ENVIRONMENTAL GUIDELINES: SOLID WASTE LANDFILLS

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EPA NSW

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1. INTRODUCTION

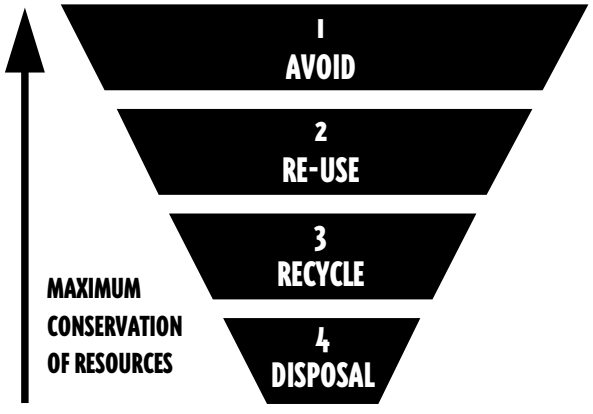
1.1 WASTE MANAGEMENT IN PERSPECTIVE

The number one priority in waste management in NSW is to reduce the amount of waste we produce. The NSW Government is committed to reducing the waste that is disposed of by 60% per capita by the year 2000, using 1990 as the base year. This target is consistent with worldwide trends and is underpinned by the philosophy of ecologically sustainable development (ESD), which requires us to use scarce natural resources more efficiently, and avoid the environmental impacts of waste disposal.

Figure 1 shows the framework that is guiding waste management in NSW. Our primary aim is to maximise conservation of resources through the effective avoidance and diversion of waste. Although we recognise that waste is best reduced or avoided at the point of production or generation, we also recognise the need for strategies for re-using and recycling those wastes that are generated. Inevitably, some waste will need to be disposed of to landfill, but this is now viewed as a last resort which also needs to be carried out in an environmentally effective and efficient manner, consistent with ESD principles.

FIGURE 1

THE WASTE MANAGEMENT HIERARCHY



1. Avoiding waste
2. Re-using materials
3. Recycling and reprocessing materials
4. Waste disposal (if the first three are not possible)

Source: EPA

Our current policy and program priorities reflect the philosophy and principles outlined above, and place the greatest emphasis on the following:

- supporting local government efforts to improve the efficiency and effectiveness of waste management
- developing green waste reprocessing systems, and facilitating the development of markets to enable the phasing out of garden waste going to landfill
- increasing re-use and recycling of building and demolition wastes
- setting targets and specific actions for reducing waste produced by significant waste-generating industries (tyres, paper, packaging)
- educating the community to reduce waste through more selective purchasing of recycled, recyclable, re-usable or refillable products, and by rejecting excessive packaging
- requiring government agencies to set the pace as model waste managers through progressive purchasing and recycling policies.

1.2 THE ROLE OF LANDFILLING

Within this framework, landfills are a mechanism for effectively treating and disposing of those wastes which, at the present time, it is neither technically feasible nor economically viable to avoid, re-use, recycle or reprocess.

The EPA is committed to ensuring that this unavoidable waste disposal is conducted in an environmentally responsible way. This includes ensuring that existing and potential landfill occupiers are aware of the risks landfilling poses to the quality of air, water, land and community amenity. It also involves ensuring that these occupiers take responsibility for managing these risks in the most effective way possible, e.g. by encouraging stabilisation of landfilled waste within one generation.

1.3 THE PERFORMANCE-BASED APPROACH

The purpose of these Guidelines is to launch a consistent and environmentally responsible approach to managing landfills across NSW. This is vital to instilling community confidence in landfilling activities and avoiding extremely costly land remediation programs.

Rather than prescribing actions, design specifications and standards, the EPA has selected a **performance-based** approach for these Guidelines to promote and achieve the best environmental outcomes. The inflexibility of a prescriptive approach would not reward occupiers for

judicious site selection nor technical nor management innovation, which are generally the best mechanisms for arriving at the most environmentally beneficial solution.

Under the performance-based approach, the emphasis is on achieving the most environmentally beneficial outcomes for the effective treatment and disposal of waste. These performance outcomes are defined in these Guidelines as Environmental Goals.

There is no single uniform winning solution for achieving all Environmental Goals. Many different landfill operation strategies have been developed and practised around the world, and new methods are being developed all the time. Strategies used in the last decade are quickly being superseded by new strategies, and different countries favour different options. There is particularly strong debate on the question of landfill design, construction and operations management, which largely stems 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), who argue that there are three competing strategies for solid waste disposal by landfill:

1. The containment approach used in the US and to a lesser extent in Europe.
2. The semi-aerobic method used in Japan and in some Asian areas influenced by Japan.
3. Enhanced stabilisation, a processing route which seeks to stabilise the waste as quickly as possible.

Each of these landfill strategies, and indeed any others yet to be developed, will have advantages and disadvantages for a particular landfill site. An integrated environmental approach will recognise that a given design or managerial benchmark technique may help to achieve a number of Environmental Goals. The best mix of techniques will depend on the location and the type and quantity of waste to be received.

These Guidelines assume that there are five principal environmental management techniques for landfills which a landfill occupier must consider in order to achieve the best environmental outcome:

- **site selection** - an appropriate location will have natural barriers and buffer distances to help reduce environmental risk
- **design and construction** - including all aspects of the design and construction of the landfill and associated infrastructure
- **monitoring** - including all monitoring and reporting of air, water, noise and waste
- **site operations management** - including all operational measures required to manage a landfill in an environmentally acceptable manner
- **remediation and post-closure management** - including the measures needed to minimise the impact of closed landfills and ensure the beneficial use of landfill sites after closure.

Applicants for of new facilities need to realise that environment protection is achieved through a combination of good planning and an integrated and thorough approach to design, operation and management. There is no substitute for selecting an environmentally sound site and adopting ongoing management measures to protect the environmental integrity of the site.

In the case of existing landfills, the chance to select the best site is long gone. Instead, the priority is to ensure that the facilities are operated in a manner that minimises environmental impact, and achieves effective site remediation. For existing facilities, the performance-based approach recognises that retrospective requirement of design and construction techniques could place an undue burden of cost on the industry (which would in turn be passed on to the community via waste disposal fees). In some cases, such costs may be disproportionate to the environmental benefit received. The location of a facility, the wastes it receives and/or its remaining life span may be such that there are techniques other than design and construction techniques which achieve the desired environmental outcome. The environmental solutions must be appropriate to deal with the problems at hand. The performance-based approach encourages the occupiers of landfills to use their initiative to develop solutions appropriate for their landfill.

Companion guidelines developed by the Department of Urban Affairs and Planning (DUAP 1996) provide advice about landfill site selection, and the environmental assessment of new landfill proposals or substantial extensions to existing landfills. Although primarily directed at landfill proposals that require an Environmental Impact Statement (EIS), the principles contained in those guidelines are relevant to all landfill proposals.

These Guidelines focus on the environmental management of landfills, which needs to be considered both ‘up front’ during the planning process and during the life of the landfill. They have been developed to provide the community, local councils and landfill occupiers with:

- a clear outline of the environmental issues that need to be managed

- a system for regulating landfills which ensures that Environmental Goals are met using the most effective, affordable and innovative mix of mechanisms available, recognising that the level and timing of regulation should be influenced by:
  - the environmental qualities and location of the landfill site
  - the quantity and type of waste received
  - whether the landfill is new or existing
- an outline of some of the techniques currently available to manage the environmental issues.

These Guidelines require current and future occupiers to:

- acknowledge the environmental issues the EPA expects them to manage
- recognise the Environmental Goals associated with managing the environmental issues, and the level of performance the EPA expects
- consider their strategic approach to landfilling when establishing their siting, design, monitoring, management and remediation techniques and to consider the benchmark techniques when arriving at their preferred approach to meeting the Environmental Goals.

2. ENVIRONMENTAL ISSUES AND GOALS IN LANDFILLING

The environmental issues of primary concern to the community and the EPA in relation to landfilling operations are:

1. **Water pollution** - i.e. discharges of pollutants to ground and surface waters.
2. **Air pollution** - i.e. emissions of pollutants to the atmosphere.
3. **Land management** and **conservation**.
4. **Hazards** and **loss of amenity**.

2.1 WATER POLLUTION

Ground and surface waters can be contaminated by untreated leachate from landfill sites. Leachate is the liquid that percolates through landfills as a result of infiltration and/or decomposition of the wastes. It may cause serious water pollution if it is not properly managed.

Surface water run-off from a landfill site can cause unacceptable sediment loads in receiving waters, while uncontrolled surface water run-on can lead to excessive generation of leachate.

Environmental Goals

Landfill design, monitoring, management and remediation must comply with the following Environmental Goals:

2.1.1 Preventing pollution of water by leachate

Leachate must be controlled within the landfill site, ensuring that neither groundwater nor surface water is polluted.

2.1.2 Detecting water pollution

Effective mechanisms must be developed for early detection of groundwater and surface water pollution.

2.1.3 Remediating water pollution

Any detected groundwater or surface water pollution needs to be speedily remediated.

2.2 AIR POLLUTION

Uncontrolled landfill gas emissions are not a sustainable landfill practice. Landfills primarily produce methane and carbon dioxide which, if not contained, can contribute to the 'greenhouse effect'. Unmanaged gas emissions also represent a lost energy/fuel source. Landfill gas can also contain a variety of corrosive, toxic or odorous components. Methane represents an explosion risk which may occur on-site or off-site.

Environmental Goals

Landfill design, monitoring, management and remediation must comply with the following Environmental Goals:

2.2.1 Preventing landfill gas emissions

Landfill gas must be controlled in such a way that:

- it does not reach explosive concentrations
- greenhouse gas emissions are minimised
- landfill gas is sustainably utilised
- odorous emissions meet relevant environmental legislation
- airborne impurities, pathogens and toxins do not pose a health risk to the community.

2.2.2 Detecting landfill gas emissions

Effective mechanisms for detecting landfill gas emissions must be put in place.

2.2.3 Remediating landfill gas emissions

Any uncontrolled gas emissions detected must be effectively remediated.

2.3 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 should result in efficient remediation, enabling land to be used for other purposes following closure. Land management and conservation goals include diverting waste materials that can be re-used or recycled from landfills to minimise the loss of capacity, and managing the site to ensure that unsuitable wastes are not received and that the nature of wastes that are received is known.

Environmental Goals

Landfill design, monitoring, management and remediation must comply with the following Environmental Goals:

2.3.1 Assuring quality of design, construction and operation

All design, construction and operation activities must be carried out in accordance with a quality system acceptable to the EPA.

2.3.2 Assuring quality of incoming waste

Each site must receive only those wastes that it is licensed to receive, and due diligence should be exercised in screening incoming wastes.

2.3.3 Recording of wastes received

The nature and quantity of all wastes received must be known and recorded.

2.3.4 Minimising landfill space used

Landfill space must be used optimally, and valued as a scarce resource.

2.3.5 Maximisation of recycling

Before each licence renewal, a recycling plan must be prepared for all types of waste which the site is licensed to receive.

2.3.6 Remediating landfill after closure

Operational and post-closure procedures must ensure that the former landfill site can be used by the community for other beneficial purposes as soon as practicable after landfilling is completed.

2.4 HAZARDS AND LOSS OF AMENITY

The potential hazards and amenity impacts from landfills include fire, birds, dust, odour, pests, vermin and litter. Each of these potential impacts may occur on-site or off-site.

Environmental Goals

Landfill design, monitoring, management and remediation must comply with the following Environmental Goals:

2.4.1 Preventing unauthorised entry

Unauthorised entry to the site and to the tipping face needs to be prevented.

2.4.2 Preventing degradation of local amenity

Vehicles leaving a landfill site must not distribute litter and site materials in surrounding streets. Odours, dust, vermin, weeds and litter must be effectively controlled on-site.

2.4.3 Preventing noise pollution

Noise emissions from the landfill operation must comply with noise control legislation.

2.4.4 Adequate fire-fighting capacity

Each landfill site must have adequate fire-fighting plans, equipment and staff to effectively manage fire outbreaks at any part of the landfill site.

2.4.5 Adequate staffing and training

The level and nature of staffing at each landfill site must be adequate for environmentally responsible and safe management of a landfill.

3. ENVIRONMENTAL MANAGEMENT OF LANDFILLS

The challenge in landfill management is to address environmental concerns by achieving the Environmental Goals set out in section 2 above. The goals are geared towards:

- preventing water pollution
- preventing air pollution
- promoting responsible land management and conservation
- preventing hazards and loss of amenity.

The EPA approach to managing landfills has four components:

1. Economic and educational measures to discourage over-reliance on waste disposal and promote waste management alternatives (*see* 3.1 below).
2. A focused system of licensing landfills to ensure effective control of those facilities which, because of the location and type of waste received, pose the greatest threat to the environment (*see* 3.2 below).
3. A performance-based site assessment and management strategy set out in a Landfill Environmental Management Plan (LEMP) for each site, to ensure landfill occupiers select the most appropriate and innovative means of meeting the specified Environmental Goals, given the location of the site and the type and quantity of waste received (*see* 3.3 below).
4. Performance reporting (*see* 3.4 below).

3.1 ECONOMICS AND EDUCATION

The EPA uses economic and educative tools alongside regulatory measures to achieve desired environmental outcomes.

In the case of landfills, the EPA may require different levels of licence fees and financial assurances from different occupiers, depending on the nature of a facility and its established or proposed location. These licence fees and assurances may be reduced over time if there is a greater degree of certainty that the facility will not harm the environment.

The broad goal of promoting waste reduction, the associated need to discourage the disposal of waste, and the need to cover the cost of environmental externalities created by landfills will be recognised through the promotion of true cost pricing at landfills and the retention of the existing levy on waste disposal. The extension of the levy to landfills outside Sydney is subject to ongoing consideration.

Rebates and exemptions will apply as an incentive where recycling and waste recovery initiatives are introduced.

The EPA is also developing a range of **education and information programs** to encourage source separation, recycling, reprocessing, and composting of waste, and to conserve landfills and reduce their environmental impact.

For wastes such as green waste and tyres, reprocessing is the most desirable waste management option. A range of policy, education and economic instruments will be applied to promote reprocessing, and bans on landfilling these wastes will be phased in.

3.2 REGULATION

Landfills are subject to environment protection regulation in two stages - planning and operation.

Regulation at the **planning stage** involves gaining approval for a new landfill or a significant extension to an existing landfill. This may require the preparation of an EIS and public consultation before consent from the consent authority under Part 4 or approval under Part 5 of the Environmental Planning and Assessment Act. The Department of Urban Affairs and Planning (DUAP) can nominate what should be included in an EIS. In order to assist, the DUAP has produced the *EIS Practice Guideline: Landfilling* (1996), which should be read in conjunction with these Guidelines.

The Minister for Urban Affairs and Planning has introduced a State Environmental Planning Policy (SEPP) to provide a more ordered and strategic approach to landfill planning.

The SEPP establishes the Minister for Urban Affairs and Planning as the consent authority for regional putrescible landfill proposals from local councils, Waste Planning and Management Boards or from the Waste Service. The SEPP covers proposed extensions to existing putrescible landfills and proposed upgrading of non-putrescible landfills to putrescible status. Local councils are still responsible for determining applications for individual local council landfills.

In making decisions on landfill proposals the Minister may have regard to the need for additional landfill capacity and whether the facility is identified in an approved Regional Waste Plan as the preferred disposal option.

