department of Environment, London.

Department of Environment (UK). 1991. *Landfill Gas, Waste Management Paper No 27.* Department of Environment, London.

Department of Water Resources. 1992. *River Water Quality Monitoring Strategy: Key sites Program Operations Manual.* Department of Water Resources, Parramatta.

Di Stefano and AD Needhan. 1994. *Geosynthetic lining of steep wall quarry landfills utilising polystyrene facings.* Waste Management. February.

Environment Council. 1994. *Amended Proposal for a Council Directive on the Landfill of Waste*; Cat No; CB-CO-93-305-EN-C; Office for Official Publications of the European Communities, Brussels.

Environment Protection Authority. 1994. *Draft Guideline on Leachate Assessment of Industrial Solid Waste for Landfill Disposal.* New South Wales EPA, Sydney.

Environment Protection Authority. 1994b.*Water Quality Investigations Manual, Preferred Methods for Sampling and Analysis-Draft.* New South Wales EPA, Sydney.

Federal Ministry for the Environment. 1993. *Environmental Policy in Germany, Technical Instructions on Waste from Human Settlements (TA Siedlungsabfall) and Supplementary Recommendations and Information.* The Federal Ministry for the Environment (Translated by Language Services of the Federal Environment Ministry), Bonn.

German Geotechnical Society (editors). 1991. *Geotechnics of Landfills and Contaminated Land Technical Recommendations "GLC".* Ernst & Sohn Verlag Für Archektur und technische Wissenschaften, Berlin.

Health Department of Western Australia. 1993. *Draft Code of Practice, Country Landfill Management and Country Landfill Burning Requirements.* HDWA, Perth.

Health Department of Western Australia. 1993. *Draft Criteria for Landfill Management.* HDWA, Perth.

Health Department of Western Australia. 1993. *Draft Landfill Sites - Waste Acceptance Criteria.* HDWA, Perth.

Hirschberg, K-J. 1993. *Guidelines for Groundwater Monitoring at Municipal Landfill Sites.* Geological Survey of Western Australia, Perth.

Hopper, D. 1993. *Opting for an Impermeable Gas and Leachate Barrier.* Waste Management. February.

Kast K and J Brauns. *Controllable and Repairable Liner System for Landfills.* Proceedings of Sardinia 93, Fourth International Landfill Symposium, S. Margherita di Pula, Cagliari, Italy; 11-15 October 1993.

Lee, GF and A Jones-Lee. 1993. *Revisions of State MSW Landfill Regulations: Issues for Consideration for the Protection of Groundwater Quality.* Environmental Management Review, No. 29, Third Quarter, 31-54.

Maryland Solid Waste Management Regulations (Code of Maryland Regulations, Title 26, Department of the Environment, Subtitle 04, Regulation of Water Supply, Sewage Disposal and Solid Waste, Chapter 07 - Solid Waste Management); Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1201:0501.

New Jersey Administrative Code, Title 7, Department of Environmental Protection, Chapter 26 - Bureau of Solid Waste Management. *New Jersey Solid and Hazardous Waste Management Regulations*; Environment Reporter; Bureau of National Affairs Inc; Washington DC; 1251:0501.

New Jersey Statutes Annotated, Title 13, Conservation and Development - Parks and Reservations, *Chapter 1E - Solid Waste Management, Sections 100 et seq.*; Environment Reporter; Bureau of National Affairs Inc; Washington DC; 1251:0221

Overmann LK, JW Cowland, NK Mattravers, WK Shung, BS Lee and CH Wan. *Chemical Resistance Testing of Liner Materials for Hong Kong Landfills.* Proceedings of Sardinia 93, Fourth International Landfill Symposium, S. Margherita di Pula, Cagliari, Italy; 11-15 October 1993.

Parametrix, Inc. 1987. *Solid Waste Landfill Design Manual.* Washington State Department of Ecology, Olympia.

