# REVIEW OF THE APPLICATION OF LANDFILL STANDARDS

WRIGHT CORPORATE STRATEGY PTY LIMITED
March 2010

Disclaimer.  The views and opinions expressed in this document are those of Wright Corporate Strategy and do not necessarily reflect those of the Australian Government or the Minister for the Environment, Heritage and the Arts, and the data in this document has been based on information that was available as at September 2009.

## Table of Contents


| | page |
|---|---|
| Executive Summary | 1 |
| 1. Introduction | 12 |
| 2. Landfill Context | 13 |
| 3. Overview of Waste and Landfill Classification in Australia | 15 |
| 4. Landfill Deployment and Waste Disposal | 18 |
| 5. Regulatory Guidelines for Australian Landfills | 25 |
| 6. Performance of Australian Landfills | 36 |
| 7. Groundwater Monitoring Results | 54 |
| 8. International Landfill Regulatory Requirements | 58 |
| References | 72 |
| ATTACHMENT A | 73 |

# EXECUTIVE SUMMARY

Australia's licensed landfills receive around 21 million tonnes of waste each year. The annual disposal rate has been broadly consistent over the last decade despite substantial growth in resource recovery and recycling. Indeed, the strong annual growth in waste generated has been taken up by offsetting growth in recycling. Although landfill today is just one of the main waste treatment pathways, it remains the favoured destination for unwanted materials.

This Study was commissioned by the Australian Department of the Environment, Water, Heritage, and the Arts to provide a snapshot of current Australian landfill management performance and a comparison of this performance with best practice techniques. As landfill monitoring data is provided to EPAs on a commercial-in-confidence basis, it has not proved feasible to gain detailed actual performance information in a format that would be suitable for valid, comprehensive conclusions to be reached and compared at a national scale.

A different, but potentially useful alternative approach has been taken. Environment agencies and EPAs in Australian jurisdictions have established policy and regulatory requirements for sustainable waste management and landfill performance. These requirements are published as *landfill management guidelines* prepared by Australian States and Territories – they typically cover landfill siting, design, construction, and operation. These requirements form the main heads for best practice performance and the basis to benchmark standards for performance which are set to protect the environment.

The Study examined the Landfill Guidelines for all jurisdictions (except Western Australia and ACT which do not have published guidelines). The requirements were summarised and presented as a comparison of performance *controls* by jurisdiction. In order to assess how landfill management practice aligns with the published Landfill Guidelines, the Study drew on a comprehensive, published *National Landfill Survey* (WMAA 2007). This enabled a clear comparison to be made between nominated best practice performance, as seen by the EPAs, and implementation of controls that should result in best practice performance.

The study also examined international landfill practice as specified in regulatory frameworks of the European Union, the United Kingdom and the United States.

The main study findings are set out below.

## Landfill Context (Chapter 2)

As the take-up of resource recovery actions has increased, landfill has been relegated from its position as the pre-eminent waste treatment option, to be just one part of the waste management infrastructure pool. Indeed, landfill now occupies the bottom rung of the almost universal waste hierarchy. With the transition to waste materials being seen as potential resources, the functions of landfill are expanding. Performance tasks now range from the traditional, but still vital, function of protecting public health, to the sophisticated recovery of gas for conversion to energy. The basic landfill tasks include:

Protecting public health and the local environment:

- design and operation to mitigate water, odour, and noise emissions;
- design and operation to control vermin, wind-blown litter, and dust.

Protecting the global environment:

- design and operation to maximise capture and use landfill gas emissions;
- provision of landfill-based opportunities to recover materials and products suitable for beneficial uses.

Providing an efficient and effective final disposal option for residual waste:

- sound monitoring and control of operations;
- capacity and scale of operations for efficient management.

## Waste and Landfill Classifications (Chapter 3)

There are significant differences between jurisdictions in the way that waste is classified and the commensurate classes of landfill that are permitted. *Waste* classification schemes range from two categories, used by Queensland, to seven categories used by Western Australia. Similarly, *landfill* classification schemes vary from a single classification, used by South Australia, to five categories used by Western Australia.

Despite the variety of classifications, the main classes of both waste and landfill types are putrescible waste, non-putrescible waste, inert waste, and hazardous waste.

## Waste Disposal (Chapter 4)

Drawing on the Waste Management Association of Australia *National landfill Survey* (WMAA 2007) and estimates by WCS, it appears that Australia has at least 459 landfills of sufficient capacity to be licensed to receive waste. The main scale categories adopted for this Study and estimated landfill stock are shown at Table ES-1.

**Table ES-1 Landfill Size-Classes**

| Category | Annual Tonnage Received | Estimated Landfill Stock |
|---|---|---|
| Small | Less than 10,000 tonnes/year (not including open, unattended, or unlicensed tips) | 262 |
| Medium | Greater than 10,000 tonnes/year and less than 100,000 tonnes/year | 133 |
| Large | Greater than 100,000 tonnes/year | 64 |

Source: WMAA National Landfill Survey (WMAA 2007)

Based on the results of the *National Landfill Survey*, almost three quarters (73%) of the solid waste disposed to landfill in Australia is placed in around 64 large landfills, each of which receive more than 100,000 tonnes of waste/year. Only a very small proportion (3%) of the waste disposed to landfill in Australia each year is placed in small landfills that receive less than 10,000 tonnes/year.

The number of these small landfills is relatively large (at 262 landfills accounted for in the WMAA *National Landfill Survey*) and significant (57% of landfills in the WMAA database). And this number is supplemented by many hundred small unlicensed, unattended tips. The potential threat to environment and human health is geographically widespread, but collectively significant.

Also of significance in respect of the importance of effective landfill management and regulatory compliance are the approximately 133 medium sized landfills (29% of all sites in the database) that receive almost 5 million tonnes/year – approximately one quarter of all solid waste disposed to landfill in Australia.

## Regulatory Guidelines for Australian Landfills (Chapter 5)

Environment agencies and EPAs in Australian jurisdictions have established policy and regulatory requirements for sustainable waste management and landfill performance. These requirements form the main heads for performance objectives and the basis to benchmark standards which are set to protect the environment.

The Australian State and Territory Landfill Guidelines are broadly framed to provide firm, but not dogmatic, regulatory guidance (see References pp 70). It is important to appreciate that this guidance is backed by specific development approvals and landfill licence conditions which cover detailed requirements in the context of exact waste disposal plans and the landfill setting. The majority of requirements in Australian Landfill Guidelines are expressed as outcome-oriented statements (such as the Queensland requirement to *protect groundwater quality*). They also contain a number of practice requirements, such as those relating to waste acceptance, and monitoring and reporting. In general, the guidelines

provide clear direction subject to environmental assessment requirements for specific projects.

## Implementation of Performance Controls in Accordance with Landfill Guidelines (Chapter 6)

As noted above, it has not proved feasible to gain landfill performance information that coincides with the *outcome* requirements expressed in the various Landfill Guidelines. This particularly relates to the landfill design and construction sections of the guidelines, for which the requirements are expressed in terms of outcomes such as *"...prevent leachate from entering groundwater" and "...prevent surface water from mixing with waste and carrying contaminants off-site".* These important outcomes are difficult to measure at a scale that would be suitable for valid, comprehensive conclusions to be reached at a national or a jurisdiction scale.

In order to assess how actual landfill design, construction and operation aligns with the intent of published Landfill Guidelines, the Study drew on a published *National Landfill Survey* (WMAA 2007). The *National Landfill Survey* developed by the Waste Management Association of Australia provide significant information on the design and operation of landfills across Australia. The survey asked questions about landfill features and practices.

The database was examined in order to develop a comparison between performance outcomes, as seen by the various EPAs, and implementation of practices and control measures fundamental to achieving the nominated outcomes. In addition, the findings of the WMAA 2007 survey were compared with the (initial) findings of the WMAA 2009 survey for which (only) aggregate information was published at the completion of this study.

Tables ES-2 and ES-3 below illustrate the alignment between the (generalised) Landfill Guideline requirements and the relevant *National Landfill Survey* measures.

As shown in Table ES-2, the *National Landfill Survey* examined the implementation of infrastructure items and control systems that are essential requirements for achieving the

outcomes prescribed in the Landfill Guidelines. These control measures are a valid proxy in lieu of detailed jurisdictional reporting against the intent of landfill guidelines.

**Table ES-2. Guideline Requirements for Design and Construction Versus WMAA Survey Measures**

| Guideline Issue | Guideline Requirement - Design and Construction | WMAA Survey Measure | Relevance of WMAA Survey Measure to Guideline Requirement |
|---|---|---|---|
| Landfill liner structure | Prevent leachate from entering groundwater | Existence of and type of liner structure | Indirect, but fundamental for compliance with Guideline |
| Leachate collection and treatment | Collect leachate and prevent escape to groundwater | Existence of leachate collection, treatment and monitoring systems | Direct and indirect, but fundamental for compliance with Guideline |
| Water management | Prevent surface water from mixing with waste and carrying contaminants off-site | Existence of stormwater management control and monitoring systems | Indirect, but fundamental for compliance with Guideline |
| Air emissions | Prevent odour and dust emission impacts on amenity and health | Existence of systems for waste compaction, daily cover, odour control and odour monitoring | Indirect, but the key requirement for compliance with Guideline |
| Landfill gas management | Control landfill gas (LFG) to minimise GHG emissions | Existence of systems for capture of landfill gas and flaring or conversion to energy, and LFG monitoring and reporting | Indirect, but fundamental for compliance with Guideline |

As shown in Table ES-3, the WMAA survey also examined use of both practices that directly

respond to Landfill Guideline issues, and use of control systems that are fundamental to achieving the outcomes prescribed in the Landfill Guidelines. Again, the control measures, needed to a lesser extent here, are a valid proxy in lieu of reporting against Landfill Guidelines.