Regulation at the **operational stage** will occur through the new waste licensing scheme set down in the Waste Minimisation and Management Act 1995. A licence for

waste disposal will be required depending on the location of the facility and/or wastes received as set down below.

3.2.1 Locational criteria

As noted earlier, the location is a primary determinant of the extent to which a landfill poses an environmental risk. Judicious location of a landfill is the single most effective environmental management tool. The aim is to avoid the need for impact mitigation and ongoing management by selecting a site where natural barriers protect environmental quality and where there will not be adverse impact on existing and future development.

The hydrogeological characteristics of a site will have a critical bearing on the need for and nature of measures to control leachate. If a landfill is located in an area with permeable substrata, any leachate generated will rapidly pollute the groundwater (and even surface water) unless an adequate barrier system is installed.

The potential damage by leachate can also be more critical if the landfill is located in a drinking water catchment, in a floodway subject to washout, or in a high rainfall area. Landfills can also cause a localised loss of amenity due to litter, dust, odour, noise, and vermin problems. Proximity to existing and proposed developments and the strength and direction of prevailing winds will be key issues in this regard.

Applicants are advised about aspects of dealing with locational issues in the *EIS Practice Guideline: Landfilling* (DUAP 1996). The schedule of environmentally sensitive sites set down in those guidelines is particularly relevant. The schedule is designed to acknowledge the importance of determining as early as practicable whether a proposed landfill site is subject to a significant environmental constraint, or is of such environmental value that it should be excluded from further consideration as a potential site. Table 1 below identifies areas which are considered to be inappropriate for landfills because of their environmental sensitivity.

To ensure the environmental protection of these areas, and to provide certainty to developers seeking sites for landfill, DUAP recommends that: 'proponents ensure that areas included in Table 1 are excluded from consideration for a landfill early in the site selection process' (DUAP 1996).

The DUAP guidelines also set out the steps to be taken when selecting an appropriate site, with heavy emphasis on conducting appropriate geological, hydrogeological, topographic and meteorological evaluations to establish the appropriateness of a site. A formal EIS is required under Schedule 3 of the Environmental Planning and Assessment Act if a proposed landfill is to dispose of solid waste that comprises:

- more than 100,000 tonnes per annum of clean fill (such as soil, sand and gravel) that is likely to cause significant impacts on drainage or flooding
- more than 1,000 tonnes per annum of sludge or effluent
- more than 200 tonnes per annum of other waste material.

A formal EIS is also required if a landfill is proposed in one of the following locations:

- in or within 100 metres of a natural waterbody, wetlands, coastal dune fields or an environmentally sensitive area
- in an area of high watertable, highly permeable soils, acid sulphate, sodic or saline soils
- within a drinking water catchment
- within a catchment of an estuary where the entrance to the sea is intermittently open
- on a floodplain
- within 250 metres of a residential zone or a dwelling not associated with the development and, in the opinion of the consent authority (having regard to topography and local meteorological conditions), likely to significantly affect the amenity of the neighbourhood by reason of noise, visual impact, air pollution (including odour, smoke, fumes or dust), vermin or traffic.

Following introduction of the Waste Minimisation and Management Act 1995, the licensing requirements will be set down in regulations.

In the case of **new landfills**, the EPA will:

- require licences for all landfills proposed for sensitive areas listed in Table 1 irrespective of the volume or type of waste received - however, the EPA will generally **not** be prepared to issue a licence for landfills in such locations
- require licences for all landfills proposed in the Sydney, Hunter and Illawarra regions (see Appendix E) irrespective of the quantity or type of waste received.

In the case of **existing landfills**, the EPA will:

- require licences for any currently unlicensed landfills located in a sensitive area listed in Table 1 irrespective of the quantity or type of waste received
- continue to require licences from all currently licensed or registered landfills in NSW

TABLE 1

ENVIRONMENTALLY SENSITIVE AND INAPPROPRIATE AREAS FOR LANDFILLING

Objective	Inappropriate areas
To avoid the risk of damaging areas of high environmental value.	A site within an area of significant environmental value, as identified under relevant legislation, including: • Areas reserved or dedicated in the National Parks and Wildlife Act 1974 (NP&W Act), such as: · National Parks · nature reserves · historic sites · areas covered by a Conservation Agreement · other areas protected under this Act • World Heritage Areas • Wilderness Areas identified or declared under the Wilderness Act 1987 • items included on the Register of National Estate • Marine Reserves, Aquatic Reserves, Marine National Parks or Nature Reserves • sites within 250 m of any of the above areas.
To avoid the risk of polluting drinking water should failure of the landfill occur.	Sites within an identified sensitive location within a drinking water catchment, being: • any site mapped as 'Special Areas' under the 'Sydney Water' regulation (formerly Sydney Water Board) • lands within 3 km of the top water level of the following storage: · Wingecarribee Reservoir · Fitzroy Falls Reservoir · Tallowa Dam • any lands nominated as 'Special Areas' (or similar wording) by local water supply authorities (e.g. Councils).
To ensure that the environmental values of these areas are protected.	Sites which have: • known high scenic, scientific, cultural, heritage or environmental value and which are zoned under a planning instrument for environmental protection purposes • special protection under a planning instrument - e.g. SEPP 14 Wetlands, REP 20 Wetlands, SEPP 26 Littoral Rainforests, areas identified as core koala habitat under SEPP 44 Koala Habitats or areas similarly protected.
To protect groundwater and surface water resources.	Sites located: • within watercourses or within 40 m of a permanent or intermittent watercourse • on alluvial soil which has been identified by the Department of Land and Water Conservation as having highly vulnerable groundwater.
To avoid sites which may be susceptible to slippage, or which may have unsuitable substrata.	Sites within a karst region (either protected under the NP&W Act or not), or with substrata which are prone to slippage.
To avoid the risk of landfill washout in the event of significant flood.	Sites within a floodway which may be subject to washout during a major flood. (Councils should be consulted for information about local flooding characteristics. A major flood is considered to be a 1:100 year event.)
To control amenity impacts on residents.	Sites within 250 m of a residential zone or dwelling.

Adapted from *EIS Practice Guideline: Landfilling*, Table 1 (DUAP 1996)

- require licences for all existing unlicensed landfills located within the Sydney, Hunter and Illawarra regions (see Appendix E) irrespective of the quantity or type of waste received.

These provisions are designed to protect environmental values irrespective of the type or quantity of waste received. It is, however, recognised that existing rural landfills located in 'sensitive areas' may be regulated for the first time. The transitional arrangements set down in the implementation program in section 3.5 below are designed to address this.

3.2.2 Waste type and quantity criteria

The types of waste received at a landfill determine the potential pollutants that can be generated and hence the potential environmental risk.

If a landfill is only receiving relatively **inert materials** such as building and demolition wastes which have no potentially hazardous characteristics, the potential environmental impacts are generally restricted to dust, noise and sedimentation, which can be readily controlled.

Inert waste is defined as waste which does not undergo environmentally significant physical, chemical or biological transformations and has no potentially hazardous content once landfilled. This waste from building and demolition activities includes bricks, concrete, glass, plastics, metal and timber. It must not be contaminated or mixed with any other material. (For levels of unacceptable contamination, see relevant EPA guidelines or seek EPA advice.) Inert waste does not include clean excavated natural materials received with no other waste.

If a landfill is receiving wastes with a **degradable content**, polluting leachate and odours are more likely to be generated and require careful management.

These wastes are defined as **solid waste**, which means any non-hazardous, solid, degradable waste. These include putrescible wastes; garden wastes; uncontaminated biosolids; and clinical and related waste (including contaminated waste) sterilised to a standard acceptable to the Department of Health. Solid waste shall contain less than 200 mL/tonne or 200 g/tonne of hazardous wastes. All solid waste shall have an angle of repose of greater than five degrees (5°) and have no free liquids.

Hazardous wastes pose the most significant management challenge given their higher potential to cause harm as a result of their:

- flammability
- corrosivity
- potential to cause infection
- reactivity (violently reactive, oxidising or explosive)
- toxicity.

Depending on the location and the types of waste received, the environmental risk posed by a landfill can also be proportional to the **amount** of waste received at the landfill. If a landfill is well located, receival of small amounts of inert and solid wastes will have minimal environmental impact, and the cost of many of the environmental management techniques that apply to managing larger landfills is difficult to justify. Many of the amenity impacts of smaller landfills (such as noise, odour and dust) may be easily managed through passive controls, but more active tools are required for larger landfills.

3.2.3 Proposed landfill categories

For the purposes of regulation, **three categories** of landfill have been established.

Inert waste landfill means any landfill that accepts only inert wastes.

Inert waste landfills are subdivided into two classes:

- Class 1 - all inert wastes including stabilised asbestos cement and physically, chemically or biologically fixed, treated or processed waste in accordance with any special requirements that may be set by the EPA.
- Class 2 - all inert wastes except stabilised asbestos cement or physically, chemically or biologically fixed, treated or processed waste.

Solid waste landfill means any landfill that accepts solid waste. A solid waste landfill may also receive inert waste.

Solid waste landfills are subdivided into two classes:

- Class 1 - all solid waste including putrescible waste and other wastes approved by the EPA.
- Class 2 - all solid waste with the exception of putrescible waste and other wastes approved by the EPA.

Putrescible waste means food or animal matter (including dead animals or animal parts), or unstable or untreated biosolids.

It should be noted that the Government envisages banning garden wastes from landfills in the near future.

Hazardous waste landfill means any landfill that accepts any wastes formally defined as 'hazardous wastes' in statutory instruments (*see* Appendix B for current definition) or as specifically determined through any special requirements that may be set by the EPA.

3.2.4 Landfills that *will* need to be licensed

Inert waste landfills that receive more than 20,000 tonnes of waste per annum will need to be licensed irrespective of where they are located. All licensed inert landfills will have to comply with the following Environmental Goals (taken from section 2 above):

- Preventing pollution of water by leachate (2.1.1)
- Detecting water pollution (2.1.2)
- Remediating water pollution (2.1.3)
- Assuring quality of design, construction and operation (2.3.1)
- Assuring quality of incoming waste (2.3.2)
- Recording of wastes received (2.3.3)
- Minimising landfill space used (2.3.4)
- Maximisation of recycling (2.3.5)
- Remediating landfill after closure (2.3.6)
- Preventing unauthorised entry (2.4.1)
- Preventing degradation of local amenity (2.4.2)
- Preventing noise pollution (2.4.3)
- Adequate fire-fighting capacity (2.4.4)
- Adequate staffing and training (2.4.5)

Solid waste landfills that receive more than 5,000 tonnes of waste per annum need to be licensed irrespective of where they are located. They also need to meet all Environmental Goals set down in section 2.

Hazardous waste landfills will need to be licensed irrespective of their location or the quantity of waste received. They also need to meet all the performance goals set down in section 2, plus any other special requirements that may be set by the EPA in future special purpose guidelines relating to the disposal of hazardous wastes.

3.2.5 Class 1 solid waste landfill licensing: special arrangements involving supervisory licences

In order to give effect to the Government's policy of public sector control of 'putrescible landfills', the Waste Minimisation and Management Act provides that a licence for a Class 1 solid waste (putrescible) landfill must be held by a public authority. A private entity can only hold a licence for a Class 1 solid waste landfill if a public authority holds a separate 'supervisory licence' in respect of the site. As a result, in the case of putrescible landfills, there may be more than one licence issued by the EPA for the site. The aim of the supervisory licence is to ensure that a public authority is accountable for controlling key aspects of the site's management that are linked to meeting environmental goals:

- the charge for waste disposal
- the quantity and nature of the waste received
- the design of new facilities
- the separation, re-use, reprocessing and recycling of waste at the facility.

3.2.6 Landfills that *won't* need to be licensed

Some landfills will not need to be licensed under this regulatory scheme due to the relatively small quantity of waste received and the optimal or remote location of the facility, which together means that they do not pose a significant environmental risk. However, it is recognised that if these small landfills are poorly managed, localised environmental degradation can occur.

In relation to landfills that do not require licensing under the proposed new waste legislation, landfill occupiers will still be required to notify the EPA annually of the location, type and quantity of waste received, and ownership details of the landfill.

3.2.7 Offences and penalties

The Waste Minimisation and Management (WMM) Act rectifies the current inadequate penalty structure and provides an added incentive for environmentally responsible handling and disposal of waste.

Failure to hold a licence where this is required under these guidelines and the associated WMM regulations is an offence. There is a maximum penalty of $125,000 for a corporation (with a daily maximum of $60,000 if the offence continues) and a maximum penalty of $60,000 for an individual (with a daily maximum of $30,000 if the offence continues). Similar penalties may also apply for contravention of any conditions attached to licences, for example, the requirement to prepare and comply with a LEMP.

The WMM Act also enables authorised EPA officers to issue on the spot fines of $500 for contravention of licence conditions.

There will be a strict liability offence for the unauthorised disposal of waste. A breach of the provision will be an offence under the Environmental Offences and Penalties (EOP) Act. The owner of a dumped substance (as well as the dumper) will be liable for the offence unless the owner can establish 'due diligence' - a defence similar to that provided by section 7 of the EOP Act. This is consistent with the existing provision in section 6 of the EOP Act, and with the philosophy of 'cradle to grave' responsibility for proper disposal of waste.

A maximum penalty of $125,000 for a corporation (with a daily maximum of $60,000), and a maximum penalty of $60,000 for an individual (with a daily maximum of $30,000) will apply to the new dumping offences.

3.3 PERFORMANCE-BASED SITE ASSESSMENT AND MANAGEMENT STRATEGIES

3.3.1 Landfill Environmental Management Plans

When a facility is to be licensed, the key issue is that it must achieve the Environmental Goals set down in section 2. The onus is on the occupier to select the best mix of techniques for site development and management to achieve the required outcome. The scheme is in this sense **performance-based** and not prescriptive.

The preferred mix of techniques is to be set out by the occupier in a Landfill Environmental Management Plan (LEMP). The LEMP must systematically cover the following points:

- **Site overview** - covering the broad locational and environmental characteristics of the site. The site overview should include:
  - a real property description, including ownership and tenure details, existing and previous use, existing buildings and other developments on-site
  - details of zoning, including permissibility and land use constraints, any easements, relevant provisions of any regional or local management plan for the area, and any heritage, environment protection or other restrictions affecting the site
  - details of any current development approval including conditions of consent (if any of the measures proposed in the LEMP conflict with any development consents for the site, the consent authority should be consulted and the results of this consultation should be included in the LEMP)
  - information about the surrounding environmental characteristics, including details of topography, soils and geology, groundwater and surface water, local meteorology, flora and fauna, significant environmental features, areas affected by conservation agreements, and details of planning approvals applying to the site.
- **Landfill structure and operations overview** - outlining the landfill design/construction concepts, specifications, general operating philosophy, the nature and quantity of wastes to be received, recycling to be conducted, the intended life of the landfill and predicted financial guarantees over the life of the landfill. In the event that a public authority supervisory licence is involved in the application, the public authority must ensure that the arrangements are specified in the LEMP under which the public authority has the capacity to exercise control over the waste facility with respect to the matters referred to in 3.2.5.
- **Discharges of pollutants to waters** - describing in detail mechanisms for preventing groundwater and surface water contamination to meet the Environmental Goals contained in section 2. This must include detailed groundwater and surface water monitoring programs, and an erosion sediment control program, including details identifying the volume and concentration of pollutants that may be discharged to either surface water or ground water from the landfill site.
- **Emission of pollutants to the atmosphere** - describing in detail mechanisms for controlling emissions to meet the Environmental Goals in section 2.
- **Land management and conservation** - describing in detail the measures to be adopted to help meet waste reduction goals, the degree of control over waste taken into the site, and the proposed approach to site closure and remediation (including post-closure monitoring, final site contouring, proposed future uses etc.) to meet the Environmental Goals in section 2.
- **Prevention of hazard and loss of amenity** - identifying mechanisms for managing dust, birds, litter, noise, pests, vermin, odour, traffic and fire to meet the Environmental Goals in section 2.