Pennsylvania Code 25 - Environmental Resources, *Chapter 273 - Municipal Waste Landfills); Environment Reporter*; Bureau of National Affairs Inc.; Washington DC; 1291:1101

Pierson P, T Pelte and JP Gourc. *Behaviour of Geomembranes Exposed to Solar Radiation.* Proceedings of Sardinia 93, Fourth International Landfill Symposium, S. Margherita di Pula, Cagliari, Italy; 11-15 October 1993.

Rhode Island Department of Environmental Management, Division of Air and Hazardous Materials, *Regulation DEM-DAHM-SW03-92 - Rules and Regulations for Solid Waste Management Facilities*; Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1301:0501

Row RK and MJ Fraser. *Long Term Behaviour of Engineered Barrier Systems.* Proceedings of Sardinia 93, Fourth International Landfill Symposium, S. Margherita di Pula, Cagliari, Italy; 11-15 October 1993.

Rudolph, V and A Krol. 1994. *MSW Landfills - a research perspective.* In Landfill '94 A Seminar dealing with current landfill regulatory and technical issues. Banksia Environmental Foundation, North Ryde.

Standards Association of Australia. 1984. *Australian Standard 2724.1-1984 Ambient Air-Particulate Matter Part 1-Determination of Deposited Matter as Insoluble Solids, Ash, Combustible Matter, Soluble Solids and Total Solids.* Standards Association of Australia, North Sydney.

Standards Association of Australia. 1987. *Australian Standard 2990-1987. Quality Systems for Engineering and Construction Projects.* Standards Association of Australia, North Sydney.

Texas Administrative Code, Title 31 - Natural Resources and Conservation, Part IX Texas Water Commission, *Chapter 330 - Municipal Solid Waste*; Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1321:0501

USEPA. 1989. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (PB89-151047), Office of Solid Waste, Washington.

USEPA. 1991. *Handbook: Groundwater. Volume II: Methodology* (EPA/625/6-90/016b), Center for Environmental Research Information, Cincinnati.

USEPA. 1991b. *Solid Waste Disposal Facility Criteria; Final Rule.* 40 CFR Parts 257 and 258, Federal Register 56(196): 50978-51119,Washington.

USEPA. 1991c. *Standards of Performance for New Stationary Sources: Standards of Performance for Municipal Solid Waste (MSW) Landfills.* 40 CFR Part 60. Federal Register 56(104) : 24468-24528, Washington.

USEPA. 1992. *SW-846 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Office of Solid Waste and Emergency Response, Washington D.C.

Victorian Government Gazette. 1991. *State Environment Protection Policy (Siting and management of Landfills Receiving Municipal Wastes) made pursuant to the Environment Protection Act 1970.* No S40, Melbourne.

West Virginia Code of State Regulations, Title 47, Legislative Rules, Department of Natural Resources, *Series 38 - Solid Waste Management,* Environment Reporter; Bureau of National Affairs Inc.; Washington DC; 1346:0501

GLOSSARY

Amenity - The current existence of healthy, pleasant and agreeable (community) surroundings

Aquifer - A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

Attenuation zone - A part of an aquifer adjacent to the tipping area where pollutants in leachate are attenuated by natural processes.

Batch - Samples taken from one site in one day.

Beneficial use - Any use of the environment which is of public benefit including welfare, safety, health or aesthetic enjoyment. It further includes any natural resource.

Biosolids - The particulate matter, mainly organic, removed during sewage treatment (previously referred to as sewage sludge).

Bird hazard - Means an increase in the likelihood of bird/ aircraft collisions that may cause damage to the aircraft or injury to its occupants.

Building and demolition waste - Waste material arising as a result of new building construction, refurbishment or demolition of existing buildings/structures. Materials include bricks, tiles, concrete, steel, glass, plastics and other products generally used in the building industry. Soil or naturally occurring excavated material (clean fill) is in connection with construction activities is also classified as building and demolition waste.