**Table ES-3. Guideline Requirements for Operation Versus WMAA Survey Measures**

| Guideline Issue | Guideline Requirement - Landfill Operation | WMAA Survey Measure | Relevance of WMAA Survey Measure to Guideline Requirement |
|---|---|---|---|
| Waste acceptance | Accept only waste for which the facility is licensed | Existence of a weighbridge, waste inspection arrangements and reporting | Direct and indirect measures |
| Resource recovery and pretreatment | Recovery and recycling of suitable materials delivered to landfill | Existence of small vehicle transfer station, recycling centre, and reported recovery level for nominated materials | Direct and indirect measures |
| Litter, odour and dust control | Litter, odour and dust control to avoid impact beyond landfill boundary | Existence of litter control nets, odour controls, use of waste compaction and daily cover, and dust monitoring | Direct and indirect measures |
| Disease vector control and cover | Protect local amenity and deny access by vermin by use of cover material | Use of cover material, and vermin control measures | Direct measure |
| Monitoring and reporting | Regular monitoring and reporting covering nominated pollutant impacts | Adherence to regular monitoring and reporting | Direct measure |

The results of the analyses, as shown by the WMAA Surveys (WMAA 2007 and WMAA 2009) are described below in summary form.

***Design and construction performance*** – In broad terms, two of the reported performance requirements stand out as examples of relatively *poor* compliance with the intent of Landfill Guidelines across most jurisdictions:

- Inadequate use in Small landfills of landfill liners and leachate collection systems to prevent contamination of groundwater. Application of both types of control systems was rated as low in survey responses.

- Limited use of landfill gas capture systems to minimise release of greenhouse gas emissions. This applies particularly to Small and Medium sized landfills for which the survey response was low. The survey response for Large landfills was just one step higher at low to moderate.

Overall, the application of measures that would enable compliance with Landfill Guidelines for design and construction requirements appears to have been satisfactory for Large landfills, marginal for Medium landfills, and at an unsatisfactory low level for Small landfills.

***Operational performance*** – In broad terms, the application of measures in respect of Landfill Guidelines for operating systems and practices appears to have been satisfactory for Large and Medium landfills, and unsatisfactory for Small landfills. Implementation of operating practices at Small landfills (including monitoring and reporting) in keeping with Landfill Guidelines is recorded as low to moderate.

In the application of both design/construction and operational performance measures across all criteria, Small and Medium landfills fared considerably worse than Large landfills, according to the survey results.

## Groundwater Monitoring Results (Chapter 7)

It has been possible to review the results of a special set of groundwater monitoring studies prepared by the EPA in one Australian jurisdiction. The studies reviewed were completed in 2006 and covered 17 landfill sites, including small, medium, and large facilities. Although an overall national situation cannot be inferred from the data available, the review does indicate some instances of actual or potential pollution of groundwater, with elevated levels of ammonia, nitrates, and/or potassium.

In brief, some groundwater pollution incidents were recorded for around half of all sites: pollution was detected at five of the 17 landfill sites examined; and mild or slight pollution was detected at a further three sites. In addition, possible pollution was detected at two sites – the uncertainty relates the presence of high background levels of subject chemicals. Minor change in groundwater chemistry was detected at three sites.

In all but one of these 13 cases, the entire landfill was unlined or had substantial (previously filled) cells that were unlined. In these cases, groundwater pollution was indicated at bores closest to the unlined parts of the landfill. The single case in which groundwater pollution was recorded from a lined landfill was where off-site construction had caused a fault in the liner system.

Although not at a national level, these findings indicate the pollution control qualities of landfill liner systems and demonstrate that without liners in place groundwater pollution episodes can be expected. The results provide a high level of confidence in the use of control actions for groundwater protection as a proxy for the unavailable comprehensive pollution monitoring data.

## International Landfill Regulation (Chapter 8)

In keeping with their status as regulations rather than guidelines, the requirements of the EU, UK, and USA are considerably more directive than those contained in the guideline documents issued by Australian jurisdictions. The language used in the selected

international landfill regulations and directives is quite prescriptive even though reference is invariably made to the need to comply with State and regional requirements.

The requirements contain a mix of outcome oriented statements (such as the USA requirement that *no polluted water shall be discharged to waters*) and more direct input requirements (such as the EU requirement to *prevent surface water from entering the landfill and collect and treat contaminated water to the standard required*).

Within the scope of this study it has not been possible to locate documentary evidence of the overall performance of landfills in the EU States, UK or USA.

## Pointers for Policy Direction

### Public Reporting of Landfill Performance

The WMAA survey, which asks questions about the existence of landfill structural control measures and practices to protect the environment, has proved valuable in predicting landfill actual performance. However, the WMAA Survey database is no substitute for open, aggregate reporting at jurisdiction level on the "state of the landfill environment". Such reporting could readily be compiled from annual landfill reports provided to EPAs in Australian jurisdictions.

### Indicators of Landfill Performance

Implementation of design, construction and operating measures that would enable Large landfills to comply with Landfill Guidelines is in the high or moderate to high compliance category. This is considered satisfactory and aggregate performance is likely to improve over time.

Implementation of control measures for Medium scale landfills is mixed, though mainly in the moderate or moderate to high category. There is clear scope for improved groundwater protection and landfill gas capture at these landfills.

The stock of Small landfills is poorly equipped with control measures and practices which would enable them to comply with Landfill Guidelines. The WMAA survey reports that implementation of fundamental measures, such as liner systems, leachate collection, landfill gas capture, surface water management, and waste acceptance controls, are largely in the low or low to moderate category. Without such measures and practices, Small landfills are unable to comply with the requirements of Landfill Guidelines.

**The Future of Small Landfills**

It appears that small landfill sites are the last to gain the benefit of good-practice design, construction and operating measures and are least likely to perform in accordance with modern, expected practice. Many of these landfills are required to service towns and villages in remote areas and alternative arrangements are simply unavailable. Environmental performance of these remote landfills should be progressively improved.

Hundreds of other small landfills, however, are sited in regional (rather than remote) areas (such as the Orana and Central West Regions of NSW where only 13 of the 117 existing landfills are of sufficient scale to be licensed). Many of these facilities are marginal and should be phased out in favour of nearby larger facilities that offer improved resource recovery and the scale for future residual waste processing along with environmentally sound waste disposal controls.

**Lessons from EU Regulation?**

The EU landfill regulation-based approach warrants consideration. Would improved landfill performance be attained with the blanket directive and regulatory approach adopted by the EU rather than the Australian approach of jurisdictional guidelines and case by case regulatory requirements? The blanket approach may threaten cost-effectiveness and, in any case, many landfills in current use pre-date the development of Landfill Guidelines. It appears that the greater opportunity to improve landfill performance could come through retrospective regulation requiring licensing of all landfills already in service and increased regulatory control of practice directions contained in Landfill Guidelines.

## Introduction

This report sets out the results of a desk-top study of landfill practice and performance controls. The main purpose of the study is to compare reported practice in landfill development and management with required practice as described by Australian regulatory authorities. By highlighting any divergence between the performance of landfills in protecting the environment and public health, on the one hand, and regulatory expectations, on the other hand, it is hoped to secure improved overall landfill performance.

The focus of the study is the 21 million tonnes of routine residual waste presented each year to landfill following discard by household, business and government. Nothing in the report should be taken to imply any position on the importance of increased resource recovery. The study merely recognises that residual waste (following resource recovery) should be managed in the safest possible manner.

The report commences with a survey of Australian waste and landfill classification schemes as defined by each jurisdiction (Chapter 3). This is supplemented by a snapshot of current waste disposal to Australian landfills (Chapter 4). The centrepiece of the study is an examination of required practice in landfill design, construction and operation, as defined in environment agency and EPA Landfill Guidelines (Chapter 5), together with an analysis of actual adherence to the intent of these guidelines (Chapter 6). This is followed by an examination of actual landfill performance (Chapter 7). International landfill regulatory requirements are also described (Chapter 8).

The study provides a suitable basis for comparison of the implementation of regulatory performance controls with landfill best practice as represented by landfill regulatory guidelines.

# 2. Landfill Context

## The Role of Landfill and the Performance Objectives for "Good Practice"

Landfill has for centuries been used as the primary means of disposing of unwanted materials or waste. The technology and performance of landfill facilities has progressively improved in order to address risks to human health, the environment, and operator health and safety. But despite great advances in resource recovery, landfill remains a critically important part of the waste management infrastructure.

While landfill technology and operating practice has improved, the challenge to environment protection has increased as the waste stream has evolved to include a wider variety of moderately toxic and polluting materials. The density of mildly toxic materials in the residual waste stream has probably lifted in line with the success in recycling of largely inert materials.

As the quest for conservation of resources has intensified, landfill has been relegated from its position as the pre-eminent waste treatment option, to be just one part of the waste management infrastructure pool. Indeed, landfill now occupies the bottom rung of the almost universal waste hierarchy.

As the transition from the old way of managing waste progresses to a new way of seeing waste materials as potential resources, it is appropriate to consider the performance tasks of landfill. At the current position in the transition the key performance needs for landfill are:

Protecting public health and the local environment:

- design and operation to mitigate water, odour, and noise emissions;
- design and operation to control vermin, wind-blown litter, and dust.

Protecting the global environment:

- design and operation to maximise capture and use landfill gas emissions;
- provision of landfill-based opportunities to recover materials and products suitable for beneficial uses.

Providing an efficient and effective final disposal option for residual waste:

- sound monitoring and control of operations;
- capacity and scale of operations for efficient management.

## How the Chosen Waste Strategy Affects the Good Practice Imperative

The performance requirements of any specific landfill must be considered within the framework of the role the landfill is called-on to play. Thus, a landfill which is designated for, and licensed to receive, only inert building waste has a different performance challenge from a landfill designated to receive mixed putrescible waste. Best practice design and operation will vary between such landfills in order to provide a given level of environment protection. Best practice requirements will also vary according to climatic conditions. Some jurisdictions classify and license landfills according to the waste mix for which they are designed; others prefer more generic classifications.

In order to assess or suggest good practice in an organised way, it is useful to classify landfills according to the broad waste stream they might in future be designated to receive. What goes into the landfill is the key determinant of the technology and practice regime for the landfill.

Future waste management strategy will become more sophisticated as our understanding of waste characteristics and recycling technologies increases. And decisions that are made in shaping future waste strategy will alter the characteristics of waste flows – and change the practices needed to meet the key performance requirements proposed above.

# 3. Overview of Waste and Landfill Classification in Australia

## Australian Waste and Landfill Classification

There are significant differences between jurisdictions in the way that waste is classified and the commensurate classes of landfill that are permitted. The approach adopted by each jurisdiction is presented at Box 1, which sets out both the waste classifications and the landfill classifications adopted by each Australian jurisdiction.

In summary, *waste classification* schemes range from two categories, used by Queensland, to seven categories used by Western Australia. Similarly, *landfill classification* schemes vary from a single classification, used by South Australia, to five categories used by New South Wales and Western Australia.