In the case of new landfills, most of these matters will have been documented in the EIS phase. Documentation can be reproduced from the EIS, the 'Draft Environmental Management Plan' and/or the 'Proposals for Ongoing Monitoring' required under the *EIS Practice Guideline: Landfilling* (DUAP 1996), with necessary supplementation.

3.3.2 Benchmark techniques

Appendix A of these Guidelines sets out possible benchmark techniques which (depending on the location of the site and the type and quantity of waste received) may be suitable for a landfill and help to achieve each of the specified Environmental Goals. These benchmark techniques can be included in the LEMP. The EPA will use these benchmark techniques as a point of reference when assessing LEMPs and licence applications from landfill occupiers or applicants.

These benchmark techniques for design and construction, management, monitoring, remediation and post-closure management will apply to all landfills that need to be licensed under section 3.2, unless the EPA is satisfied that:

- In the case of **existing landfills**, the location and 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 practices are in place.

or

- In the case of **new landfills** or **substantial extensions** to existing landfills, the natural attributes of the site or proposed alternative environment protection techniques will enable the occupier to meet the Environmental Goal(s) and provide environmental performance at least equal to or better than the benchmark techniques. This performance must be able to be demonstrated to the EPA.

All LEMPs must be accompanied by a statement which highlights those areas of design, monitoring, management and remediation where there is to be a departure from the benchmark techniques set down in Appendix A, and describe the alternative approach(es) to be adopted.

Where alternative benchmark techniques are proposed, the applicant will also need to provide documentation which does either one of the following:

1. Identifies the extent to which the system is used successfully elsewhere and certifies that:
   - the conditions are comparable
   - the system has been operating long enough to be sure of the possible consequences
   - the prospective occupier can duplicate the system
   - it can be demonstrated why the system works
   - there is no countervailing evidence, and
   - the proposal is compatible with other aspects of the proposed landfill operation.

   or
2. Demonstrates the soundness of the proposal in field or laboratory tests and:
   - the conditions simulate the proper operating conditions
   - it is demonstrated why the system works
   - there is little or no countervailing evidence
   - the EPA can, if desired, replicate the test results produced by the applicant, and
   - the proposal is compatible with other aspects of the proposed landfill operation.

If, in the opinion of the EPA, the proposed departures from the benchmark techniques may represent an increased risk of harm to the environment, the EPA may request an independent risk assessment.

The risk assessment will need to follow a professional and recognised ecological, health or operational hazard risk assessment technique. The assessment should systematically analyse site conditions, contaminant sources, exposure pathways, and receptor characteristics related to the proposed or established site in order to estimate the risks to the natural environment.

The risk assessment should be conducted by a competent risk assessor and demonstrate that the alternative technique(s) will achieve the Environmental Goal(s) and provide at least equal or better environmental performance than the most suitable and relevant combination of benchmark techniques, and that this performance can be demonstrated to the EPA. The uncertainty in this assessment should be characterised, and the person performing this analysis must present a clear and explicit explanation of their findings. An EPA guideline for risk assessment must be followed.

3.3.3 Special requirements for supervisory licences

In relation to applications for a supervisory licence (*see* 3.2.5) the Landfill Environmental Management Plan (LEMP) must specify the arrangements under which the public authority has the capacity to exercise control over the waste facility with respect to:

- the types and volume of waste received at the waste facility
- the design of the waste facility
- the separation, re-use, reprocessing and recycling of waste received at the facility
- the cost of waste disposal

In practical terms, the major focus of the supervisory licensee with respect to meeting Environmental Goals will be land management and conservation (section 2.3). The meeting of all Environmental Goals from 2.3.1 to 2.3.6 will be the joint responsibility of the supervisory licensee and the occupier. This will include the co-signing of all reports by the supervisory licensee and the occupier for forwarding to the EPA as defined in section 3.4 Performance Reporting Requirements.

3.4 PERFORMANCE REPORTING REQUIREMENTS

3.4.1 Incident reporting

The EPA should be notified of any incident that represents a threat to the environment and which may lead to a breach of licence conditions as soon as practicable within three hours of the incident first being identified. Initial contact can be made via the EPA's 24-hour Pollution Line and a written notice should follow within 14 days. Such incidents include:

- identifying non-domestic quantities (more than 200 mL/tonne or 200 g/tonne) of hazardous substances among waste
- fires at the landfill, either surface or subsurface
- mixing of leachate and stormwater or waste and stormwater
- identification of any failure of an environmental protection system
- identification of significant difference in groundwater indicator parameters
- detection of subsurface gas migration in a perimeter gas well at greater than 1.25 per cent methane (volume for volume (v/v))
- any other incident or observation that could potentially pose an immediate environmental hazard outside normal operating conditions
- any proposed change in the landfill's ownership or occupier. (EPA approval required before the ownership or occupier may change, i.e. transfer of licence.)

3.4.2 Monthly reports

Each month, the occupier will be required to send to the EPA a report on 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 in Appendix D.

3.4.3 Annual report

Each year, the following information shall be provided in support of the annual licence renewal application (with all information up-to-date to within 30 days of the licence renewal date):

- Summary Report of the total non-hazardous waste received during the past 12 months (including cover material), its composition, broken down into tonnes of municipal, commercial and industrial, building and demolition waste, and its eventual fate (including recycling markets).
- A report from a registered surveyor or an alternative approved by the EPA 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.
- An estimate of remaining landfill capacity and life based on current and projected waste acceptance rates.
- A hydrogeological report that assesses the changes detected in the groundwater monitoring results over the period of operation, updated for the last 12 months. Any changes in hydraulic gradient or statistically significant variations in contaminant concentrations should be highlighted and explained.
- A leachate collection report that identifies the quantity and composition of any leachate generated over the past 12 months. Any trends should be highlighted and explained in terms of the biological activity within the landfill. The trends should generally be related to monthly rainfall and quarterly sampling results.
- A landfill gas emissions report to demonstrate achievement of the appropriate environmental objectives in the past 12 months. Perimeter well monitoring results shall be presented in graphical and tabular format. If extraction is being carried out, the volume and composition of the raw gas and the stack gases should be identified, and any changes over time explained. Where energy is being recovered from the gas, the energy recovered should be quoted in kilowatts per hour or megajoules where applicable.
- The record of odour, litter or other complaints received by the facility in the past 12 months and comments on their correlation with prevailing weather conditions or waste reception circumstances.
- A summary report of surface water monitoring results over the period of operation updated for the past 12 months. Any changes in water levels and statistically significant variations in contaminants should be highlighted and explained.
- A summary of all dust monitoring results gathered over the past 12 months, with statistically significant variations explained.
- A summary of any incident reports for the 12-month period.
- Any other specific information requested by the EPA.

In the event that a landfill is subject to a supervisory licence the supervisory licensee must co-sign (with the occupier) all reports to the EPA, i.e. the reports outlined in sections 3.4.1, 3.4.2 and 3.4.3.

For identification purposes every report must contain the following information:

- the EPA licence number(s)
- the location of the landfill (lot and DP number)
- the size of the landfill lot (in hectares)
- the name and address of the occupier of the landfill.

3.5 PHASED IMPLEMENTATION PROGRAM

3.5.1 New landfills or substantial extensions

The Guidelines will apply immediately to new landfills. This means that all new landfill licence applications and applications for a substantial extension to an existing licence (being an extension requiring an EIS under Schedule 3 of the Environmental Planning and Assessment Regulations) will need to be accompanied by a Landfill Environmental Management Plan (LEMP) which outlines a robust regime of environmental regulation, based on the location of the landfill and the type and quantity of waste received.

3.5.2 Existing metropolitan landfills

It is recognised that LEMPs will take significant time and resources to develop, particularly if baseline geological and hydrogeological work is not available.

Therefore, every established registered landfill in the former Metropolitan Waste Disposal Region will have until 31 December 1996 to provide an LEMP addressing the same matters to be covered in the LEMP for new landfills (see section 3.3). This requirement will be attached as a condition of all landfill licences.

3.5.3 Existing rural landfills

To date, landfills outside the Sydney area have generally not been regulated. Some have been regulated under the pollution control legislation, but many have never been required to hold a licence.

An immediate shift to state-of-the-art facilities for unlicensed landfills would be practically and financially difficult for rural communities to achieve. For that reason, existing unregistered landfills outside the former Metropolitan Waste Disposal Region which need to be licensed under the new regulatory scheme, must produce an LEMP by 31 December 1997. The plan itself will set down a sustainable program for implementing the plan.

Landfills outside the former Metropolitan Waste Disposal Region currently licensed under the pollution control legislation will be bound by the 31 December 1996 deadline that applies to existing landfills in the Sydney Region.

3.5.4 Existing non-putrescible landfills in Sydney

There is no non-putrescible landfill class in the new classification scheme as set down in 3.2.3 Proposed Landfill Categories. It is recognised that the absence of a formal waste classification process and *ad hoc* licence amendments to date have led to a situation where many existing 'non-putrescible' landfills will not readily fall into the inert or solid waste category. Immediate application of the new classification scheme could mean either substantial new expenditure to keep receiving the solid wastes currently being accepted lawfully, or a substantial loss of business for these landfills.

To deal with this situation, those landfills currently registered as 'non-putrescible' in the former Metropolitan Waste Disposal Region will be given an initial licence to operate as a Solid Waste Class 2 Landfill and have until 31 December 1997 to submit an LEMP. The landfill occupier will have to choose before that deadline whether to demonstrate that their landfill meets the Solid Waste Class 2 standard, or to severely restrict the nature of wastes received and comply with the more modest management requirements of an Inert Waste Landfill.

FIGURE 2

LICENSING ASSESSMENT PROCESS FOR NEW LANDFILLS AND SUBSTANTIAL VARIATIONS THAT REQUIRE AN ENVIRONMENTAL IMPACT STATEMENT (EIS)

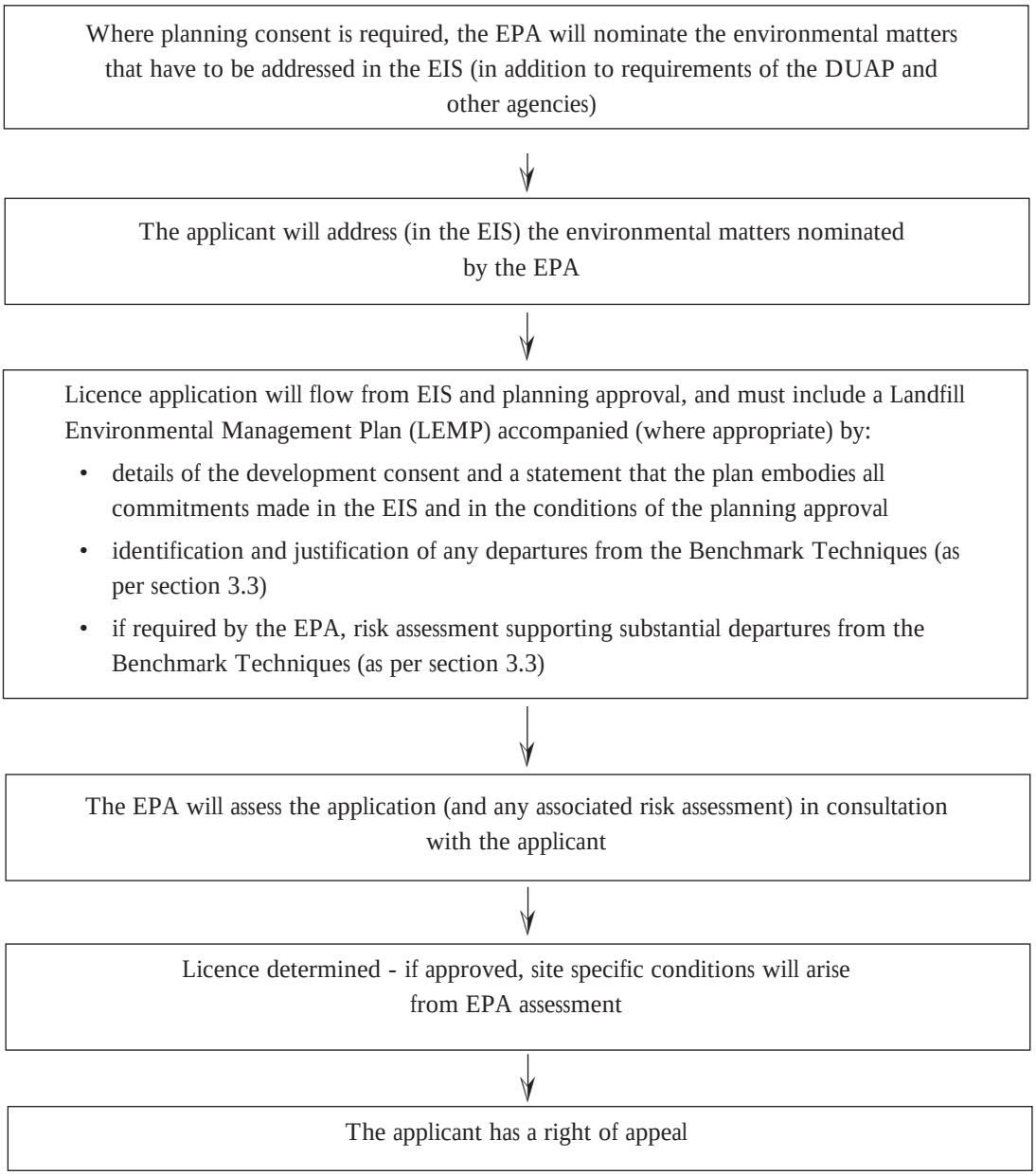
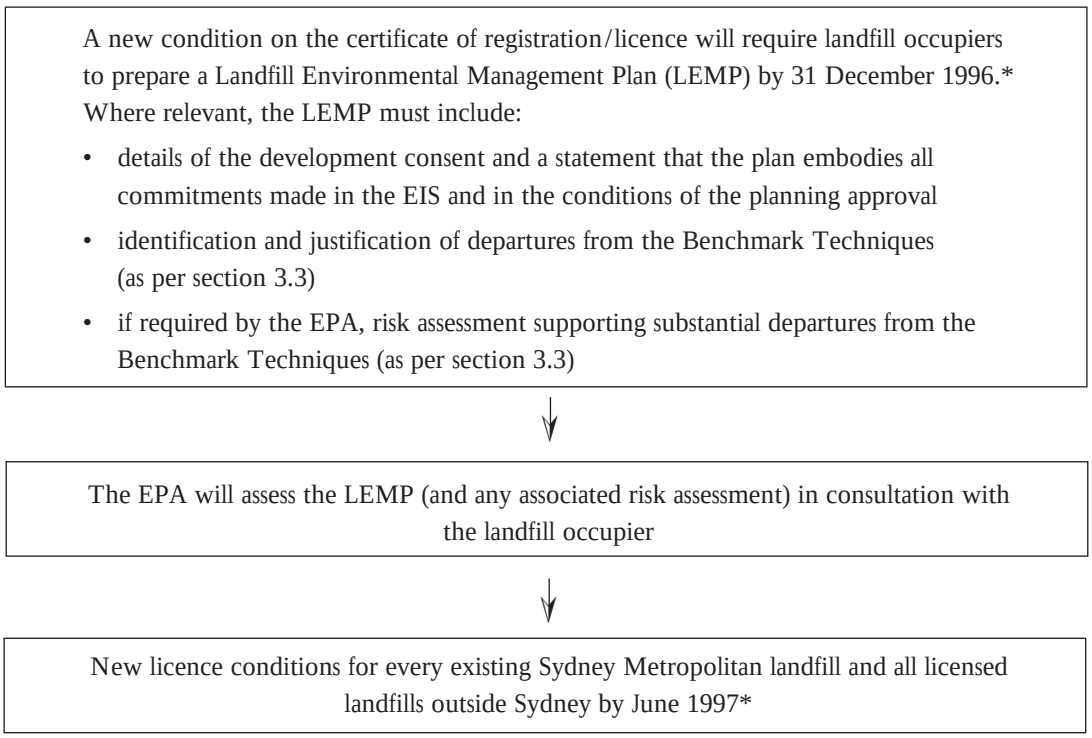
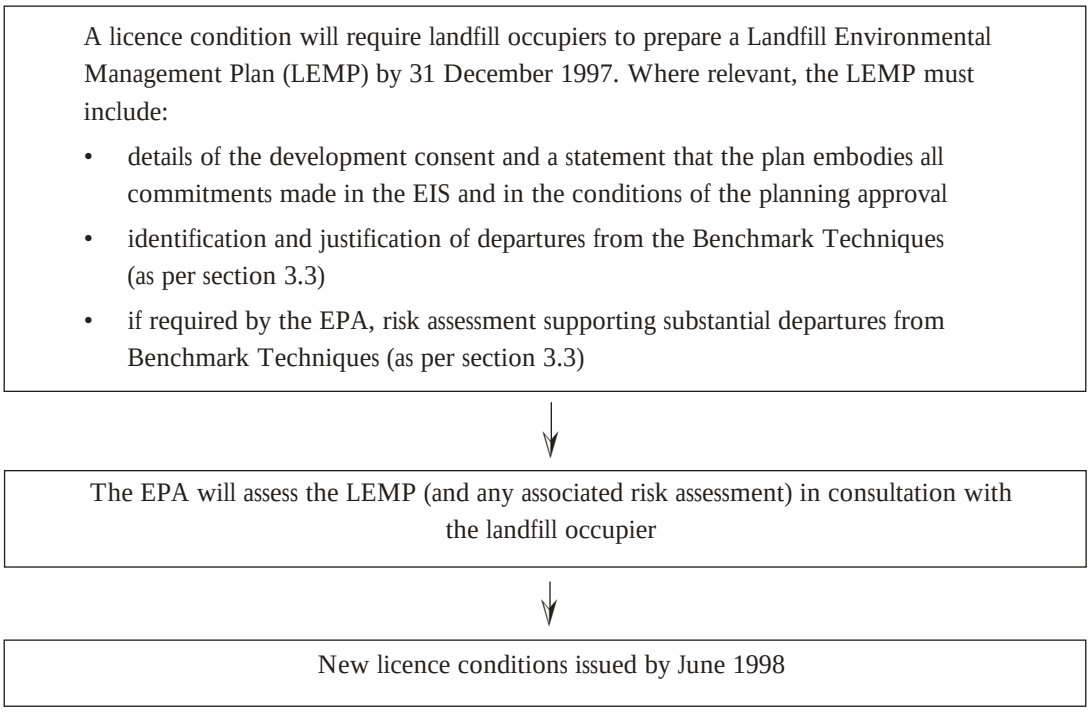