Buffer distance - The distance between the tipping area of a landfill site and a segment of the environment to be protected.

Cell - A section of solid waste that is formed by an earth compartment, compacted and covered over with cover material in a solid waste landfill depot.

Clean fill - Material consisting of clay, soil, crushed rock and like inert mineral filling, up to a maximum of 200 mm in size which is not contaminated.

Closure plan - A plan, specifically tailored to be appropriate for an individual site, establishing procedures for the closure of the site.
Information to be included in this plan includes:

a	Timetable for staged rehabilitation
b	Final contours
c	Revegetation program
d	Proposed post closure use

Commercial waste - Waste material generated by commercial establishments such as office buildings, stores, markets, theatres, hotels and warehouses which is of a non hazardous waste.

Composting - The process of using micro-organisms to convert organic material into humus for soil conditioner and low-grade fertiliser.

Construction waste - Solid waste material discarded from construction sites, not including hazardous or biodegradable material.

Cover material - Material used to cover compacted solid waste at waste disposal depots.

Decomposition - The breakdown of organic waste materials by micro-organisms.

Demolition waste - Waste materials produced from the destruction of buildings, roads and footpaths not including biodegradable material or hazardous waste.

Effluent - Any matter or thing whether solid or liquid or a combination of any solids and liquids, that is of a kind that may be removed from a septic tank, septic closet, chemical closet, sullage pit or grease trap, or from any holding tank or other container forming part of or used in connection with a septic tank, septic closet, chemical closet, sullage pit or grease trap.

Energy recovery - Resource recovery in which all or part of the waste materials going into a recovery facility are burned to produce energy for heating or cooling purposed or the generation of electricity.

EPA - New South Wales Environment Protection Authority.

Garbage - All refuse other than trade waste and effluent. Garbage is conventionally thought of as the organic waste materials, usually food wastes, that decompose and putrefy.

Groundwater - Any water contained in or occurring in an aquifer.

Green waste - Organic putrescible material including foodstuffs, grass and wood as specified in the National Waste Classification System.

Hazardous waste - Any waste containing significant quantities of a substance which may present danger-

* to the life or health of living organisms when released into the environment; or
* to the safety of humans or equipment if incorrectly handled;

and is specified in the "Major Groups of Hazardous Wastes" below:

* cyanides, surface treatment and heat treatment wastes
* acids
* alkalis

* inorganic chemicals
* reactive chemicals
* paints, lacquers, varnish, resins, inks, dyes, pigments, adhesives
* organic solvents, solvent residues
* pesticides
* oils, hydrocarbons, emulsions
* industrial washwaters, effluents
* organic chemicals
* solid/sludge waste requiring special handling
* clinical and pharmaceutical wastes
* declared chemical wastes under the Environmentally Hazardous Chemicals Act, 1985.

This classification Includes industrial waste with leachate contaminant concentrations greater than those outlined in Table 1 of "Environmental Guideline -Landfill Disposal of Industrial Waste", 1993.

Hazardous Waste properties includes toxicity, flammability, chemical reactivity, corrosivity and infectiousness.

Industrial waste - Waste material generated by industrial or manufacturing processes which does not include hazardous waste or biodegradable material.

Inert waste - Waste which does not undergo physical, chemical or biological transformations. This class of waste includes building (demolition wastes), gravel, stone, soil. Inert waste is distinct from and does not include any biodegradable waste, hazardous wastes and green waste (garden waste, trees and leaves)

Landfill gas - Gaseous emissions from the anaerobic decomposition of waste.

Landfill gas management plan - A plan, specifically tailored to be appropriate for an individual site, establishing procedures for the monitoring and control of landfill gas.
This plan shall ensure that:

a. landfill gas does not pose an explosion hazard
b. the community amenity is not degraded by odour emissions
c. community health is not degraded by emissions of hazardous air pollutants
d. the impact of greenhouse gas emissions is minimised

Landfill management plan (LMP) - A detailed plan of the operations of a landfill site from its greenfield state to its fully rehabilitated state including after-care.