Despite the variety of classifications, the main classes of both waste and landfill types are putrescible waste, non-putrescible waste, inert waste, and hazardous waste. The focus of this Study is the main landfill types: putrescible, non-putrescible, and inert. There are few dedicated hazardous landfills in Australia.

## Box 1. Waste and Landfill Classifications

| Jurisdiction | Waste Classifications[1] | Landfill Classifications |
|---|---|---|
| New South Wales | Four classifications:<br>- General (non-putrescible)<br>- General (putrescible)<br>- Restricted[2]<br>- Hazardous. | Three major categories of landfill, with sub-classes in two categories:<br>- General Solid Waste (Non Putrescible)<br>- General Solid Waste (Putrescible)<br>- Hazardous – for any waste designated as hazardous. |
| Victoria | Five classifications:<br>- Fill<br>- Solid inert<br>- Putrescible<br>- Prescribed<br>- Prescribed (Contaminated Soil). | Three classifications based on acceptable waste types:<br>- Type 1 – Prescribed Industrial waste (PIW) containment facility<br>- Type 2 – Putrescible, inert, fill, and Category C PIW<br>- Type 3 – inert, fill. |
| Queensland | Two classifications:<br>- General<br>- Regulated[3] | Three categories:<br>- Putrescible waste.<br>- Non-putrescible waste.<br>- Inert waste. |

[1] "Wastes" refers to solid wastes other than clinical and related wastes.
[2] Restricted solid wastes in NSW are specifically gazetted – none have been nominated as yet.
[3] "Regulated Waste" in Queensland covers oils, tyres, clinical waste, asbestos, batteries, abattoir effluent and lead.

| Jurisdiction | Waste Classifications[1] | Landfill Classifications |
|---|---|---|
| Western Australia | Seven classifications:<br>- Clean fill<br>- Inert Type 1<br>- Inert Type 2<br>- Inert Type 3<br>- Contaminated solid waste<br>- Special Type 1<br>- Special Type 2. | Five classes of landfill based on acceptable waste types and design inclusions:<br>- Class I – unlined – fill, Inert Type 1, Contaminated solid waste[4], Inert Type 2[3], Inert Type 3[3], Special Type 1.<br>- Class II – unlined – fill, Inert Type 1, Putrescible, Contaminated solid waste[3], Inert Type 2[3], Inert Type 3[3], Special Type 1[3], Special Type 2[3].<br>- Class III – lined and may have leachate collection – fill, Inert Type 1, Putrescible, Contaminated solid waste[3], Inert Type 2[3], Inert Type 3[3], Special Type 1, Special Type 2.<br>- Class IV – double lined with leachate collection – contaminated soils and sludges.<br>- Class V – the Mount Walton East intractable waste disposal facility. |
| South Australia | Four classifications:<br>- Inert<br>- C&I (General) – excludes listed wastes<br>- C&D (Inert) – excludes foreign materials[5]<br>- Municipal Solid Waste. | Landfill sites are classified according to the amount of waste received per annum, and the potential to generate leachate. The classes ranging from <1,000 tpa to >200,000 tonnes/year. |
| Tasmania | Four classifications:<br>- Solid inert<br>- Potentially contaminated<br>- Putrescible<br>- Controlled. | Level 2 landfills receive >100 tonnes/year and require management systems as set out in legislation. There are three categories of landfill:<br>- Category A – solid inert<br>- Category B – putrescible<br>- Category C – secure. |
| Northern Territory | Classifications under development. | General A, B, C based on size. Classifications under development. |

[4] Requires special approval conditions

[5] "Foreign materials" – in the SA context includes green waste, plastics, electrical wiring, timber, paper, insulation, tins, packaging and other waste associated with construction or demolition of a building or other infrastructure. Foreign material must not be Municipal Solid Waste, Liquid, Listed, Hazardous or Radioactive Waste.

# 4. Landfill Deployment and Waste Disposal

The purpose of this Chapter is to establish an indication of the scale and deployment of landfills across Australian jurisdictions. Much of the information used in this Chapter was drawn from the National Landfill Survey conducted by the Waste Management Association of Australia (WMAA 2007). Although published in 2007, the survey drew on data collected in 2005/06 which established a reasonably comprehensive landfill database. WMAA claims that the survey database represents >95% of all landfills in NSW, QLD, VIC, SA and WA, and 50% of the Tasmania landfill stock. No response was received from the ACT or NT and estimates of substantial landfill stock were made by WCS to complete the national picture.

## Landfill Classes

As shown at Chapter 3, landfill definitions vary greatly between jurisdictions, as do the types of wastes that are permitted for various classes of landfill. For the purposes of this study, two waste-acceptance classes of solid waste landfill have been adopted in order to permit reasonable comparison of requirements and practise between jurisdictions. These are summarised at Table 4-1 below.

**Table 4-1 Two Basic Landfill Classes**

| Landfill Class | Acceptable Waste |
|---|---|
| General Waste - Putrescible | All solid wastes, excluding:<br>- industrial hazardous wastes. |
| Inert Solid, Non-Putrescible Waste | All solid wastes, excluding:<br>- industrial hazardous wastes,<br>- biodegradable wastes,<br>- hazardous domestic wastes, and<br>- E-wastes. |

## Landfill Deployment by Waste-Acceptance Type

Based on the WMAA National Landfill Survey (WMAA 2007) the approximate number of licensed landfills in each of the two landfill waste-acceptance classes is presented at Table 4-2. Despite a licence to accept putrescible waste, *General Putrescible* waste landfills accept substantial amounts of inert waste.

**Table 4-2 Approximate Number of Landfill by Class and Jurisdiction**

| Jurisdiction | Approximate Number of Landfills | | |
|---|---|---|---|
| | Inert Solid Non-Putrescible | General Putrescible | Total |
| **NSW** | 9 | 76 | 85 |
| **Vic** | 7 | 50 | 57 |
| **Qld** | 4 | 93 | 97 |
| **WA** | 21 | 100 | 121 |
| **SA** | Nil | 71 | 71 |
| **Tas**[1] | Nil | 11 | 11 |
| **ACT**[1] | Nil | 1 | 1 |
| **NT**[1] | Nil | 16 | 16 |
| **Aust** | **41** | **417** | **459** |

Source: Compiled by WCS from data in the WMAA National Landfill Survey 2007.
Notes: 1. Estimated by WCS.
2. A subsequent WMAA survey (WMAA 2009) recorded 324 responses.

In addition, three size-classes of landfill have been adopted to condense the wide variation of landfill scale across each jurisdiction. These are summarised at Table 4-3.

**Table 4-3 Landfill Size-Classes**

| Category | Annual Tonnage Received |
|---|---|
| Small | Less than 10,000 tonnes/year (not including open, unattended tips) |
| Medium | Greater than 10,000 tonnes/year and less than 100,000 tonnes/year |
| Large | Greater than 100,000 tonnes/year |

## Landfill Deployment by Landfill Size Class

At Table 4-4, the approximate number of landfills in each of the three size-classes is presented. In general, large landfills are located in or near major cities with population of >500,000 and provide services to major cities. Medium sized landfills are located in cities and substantial towns servicing populations of around 25,000 to 100,000.

Small landfills are deployed in rural and remote areas to service small towns and villages with population of <10,000. In addition to the large number of small landfills captured by the survey, many hundred small, unlicensed landfills exist. These are generally in rural and remote areas to service villages with population of <2,000. A recent regional resource management plan prepared for the NetWaste region (NetWaste 2008), which covers the Central West and Orana Regions of NSW, identified 117 landfills (population 380,000 and area of 420,000km$^2$). However, only 13 landfills are licensed by the NSW EPA in this area. The remainder fall below threshold licence limits. At least 64 landfills are unsupervised and most of these are open 24 hours/day 7 days/week.

**Table 4-4 Number of Landfill by Size-Class and Jurisdiction**

| | Landfill Size-Class | | | |
|---|---|---|---|---|
| | **Small** | **Medium** | **Large** | **Total** |
| **NSW** | 30 | 40 | 15 | 85 |
| **Vic** | 8 | 30 | 19 | 57 |
| **Qld** | 63 | 22 | 12 | 97 |
| **WA** | 87 | 23 | 11 | 121 |
| **SA** | 58 | 8 | 5 | 71 |
| **Tas** | 3 | 7 | 1 | 11 |
| **ACT**[1] | nil | nil | 1 | 1 |
| **NT**[1] | 13 | 3 | Nil | 16 |
| **Aust** | **262** | **133** | **64** | **459** |

Source: Compiled by WCS from data in the WMAA National Landfill Survey 2007.
Notes: 1. Estimated by WCS.

It has not been possible to gain information on the number of landfills closed (and potentially active) over the last 50 years. WCS estimates that this to be in the order of 200 to 300 landfills.

## Waste Disposal

The survey also covers waste disposal, and at Table 4-5 waste disposal to each of the adopted landfill classes in each jurisdiction is summarised. The data confirm the common view that overall waste disposal is at around 21 million tonnes/year. The table shows disposal of around 14 million tonnes/year to General Putrescible waste landfills, and 7 million tonnes/year to Inert and General Non-putrescible landfills.

## Table 4-5 Estimated Disposal of Waste to Landfill in Australia

| Jurisdiction | Waste Class | Tonnes Disposed (millions/year) | | |
|---|---|---|---|---|
| | | Total | Inert Solid Non-Putrescible | General Putrescible |
| **NSW** | Inert | 2.0 | | |
| | Solid Class 1 | 3.1 | | |
| | Solid Class 2 | 1.4 | | |
| | Total | 6.5 | 3.4 | 3.1 |
| **Vic** | Type 3 | 2.0 | | |
| | Type 2 | 2.9 | | |
| | Total | 4.9 | 2.0 | 2.9 |
| **WA** | Class I | 1.6 | | |
| | Class II | 2.0 | | |
| | Total | 3.6 | 1.6 | 2.0 |
| **Tas** | Solid Inert | 0.1 | | |
| | Putrescible | 0.3 | | |
| | Total | 0.4 | 0.1 | 0.3 |
| **SA** | General | 1.3 | | 1.3 |
| **Qld** | General | 4.0 | | 4.0 |
| **ACT**[1] | General | 0.2 | | 0.2 |
| **NT**[1] | General | 0.3 | | 0.3 |
| **Australia** | | **21.2** | **7.1** | **14.1** |

Source: Compiled by WCS from data in the WMAA National Landfill Survey 2007.
Notes: 1. Estimated by WCS.