FIGURE 3
LICENSING ASSESSMENT PROCESS FOR EXISTING REGISTERED/LICENSED LANDFILLS



* Except in the case of existing non-putrescible landfills where the LEMP will not be due until 31 December 1997 (these landfills can continue to receive solid waste components of the waste stream until that time - *see* section 3.5.4)

FIGURE 4
LICENSING ASSESSMENT PROCESS FOR EXISTING UNLICENSED LANDFILLS



APPENDIX A
BENCHMARK TECHNIQUES

INTRODUCTION

The Environmental Goals set out in section 2 of these Guidelines provide the basis for performance-based environmental management and regulation of landfills. The benchmark techniques listed in this Appendix provide guidance on possible solutions for effectively achieving these goals.

The selection of a mix of techniques for meeting the Environmental Goals in relation to any given site should be considered in the light of four key points:

- The best environmental result will be achieved via 'up front' decisions on the location of a facility, and the types of wastes to be received. The management, design, and construction techniques to be applied will be dependent on the nature of these early decisions.
- There is no impediment to rejecting some techniques in relation to a given facility. The occupier should select those techniques that are applicable to meeting the goals, identify those that are not, and justify the omissions or alternatives put forward. The benchmark techniques provided in this section are to be used primarily to indicate the level of confidence required to meet the Environmental Goals.
- A combination of design and construction, operations management, monitoring, remediation and post-closure management measures will generally be required to deal with the range of potential environmental impacts for a given site. For example, the need for design of the leachate containment system for a particular facility (which can be one of the most expensive components of a landfill) should be based on:
  - geological formation
  - hydrology
  - style of landfill operation
  - anticipated nature and quantity of wastes to be received
  - meteorology
  - elevation
  - quality of groundwater, and
  - leachate detection and controls.
- There is no impediment to using operational or design techniques not listed in this Appendix. But the use of a unique management option to meet an Environmental Goal must not cause a reduction in certainty with regard to environment protection. The use of alternative techniques may necessitate additional requirements to ensure the Environmental Goal will be reached. This extra support may, for example, take the form of additional monitoring or higher financial assurances.

This Appendix lists the Benchmark Techniques which should be considered by occupiers when developing an LEMP. Each Benchmark Technique is related to a primary Environmental Goal, but the techniques are part of an integrated environment protection system, and a change in one Benchmark Technique may affect other related Environmental Goals. These primary and related goals are signalled for each Benchmark Technique. The implication of this is that, in making a decision not to adopt a particular technique or to substantially vary the technique, the occupier will be expected to clearly state the alternative method by which the primary Environmental Goal will be met, and satisfy the EPA that the decision does not impact on the ability to meet the related Environmental Goals.

1. LEACHATE BARRIER SYSTEM

Primary Environmental Goal

2.1.1 Preventing pollution of water by leachate

Related Environmental Goals

2.1.2 Detecting water pollution

2.1.3 Remediating water pollution

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.2 Preventing degradation of local amenity

The leachate barrier system should be designed to contain leachate over the period of time that the waste poses a potential environmental risk.

The leachate barrier system should be designed and installed in accordance with the quality requirements specified in an approved Construction Quality Assurance Program.

The benchmark technique for a leachate barrier system for new landfills and lateral expansions of operating landfills is a liner system that forms a barrier between groundwater, soil and substrata, and the waste. Characteristics of a suitable liner include:

- A recompacted clay or modified soil liner at least 90 centimetres thick with an *in situ* co-efficient of permeability of less than 10^{-9} ms^{-1}. Successive layers should be of compatible material and each underlying layer should be scoured to prevent excessive permeability due to laminations. The sides should generally have a slope not exceeding a gradient of one vertical to three horizontal in order to allow suitable compaction of the barrier and to facilitate subsequent testing.
- If the landfill is located in an area of poor hydrological conditions or otherwise poses a significant potential threat to groundwaters or surface waters, the clay or modified soil liner should be overlaid with a flexible membrane liner (FML) of minimum co-efficient of permeability of 10^{-14} ms^{-1}. The FML should have material properties that will ensure that it maintains this permeability for a period at least equivalent to the reactive life of the waste contained by the FML. The FML should have a minimum thickness of 1.5 millimetres, and be laid following procedures in an approved construction quality assurance program. All joins and repairs should be fully tested to ensure liner integrity is not breached at these locations, and the FML should be protected by an overlay of soil with low abrasive properties or synthetic non-woven geotextile of sufficient depth to protect the FML against load-induced damage.
- Where the natural geology of the site is proposed to be used as the leachate barrier system, an extensive hydrogeological investigation is to be conducted by a competent entity to prove the efficacy of the barrier. This assessment should include, but not be limited to, the following:
  - the extent of the material
  - the permeability of the material to leachate and gas
  - the integrity of the material, and the presence of any imperfections that may compromise its effectiveness (e.g. root holes, cracks, or gravel layers)
  - any possible reactions between the material and the leachate.
- The surface of the liner or natural barrier should be so formed that once settling has finished, the upper surface of the liner or barrier must exhibit a transverse gradient of greater than three per cent and a longitudinal gradient of greater than one per cent.

2. LEACHATE COLLECTION SYSTEM

Primary Environmental Goal

2.1.1 Preventing pollution of water by leachate

Related Environmental Goals

2.1.2 Detecting water pollution

2.1.3 Remediating water pollution

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.2 Preventing degradation of local amenity

All leachate in excess of the field capacity of the waste should be collected in a leachate collection system and prevented from escaping from the landfill into groundwater, surface water or subsoil.

The leachate collection system should be designed and installed in accordance with the quality requirements specified in an approved Construction Quality Assurance Program.

Acceptable designs include the following:

- Over the liner, a drainage layer should be installed of a thickness of greater than 30 centimetres. The drainage material should exhibit a co-efficient of permeability $K > 1 \times 10^{-3}$ ms^{-1}.
- The drainage media should be selected to have sufficiently large pore space to prevent encrustation. Gravel or a combination of gravel and a geonet may be used. The gravel selected ideally should be:
  - rounded
  - of grain size greater than 20 millimetres
  - smooth-surfaced
  - non-reactive in mildly acidic conditions
  - relatively uniform in grain size, and
  - free of carbonates that could form encrustations around the collector pipes.

  Geotextiles should not be used where their low porosity and consequent encrustation could result in blockage of the drainage system.
- Perforated collector pipes should be placed within the drainage layer at intervals of not more than 50 metres to facilitate the collection and discharge of leachate. These pipes should generally:
  - be a minimum 150 millimetres in diameter
  - be strong enough not to collapse under the weight of the waste
  - have a minimum longitudinal gradient of one per cent, and
  - be capable of being rinsed and monitored.
- In order to facilitate predictable movement of leachate and prevent the creation of perched water tables, the occupier should puncture or remove previously applied daily or intermediate cover prior to further filling, or demonstrate that perched water tables will not form.
- Leachate should be collected and stored either in a dam that is lined to a similar standard to the landfill liner, or in above-ground tanks surrounded by a bund with a capacity of 110% (or greater) of the tanks within the bund. The dam or tanks should have high-level alarms that are interlocked to the discharge pump or line, so that they cannot be overfilled. If the leachate dam or tanks are open at the top, they should generally be capable of accepting a 1 in 25 year, one-day-duration storm event without overflowing.
- Leachate should be tested before its release to disposal. The analysis is conducted in accordance with the requirements set down in Appendix A (*see* '8. Leachate Monitoring Program'). There will be individual requirements in relation to the concentration of pollutants, dependent on the site's soil chemistry and specific operating conditions.
- Leachate should be disposed of only by one or more of the following methods:
  - discharge to sewer in accordance with the water authority requirements
  - spraying or land application over completed areas of the landfill or injection back into the landfill, in accordance with the conditions of the licence, or
  - treatment to an acceptable quality and discharge in accordance with the conditions of the licence.

3. SURFACE WATER CONTROLS

Primary Environmental Goal

2.1.1 Preventing pollution of water by leachate

Related Environmental Goals

2.1.2 Detecting water pollution

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

To avoid the generation of excessive leachate, erosion of cover material and/or waste from the landfill, surface water controls should prevent any surface water from mixing with waste, and prevent any sediment or contaminants from being carried off the landfill site.

The surface water controls should generally conform with the following principles:

- All water that has entered waste-filled areas, and water that has been contaminated by leachate, should be handled and treated in the same manner as leachate.
- All surface water that has been collected from cleared or non-vegetated surfaces should be treated in accordance with the *Stormwater Manual* currently being developed by several NSW Government agencies.
- The exposed or cleared areas at the landfill site should be minimised at all times, and all topsoil set aside for revegetation purposes. All completed areas of the landfill should be progressively revegetated, and any areas exposed for greater than 30 days should be stabilised so as to prevent soil erosion.

4. GROUNDWATER MONITORING NETWORK

Primary Environmental Goal

2.1.2 Detecting water pollution

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

The design, number and location of wells or lysimeters in the groundwater monitoring network should be able to demonstrate that groundwater or subsoil is not contaminated, and ensure early detection of any contamination by means of regular representative samples of groundwater and water vapour from the vadose zone.

The requirements for establishing a groundwater and subsoil monitoring network should include the following:

- If only one thin (less than five metres thick) aquifer is identified on-site, single fully-slotted bores are regarded as sufficiently reliable indicator bores for contaminants. If multiple aquifers are identified on-site, or an aquifer greater than five metres thick is identified, the monitoring bores will be:
  - a nest of bores, slotted over different intervals
  - a multi-port bore, or
  - an appropriate combination of both.
- Monitoring bores should generally have a minimum internal diameter of 50 millimetres in order to allow adequate sampling.
- The selected monitoring bore design should include suitable strength pipe with slotted sections gravel-packed and adequate cement/bentonite seals between these sections. The standpipe should be adequately sealed near ground level using cement-based grout with the top of the standpipe covered by a security cover. Additionally, the standpipe should be constructed to prevent the entry of surface water and to prevent extraneous material such as insects from getting into the well.
- The porous media surrounding the monitoring bores and the lysimeter cup should be selected to ensure that they do not affect the sample's accuracy.
- Installation and well maintenance should be undertaken following standard references on this subject such as:

- the USEPA's *Handbook: Groundwater. Volume II: Methodology* (1991)
- Hirschberg's *Guidelines for Groundwater Monitoring at Municipal Landfill Sites* (1993).

The LEMP should clearly identify the number of wells, drilling method, material used in well construction, procedures used for well development and well security. The quality standards established in the approved construction quality control program (*see* '20. Assurance of quality' below) should be applied to the establishment and operation of the groundwater monitoring system.

- The groundwater monitoring program 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 groundwater. A suction lysimeter is used to extract pore water when groundwater is absent. These devices should indicate the presence and quality of leachate in the geological formation.

5. GROUNDWATER MONITORING PROGRAM

Primary Environmental Goal

2.1.2 Detecting water pollution

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

The groundwater monitoring program should effectively monitor and report groundwater character, and ensure early detection and reporting of possible pollution of groundwater.

A comprehensive hydrological investigation of the site and the surrounding groundwater regime should have been conducted before the site was established. (The technique employed should take into consideration DUAP's *EIS Practice Guideline: Landfilling* (DUAP 1996)). The groundwater flow and flow pathways for all aquifers on-site should be identified with a high degree of certainty, via a groundwater monitoring program. The monitoring should include the following:

- A groundwater monitoring program set down in the LEMP.
- 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 set down in the LEMP. This plan should be supported by adequate documentation outlining groundwater hydraulics. When it is not possible to locate hydraulically up-gradient wells, applicants should have a number of samples taken at compliance point wells to characterise background groundwater characteristics prior to landfilling activities.
- The recommended groundwater indicator parameters and respective detection limits are listed in Table 2. Occupiers may apply to vary the indicators chosen based on the groundwater assessment of the site. The justification of the selection of the indicator parameters should be included in the LEMP, which should also detail how the limits for the specific indicators adopted will provide an indication of all the possible types of pollution that may occur. Any changes in concentration for these indicators should be able to be taken as evidence that leachate has been

in contact with groundwater, and that the Groundwater Assessment Program must be implemented.