Leachate - Liquid that has percolated through waste and has extracted dissolved or suspended materials from it.

Litter - Solid waste that has been carelessly discarded and is outside the collection system.

Lysimeter - An instrument to collect water flowing through the vadose zone or unsaturated zone in soil.

Material recovery - A form of resource recovery in which the emphasis is on separating and processing waste materials.

Medical waste - Any waste material consisting of body parts, syringes, surgical equipment, vessels containing liquid body substance or cultures. Cytotoxic, animal carcasses and veterinary equipment are also in this category.

Methane (CH_4) - An explosive, odourless and colourless gas produced in a landfill by putrescible waste undergoing anaerobic decomposition.

Solid waste (SW) - means any biodegradable (putrescible) or inert wastes generated at domestic, commercial, industrial or construction sites including night soil or spadeable (contain less than 70-75% moisture) bio-solids. Liquid and hazardous wastes are not included in this classification.

Solid waste landfill - A site for the disposal of municipal solid waste by landfilling.

Putrescible waste - Biodegradable waste able to be decomposed by microbial action including green waste.

Recycling - A resource recovery method involving the collection and processing of a waste product for use as a raw material in the manufacturing of the same product or a similar one.

Regional Waste Authority - The regional body of local councils responsible for planning and ensuring a high standard of waste management of all solid wastes generated within their region.

Regional Waste Management Plan - The integrated regional waste management plan produced by the RWA with strategies developed after planners have conducted a thorough assessment of the waste generated and the waste disposal options.

Relative percent difference - The mean of duplicate samples divided by the average and expressed as a percent.

Resource recovery - The extraction and utilisation of materials from mixed waste. Materials recovered can be used in the manufacture of new products. Recovery of value includes energy by utilising components of waste as a fuel, production of compost using solid waste as a medium, and reclamation of land.

Run off - The portion of precipitation that drains from an area as surface flow.

Run on - Where surface water runs off one site and flows onto the site in question (ie. the landfill site)

Sanitary landfill - A method of disposing of waste on land without creating nuisances or hazards to public health or safety.

Spadeable sludge - A sludge material that behaves sufficiently like a solid to be able to be moved by a spade in normal outdoor temperatures.

Sludge - Semi-liquid waste that is the residue from the treatment of sewage or other industrial process.

Surface water - Surface water includes all natural and man made waterways or channels whether flow is intermittent or not; all lakes and impoundments (except lined dams associated with landfilling activities; and other marshes, lagoons and swamps.

Trade waste - Any matter or thing, whether solid, gaseous or liquid or a combination of solids, gases and liquids (or any of them), that is of a kind that comprises refuse from any industrial, chemical, trade or business process or operation, including any building or demolition work.

Transfer station - A waste handling facility used to transfer waste from collection vehicles to a bulk haul vehicle in order to achieve long distance transportation efficiency. It may also be used to sort and redirect waste with the potential to recycle prior to disposal.

Uppermost Aquifer - The nearest geological media to the base of the landfill which does or could potentially act as an aquifer.

Vadose Zone - The zone beneath the topsoil and overlying the water table, in which water in pore spaces coexists with air or in which the geological materials are unsaturated.

Vector - A carrier that is capable of transmitting a pathogen from one organism to another.

Waste - means effluent, garbage or trade waste, and it includes any substance, matter or thing prescribed by the regulations to be waste for the purposes of this section. A substance, matter or thing is not precluded from being waste for the purposes of this Waste Disposal Act merely because it can be, has been, or is partially refined or recycled.

Waste depot - A depot is a place for the reception, storage, treatment or disposal of waste and includes a place declared by regulation to be a waste depot.

Water table - The level of the upper surface of groundwater.