NSW and Victoria are the largest contributors, providing 11.5 million tonnes/year or 56% of the total disposal haul. With Western Australia (3.6 million tonnes) and Queensland (3.2 million tonnes) the top four waste producing States account for 89% of waste sent to landfill.

## Analysis of Waste Disposal Data

In respect of landfill utilisation and the three size-classes selected, Table 5-2 presents the annual tonnes of waste disposed to landfill in each jurisdiction at landfills for each size-class.

**Table 4-6 Waste Disposal to Landfill by Size-Class and Jurisdiction**

| | Disposals by Licensed Landfill Size-Class | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Small | | Medium | | Large | | Total | |
| | No. | Tonnes | No. | Tonnes | No. | Tonnes | No. | Tonnes |
| **NSW** | 30 | 0.14 | 40 | 1.40 | 15 | 4.91 | 85 | 6.45 |
| **Vic** | 8 | 0.03 | 30 | 1.37 | 19 | 3.59 | 58 | 4.99 |
| **WA** | 87 | 0.17 | 23 | 0.76 | 11 | 2.70 | 122 | 3.63 |
| **Tas** | 3 | 0.01 | 7 | 0.29 | 1 | 0.12 | 11 | 0.42 |
| **SA** | 58 | 0.11 | 8 | 0.25 | 5 | 0.92 | 71 | 1.28 |
| **Qld** | 63 | 0.14 | 22 | 0.90 | 12 | 2.97 | 100 | 4.01 |
| **ACT**[1] | Nil | Nil | Nil | Nil | 1 | 0.19 | 1 | 0.19 |
| **NT**[1] | 13 | 0 | 3 | 0.30 | Nil | 0 | 4 | 0.30 |
| **Australia** | **262** | **0.60** | **133** | **4.97** | **64** | **15.21** | **459** | **21.27** |
| **% of No.** | **57%** | | **29%** | | **14%** | | | |
| **% of Tonnes.** | | **3%** | | **24%** | | **73%** | | |

Source: Compiled by WCS from data in the WMAA National Landfill Survey 2007.
Notes: 1: Estimated by WCS.

## Findings

Based on the results of the *National Landfill Survey*, almost three quarters (73%) of the solid waste disposed to landfill in Australia is placed in around 64 large landfills, each of which receive more than 100,000 tonnes of waste/year. Only a very small proportion (3%) of the waste disposed to landfill in Australia each year is placed in small landfills that receive less than 10,000 tonnes/year.

The number of these small landfills is relatively large (at 262 landfills accounted for in the WMAA *National Landfill Survey*) and significant (57% of landfills in the WMAA database). And this number is supplemented by many hundred small unlicensed, unattended tips. The potential threat to environment and human health is geographically widespread, but collectively significant.

Also of significance in respect of the importance of effective landfill management and regulatory compliance are the approximately 133 medium sized landfills (29% of all sites in the database) that receive almost 5 million tonnes/year – approximately one quarter of all solid waste disposed to landfill in Australia.

# 5. Regulatory Requirements for Australian Landfills

A key purpose of this study is to provide a snap-shot of Australian landfill management techniques. This Chapter draws on published information to describe regulatory requirements, by jurisdiction, covering three main themes:

- Landfill planning and minimisation of disposal.
- Landfill design and construction.
- Landfill operations.

The approach taken has been to review the general landfill regulatory requirements or guidelines established by each jurisdiction to draw out regulatory and practice requirements.

## Establishing Minimum Practice or Benchmark Performance Requirements

Environment agencies and EPAs from Australian jurisdictions have established policy and regulatory requirements for sustainable waste management and landfill performance. These requirements form the main heads for performance objectives and the basis to benchmark standards which are set to protect the environment.

It is usual for EPAs to establish fairly broad performance objectives and/or outcome requirements. In some cases, several ways are suggested in which these objectives might be met. This approach leaves the landfill designer with the responsibility of determining the most appropriate solution for the specific circumstances and avoids the regulatory authority tacitly assuming a measure of responsibility for the outcome.

The Australian State and Territory Landfill Guidelines are broadly framed to provide firm, but not dogmatic, regulatory guidance (see References pp 70). It is important to appreciate that this “guidance” is backed by specific landfill licence conditions which cover detailed requirements in the context of exact waste disposal plans and the landfill setting. This contrasts with the rather more prescriptive requirements adopted in international published

regulatory documents. The Australian Landfill Guideline process relies more on jurisdictional planning and environment assessment being used to determine specific landfill requirements on a case by case basis. Despite this difference in approach, requirements for some criteria are expressed quite firmly, usually in terms of *preventing* nominated outcomes; on other criteria, requirements are expressed in less actionable terms, such as *minimising* outcomes.

However, the majority of requirements are expressed as outcome-oriented statements (such as the Queensland requirement to *protect groundwater quality*). The Guidelines do contain some direct input requirements (such as the Queensland requirement for daily cover with a minimum of 200mm soil or alternative material). They also contain a number of practice requirements such as those relating to waste acceptance, and monitoring and reporting. In general, the guidelines provide clear regulatory intent subject to environmental assessment requirements for specific projects.

A comparison of the Australian jurisdiction Landfill Guidelines is set out below. Note that Western Australia and ACT publish general information on waste management and minimisation, but have not published Landfill Guidelines that specify design, construction and operating requirements. The various Landfill Guideline requirements are summarised at Tables 5-1 to 5-3. A full explanation is set out below.

## Landfill Planning and Minimisation of Disposal

### *Landfill classifications*

Six of the eight Australian jurisdictions have adopted a classification scheme based on the type of waste permitted to be accepted at the landfill. However, the Northern Territory classification is based on landfill size, while South Australia has adopted a hybrid scheme which includes both size and leachate production potential.

### *Planning and siting considerations*

All jurisdictions require careful consideration of site suitability, scope to protect the environment, and management of community issues. NSW and Tasmania require demonstration that demand exists to justify additional landfill capacity.

### *Waste minimisation*

All jurisdictions make clear that waste disposal is at the bottom of the hierarchy and any new (or extended) facility must be considered within the context of an integrated resource recovery and waste management plan.

## Landfill Design and Construction

### *Landfill liner structure*

All jurisdictions require either *protection of groundwater* or *prevention of pollution*. Victoria goes further in specifying maximum seepage requirements.

### *Leachate collection and treatment*

NSW, Victoria and Tasmania specifically require provision of a leachate collection system; other jurisdictions require protection of groundwater and environment.

### *Water management – stormwater, leachate, groundwater*

All jurisdictions make strong directive statements covering on-site water management and protection of off-site receiving waters.

### *Air emissions*

All jurisdictions make strong directive statements covering odour emission management and prevention of health risks from airborne particulate matter.

### *Landfill gas management*

Requirements in relation to landfill gas management are generally expressed in terms of *minimising* emissions. NSW requires landfill operators to "...suitably utilise landfill gas". Victoria requires facilities receiving more than 40,000 tonnes/year to install a landfill gas control system, and Queensland requires all landfills receiving more than 20,000 tonnes/year to have a gas collection system. South Australia requires gas concentrations in monitoring bores to be limited to 1% methane and 1.5% carbon dioxide.

The EU and UK regulations are more prescriptive. They require *all* landfills receiving biodegradable waste to collect, treat, and use landfill gas.

## Landfill Operational Requirements

All jurisdictions require development of a Landfill Environmental Management Plan (LEMP) by the landfill proponent. Thus, the operational requirements specified in guidelines are generally framed to provide guidance in developing the LEMP suitable for approval by the Consent Authority.

### *Waste acceptance*

All guidelines and regulations require operators to ensure that only permitted materials are accepted together with regular reporting of waste types and quantities received. NSW and Tasmania go further and, in harmony with EU/UK regulations, require assurance that a system is in place to assure compliance.

***Resource recovery and pre-treatment***

All Australian jurisdictions require landfill operators to be active in recovering and recycling suitable dry material accepted at landfill. NSW requires a recycling plan to accompany any landfill development application. This is seen as a recovery-of-last-resort action and is in contrast with the EU/UK position which is based on all possible dry materials recovery and recycling being done before the waste is accepted at the landfill site. Conditions do differ and recycling at landfill has become accepted practice in Australia as the final destination for potential resource recovery.

Only Victoria goes beyond dry recycling and specifies that (putrescible) waste should be pre-treated to maximise stability before disposal. This matches the EU/UK requirement which has been driven by the need to conserve landfill capacity (with only four to five years remaining) and landfill gas abatement.

***Litter, odour and dust control***

All jurisdictions specify protection of local amenity in a way that ought to ensure that development applications are accompanied by definite plans to control litter, dust and odour.

***Disease vector control and landfill cover***

All jurisdictions require cover material to be used on at least a daily basis. Queensland specifies a minimum of 200mm of soil or alternative material.

***Monitoring and reporting***

All jurisdictions specify regular monitoring and at least annual reporting requirements. This generally covers groundwater, surface water, leachate, and gas, as well as recording of waste types, sources and management action. Further comprehensive reporting is generally designated in specific landfill licences.