- All groundwater detection monitoring wells and lysimeters should be sampled by a suitably qualified and approved person on a quarterly basis. More frequent sampling may be required if the strata is highly permeable or contains highly vulnerable groundwater. This frequency may be relaxed if the occupier can demonstrate that there are no seasonal effects and the data is statistically constant after data has been collected for at least five consecutive years.

TABLE 2
INDICATOR PARAMETERS FOR GROUNDWATER DETECTION MONITORING PROGRAM

Chemical or Property	Required Detection Level (RDL) in mg/L
Absorbable organic halogens (AOX)	10
Alkalinity	1,000
Ammonia	50
Calcium	5,000
Chloride	5,000
Fluoride	500
Iron	300
Magnesium	5,000
Manganese	50
Nitrate	100
pH	0.1 pH unit
Total phenolics*	50
Potassium	5,000
Sodium	5,000
Sulphate	5,000
Total organic carbon (TOC)**	50

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

** For groundwater analyse filtrate from a 0.45 micron pore diameter filter; for surface water analyse TOC on an unfiltered water sample.

- Water samples should be taken in accordance with procedures outlined in the USEPA's *Handbook: Groundwater. Volume II: Methodology* (1991). It is recommended that this handbook be referred to directly, but the appropriate sampling procedures are summarised below:
  - Hydrological measurements to establish the standing water level with an accuracy of ±0.3 centimetres.
  - 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% of the previous reading. These readings should generally be taken after a minimum of two well volumes have been purged.
  - Samples must be taken with a positive displacement pump or dual valve bailer. When taking the organic samples the flow rate should be reduced to approximately 100 ml/minute to reduce the loss of volatile components.
  - Anions, cations and alkalinity determinations should be made on unfiltered samples since filtration may cause changes in their values. Filtration and preservation of the other samples, as necessary, should be performed in the field.
  - Field analysis of samples shall be performed for alkalinity, pH, eH and temperature.
  - Sample containers and preservation shall follow the procedures outlined in the present edition of *Standard Methods for the Examination of Water and Wastewater* (APHA 1995).
- The minimum field quality control requirements should generally comprise:
  - Testing of field blanks (representing five per cent or at least one blank where less than 20 samples are analysed in a batch) with a documented investigation report required if blanks exceed the required detection limits.
  - Testing of field spikes (representing five per cent 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 80-120% range. The USEPA Handbook (1991) provides detailed instruction on the preparation and use of field spikes.
  - Testing of duplicate field samples (representing five per cent or at least one duplicate where less than 20 samples are analysed in a batch) with a requirement for a documented investigation report if the variation between duplicates exceeds 20% relative per cent difference (RPD).
  - 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 techniques, as outlined in the LEMP, should be used to perform this assessment. A simplified discussion on groundwater data can be found in the USEPA's *Statistical Analysis of Groundwater Monitoring Data (*1989), and the Addendum dated July 1992.

6. GROUNDWATER ASSESSMENT PROGRAM

Primary Environmental Goal

2.1.2 Detecting water pollution

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

If the groundwater monitoring program detects a possible failure of the leachate containment system, a groundwater assessment program should be established to determine the extent of that failure.

If the sampling of groundwater monitoring bores or lysimeters indicates levels for any chosen indicator exceeding the limits agreed to in the LEMP, the affected groundwater monitoring bores or lysimeters should be resampled as soon as possible. If the anomaly is verified in resampling, the EPA should be notified immediately by phone and in writing within 14 days of verification of the increase in the groundwater indicator contaminants.

Within 28 days of the notification, the occupier should prepare a Groundwater Assessment Plan which identifies the specific contaminants and extent of the pollution to the groundwater. The Groundwater Assessment Plan should include a submission to the EPA of a list of proposed anolytes for evaluation, and a monitoring program for sampling the groundwater wells and lysimeters. The list of anolytes needs to be based on the detection of monitoring variations and the contaminant content of the leachate.

The proposal would need to be supported by a justification for the selection of anolytes. Any information obtained during this assessment should be used to prepare the Groundwater Contamination Remediation Plan.

7. SURFACE WATER MONITORING PROGRAM

Primary Environmental Goal

2.1.2 Detecting water pollution

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

The surface water monitoring program must be able to demonstrate that surface water is not polluted by the landfill.

Surveyed monitoring points should be established in the receiving waters at all site discharge locations upstream and downstream of the landfill. Procedures for obtaining the representative sample should be outlined in the LEMP.

Quarterly sampling is recommended when surface water is present. Tests should be conducted from a representative sample for all the indicators selected for the groundwater monitoring program (Table 2) in the LEMP, and also for total suspended solids. This sampling and analysis program should use the same quality control program nominated for the groundwater monitoring program in the LEMP.

If the surface water monitoring program detects water pollution, the occupier should follow the procedures outlined in the Water Contamination Remediation Plan to investigate surface water pollution.

8. LEACHATE MONITORING PROGRAM

Primary Environmental Goal

2.1.1 Preventing pollution of water by leachate

Related Environmental Goals

2.1.2 Detecting water pollution

2.1.3 Remediating water pollution

2.3.1 Assuring quality of design, construction and operation

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

A leachate monitoring program is recommended 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. Any disposal method for leachate should be approved by the EPA and outlined in the LEMP. Off-site disposal of untreated leachate should be limited to discharge to an approved treatment facility.

Initial characterisation testing is to be 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). Additional quarterly or batch testing of a representative sample for all contaminants may be required as agreed in the groundwater monitoring program.

9. WATER CONTAMINATION REMEDIATION PLAN

Primary Environmental Goal

2.1.3 Remediating water pollution

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.2 Detecting water pollution

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

A Groundwater Contamination Remediation Plan should be developed if groundwater or subsoil contamination is confirmed via the Groundwater Assessment Plan, or identified by external monitoring. The Groundwater Contamination Remediation Plan should describe 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. Appendix C contains a flow chart that graphically depicts the relationship between the various groundwater monitoring programs and plans in these Guidelines.

Landfill occupiers should be aware that the costs associated with groundwater remediation are immense, and remediation may take several years.

The landfill occupier must detail the procedures to deal with any possible surface water contamination incident in the LEMP. If surface water pollution is detected, the landfill occupier should take immediate action to contain the pollution, and prepare a report to the EPA detailing the nature and source of the contamination, any actions taken, and future actions that will be carried out to prevent recurrence. When the future actions are approved by the EPA, these should be carried out immediately.

10. LANDFILL GAS CONTAINMENT SYSTEM

Primary Environmental Goal

2.2.1 Preventing landfill gas emissions

Related Environmental Goals

2.2.2 Detecting landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

The landfill gas generated in the landfill should be contained by other benchmark techniques, for example:

1. Leachate barrier system
28. Site capping and revegetation
33. Covering of waste.

The design of these techniques must take into consideration the landfill gas containment system.

II. EXTRACTION AND DISPOSAL OF LANDFILL GAS

Primary Environmental Goal

2.2.1 Preventing landfill gas emissions

Related Environmental Goals

2.2.2 Detecting landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

A gas extraction system should be used to extract and, where possible, combust landfill gases. This system should reduce the risk of explosion and fire, reduce the contribution to greenhouse gases (methane is 20 to 30 times more potent than carbon dioxide), and lower the level of toxic organic compounds emitted from landfills. In conformance with the EPA's commitment to using landfill as a resource, applicants should evaluate generation of electricity as an option when designing the extraction system.

An appropriate and effective gas extraction/control system is recommended where the building monitoring or perimeter well testing shows methane concentrations exceeding 1.25% methane (v/v) or 25% of the lower explosive limit.

Any landfill gas condensate collected should be handled in the same manner as leachate, with the exception that it should not be spray-irrigated because of the low pH and the potential odour. Condensate should be disposed of in a manner approved by the EPA.

Energy should be recovered from the landfill gas where possible, either by directly using the gas or by generating electricity for export. All electricity-generation equipment should be designed in a manner that ensures the following air quality goals are not exceeded:

- One hour maximum NO_2 concentration - 320 $\mu g/m^3$
- Annual average NO_2 concentration - 103 $\mu g/m^3$

For any landfill gas oxidation system, landfill occupiers should quantify non-methane organic compounds (NMOC) emissions prior to and following thermal oxidation. Thermal oxidation in this context may mean flaring or electricity generation.

NMOC should be destroyed by a landfill gas oxidation system (flares or engines). Landfill gas contains a large number of NMOCs. Some of these compounds are toxic air contaminants that occur in the 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, and oxidation systems or similar pollution control devices are needed to destroy these contaminants.

The sampling and analysis will need to be undertaken in accordance with requirements issued by the EPA's Air, Noise and Transport Branch. It is necessary to have greater than a 98% destruction efficiency for NMOC prior to atmospheric emission.

12. FIRE PREVENTION

Primary Environmental Goal

2.2.1 Preventing landfill gas emissions

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.4.4 Adequate fire-fighting capacity

2.4.5 Adequate staffing and training

The licensed landfill occupier should prevent fires at the landfill in order to minimise emissions to the atmosphere. The following points should be covered:

- The occupier should 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.
- Stockpiles of approved amounts of combustibles for recycling and composting (such as tyres, wood or vegetation) should be divided into small piles or windrows so that any burning material can be kept away from or readily separated from additional fuel.
- Cell construction, compaction and use of cover material should be undertaken in a manner conducive to the prevention of a landfill fire.
- All sealed or contaminated drums should be banned from landfill unless they are delivered as a special waste whose contents are clearly identified and suitable for acceptance.
- All fuels or flammable solvents for operational use should be stored in an appropriately ventilated and secure store. This store should be located on unfilled land, and all flammable liquids should be stored within a bund of 110% capacity of the volume of those flammable liquids so that any release of raw or burning fuel would not cause a fire in the filled waste, or impact on stormwater.

13. CONTROLLED BURNING

Primary Environmental Goal

2.2.1 Preventing landfill gas emissions

Related Environmental Goals

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.4 Adequate fire-fighting capacity

2.4.5 Adequate staffing and training

The release of leachate and/or pollutants into the atmosphere as a result of burning waste at landfills should be prevented. The increases in particulate emissions and decreases in site safety arising from landfill fires outweigh any perceived benefit in waste reduction. Waste reduction strategies (e.g. composting and mulching) and materials re-use are approved methods for reducing waste.

Open burning of waste will continue to be banned in the Sydney metropolitan area. In rural areas, the occupier should not burn any materials without the written permission of the EPA. But in any event, rural occupiers may not burn the 'banned wastes' listed below. 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 occupier's obligation to ensure that permission is granted by other control bodies such as the local Council and/or fire authority or National Parks and Wildlife Service where appropriate.

Any burning of waste should comply with the following provisions:

- The following materials are banned from burning at all landfills:
  - hazardous wastes
  - chemical containers
  - municipal garbage
  - food wastes
  - paint or paint containers
  - petroleum, oil or bitumen
  - plastics or rubber (including tyres)
  - wet materials
  - chemically treated timbers
  - clinical wastes.

- Vegetation, timber, paper and cardboard are the only waste materials suitable for burning.
- Where the clearing of on-site vegetation or the preparation of fire breaks is to involve burning, approval needs to be obtained from the local Council and/or fire authority.
- A person, authorised by the occupier, should be in attendance at all times of burning, and shall be solely responsible for lighting and controlling fires.
- Waste materials for burning should be arranged in windrows, trenches or pits.
- A fire should not be located within 50 metres of any site perimeter or working face of the landfill.
- A fire should not be located over a previously filled area of the landfill or in a location that is likely to contain landfill gas, unless it is proven to the EPA that landfill gas is not present in that area.
- A fire should not be located so that it may be offensive or potentially harmful to any person at or beyond the landfill boundary.
- Burning should be restricted to daylight hours.

14. SITE CLOSURE

Primary Environmental Goal

2.2.1 Preventing landfill gas emissions

Related Environmental Goals

2.2.2 Detecting landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

A landfill site should be closed in a manner that reduces to a minimum the emission of landfill gases. This may involve capping and revegetation designed to have the net effect of decreasing the emission of landfill gas through the surface of the landfill. This measure will also improve the potential for containing landfill gas. Landfill occupiers should be aware that as escape through the surface becomes more difficult there is a potential for greater lateral movement of gas. Closure and capping are covered in significant detail in ‘28. Site capping and revegetation’ below.

15. SUBSURFACE GAS MONITORING DEVICES

Primary Environmental Goal

2.2.2 Detecting landfill gas emissions

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

Landfill gas monitoring devices should be capable of detecting landfill gas in sufficiently low concentrations to ensure that landfill gas is not migrating off-site, and toxic air emissions are not a threat to the community.

Monitoring wells should be installed around the perimeter of the site, at a depth equal to the minimum groundwater level, the greatest depth of refuse, or 10 metres below underground utilities or manholes within 50 metres of the landfill. These wells should be placed at intervals sufficiently small to be able to detect any potential off-site migration.

The spacing and design of these wells should be determined based on a site investigation, and detailed in the LEMP. If distinct lithological units that could act as a conduit for landfill gas were identified in the site investigation, then either multi-port wells that are able to monitor the distinct lithological units separately, or separate wells for every distinct unit should be installed.

Well construction details should be submitted to the EPA for approval prior to installation. Generally, the EPA will require individual slotted probes with bentonite seals between monitoring zones, with the monitoring zones back-filled with pea gravel to facilitate movement of gas.

16. SUBSURFACE GAS MONITORING PROGRAM

Primary Environmental Goal

2.2.2 Detecting landfill gas emissions

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

A subsurface gas monitoring program should be implemented to demonstrate that gas is not migrating off-site.

Monitoring should be conducted on a quarterly frequency. Detection above 1.25% methane (v/v) will require notification to the EPA within 24 hours, and an increase in the frequency of monitoring. Procedures for sampling should be nominated in the LEMP and should include the flushing of one probe casing volume prior to taking the reading.

Where landfill gas odours are of concern, hydrogen sulfide (H_2S) gas may also need to be measured. The testing should be conducted *in situ* using a properly maintained, zeroed and calibrated field instrument.

The tabulated results of all monitoring are to be submitted as part of an annual report, unless subsurface methane is detected above 1.25% (v/v), in which case more frequent reporting will be required by the EPA.

17. SURFACE GAS EMISSION MONITORING

Primary Environmental Goal

2.2.2 Detecting landfill gas emissions

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

Surface gas migration monitoring should demonstrate that the cover material and extraction system is controlling the emission of landfill gas. This can be achieved by the landfill occupier testing the atmosphere five centimetres above the ground surface in areas with intermediate or final cover where wastes have been placed. A field technician would start at a point five metres away from the waste perimeter. The technician would then walk across the waste parallel to the boundary of the landfill until reaching the opposite side, and then repeat this procedure every 25 metres inward from the perimeter across the centre of the site to the opposite side of the waste landfill. This monitoring is to be performed on calm days (winds below 10 kilometres per hour).

The occupier 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 must also be investigated for methane emissions.

This monitoring should be conducted on a monthly frequency using a zeroed and calibrated methane gas detector, unless the landfill occupier obtains approval from the EPA to vary the frequency of monitoring based on site assessment or monitoring results.

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

Reports on monitoring and corrective action will form part of the annual report. This monitoring is to continue until the certificate of completeness is issued or the occupier satisfies the EPA that landfill gas is no longer present in significant quantities to pose an environmental risk or inhibit revegetation.

18. GAS ACCUMULATION MONITORING

Primary Environmental Goal

2.2.2 Detecting landfill gas emissions

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.3 Remediating landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

Landfill gas must not accumulate in buildings and pose a danger of explosion. All buildings within 250 metres of deposited waste or areas identified in the LEMP as having potential to have methane concentrations of greater than 1.25% (v/v) in the subsurface should be tested on a monthly frequency with a tested and calibrated methane detector. If any buildings are to be built within this area they should be designed so as not to accumulate methane gas.

Buildings are not to have gas concentrations exceeding 1.25% methane (v/v). If methane is detected above this threshold, daily testing is required until ventilation or other measures control the methane build-up.

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

19. REMEDIATION OF UNCONTROLLED LANDFILL GAS EMISSIONS

Primary Environmental Goal

2.2.3 Remediating landfill gas emissions

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.2 Detecting landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

The EPA must be notified within 24 hours of detection of:

- methane at concentrations greater than 1.25% (v/v) in the surface, subsurface or building monitoring
- a one hour average NO_2 above 320 $\mu g/m^3$ from electricity generating equipment
- NMOC destruction below 98% from gas burning flare or engine.

A written assessment of the emissions and management controls implemented or proposed to be implemented to prevent further emissions should be provided to the EPA within 14 days of the incident.

20. ASSURANCE OF QUALITY

Primary Environmental Goal

2.3.1 Assuring quality of design, construction and operation

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.2 Detecting water pollution

2.2.1 Preventing landfill gas emissions

2.2.2 Detecting landfill gas emissions

2.3.4 Minimising landfill space used

2.3.6 Remediating landfill after closure

2.4.1 Preventing unauthorised entry

2.4.2 Preventing degradation of local amenity

2.4.3 Preventing noise pollution

2.4.5 Adequate staffing and training

To minimise the risk of the landfill having deleterious effects on the surrounding environment, the occupier should construct and operate the landfill to an appropriate quality management system. The following techniques are recommended:

- A fully documented Construction Quality Assurance System be developed in accordance with Australian Standard (AS) 3905.2. All the materials and processes associated with site development, landfill liner and the leachate drainage system must be in accordance with AS 3905.2. A suitable level of quality assurance may be selected for other materials or processes on the site (e.g. slurry wall construction) in accordance with the environmental implications posed by failure.
- A fully documented Environmental Management Quality System be developed and implemented, using for guidance the AS/NZS/ISO 9001/9004:1994 Quality Standards and the Interim Standards AS/NZS/ISO 1401(Int.) and AS/NZS/ISO 1404(Int.) Environment Management System Standards. These systems should cover all aspects of the operation which have actual or potential impacts on the environment.

21. SCREENING OF WASTES RECEIVED

Primary Environmental Goal

2.3.2 Assuring quality of incoming waste

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.3 Recording of wastes received

2.3.4 Minimising landfill space used

2.3.5 Maximisation of recycling

2.3.6 Remediating landfill after closure

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

The landfill occupier should have in place waste acceptance and screening procedures to ensure that the site does not accept wastes that are prohibited from entry.

The complexity of a screening program does not necessarily increase as the wastes received at the site increase in sensitivity. In fact, in some instances the reverse could be seen to apply. That is, an Inert Waste Landfill would generally require extensive screening procedures to ensure that putrescible and other solid wastes and hazardous wastes are not received, while a Solid Waste Landfill with sophisticated design controls in place may require a less detailed program. Similarly, a Solid Waste Class 2 Landfill would be expected to develop and implement a plan to screen incoming waste for putrescible wastes and hazardous wastes, and to ensure that these loads are not accepted.

Generally, the following practices will be applied:

- The landfill occupier should ensure that signs clearly indicating the types of wastes that are to be accepted and those that are not to be accepted are prominently displayed at the point of entry.
- The landfill occupier should nominate a program of inspection for incoming waste loads. This may involve directing selected loads to a separate area to dump the load, then closely examining the dumped load for any unapproved wastes.
- The landfill occupier should check that all waste sludges and wastes that are controlled under a tracking system have all appropriate documentation prior to acceptance at the site.
- The landfill occupier should have a process to establish that soil and other inert material received is not contaminated according to the relevant EPA guideline. In the case of inert and solid waste landfills, this process must be able to screen out any single amount of hazardous waste greater than 200 mL/tonne or 200 g/tonne.
- The landfill occupier should ensure that records of all inspections are maintained for at least four years.
- The EPA's Regional Office should be notified if any unauthorised hazardous wastes have been found on-site, and notified of the identity of any party responsible for dumping hazardous waste with other waste types according to incident reporting requirements in section 3.4.1 above.
- Supervision of tipping activity at the tip face should be maintained when wastes are received at all landfills to ensure the accountability of those depositing unacceptable wastes at the site. Where facilities receive in excess of 500 tonnes per week (25,000 tonnes per annum) this supervision should be undertaken by someone other than the compactor driver.
- All landfill occupiers should ensure adequate training of landfill staff to recognise and handle hazardous or other unapproved wastes.

22. MEASUREMENT OF QUANTITIES OF WASTES RECEIVED

Primary Environmental Goal

2.3.3 Recording of wastes received

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.1 Preventing unauthorised entry

2.4.5 Adequate staffing and training

All landfill operations accepting in excess of 25,000 tonnes per annum of waste should:

- install a weighbridge, and
- lodge a report on the total quantity of waste received every 12 months, compiled by a registered surveyor or by an alternative method approved by the EPA.

Any weighbridge used should have a valid Calibration Certificate from the Department of Consumer Affairs at all times.

Any weighbridge used should be operational at all times of landfill activity. Should the weighbridge be inoperative, the occupier will notify the EPA immediately and ensure that it is repaired as soon as practicable. While the weighbridge is inoperable, all vehicles will be recorded and tonnages calculated from the truck factors provided in Appendix D.

Landfills which accept less than 25,000 tonnes per annum of waste will be required to lodge a report every 12 months on the total quantity of waste received and at the facilitity the previous 12 months. The report is to be compiled by a registered surveyor or by an alternative method approved by the EPA.

23. RECORDING OF THE QUANTITIES, TYPES AND SOURCES OF WASTES RECEIVED

Primary Environmental Goal

2.3.3 Recording of wastes received

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.1 Preventing unauthorised entry

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

Each month, landfill occupiers must provide data to the EPA on the amount, type and source of waste according to the National Waste Classification System. This requirement extends to all materials accepted on-site. A copy of the reporting form can be found in Appendix D.

The landfill occupier must have a survey of the site compiled by a registered surveyor or by an alternative method approved by the EPA on an annual basis to confirm the volume of landfill space consumed in the past 12 months.

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.

Controls should be established to prevent vehicles from entering and exiting the site without generating a permanent record.

24. COMPACTION OF WASTE

Primary Environmental Goal

2.3.4 Minimising landfill space used

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.5 Adequate staffing and training

The amount of landfill space and land used to dispose of waste can be minimised by proper compaction. Compaction also improves the stability of landfills, and minimises voids that would encourage vermin, fires or excess generation of leachate.

Landfill occupiers are expected to ensure that maximum compaction is achieved for the capacity of the machines used. For landfills receiving over 50,000 tonnes of waste per annum, the waste compaction goal is 850 kg/m^3, excluding cover material. For landfills receiving less than 50,000 tonnes per annum, the waste compaction goal is 650 kg/m^3, excluding cover material. An exception to this is where the landfill is being operated as a bioreactor, and the landfill is to be mined or stabilised after degradation is completed. The achieved compaction rate (excluding cover material) will be submitted in the annual report to the EPA.

25. RECYCLING

Primary Environmental Goal

2.3.5 Maximisation of recycling

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.4 Minimising landfill space used

2.4.5 Adequate staffing and training

The LEMP should include a plan to recover and recycle, re-use or reprocess wastes that can be viably recycled. Landfill occupiers should:

- nominate amounts and areas to receive and store recyclable/re-usable materials, and
- submit a plan for the processing and/or marketing of all materials separated, and for disposing of any materials separated but not suitable for recycling/re-use/reprocessing.

26. FINANCIAL ASSURANCE

Primary Environmental Goal

2.3.6 Remediating landfill after closure

Related Environmental Goals

2.1.3 Remediating water pollution

2.2.3 Remediating landfill gas emissions

2.4.2 Preventing degradation of local amenity

Financial assurance is a means of ensuring that landfill occupiers adequately plan for emergency closure, site remediation and post-closure care, 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.

- The LEMP should include a well-documented assessment of the potential cost, prepared by an independent consultant, for a third party contractor to undertake each of the following:
  - close down the current operation at any time and remediate the site to a standard acceptable for its planned future use
  - continue post-closure care and monitoring (bearing in mind that the period of after-care is significantly influenced by the design philosophy)
  - complete the required remediation of environmental impacts that may be identified.
- The financial assurance required by the EPA will be negotiated in one or more of the following forms:
  - an insurance policy
  - a bank guarantee of funds or letter of credit
  - a bond
  - a third party guarantee
  - a fund established and maintained by a public authority
  - any other form of security that the EPA considers appropriate and specifies in the licence as a condition.

  The preferred approach must be nominated in the LEMP.
- The annual report for a landfill (see section 3.4.3 above) may nominate any variations for the level at which the financial guarantee is set for the forthcoming years' activity for a particular site based on the current operations and the extent of site activity planned. The nominated variations must be approved by the EPA.
- A financial assurance (or any part of it) may be called on by the EPA if the EPA:
  - is satisfied that the last licensee has failed to comply with the requirements of the closure plan approved by the EPA, or
  - is satisfied that a licensee has contravened any condition of the licence relating to site remediation work, or
  - incurs or proposes to incur costs or expenses in taking action that is covered by the financial assurance.
- The requirement to provide a financial assurance lapses and no longer binds the person who was required to provide it if the EPA is satisfied:
  - that the site remediation work has been completed in accordance with a post-closure plan approved by the EPA (as detailed in 29. Closure of Landfill), and
  - that further environmental management of the premises is not required.

The person may provide the EPA with a certified statement of completion to the effect that site remediation work has been completed and that further environmental management of the premises is not required. If the EPA approves the statement, the requirement for provision of the financial assurance lapses.

27. FILLING PLAN/CONTOURS

Primary Environmental Goal

2.3.4 Minimising landfill space used

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

The landfill contours should be managed in a systematic manner as outlined in the LEMP.

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

- The landfill occupier will update the filling plan section of the LEMP when each cell is started or completed, or when directed by the EPA.
- The filling plan will identify the type of waste in each cell and the location of any special burials such as asbestos or decontaminated soil.
- This survey will be conducted by a registered surveyor or by an alternative method agreed to by the EPA, and will ensure that the same grid and standard height datum is used for successive filling plan contour recordings.

28. SITE CAPPING AND REVEGETATION

Primary Environmental Goal

2.3.6 Remediating landfill after closure

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.4 Minimising landfill space used

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

Site capping and revegetation should ensure that the final surface provides a barrier to the migration of water into the waste, controls emissions to water and atmosphere, promotes sound land management and conservation, and prevents hazards and protects amenity. This would include the following points:

- The occupier will commence capping the completed filling areas within 30 days of completion of landfilling in that area, weather permitting.
- The landfill should have a final capping comprising five parts:
  - the seal-bearing surface
  - the gas drainage layer
  - the sealing layer
  - the infiltration drainage layer, and
  - the revegetation layer.
- The seal-bearing surface should consist of a properly designed and engineered layer of material.
- The gas drainage layer should have a minimum thickness of 30 centimetres. The calcium carbonate content of the gas drainage layer must not exceed 10% by weight to prevent encrustation.
- A sealing layer should consist of a clay layer at least 50 centimetres thick and having a permeability less than $K = 10^{-8}$ ms^{-1}.
- A drainage layer of permeability not less than $K = 10^{-5}$ ms^{-1} should be placed over the sealing layer. The drainage layer will be not less than 30 centimetres deep.
- A revegetation layer of depth of not less than 100 centimetres should be placed over the drainage layer. Plants selected for revegetation shall have root systems

which will not penetrate beyond the revegetation layer or block the drainage layer.

- The final settlement of the seal-bearing surface should leave a gradient of greater than 5% to defined drainage points.
- If the sealing layer is left for a period exceeding seven days before being covered by the revegetation layer, it should be covered by a flexible membrane liner protection layer.

29. LANDFILL CLOSURE AND POST-CLOSURE MONITORING AND MAINTENANCE

Primary Environmental Goal

2.3.6 Remediating landfill after closure

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.1.2 Detecting water pollution

2.2.1 Preventing landfill gas emissions

2.2.2 Detecting landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.1 Preventing unauthorised entry

2.4.2 Preventing degradation of local amenity

2.4.3 Preventing noise pollution

2.4.5 Adequate staffing and training

The Waste Minimisation and Management Act requires that within three months of the completion of a landfill's waste receipt operations, the last licensee must submit for approval to the EPA a written Closure Plan.

To ensure that the landfill continues to be non-polluting and does not cause environmental harm after site closure, the Closure Plan will include putting into place a post-closure monitoring and maintenance program which ensures the long-term integrity of the landfill. As with many other activities, post-closure monitoring and maintenance will control multiple environmental objectives, including emissions to water, emissions to the atmosphere, and protection of land use and local amenity. This monitoring and maintenance must be provided until the landfill does not pose a threat to the environment.

Specifically the Plan should:

- specify the steps taken or to be taken in closing and stabilising the premises concerned and the time frame for doing so
- ensure that all leachate collection, gas collection and stormwater sediment controls, monitoring and reporting practices, are maintained at a standard equivalent to that employed during the operational life of the landfill
- ensure that neighbouring residents are advised of contact persons to discuss any problems (e.g. odour emissions). Records of these complaints should be kept in the same manner as approved during operation.

- 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 remediation should be documented and reported in the same way as for an operating facility.
- The EPA may approve the Closure Plan as submitted, or it may vary the Plan before approving it.

  When sufficient evidence can be provided that the landfill is stable and non-polluting, the occupier may seek to complete all obligations and retrieve the financial assurance by submitting a certified statement of completion to the effect that site remediation work has been completed and further environmental management of the premises is not required.

Generally, this statement will be expected to show that:

- Gas concentration levels in all perimeter gas wells have fallen to less than 1% methane (v/v) and less than 1.5% carbon dioxide for a period of 24 months.
- Waste stabilisation has been completed. This would be documented by the composition of the leachate changing to a low level of contamination, and posing no hazard to the environment.
- Groundwater monitoring has indicated no failure of the landfill liner that would pose a threat to groundwater quality.
- The landfill capping has been assessed over some years and found to be stable with acceptable surface water drainage.
- Documentation to demonstrate that all functions in the closure planning segment of the LEMP and the written confirmation of procedures have been completed.
- The site has been placed on the Unhealthy Building Land Register.

Once the EPA has approved the certified statement of completion, the last licensee can cease the maintenance and monitoring of the site, and any the financial assurance requirements will lapse.