**Table 5-1 Planning and Waste Minimisation Requirements**

| Jurisdiction | Landfill Classifications | Planning and Siting Considerations | Waste Minimisation |
|---|---|---|---|
| NSW | Three classifications:<br>• General solid waste (putrescible) landfill.<br>• General Solid Waste (non-putrescible) landfill.<br>• Hazardous waste landfill. | Covered by separate planning approval arrangements with specific reference to:<br>• Demonstrated justifiable demand for a landfill.<br>• Protection of the environment.<br>• Groundwater and surface water.<br>• Community considerations. | Covered by the NSW Waste Avoidance and Resource Recovery Strategy. |
| Victoria | Three classifications:<br>Type 1. Prescribed industrial waste.<br>Type 2. Putrescible waste, solid inert waste, fill material.<br>Type 3. Solid inert waste, fill material. | Siting considerations refer to both specific and general requirements and include:<br>• Community needs.<br>• Landfill type.<br>• Buffer distances.<br>• Groundwater and surface water.<br>• Flora and fauna.<br>• Infrastructure available.<br>• Land ownership and geology. | Municipal landfills are part of a waste management system where every opportunity should have already been taken to avoid waste production and remove recyclable material from the waste stream before it arrives at the landfill. |
| Queensland | Three classifications:<br>• Putrescible.<br>• Non-putrescible.<br>• Inert. | Siting considerations refer to both specific and general requirements and include:<br>• Community needs.<br>• Landfill type.<br>• Groundwater and surface water.<br>• Flora and fauna.<br>• Infrastructure available.<br>• Geology.<br>• Adjacent land uses.<br>• Biodiversity.<br>• Geological setting. | Landfill is the least preferred waste treatment procedure. Every effort should be taken to avoid waste production and remove recyclable material before waste is sent to landfill. |

| Jurisdiction | Landfill Classifications | Planning and Siting Considerations | Waste Minimisation |
|---|---|---|---|
| WA | Three classes:<br>Class 1. Unlined, inert waste.<br>Class 2. Unlined, inert, putrescible, and special waste.<br>Class 3. Lined, inert, putrescible, and special wastes. | Covered by separate planning approval requirements. | Covered by separate waste strategy. |
| SA | Classification is based on:<br>• Capacity (small, medium, large).<br>• Site conditions and potential to generate leachate (Type B+, Type B-). | Siting considerations refer to both specific and general requirements and include:<br>• Community issues.<br>• Environment protection.<br>• Buffer distances.<br>• Groundwater and surface water.<br>• Flora and fauna.<br>• Aboriginal heritage.<br>• Infrastructure available.<br>• Geology. | Consideration of and integration with the regional waste management plan including resource recovery and pre-treatment. |
| Tasmania | Classification is based on:<br>• Type A. Solid inert waste landfill.<br>• Type B. Putrescible waste landfill.<br>• Type C. Secure Landfill. | Siting considerations include:<br>• Demand for further landfill space.<br>• Community liaison.<br>• Geology.<br>• Waste proximity and transport.<br>• Land zoning. | Typically, a waste minimisation system will be in place to provide opportunities for recovery of resources prior to the waste being received at the landfill. |
| NT | Category A. Community facilities serving more than 20,000 people.<br>Category B. Community facilities serving 500-2,000 people.<br>Category C. Community facilities serving less than 500 people. | Siting considerations include:<br>• Site capacity.<br>• Hydrology.<br>• Local topography and soils.<br>• Adjacent land-use.<br>• Climate.<br>• Local flora and fauna.<br>• Road access. | As part of the integrated waste management strategy, disposal of waste to landfill should only be undertaken as a last resort. |

Source: State and Territory Landfill Guidelines.

## Table 5-2 Design and Construction Requirements

| Jurisdiction | Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|---|
| NSW | Prevent pollution of water by leachate. | Leachate should be collected in a leachate collection system and prevented from escaping into groundwater, surface water or subsoil. | Prevent surface water from mixing with waste and prevent sediments or contaminants being carried off the landfill site. | Odour emission within legislative requirement.<br>Prevent health risk from airborne material. | Minimise GHG emissions.<br>Suitably utilise landfill gas. |
| Victoria | Maintain groundwater quality as close as practicable to background levels.<br>Max seepage: 10L/ha/day (Type 2).<br>Max seepage: 1,000L/ha/day (Type 3). | Drain leachate to minimise head above the liner. | Protect receiving waters and avoid adverse environmental impact on surface water and groundwater. | Prevent off-site odour impact.<br>Prevent dust impact on amenity and health. | Minimise GHG emissions.<br>Prevent subsurface migration of gas.<br>Facilities receiving >40,000tpa to have a landfill gas control system. |
| Queensland | Protect groundwater by reducing seepage of leachate.<br>Retard lateral movement of landfill gas.<br>Recommended minimum liner:<br>• Sub-base 300mm.<br>• Clay liner 600mm.<br>• Drainage layer 300mm. | Protect groundwater quality. | Prevent contamination of surface water and groundwater. | Prevent offensive or noxious odours beyond the landfill boundary.<br>Minimise release of dust and particulate matter. | Minimise potential for global warming and landfill gas subsurface migration.<br>All landfills receiving > 20,000 tonnes/year require gas collection system. |
| WA[1] | | | | | |

| Jurisdiction | Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|---|
| SA | Safeguard groundwater from leachate impacts. | Minimise generation of leachate; safeguard surface water and groundwater. | Safeguard surface water from stormwater and sediment impacts. | Prevent unacceptable health risk from airborne impurities, pathogens and toxins.<br>Prevent nuisance or offence from odours, emissions or dust. | Prevent adverse impacts from landfill gas.<br>Limit gas concentrations in monitoring bores to <1% methane and <1.5% carbon dioxide.<br>Sustainably use as much landfill gas as reasonably practicable. |
| Tasmania | Design to prevent pollution of water by leachate. | Landfills must be equipped with a leachate collection system. Excess leachate must be prevented from escaping from the landfill into groundwater or surface waters. | Uncontaminated surface water must be prevented from mixing with waste and/or carrying sediments off the landfill site. | Design to ensure that operations minimise off-site impacts resulting from dust, litter, noise so that environmental nuisance is not caused. | Landfill gas must not present a source of odour or an explosion or toxicity hazard.<br>The contribution to greenhouse gas emissions should be minimised. |
| ACT[1] | | | | | |
| NT | | Contaminated water should be retained on-site and evaporated or treated. | Prevent surface water from coming into contact with exposed wastes.<br>Minimise production of leachate. | | |

Source: State and Territory landfill guidelines.
Notes: 1. No specific landfill siting, design and management guidelines published.

**Table 5-3. Operational Requirements**

| Jurisdiction | Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|---|
| NSW | Assurance that nature and quantity of waste received is known and recorded. | Recycling plan required for all waste for which the facility is licensed. | Prevent degradation of local amenity. | Prevent degradation of local amenity. | Monthly report of waste received and recycled.<br>Annual report covering groundwater, leachate, surface water, air quality, vermin, landfill gas capture. |
| Victoria | Ensure that only appropriate wastes are deposited. | Divert wastes from landfill by establishing an operation to salvage and recycle suitable wastes delivered to landfill.<br>To reduce the long-term risk posed by the waste and improve landfill performance, re-treat waste to maximise stability before disposal. | Keep the landfill and surrounding area in a litter free condition, so that no litter reaches beyond the landfill boundary. | Minimise disease vectors by deny pests food/shelter.<br>Cover at least daily with soil or approved material. | Monitor six monthly and and report annually on measures to protect environment: groundwater, leachate, surface water, air quality, vermin, landfill gas capture. |
| Queensland | Ensure that only permitted materials are deposited. | Recycle suitable material not recovered prior to acceptance at landfill. | Litter control strategy and retrieval scheme required. | Daily cover with a minimum of 200mm soil or alternative material. | Annual report of sources, volumes and composition of waste accepted and recycled.<br>Environmental monitoring and reporting included in landfill approval conditions. |
| WA[1] | N/A | N/A | N/A | N/A | Quarterly report of waste quantities and types received. |
| SA | Covered as part of LEMP. | Facilitate waste diversion and recycling.<br>Provide public drop-off and recycling areas | Covered as part of LEMP. | Minimise extent of tipping face and ensure daily covering. | Covered as part of LEMP process, with annual reporting of groundwater, leachate, surface water, air quality, vermin, LFG capture. |

| Jurisdiction | Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|---|
| Tasmania | Accept only those wastes that are consistent with the appropriate category of the landfill under the Landfill Classification System and stipulated in permit conditions. | Provide for recovery and diversion of waste materials.<br>Develop procedures for diversion and recovery f selected waste materials that are suitable for reuse, reprocessing, or recycling. | Odour must not be detectable beyond the landfill boundary.<br>All reasonable steps must be taken to prevent litter leaving the site, and regular clean-up adjacent to the boundary is required.<br>Dust must be controlled to ensure that environmental nuisance does not occur beyond the landfill boundary. | Waste must be placed in a manner that minimises litter and pest animal problems, and optimises use of landfill space.<br>Wastes must be covered by a suitable material at the completion of daily operations or more frequently as required. | Regular monitoring and annual reporting of groundwater, surface water, leachate and LFG (flow, composition and combustion efficiency) must be conducted.<br>Maintain accurate records of the amount, type, source, and management of wastes received. |
| ACT[1] | N/A | N/A | N/A | N/A | N/A |
| NT | | Where recycling is viable, areas should be provided for: storage of large items; containers for depositing small items. | Cover material should be applied to control litter and odour.<br>Litter should be managed through fencing and regular patrols to remove accumulated wind-blown material. | Cover material should be applied to control vectors.<br>An operational plan for animal control should be developed and implemented. | All landfill operations should have a monitoring program for detecting and reporting situations adverse to public health and the environment. Including groundwater, leachate, surface water, air quality, vermin, landfill gas capture. |

Source: State and Territory landfill guidelines
Notes: 1. No specific landfill siting, design, and management guidelines published.

# 6. Performance of Australian Landfills

The Landfill Guideline requirements reported at Chapter 5 provide a perspective of landfill features, controls and operating practices that combine to deliver specific performance outcomes. The purpose of this Chapter is to describe how well the intent of each of the main guideline requirements is satisfied in design, construction and operation of landfills.

## Measures of Landfill Performance

It has not proved feasible to gain landfill performance information that fully coincides with all the outcome and practice requirements expressed in the various Landfill Guidelines. This particularly relates to the landfill design and construction requirements, for which the requirements are expressed in terms of outcomes such as *"...prevent leachate from entering groundwater" and "...prevent surface water from mixing with waste and carrying contaminants off-site".* These important outcomes are difficult to measure at a scale that would be suitable for valid, comprehensive conclusions to be reached, and compared, at a national or a jurisdiction scale.

In order to assess how actual landfill design, construction and operation practice aligns with the published Landfill Guidelines, the Study drew on a published National Landfill Survey (WMAA 2007) described at Chapter 4. The *National Landfill Survey* and the database developed by the Waste Management Association of Australia provide significant information on the design and operation of landfills across Australia. The survey asked questions about landfill features and practices.

The database was examined in order to develop a comparison between nominated best practice performance outcomes, as seen by the various EPAs, and implementation of control measures and practices which would be fundamental to achieving the nominated outcomes.

Tables 6-1 and 6-2 below illustrate the alignment between the (generalised) Landfill Guideline requirements and the relevant WMAA survey measures.

As shown in Table 6-1, the WMAA survey examined the implementation of infrastructure items and systems that are essential requirements for achieving the outcomes prescribed in the Landfill Guidelines.