30. SECURITY OF SITE

Primary Environmental Goal

2.4.1 Preventing unauthorised entry

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.3.3 Recording of wastes received

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

Unauthorised entry to landfills can lead to waste dumping, fires, and vandalism of pollution control devices, as well as loss of amenity. The occupier should generally ensure that:

- Lockable security gates are installed and maintained.
- Landfills in urban areas, those located on extractive industry sites and all those receiving more than 25,000 tonnes per annum install and maintain a physical barrier that may include a 1.8 metre high wire mesh fence around the perimeter of the site.
- Landfills in rural areas receiving less than 25,000 tonnes per annum should install perimeter stock fences and 1.8 metre high wire mesh fences around the active tipping area and all flammable storage areas.

31. LITTER CONTROL

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.4.1 Preventing unauthorised entry

2.4.5 Adequate staffing and training

Local amenity should not be degraded by litter. Wind-blown litter is a nuisance to the community in the vicinity of landfill sites, and should generally be controlled by the following techniques:

- The occupier should introduce procedures that prevent the unnecessary proliferation of litter. Such procedures might include continuous compaction and use of litter fences, and the occupier is responsible for ensuring that all wind-blown litter that leaves the site is retrieved.
- All litter fences, perimeter fences and gates should be inspected daily and cleared of litter on a daily basis or as required.
- Entry and exit signs need to advise transport operators that they can be fined for any litter on public roads resulting from their improper transportation of waste.
- All litter that leaves the site should be retrieved on a daily basis.

32. CLEANING OF VEHICLES

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

To minimise effects on both local amenity and quality of stormwater run-off, all mud and waste materials on vehicles that leave the site should generally be removed. Vehicles using landfill sites will inadvertently collect mud and litter on their wheels as they proceed to and return from the active face.

- The landfill occupier should provide a wheel-washing or wheel-cleaning facility for use by customers. The occupier is responsible for deciding the appropriate cleaning method, taking into consideration site traffic and local road conditions. Hand-held pressure washing hoses, drive-through immersion bunds and vibration grids are all options which may suit different operations.
- The landfill occupier 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.

33. COVERING OF WASTE

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.1.1 Preventing pollution of water by leachate

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.3.4 Minimising landfill space used

2.3.6 Remediating landfill after closure

2.4.5 Adequate staffing and training

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

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 permeability barrier to control water entering the site and gas emissions, and promote revegetation.

Landfill occupiers are free to specify any alternative cover material (foams, mulch, etc.) provided 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 occupiers will be expected to maintain a stockpile or an area where cover can be won on-site in all weather conditions, adequate to meet the cover requirements of the landfill for two weeks.

1. Daily cover

Daily soil cover should be applied to a minimum depth of 15 centimetres over wastes. All waste should be covered prior to ceasing operations at the end of each day.

2. Intermediate cover

Suitably selected intermediate cover should be applied to a depth of 30 centimetres over surfaces which will be exposed for more than 90 days. The approach taken will be decided by the design philosophy, and various cover options will be considered as long as the environmental issues are addressed.

3. Cover material stockpile

Where cover material cannot be won on-site, a cover stockpile should be maintained in accordance with the LEMP.

Where all the cover material must be provided from a stockpile, a two-week supply should be maintained. As a guide, this is estimated to be one cubic metre of cover for every six tonnes of waste received.

34. DUST CONTROLS

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.5 Adequate staffing and training

Dust controls should minimise pollutants leaving the site as airborne dust, reduce stormwater sediment load, and protect local amenity. The generally expected maximum level for dust deposition is 4 g/m^2 per month as an annual mean for total solids, but the limit could be lower for landfills adjacent to sensitive areas. This deposition rate from the landfill should not be exceeded outside the site boundary.

The following measures are necessary to minimise generation of dust:

- Sealed or gravel roads should be constructed from the public roadway to the gatehouse/waste reception section of the landfill.
- Water spraying is an approved method of dust suppression for unsealed roads, but dust suppression methods additional to water spraying may be required in areas of fine soils and windy conditions.
- If required, all dust gauges are to be installed in accordance with AS 2724.1-1984 or later editions. The number of gauges and locations should be nominated by the landfill occupier and approved by the EPA. Alternatively, high-volume samplers may be installed if approved by the EPA.
- Monitoring of dust movement off-site will be required for all sites with residential development within one kilometre of the site boundary. Sampling and testing shall be carried out by a suitably qualified person and a NATA registered laboratory.

35. PEST, VERMIN AND NOXIOUS WEED CONTROLS

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.3.6 Remediating landfill after closure

2.4.1 Preventing unauthorised entry

2.4.5 Adequate staffing and training

Pests, vermin and noxious weeds should not be present at the site in sufficient numbers to pose an environmental hazard or loss of amenity in the areas neighbouring the site.

- Waste should 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.
- The landfill occupier should take steps to ensure that surfaces are adequately drained to prevent ponds of water forming on the site.
- If alternative cover materials or systems (*see* 33. Covering of waste) are used, occupiers should specify the method by which they will quantitatively monitor changes in vermin population as a result of the new cover.
- A plan to manage pests, vermin and declared noxious weeds should be developed and detailed in the LEMP.

36. ODOUR CONTROLS

Primary Environmental Goal

2.4.2 Preventing degradation of local amenity

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.2.2 Detecting landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.5 Adequate staffing and training

Landfills must have no odour impacts, in accordance with the Clean Air Act. Acceptance of wastes that are highly biodegradable, and improper gas management can lead to odour problems. Applicants are encouraged to consider at the planning stage the use of a separation distance/buffer zone as a technique for controlling the off-site movement of landfill odours. The use of sufficient distance between the landfill and sensitive receptors (i.e. residential zones) will minimise the requirement for other stringent odour controls.

The following measures will apply:

- The landfill occupier needs to take appropriate good housekeeping steps to prevent the production of odours. The use of daily cover and immediate attention to odorous waste loads will minimise the transmission of odours off-site.
- The occupier of any landfill which is identified by an odour dispersion modelling investigation (as required by DUAP 1996) 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.
- The landfill occupier will maintain a record of complaints regarding odours. This should be correlated with weather conditions and deliveries of particularly odorous wastes.

37. NOISE CONTROL

Primary Environmental Goal

2.4.3 Preventing noise pollution

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

Unless specified under an existing Noise Control Act licence, the noise generated during the operation of the landfill facility should be managed so that the following objectives can be met:

- noise from any single source does not intrude generally above the prevailing background noise level, and
- the background noise level does not exceed the level appropriate for the particular locality and land-use.

The determination of an appropriate noise limit for a particular site will therefore depend on the adjacent land-use, the existing background noise, and the nature of the noise source. Guidance on noise planning and control techniques can be found in the EPA's *Environmental Noise Control Manual* (EPA 1994a). The following are generally acceptable noise levels:

- 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.
- 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. Five 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 a.m. and 10:00 p.m. on Monday to Saturday, and between 8:00 a.m. and 10:00 p.m. on Sunday and Public Holidays; and night time as between 10:00 p.m. and 7:00 a.m. on Monday to Saturday, and between 10:00 p.m. and 8:00 a.m. on Sunday and Public Holidays.

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

38. FIRE-FIGHTING CAPACITY

Primary Environmental Goal

2.4.4 Adequate fire-fighting capacity

Related Environmental Goals

2.2.1 Preventing landfill gas emissions

2.3.1 Assuring quality of design, construction and operation

2.4.1 Preventing unauthorised entry

2.4.2 Preventing degradation of local amenity

2.4.5 Adequate staffing and training

Occupiers should have the ability to adequately fight fires at any part of the landfill site. Landfill occupiers shall demonstrate sufficient fire-fighting capacity through development of a site-specific fire management plan to minimise the incidence and impact of fire. This plan should identify:

- The procedure to follow, persons responsible, and equipment to be used in the event of a fire. This should include on-site resources and external resources (Bush Fire Brigade etc.), and how they will operate on a 24-hour-a-day basis.
- The maintenance schedule for all fire-fighting equipment and facilities. This should, at a minimum, include all equipment and facilities being visually checked for damage on a weekly basis, and test operated on a three-monthly basis.
- Details of all the fire-fighting equipment that will be installed at the flammable store and at-site buildings.
- How all fire-fighting equipment will be clearly signposted and access ensured at all times.
- How appropriate fire breaks are to be constructed and maintained around all filled areas, stockpiles of combustibles, gas extraction equipment and site buildings.
- Landfill staff training in landfill fire-fighting techniques.

39. STAFFING AND TRAINING REQUIREMENTS

Primary Environmental Goal

2.4.5 Adequate staffing and training

Related Environmental Goals

2.3.1 Assuring quality of design, construction and operation

2.4.4 Adequate fire-fighting capacity

The level and nature of staffing and training should be adequate for environmentally responsible and safe management of the landfill. Staffing requirements will vary as a function of size, type of wastes, diversity and complexity of site operations.

- Landfill occupiers 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 LEMP.
- At a minimum, staff training is to ensure that:
  - all operators of compaction or earthworks equipment are skilled at undertaking all tasks required of them
  - all those who operate gas testing, water sampling or water testing apparatus are familiar with required testing and sample retention protocols, to a standard approved by the EPA
  - all those who are to inspect or direct the placement of incoming wastes are are capable of accurate data recording, and skilled at identifying wastes that are unacceptable.

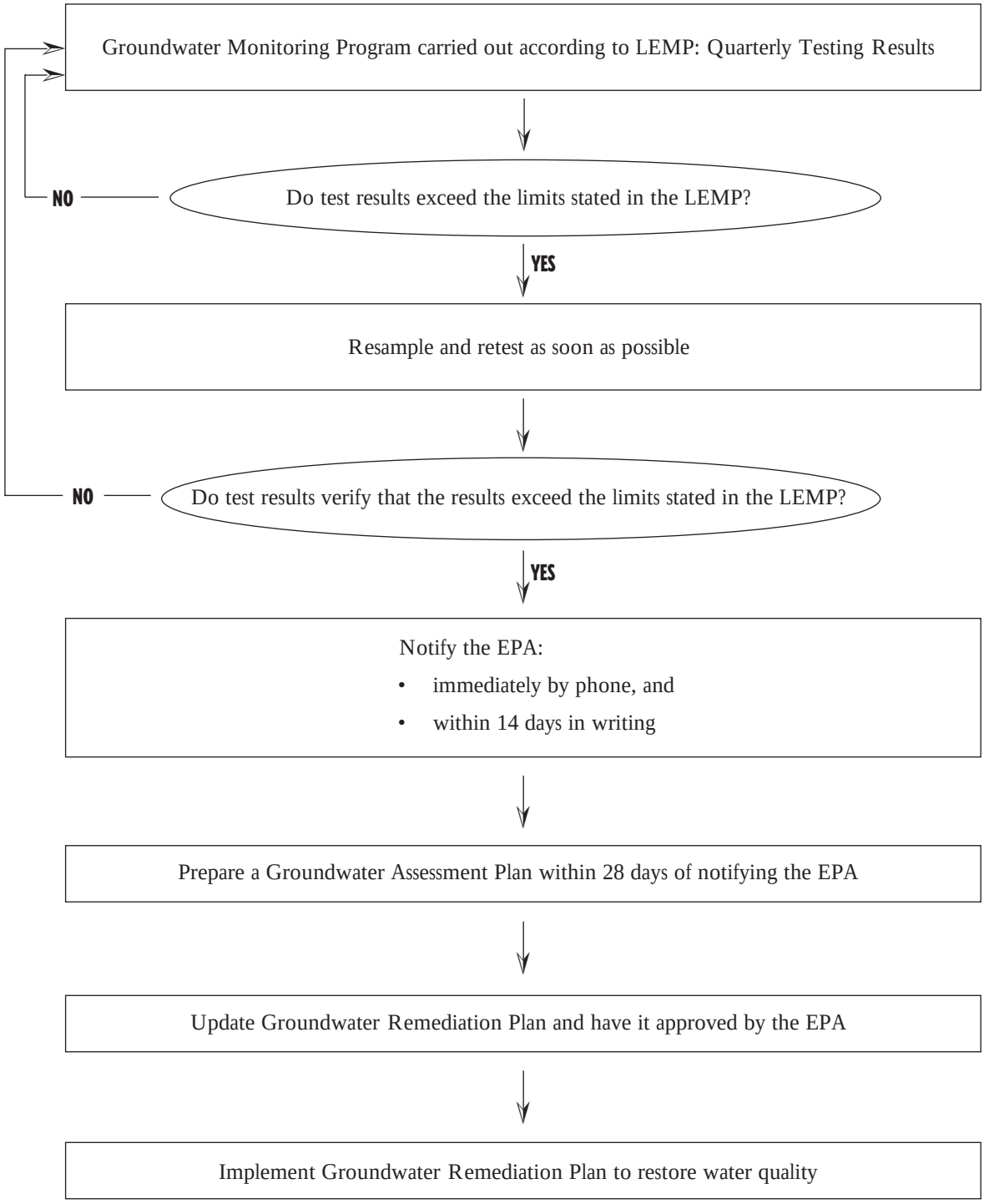
APPENDIX B
DEFINITION OF 'HAZARDOUS WASTE'

(to be finalised in the Regulations under the Waste Minimisation and Management Act)

Hazardous Waste means any waste which, through toxicity, carcinogenicity, mutagenicity, teratogenicity, flammability, explosivity, chemical reactivity, corrosivity, infectiousness or other biologically damaging properties, which may present danger to the life or health of living organisms when released into the environment, excluding:

- wastes, the discharge of which is in accordance with the provisions of a licence issued by the EPA; and
- municipal wastes (other than chemical wastes specially collected); and
- legal discharges to sewer, subject to a trade waste or customer contract; and
- biosolids when managed in accordance with the EPA's draft *Environmental Management Guidelines for the Use and Disposal of Biosolids*.