**Table 6-1. Guideline Requirements for Design and Construction Versus WMAA Survey Measures**

| Guideline Issue | Guideline Requirement - Design and Construction | WMAA Survey Measure | Relevance of WMAA Survey Measure to Guideline Requirement |
|---|---|---|---|
| Landfill liner structure | Prevent leachate from entering groundwater | Existence of and type of liner structure | Indirect, but fundamental for compliance with Guideline |
| Leachate collection and treatment | Collect leachate and prevent escape to groundwater | Existence of leachate collection, treatment and monitoring systems | Direct and indirect, but fundamental for compliance with Guideline |
| Water management | Prevent surface water from mixing with waste and carrying contaminants off-site | Existence of stormwater management control and monitoring systems | Indirect, but fundamental for compliance with Guideline |
| Air emissions | Prevent odour and dust emission impacts on amenity and health | Existence of systems for waste compaction, daily cover, odour control and odour monitoring | Indirect, but the key requirement for compliance with Guideline |
| Landfill gas management | Control landfill gas to minimise GHG emissions | Existence of systems for capture of landfill gas and flaring or conversion to energy, and LFG monitoring and reporting | Indirect, but fundamental for compliance with Guideline |

As shown in Table 6-2, the WMAA survey examined both the direct use of practices that respond to guideline requirements, and the implementation of systems that are fundamental to achieving the outcomes prescribed in the Landfill Guidelines.

**Table 6-2. Guideline Requirements for Operation Versus WMAA Survey Measures**

| Guideline Issue | Guideline Requirement - Landfill Operation | WMAA Survey Measure | Relevance of WMAA Survey Measure to Guideline Requirement |
|---|---|---|---|
| Waste acceptance | Accept only waste for which the facility is licensed | Existence of a weighbridge, waste inspection arrangements and reporting | Direct and indirect measures |
| Resource recovery and pretreatment | Recovery and recycling of suitable materials delivered to landfill | Existence of small vehicle transfer station, recycling centre, and reported recovery level for nominated materials | Direct and indirect measures |
| Litter, odour and dust control | Litter, odour and dust control to avoid impact beyond landfill boundary | Existence of litter control nets, odour controls, use of waste compaction and daily cover, and dust monitoring | Direct and indirect measures |
| Disease vector control and cover | Protect local amenity and deny access by vermin by use of cover material | Use of cover material, and vermin control measures | Direct measure |
| Monitoring and reporting | Regular monitoring and reporting covering nominated pollutant impacts | Adherence to regular monitoring and reporting | Direct measure |

The results of the analyses are described below in summary form.

## Landfill Performance Review

The WMAA 2007 database contains information and data that permits some analysis of the extent to which certain infrastructure, systems and operating practices have been implemented at landfills of the three size-classes chosen for the study. Drawing on inquiries of the database it is possible therefore to form a view on the likelihood of landfills meeting the Landfill Guideline requirements of the jurisdictions as set out in Chapter 5.

In the following notes, each attribute of the requirements is examined to determine the extent to which infrastructure, systems and practices are in place and used to bring about the outcomes and practices specified in the Landfill Guidelines. For each attribute assessed, a score is awarded in one of five categories: high, moderate to high, moderate, low to moderate, low. A summary finding is also presented.

In addition, the findings of the WMAA 2007 survey are compared with the (initial) findings of the WMAA 2009 survey for which initial aggregate information was released at the completion of this study. The WMAA 2009 data are not yet available on a jurisdiction basis.

### Existence of Infrastructure and Systems to Enable Compliance with Landfill Design and Construction Requirements

#### *Landfill Liner Structure*

Jurisdictions cite the prevention of leachate from entering and contaminating surrounding groundwater as the most common objective. Queensland also includes prevention of lateral migration of landfill gas as an objective of requiring landfill liners.

*Large Landfills* – in all jurisdictions other than WA, the frequency of installing a liner system comprising one or several liner types is interpreted to be at a moderate (high end of range)

level. In WA it appears that liners for large landfills may be in use at a moderate proportion of landfills.

*Medium Landfills* – in all jurisdictions, other than Tasmania, the frequency of installing liners is interpreted to be at a moderate level. In Tasmania it appears that use of liners for medium sized landfills is at a high level.

*Small Landfills* - in all jurisdictions, other than Tasmania, the frequency of installing liners is interpreted to be at a low level. In Tasmania it appears that application of liners for medium sized landfills is a relatively common occurrence.

*Finding* - Liner installation practice for protection of groundwater at Large and Medium sized landfills, where some 97% of solid waste is disposed, would appear to be moderate when compared with Landfill Guideline expectations. At Small landfills the installation of liner structures is at a low level. Landfill liner systems have been in wide use for only the last 15-20 years and are the key requirement for preventing pollution of groundwater.

*Validation with WMAA 2009 Survey* – Large and Medium landfills: moderate to high; Small landfills: low. This indicates a slight improvement in the Large and Medium landfills reporting liner installation and a steady situation for Small landfills.

***Leachate Collection, Treatment and Monitoring***

Leachate management system requirements vary considerably across the jurisdictions, but generally cite separation of leachate from ground and surface waters as a minimum objective.

The ability to achieve this objective is interpreted from analysis of the extent to which landfills have in place systems for the capture of leachate, the treatment of leachate and leachate monitoring. These are three practices that would broadly be considered to be essential for effective management of leachate and delivering on the common objective.

*Large Landfills* – in all jurisdictions other than WA, the frequency of installing leachate management systems is interpreted to be at a moderate to high level. In WA the frequency of installing leachate management systems is interpreted to be at a low to moderate level.

*Medium Landfills* – in all jurisdictions other than WA, the frequency of installing leachate management systems is interpreted to be at a moderate to high level. In WA the frequency of installing leachate management systems is interpreted to be at a low level.

*Small Landfills* – in NSW, Victoria and Tasmania, the frequency of installing leachate management systems is interpreted to be at a moderate to high level. In WA, SA and Queensland, the frequency of installing leachate management systems is interpreted to be at a low level.

*Finding* - Leachate management in accordance with Landfill Guideline expectations at Large and Medium sized landfills, where some 97% of solid waste is disposed, would appear to be at a moderate to high level. At Small landfills leachate management is low to moderate. Leachate collection is fundamental to preventing pollution of groundwater.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: moderate to high; Small landfills: low. The number of Small landfills reporting leachate collection has decreased in the WMAA 2009 survey. The leachate collection response for Medium landfills has been steady and the positive response from Large landfills has increased markedly.

***Water Management***

On-site water management system requirements vary across the jurisdictions, but generally all cite as objectives prevention of surface waters from contact with waste to minimise leachate volumes and minimise run-off of leachate contaminated water.

The ability to achieve this objective is interpreted from analysis of the extent to which landfills have in place systems for the active management and control of stormwater, the maintenance of stormwater ponds, and the monitoring of stormwater quality. These are three practices that would broadly be considered to be essential for effective management of surface waters to prevent them contacting waste and causing off-site pollution.

*Large and Medium Landfills* – in all jurisdictions, the frequency of installing stormwater management systems is interpreted to be at a moderate to high level.

*Small Landfills* - in NSW and Tasmania, the frequency of installing stormwater management systems is interpreted to be at a moderate to high level. In all other jurisdictions the frequency of installing stormwater management systems is interpreted to be at a low level.

*Finding* - Stormwater management for maintaining run-off quality and minimising leachate volumes at Large and Medium sized landfills would appear to be moderate to high in accordance with Landfill Guideline expectations. At Small landfills stormwater management is low to moderate.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: moderate to high; Small landfills: low to moderate. The number of Small landfills reporting use of stormwater controls has decreased in the WMAA 2009 survey. The use stormwater control for Medium and Large landfills has increased.

### *Air Emissions*

Air quality management system requirements generally all cite odour, airborne dust and airborne pathogens as minimum objectives to be targeted.

The ability to achieve this objective is interpreted from analysis of the extent to which landfills have in place systems for the compaction of waste, application of daily cover, installation of active odour controls, and on-site odour monitoring. These represent a suite of practices

that would broadly be considered to be essential for effective management of air emissions from landfills and delivering on the common objective.

*Large and Medium Landfills* – in all jurisdictions, the frequency of use of compaction and daily cover is interpreted to be at a high level. However, for Large landfills, odour control and monitoring is moderate, while for Medium landfills, odour control and monitoring is low to moderate.

*Small Landfills* – Use of compaction and daily cover is moderate, while the frequency of installing active air quality management systems is interpreted to be at a low level.

*Finding* - Deployment of systems and practices at Large and Medium landfills that contribute to odour and emissions management is high. However, installation of equipment for management of odour and other emissions to maintain ambient air quality at Large and Medium sized landfills is rated as moderate and low to moderate when compared with Landfill Guidelines. At Small landfills, installation of emission control equipment is low, while use of systems and practice that assist in emissions management is moderate.

*Validation with WMAA 2009 Survey* – Similar results to WMAA 2007.

***Landfill Gas***

A common landfill gas management system requirement is minimisation of greenhouse gas emissions and impacts as a minimum objective to be targeted.

The ability to achieve this objective is interpreted from analysis of the extent to which landfills have in place systems for the capture of landfill gas and either flaring or converting the gas to energy. These are considered to be minimum compliance practices essential for effective management of GHG impacts from landfill sites and delivering on the common objective.

*Large Landfills* – the frequency of installing active landfill gas management systems and practices is interpreted to be at the upper end of the low to moderate level.

*Medium and Small Landfills* - in all jurisdictions, the frequency of installing active landfill gas management systems and practices is interpreted to be at a low level.

*Finding* - the management of GHG emissions would appear to be relatively poor when compared with Landfill Guidelines, particularly for Small and Medium landfills.

*Validation with WMAA 2009 Survey* – Large landfills: moderate; Medium landfills: low; Small landfills: low. The number of Large landfills with active gas management has increased in the recent survey; reported gas management at Medium landfills has increased slightly and reported gas management at Small landfills was steady.

**Summary of Compliance with Design and Construction Requirements**

In broad terms, two of the reported performance requirements stand out as examples of relatively *poor* compliance with the intent of Landfill Guidelines across most jurisdictions:

- Inadequate use in Small landfills of landfill liners and leachate collection systems to prevent contamination of groundwater. Application of both types of control systems was rated as low in survey responses.