APPENDIX C
GROUNDWATER MONITORING, ASSESSMENT AND REMEDIATION



APPENDIX D
REPORTING FORM AND VEHICLE WEIGHT FACTORS

WASTE FACILITY RETURNS

Sheet 1 of 2

Depot Name: _____ **Date Return Lodged** ___ / ___ / ___

(As per licence registration)

This return covers the period from _____ **to** _____ **in the year** _____

1A. Municipal Waste received for disposal during the reporting period

LOCAL GOVERNMENT AREA (LGA)	Domestic Waste	Other Domestic	Other Council	Total (Tonnes)
			Total Municipal Waste disposed	**A**

1B. Municipal Waste received for reprocessing during the reporting period***

LOCAL GOVERNMENT AREA (LGA)	Domestic Waste (for reprocessing)	Other Domestic (for reprocessing)	Other Council (for reprocessing)	Total (Tonnes)
			Total Municipal Waste received for reprocessing***	**B**

*** This section(1B) is for statistical purposes only. Include this total in section 6.0 in the "Received" column.

2. Other Municipal Waste transported by small vehicles

	No of Vehicle		Weight Factor	(Tonnes)
Cars and Station Wagons		X	0.06	
Utes, Vans and Trailers		X	0.30	
			Total Small Vehicle Waste disposed	**C**

3. Commercial and Industrial (C&I) Waste received for disposal during the reporting period

Waste Component*				(Tonnes)
Commercial/Industrial (Mixed Waste)				
Tyres				
Putrescible/Organic				
Sludges and Bio-solids				
Clinical/Pharmaceutical				
Contaminated Soils				
Ferrous/Car body				
Hazardous Waste**				
Other C&I Waste (specify)*				
Other C&I Waste (specify)*				
No of small vehicles (utes,vans & trailers)		X	0.30	
			Total Commercial/Industrial Waste disposed	**D**

*Use extra page if necessary

**Includes all other hazardous wastes subjected to the National Hazardous Waste Management Guidelines

WASTE FACILITY RETURNS

Sheet 2 of 2

Depot Name: _____ **Date Return Lodged** ___ / ___ / ___

(As per licence registration)

This return covers the period from _____ **to** _____ **in the year** _____

4. Building and Demolition (B&D) Waste received for disposal during the reporting period

Waste Component*			(Tonnes)
Building/Demolition (Mixed Waste)			
Asbestos (Type 3 only)			
Separated Building Materials			
Other B&D Waste (specify)*			
Other B&D Waste (specify)*			
No of small vehicles (utes,vans & trailers)	X	0.30	
		Total Building/Demolition Waste disposed		**E**

*Use extra page if necessary

5A. Transfer Waste (Out)

(To be filled in by Transfer Station only)

WASTE TRANSFERRED OUT (Tonnes)		
Enter Depot Name	Reprocessing	Disposal

(Not to be added to "F")

5B. Transfer Waste (In)

(Depots accepting waste from Transfer Stations)

WASTE TRANSFERRED IN (Tonnes)		
Enter Depot Name	Reprocessing	Disposal

Total Transferred Waste For Disposal **F**

(Add only the disposal tonnage to total "F")

6. Recycling and Composting Products/Materials

	(All Units In Tonnes)	
	Received	Transported Out
Organic Compostable (See note below)		
Brick/Tile		
Concrete		
Building Materials		
Paper/Cardboard		
Glass		
Ferrous/Car body		
Non-Ferrous/Aluminium		
Plastics/PET		
Tyres		
Other (Specify)*		
Other (Specify)*		
Total Recycling/Composting/Reprocessing Materials			**G**

Note: Include cell 1B total and all other organic compostable from other waste streams

7. Clean Fill and Operational Materials

	Received (Tonnes)	
Clean fill, cover & capping materials		
Cell lining materials		**H**

8. Total Waste Disposed at Disposal Site (Tonnes) **(A+C+D+E+F) =** **I**

Waste Disposal Levy @ $7.20 Per Tonne **(I X $7.20) =** **$**

Waste factors by vehicle and waste type (All units in tonnes)

Vehicle type	Description	Weight factor		
Small vehicle		**All mixed waste**		
A	Car/station wagon	0.06		
B	Van/utility/trailer	0.30		
Open truck		**Municipal, commercial and industrial waste**	**Building and demolition waste**	**Clean natural excavated materials**
C	Single rear axle with two rear wheels or four small rear wheels	0.62	0.98	2.47
D	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 with 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 waste**		
H	Single steer with single rear axle		2.72	
I	Single steer with tandem rear axle		6.38	
J	Twin steer with tandem rear axle		7.96	
K	Waste transfer truck		19.89	

APPENDIX E
LOCAL GOVERNMENT AREAS IN THE SYDNEY, HUNTER AND ILLAWARRA REGIONS AFFECTED BY LICENSING PROVISIONS

SYDNEY AREA

Ashfield
Auburn
Bankstown
Baulkham Hills
Blacktown
Blue Mountains
Botany
Burwood
Camden
Campbelltown
Canterbury
Concord
Drummoyne
Fairfield
Hawkesbury
Holroyd
Hornsby
Hunters Hill
Hurstville
Kogarah
Ku-ring-gai
Lane Cove
Leichhardt
Liverpool
Manly
Marrickville
Mosman
North Sydney
Parramatta
Penrith
Pittwater
Randwick
Rockdale
Ryde
South Sydney
Strathfield
Sutherland
Sydney
Warringah
Waverley
Willoughby
Woollahra

HUNTER AREA

Cessnock
Gosford
Lake Macquarie
Maitland
Newcastle
Port Stephens
Wyong

ILLAWARRA AREA

Kiama
Shellharbour
Shoalhaven
Wingecarribee
Wollongong

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.

Avoidance/reduction

Reducing the quantity and toxicity of wastes produced and the quantity of resources consumed during the manufacture and life-time of a product.

Batch

Samples taken from one site in one day.

Beneficial use

The environmentally benign and useful application or use of a resource which is of public benefit, including welfare, safety, health or aesthetic enjoyment.

Bioremediation

The remediation or decontamination of any contaminated matter by the use of processes involving biological organisms.

Biosolids

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

Building and demolition waste

Solid and inert waste materials, arising from the demolition, erection, construction, refurbishment and alteration of buildings and the construction, repair and alteration of infrastructure including roads, bridges, dams, tunnels, railways and airports.

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 a landfill.

Clean excavated natural material

Material consisting of clay, soil and crushed rock which is not contaminated or mixed with any other material.

Clinical and related waste - (also called Medical waste)

Any cytotoxic or contaminated waste.

Commercial and industrial waste

Solid and inert wastes generated by businesses and industries (including shopping centres, restaurants and offices) and institutions (such as schools, hospitals and government offices), excluding building and demolition waste and municipal waste.

Composting

The process of the aerobic conversion of organic materials by micro-organisms into soil conditioners, compost or humus. By definition, it is a process which must be carried out under controlled conditions yielding cured products.

Construction waste - *see Building and demolition waste*.

Contaminated waste

(a) Of clinical and related waste origin:

Contaminated waste is material with the potential to cause infection. Sources include medical, nursing, dental, veterinary, pharmaceutical and similar facilities engaged in treatment, investigation, teaching or research. Contaminated waste includes:

Sharps: Any object capable of inflicting a penetrating injury contaminated with blood and/or body fluids. This includes needles, needle or syringe combinations and any other sharp objects or instruments designed to perform invasive procedures.

Bulk body fluids, blood and blood products: Including any vessel, bag or tubing containing body fluids, blood or blood products.

Disposable and dressings linen: Heavily soiled with blood and/or body fluid.

Microbiological and pathological waste: Including discarded laboratory specimens, cultures and materials that have contact with such, and biological reagents.

Tissue: Human tissue, organs, body parts, placentas and products of autopsy and animal tissue.

(b) Other than of clinical and related waste origin:

Contaminated soil or other contaminated wastes are solid wastes containing more than 200 mL/tonne or 200 g/tonne of hazardous content or wastes formally defined as 'hazardous wastes' in statutory instruments (*see* Appendix B for current definition) or as specifically determined through any special requirements that may be set by the EPA.

Cover material

Material approved by the EPA for use to cover dumped waste at landfills.

Decomposition

The breakdown of organic waste materials by micro-organisms.

Degradation

An environmentally significant natural, physical, chemical or biological transformation to a lower state.

Demolition waste - *see Building and demolition waste*.

DUAP

New South Wales Department of Urban Affairs and Planning.

EIS

Environmental Impact Statement.

EPA

New South Wales Environment Protection Authority.

Greenhouse gases

Gases, such as methane and carbon dioxide, which are implicated in the greenhouse effect, which in turn is thought to cause global warming.

Groundwater

Water saturating the voids in soil and rock; water in the zone of saturation in the Earth's crust.

Hazardous waste

Wastes currently defined as 'hazardous wastes' in the proposed Regulatory Impact Statement (*see* Appendix B).

Hazardous waste landfill

Any landfill that accepts hazardous waste (*see* definition above).

Industrial waste - *see Commercial Waste*

Inert waste

Wastes which do not undergo environmentally significant physical, chemical or biological transformations and have no potentially hazardous content once landfilled. This waste from building and demolition includes bricks, concrete, glass, plastics, metal and timber. They must not be contaminated or mixed with any other material. (For levels of unacceptable contamination, see relevant EPA guidelines or seek EPA advice.)

Inert waste landfill

Any landfill that accepts only inert wastes (*see* definition above). Inert waste landfills are subdivided into two classes:

- Class 1 - all inert wastes including stabilised asbestos cement and physically, chemically or biologically fixed, treated or processed waste, in accordance with any special requirements that may be set by the EPA.
- Class 2 - all inert wastes except stabilised asbestos cement or physically, chemically or biologically fixed, treated or processed waste.

Landfill Environmental Management Plan (LEMP)

A detailed plan for the operations of a landfill site from its greenfield state to its fully rehabilitated state including after-care.

Landfill gas

Gaseous emissions from the decomposition of waste. Also called 'biogas'.

Landfill site

A waste facility used for the purposes of disposing of waste to land.

Leachate

Liquid released by, or water that has percolated through, waste and which contains dissolved and/or suspended liquids and/or solids and/or gases.

Licence

A licence (including a supervisory licence) granted under the Waste Minimisation and Management Act 1995 and in force.

Litter

Solid waste that is outside the tipping area of the landfill site and is not part of the formal waste 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 of wastes otherwise destined for disposal in which the emphasis is on separating and processing waste materials.

Medical waste - *see Clinical and related waste and Contaminated waste*

Methane (CH_4)

An explosive, odourless and colourless gas produced in a landfill by organic waste undergoing anaerobic decomposition.

Mulching

The size-reduction of organic materials using one or more of the following processes: cutting, milling, shredding, grinding and other means. The mulch is then usually pasteurised.

Municipal waste

Solid and inert wastes arising from the three waste sub-streams:

Domestic waste - household solid and inert wastes placed out for kerbside collection

Other domestic waste - residential solid and inert wastes arising from domestic clean-up and garden waste

Other council waste - council generated solid and inert wastes arising from street sweepings, litter bins, parks and garden clean-ups, tree loppings and council engineering work.

MWDR

Metropolitan Waste Disposal Region.

Occupier

A person who has the management or control of the landfill (other than as an employee).

Organic waste

One or more of the following types of waste: garden, untreated wood, fibrous, vegetables, fruits, cereals, biosolids, manures, fatty foods, meat, fish and fatty sludges.

Poorly stabilised material

A treated material which is prone to further degradation or decomposition.

Poorly stabilised or untreated biosolids

Biosolids that only meet stabilisation grade C under the EPA's draft *Environmental Management Guidelines for the Use and Disposal of Biosolids* (EPA 1995).

Public authority

A public or local authority constituted by or under an Act and includes:

(a) a Waste Board, or

(b) a department of Public Service, or

(c) a member of staff or other person who exercises functions on behalf of a public authority, or

(d) a State owned corporation or a subsidiary of such a corporation.

Putrescible waste

Waste being food or animal matter (including dead animals or animal parts), or unstable or untreated biosolids.

Recycling

The process by which waste otherwise destined for disposal is collected, reprocessed or remanufactured and used to make a product.

Relative per cent difference

The mean of duplicate samples divided by the average and expressed as a percentage.

Remediation

Work for the remediation, rehabilitation and monitoring of premises the subject of a licence and that is required by the conditions of a licence to be carried out:

(a) while the premises are being used for the purpose to which the licence relates, or

(b) after the premises cease being used for the purpose to which the licence relates,

or both.

Reprocessing

Physical, chemical or biological processing used to transform waste, otherwise destined for disposal, into a raw material used to make a product.

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.

Re-use

A process by which waste otherwise destined for disposal is cleaned or repaired for use, for the purposes of prolonging the original product lifetime prior to treatment or reprocessing.

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 (i.e. the landfill site).

Sludge

Semi-liquid waste produced as a by-product of an industrial process.

Solid waste

Any non-hazardous, solid, degradable waste. This includes putrescible wastes; garden wastes; uncontaminated biosolids; and clinical and related waste (including contaminated waste) only where sterilised to a standard acceptable to the Department of Health. Solid waste shall contain less than 200 mL/tonne or 200 g/tonne of hazardous wastes. All solid waste shall have an angle of repose of greater than five degrees (5˚) and have no free liquids.

Solid waste landfill

Any landfill that accepts solid wastes (irrespective of whether it also accepts some inert wastes). Solid waste landfills are subdivided into two classes:

- Class 1 - All solid waste including putrescible wastes and other wastes approved by the EPA.
- Class 2 - All solid waste with the exception of putrescible wastes and other wastes approved by the EPA.

It should be noted that the Government envisages banning garden wastes from landfill in the near future.

Spadable sludge

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

Stabilised material

Material not prone to further degradation or decomposition.

Supervisory licence

The licence whereby a public authority exercises control over a Solid Waste Class 1 Landfill with respect to:

- types and quantities of waste received
- facility design
- separation, re-use, reprocessing and recycling, and
- disposal charges.

Surface water

Surface water includes all natural and constructed 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.

Toxins

Substances which are harmful to humans, animals or plants.

Transfer station

A waste facility used to transfer waste from collection vehicles to a bulk haul vehicle in order to achieve long-distance transportation efficiency.

Treatment

Physical, chemical or biological processing of a waste for 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.

v/v

Volume for volume.

Waste

Waste includes:

(a) any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such a volume, constituency or manner as to cause an alteration in the environment, or

(b) any discarded, rejected, unwanted, surplus or abandoned substance, or

(c) any otherwise discarded, rejected, unwanted surplus, or abandoned substance intended for sale or for recycling, reprocessing, recovery or purification by a separate operation from that which produced the substance, or

(d) any substance prescribed by the regulations to be waste for the purposes of this Act.

A substance is not precluded from being waste merely because it can be reprocessed, re-used or recycled.

Waste facility

Any premises used for the storage, treatment, reprocessing, sorting or disposal of waste.

Watertable

The surface of the groundwater.

BIBLIOGRAPHY

APHA 1995. *Standard Methods for the Examination of Water and Wastewater* (19th Edition). American Public Health Association, American Water Works Association and Water Environment Federation, Washington DC.

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, pp. 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 (editors) 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*. Palmerston, Northern Territory.

Department of Environment and Natural Resources (South Australia) 1994. *Draft Code of Practise for Solid Waste Disposal Depots*. S.A. Waste Management Commission, Adelaide.

Department of Environment and Planning (Tasmania) 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. London.

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

Department of Water Resources (NSW) 1992. *River Water Quality Monitoring Strategy: Key Sites Program Operations Manual*. Parramatta.

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

DUAP 1996. *EIS Practice Guideline: Landfilling*. Department of Urban Affairs and Planning (NSW).

Environment Council (EC) 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.

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

EPA 1994b. *Environmental Noise Control Manual*. NSW Environment Protection Authority, Sydney.

EPA 1994c. *Water Quality Investigations Manual, Preferred Methods for Sampling and Analysis - Draft*. NSW Environment Protection Authority, Sydney.

EPA 1995. *Environmental Management Guidelines for the Use and Disposal of Biosolids (Draft)*. NSW Environment Protection Authority, Sydney.

Federal Ministry for the Environment (Germany) 1993. *Environmental Policy in Germany, Technical Instructions on Waste from Human Settlements (TA Siedlungsabfall) and Supplementary Recommendations and Information*. (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*. Perth.

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

Health Department of Western Australia 1993. *Landfill Sites - Waste Acceptance Criteria (Draft)*. 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 1993.

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, G.F. 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, pp. 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 L.K., J.W. Cowland, N.K. Mattravers, W.K. Shung, B.S. Lee and C.H. 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 J.P. 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 R.K. and M.J. 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. 'NSW 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*. North Sydney.

Standards Association of Australia 1987. *Australian Standard 2990-1987. Quality Systems for Engineering and Construction Projects*. 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). United States Environmental Protection Agency, Office of Solid Waste, Washington DC.

USEPA 1991. *Handbook: Groundwater. Volume II: Methodology* (EPA/625/6-90/016b). United States Environmental Protection Agency, 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. United States Environmental Protection Agency, Washington DC.

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. United States Environmental Protection Agency, Washington DC.

USEPA 1992. SW-846 *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington DC.

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