- Limited use of landfill gas capture systems to minimise release of greenhouse gas emissions. This applies particularly to Small and Medium sized landfills for which the survey response was low. The survey response for Large landfills was just one step higher at low to moderate.

Overall, the application of measures that would enable compliance with Landfill Guidelines for design and construction requirements appears to have been satisfactory for Large landfills, marginal for Medium landfills, and unsatisfactory for Small landfills.

## Jurisdiction Compliance Reports

At Table 6-3 a summary is presented (based on WMAA 2007) of the application of measures for compliance with design and construction requirements. This summary covers each landfill size-class across each of the jurisdictions for which data is available. Details of the analyses of performance against each requirement are reported at Appendix A of this report, accompanied by charts of the extent to which the various practices and systems are implemented.

**Table 6-3. Level of Compliance with Design and Construction Requirements**

| Jurisdiction | Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|---|
| NSW | Large – moderate to high<br>Medium – low to moderate<br>Small – low | Large – high<br>Medium – moderate to high<br>Small – moderate | Large – high<br>Medium – high<br>Small – moderate to high | Large – high<br>Medium – high<br>Small – moderate to high | Large – low<br>Medium – low<br>Small – nil |
| Victoria | Large – moderate to high<br>Medium – moderate to low<br>Small – low | Large – high<br>Medium – moderate to high<br>Small – moderate | Large – moderate to high<br>Medium – moderate<br>Small – moderate | Large – high<br>Medium – moderate to high<br>Small – low to moderate | Large – low<br>Medium – low<br>Small – nil |
| Queensland | Large – moderate to high<br>Medium – low to moderate<br>Small – low | Large – high<br>Medium – moderate to high<br>Small – low | Large – high<br>Medium – moderate to high<br>Small – low | Large – high<br>Medium – high<br>Small – low to moderate | Large – low<br>Medium – low<br>Small – nil |
| WA | Large – low<br>Medium – low<br>Small – low | Large – low to moderate<br>Medium – low<br>Small – low | Large – moderate<br>Medium – moderate<br>Small – low | Large – moderate<br>Medium – moderate<br>Small – low | Large – low<br>Medium – low<br>Small – low |
| SA | Large – moderate to high<br>Medium – low<br>Small – low | Large – high<br>Medium – moderate<br>Small – low | Large – high<br>Medium – moderate to low<br>Small – low | Large – moderate to high<br>Medium – moderate<br>Small – low to moderate | Large – moderate<br>Medium – low<br>Small – low |
| Tasmania | Medium – moderate to high<br>Small – moderate to high | Medium – high<br>Small – high | Medium – moderate to high<br>Small – moderate to high | Medium – high<br>Small – moderate to high | Medium – low<br>Small – low |

Source: WMAA 2007 National Landfill Survey Database

**Existence of Infrastructure, Systems and Practices to Enable Compliance with Landfill Operational Requirements**

***Waste Acceptance***

Jurisdictions with requirements on waste acceptance cite as the most common objective the need to ensure that only wastes for which a facility is licensed are permitted to enter the site.

The likelihood of achieving this objective is interpreted from analysis of the extent to which landfills have in place systems for weighbridges where loads can be checked, closed circuit video monitors for observing vehicles and activities on the site, visual inspection as wastes are discharged from vehicles, and recording of waste types as they enter the site. These are considered to be a suite of operating practices that will contribute towards effective management of the types of waste entering a site and delivering on the common objective.

*Large and Medium Landfills* – in all jurisdictions, the frequency of implementation of acceptance checking practices is interpreted to be at a moderate to high level.

*Small Landfills* - in all jurisdictions, the frequency of implementation of acceptance checking practices is interpreted to be at a low to moderate level. This leaves these landfills open to risks associated with handling and placing hazardous waste shipments.

*Finding* - availability of infrastructure and acceptance checking practices to prevent inappropriate wastes entering a site at Large and Medium sized landfills would appear to be relatively good. An equivalent level of protection is not provided at Small landfills.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: high; Small landfills: moderate. The number of Small landfills reporting waste acceptance checking has increased significantly in the WMAA 2009 survey. The reported response for Medium landfills and Large landfills has increased markedly.

***Resource Recovery and Pre-Treatment***

All jurisdictions seek to have landfill operators implement some form of resource recovery at their sites – even though most medium and large landfills are not suited for intervention in the flow of materials between receipt at the gate and discharge at the tipping face. With the banning of scavenging, there is little opportunity, and unsuitable OH&S conditions for recovery of potentially salvageable resources once loads are discharged.

The main exception to this situation is where a landfill has a waste receival facility, remote from the tipping area, where loads can be discharged, cursorily sorted and despatched for recovery or disposal. Facilities such as these also afford drivers of small vehicles and self-haul loads opportunity to sort their loads as they unload their vehicles.

To assess the likelihood of achieving this operating requirement, three inquiries of the database were made:

- the extent to which specific material streams are accepted as discrete streams, and therefore most probably processed for resource recovery,
- the extent to which landfills had physical infrastructure on site where interception of recoverable materials might occur,
- the extent to which pre-treatment was employed before disposal.

In respect of specific waste streams, those tested on the database included containers (bottles and cans), paper and cardboard, building waste (concrete and bricks), garden waste and steel.

In respect of site infrastructure for intercepting potentially recoverable resources, those tested on the database included small vehicle transfer stations, recycling centres, a materials recovery facility, and a re-use shop on site.

*All Landfills* – in all jurisdictions, the frequency with which separate streams are accepted and specific infrastructure for resource recovery is available at site, is interpreted to be at a

moderate level. The frequency with which specific pre-treatment of putrescible waste, as required by Victoria, is implemented is interpreted to be at a low level.

*Finding* - availability of infrastructure and reported practices for resource recovery at landfills would appear to be at a modest level. This may reflect the greater wisdom in conducting resource recovery efforts upstream of the landfill, but it is inconsistent with the intent of most Landfill Guidelines.

*Validation with WMAA 2009 Survey* – Large landfills: moderate; Medium landfills: moderate; Small landfills: low to moderate. The reported response for Small, Medium and Large landfills has increased slightly.

***Litter, Odour and Dust Control***

Operational requirements of the jurisdictions generally all cite local amenity as the primary objective to be targeted – whether that local amenity is impacted by dust, odour or litter.

The likelihood of achieving this objective is interpreted from analysis of the extent to which landfills have in place systems for the compaction of waste, application of daily cover, installation of active odour controls, sealed roads, a water cart on site, on-site odour and dust monitoring, and active litter controls. These represent a wide suite of practices that would broadly be considered to be essential for effective management of air quality in the vicinity of landfills and delivering on the common objective.

*Small Landfills* – the frequency with which active operational systems and practices are in place to manage local amenity in respect of litter, dust and odour, is interpreted to be at a moderate level.

*Medium and Large Landfills* – in all jurisdictions, the frequency with which active operational systems and practices are in place to manage local amenity in respect of litter, dust and odour, is interpreted to be at a moderate to high level.

*Finding* - management of local amenity in respect of airborne pollutants would appear to be allow scope for improvement.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: moderate to high; Small landfills: moderate. The number of Large landfills reporting good compaction and cover use, as well as litter control practices has increased significantly in the WMAA 2009 survey. The reported response for Small and Medium landfill has been broadly steady.

***Disease Vector Control and Cover***

Operational requirements of the jurisdictions generally all cite local amenity as primary objective to be targeted, followed by denial of access for vermin to the waste.

The likelihood of achieving this objective is interpreted from analysis of the extent to which landfills have in place systems for the compaction of waste, application of daily cover, and active vermin controls. These represent a sub-set of practices that would broadly be considered to be essential for effective management of vermin and disease at landfills and delivering on the common objective.

*Small Landfills* – the frequency with which active operational systems and practices are in place to manage local amenity in respect of vermin and disease, is interpreted to be at a moderate level.

*Medium and large landfills* - the frequency of active use of vermin and disease, is interpreted to be at a moderate to high level.

*Finding* - the management of local amenity in respect of vermin and disease at large and medium sized landfills, where some 97% of solid waste is disposed, would appear to be relatively good.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: moderate to high; Small landfills: moderate. The number of Large landfills reporting good vermin control

practices has increased slightly in the WMAA 2009 survey. The reported response for Small and Medium landfill has been broadly steady.

***Monitoring and Reporting***

Operational requirements of the jurisdictions generally all cite an obligation for periodic reporting of results monitoring activities.

The level of compliance with this objective is interpreted from analysis of the extent to which landfills have in place monitoring systems for groundwater bores, leachate quality, stormwater quality, odour, dust and landfill gas. These represent a suite of monitoring systems and practices that would be considered essential for effective reporting on environmental compliance and delivering on the common objective.

*Large Landfills* – in all jurisdictions, the frequency with which active monitoring systems and practices are in place to facilitate environmental reporting, is interpreted to be at a moderate to high level.

*Medium Landfills* – the frequency with which active monitoring systems and practices are in place to facilitate environmental reporting, is interpreted to be at a moderate to high level for groundwater and leachate, and at a moderate level for stormwater, odour, dust and gas.

*Small Landfills* – in all jurisdictions, the frequency with which active monitoring systems and practices are in place to facilitate environmental reporting, is interpreted to be at a low to moderate level.

*Finding* - the ability of operators to monitor and report on environmental impacts at large and medium sized landfills would appear to be relatively good; there is substantial scope for improvement in respect of small landfills.

*Validation with WMAA 2009 Survey* – Large landfills: high; Medium landfills: moderate to high; Small landfills: low to moderate. The number of Large landfills with comprehensive

monitoring and reporting practices has increased slightly in the WMAA 2009 survey. The reported response for Small and Medium landfill has been broadly steady.

## Summary of Compliance with Operational Requirements

In broad terms, the application of measures in respect of Landfill Guidelines for operating systems and practices appears to have been satisfactory for Large and Medium landfills, and unsatisfactory for Small landfills: implementation of operating practices (including monitoring and reporting) in keeping with Landfill Guidelines is recorded as low to moderate.

## Jurisdiction Compliance Reports

At Table 6-4 a summary of the levels of compliance with operational requirements is presented for each landfill size-class across each of the jurisdictions for which data is available. Details of the analyses of performance against each requirement are reported at Appendix A of this report, accompanied by charts of the extent to which the various practices and systems are implemented.

**Table 6-4. Level of Compliance with Operational Requirements**

| Jurisdiction | Waste Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|---|
| NSW | Large – high<br>Medium – moderate to high<br>Small – low to moderate | Large – moderate to high<br>Medium –high<br>Small – moderate to high<br>Pre-treatment – low | Large – high<br>Medium – high<br>Small – moderate to high | Large – high<br>Medium – moderate to high<br>Small – moderate to high | Large – high<br>Medium – moderate to high<br>Small – moderate |
| Victoria | Large – moderate to high<br>Medium – moderate<br>Small – low to moderate | Large – moderate<br>Medium – moderate<br>Small –moderate<br>Pre-treatment – low | Large – high<br>Medium – moderate to high<br>Small – low to moderate | Large – high<br>Medium – high<br>Small – moderate to high | Large – high<br>Medium – moderate<br>Small – low |
| Queensland | Large – moderate to high<br>Medium – moderate<br>Small – low | Large – moderate<br>Medium – moderate to high<br>Small – low to moderate<br>Pre-treatment – low | Large – high<br>Medium – high<br>Small – low to moderate | Large – high<br>Medium – moderate to high<br>Small – moderate to high | Large – high<br>Medium – moderate<br>Small – low |
| WA | Large – moderate<br>Medium – moderate<br>Small – low to moderate | Large – low to moderate<br>Medium – low to moderate<br>Small – low to moderate<br>Pre-treatment – low | Large – moderate<br>Medium – moderate<br>Small – low | Large – moderate<br>Medium – moderate<br>Small – low | Large – moderate<br>Medium – moderate<br>Small – low |
| SA | Large – moderate to high<br>Medium – moderate<br>Small – low | Large – moderate<br>Medium – low to moderate<br>Small – low to moderate<br>Pre-treatment – moderate | Large – moderate to high<br>Medium – moderate<br>Small – low to moderate | Large – moderate to high<br>Medium – moderate to high<br>Small – moderate to high | Large – moderate to high<br>Medium – moderate<br>Small – low |
| Tasmania | Medium – moderate to high<br>Small – moderate | Medium – moderate<br>Small – moderate<br>Pre-treatment – nil | Medium – high<br>Small – moderate to high | Medium – high<br>Small – high | Medium – moderate to high<br>Small – moderate to high |

Source: WMAA 2007 National Landfill Survey Database

# 7. Groundwater Monitoring Results

As explained at Chapter 6, data available from the *National Landfill Survey* does not fully coincide with all the *outcome* requirements expressed in the various Landfill Guidelines. This particularly relates to the landfill design and construction requirements, for which the requirements are expressed in terms of outcomes such as *"...prevent leachate from entering groundwater" and "...prevent surface water from mixing with waste and carrying contaminants off-site".*

The *National Landfill Survey* did, however, include questions that examined the existence of features considered to be fundamental to achieving the sorts of outcomes described above – for instance: "...existence of a landfill liner system". The risk of groundwater pollution by leachate is considered to be high without the protection afforded by landfill liner systems, or where liner systems break down.

The analysis at Chapter 6 indicated that survey respondents reported a moderate level of landfill liner systems installation (WMAA 2007) [moderate to high (WMAA 2009)] for large and medium landfills. Adherence to this feature is low for small landfills. As a result, a measure of contamination of some groundwater bodies seems inevitable.

It has been possible to review the results of a special set of groundwater monitoring studies prepared by an EPA in one Australian jurisdiction. The studies were completed in 2006 and covered 17 landfill sites, including small, medium, and large facilities. Data sets ranged from six years to nine years. Although an overall national situation cannot be inferred from the data available, the review does indicate some instances of actual or potential pollution of groundwater, with elevated levels of ammonia, nitrates, and/or potassium. The results are summarised at Tables 7-1 and 7-2 below.

**Findings**

In brief, some groundwater pollution incidents were recorded for around half of all sites: pollution was detected at five of the 17 landfill sites examined; and mild or slight pollution

was detected at a further three sites. In addition, possible pollution was detected at two sites – the uncertainty relates the presence of high background levels of subject chemicals. Minor change in groundwater chemistry was detected at three sites.

In all but one of these 13 cases, the entire landfill was unlined or had substantial (previously filled) cells that were unlined. In these cases, groundwater pollution was indicated at bores closest to the unlined parts of the landfill. The single case in which groundwater pollution was recorded from a lined landfill was where off-site construction had caused a fault in the liner system.

Although not at a national level, these findings indicate the pollution control qualities of landfill liner systems and demonstrate that without liners in place groundwater pollution episodes can be expected. The results provide a high level of confidence in the use of control actions for groundwater protection as a proxy for the unavailable comprehensive pollution monitoring data.

**Table 7-1 Review Results, Metropolitan Landfills**

| Site | Classification | Liner System | Report Findings | Estimated Risk to Groundwater |
|---|---|---|---|---|
| 1 | Non-putrescible | Recent cells are lined, early cells unlined | Possible pollution of groundwater by leachate based recordings from one bore. | Low |
| 2 | Non-putrescible | Not lined | Pollution of groundwater by leachate based on recordings at two bores. | Moderate |
| 3 | Non-putrescible | Not lined | Minor changes in groundwater chemistry at one bore. | Very Low |
| 4 | Non-putrescible | Not lined | No evidence of pollution of groundwater by leachate. | Negligible. |
| 5 | Non-putrescible | Not lined | No evidence of pollution of groundwater by leachate. | Negligible |
| 6 | Putrescible | Current area is lined, older area not lined | Slight to moderate pollution of groundwater by leachate based on recordings at two bores. | Low |
| 7 | Non-putrescible | Lined | No evidence of pollution of groundwater by leachate. | Negligible |
| 8 | Non-putrescible | Not lined | Pollution of groundwater by leachate based on recordings at two bores. | Low |
| 9 | Non-putrescible | Lined | Pollution of groundwater by leachate based on recordings at four bores following compromise of liner. | Low- issue rectified |
| 10 | Putrescible | Current area is lined, older area not lined. | Minor changes in groundwater chemistry at one bore. | Negligible |

**Table 7-2 Review Results, Regional Landfills**

| Site | Classification | Liner System | Report Findings | Estimated Risk to Groundwater |
|---|---|---|---|---|
| 11 | Putrescible | Recent cells are lined, first two cells unlined | Mild pollution of groundwater by leachate based on recordings at two bores. | Low |
| 12 | Putrescible | Recent cells are lined, first cell unlined | Mild pollution of groundwater by leachate based on recordings at two bores. | Low |
| 13 | Putrescible | Current area is lined, older area not lined | Pollution of groundwater by leachate based on recordings at one bore and minor exceedances at a further two bores. | Low |
| 14 | Non-putrescible | Not lined | Pollution of groundwater by leachate based on recordings at ten locations. | Low |
| 15 | Putrescible | Current area is lined, older area not lined | Possible mild pollution of groundwater by leachate-based recordings from one bore, however, insufficient monitoring bores deployed. | Low-moderate |
| 16 | Putrescible | Not lined | No evidence of pollution of groundwater by leachate. | Negligible |
| 17 | Putrescible | Recent cells are lined, early cells unlined | Possible mild pollution of groundwater based recordings from six bores, however elevated ammonia and nitrate levels may be due to high background levels. | Low-moderate, with risk uncertainty |

# 8. International Landfill Regulatory Requirements

This Chapter reports on international requirements in landfill policy, planning and regulation. It corresponds to Chapter 6 which covered regulatory requirements set by Australian jurisdictions. This survey of requirements covers the same three main themes:

- Landfill planning and minimisation of disposal.
- Landfill design and construction.
- Landfill operations.

The survey of requirements covers the European Union, drawing on the Landfill Directive (1999), the United Kingdom, as specified in the Landfill Regulations (2002), and the United States with reference to the Resource Conservation and Recovery Act (1976) and Regulations.

## Establishing Minimum Practice or Benchmark Performance Requirements

As with Australia, there is no satisfactory publicly available reporting that provides comparative information on landfill management techniques. In lieu of such information the approach taken has been to review the landfill regulatory requirements or guidelines established by each jurisdiction at national level to draw out minimum practise requirements.

These requirements form the main heads for performance objectives and the basis to benchmark minimum standards which are set to protect the environment. The guidelines are generally written as broad performance objectives and/or outcome requirements and suggest several ways in which these objectives might be met. This approach allows regional governance to apply special requirements associated with regional circumstances or policy and leaves the landfill designer with the responsibility of determining the most appropriate solution for the specific circumstances.

## Assessment of International Landfill Requirements

### General Findings

The language used in the selected international landfill regulations and directives is generally quite prescriptive even though reference is invariably made to the need to comply with State and regional requirements.

The requirements contain a mix of outcome oriented statements (such as the USA requirement that no polluted water shall be discharged to waters) and more direct input requirements (such as the EU requirement to prevent surface water from entering the landfill and collect and treat contaminated water to the standard required). In general, the requirements are considerably more directive than those contained in documents issued by Australian jurisdictions.

A comparison of the EU, UK, and USA requirements is set out below. The detailed requirements for each of the established criteria are listed at Tables 8-1 to 8-9.

### Landfill Planning and Minimisation of Disposal

#### *Landfill classifications*

The EU has adopted a three classification scheme: inert waste; non-hazardous waste; and hazardous waste. The UK has also adopted this classification scheme. The USA scheme comprises only hazardous waste and municipal solid waste.

#### *Planning and siting considerations*

The EU requirements cover water, geological, heritage and proximity to settlement areas. USA requirements cover similar issues, while the UK requirements are set at regional level but generally defer to EU directive and regional demand for disposal and resource recovery facilities.

### *Waste minimisation*

The EU general requirement is reduction of the amount of biodegradable waste disposal (from the 1995 baseline) by 50% by 2009, and 65% by 2016. UK policy has adopted the EU targets, but is also driven by remaining national landfill capacity of only around four years.

## Landfill Design and Construction

### *Landfill liner structure*

The EU directive and UK regulation both require an artificial liner as well as a geological barrier in a strong quest to protect groundwater. The USA requirements also specify a two-component liner system.

### *Leachate collection and treatment*

The EU and UK each specify a minimum 500mm leachate drainage layer designed to minimise leachate head on the liner. The USA regulation requires that leachate head be maintained at less than 300mm.

### *Water management – stormwater, leachate, groundwater*

Both EU and UK specify that surface water should be prevented from entering the landfill or the waste material and that contaminated water must be collected and treated before discharge to the environment. The USA requirement is more outcome oriented, simply prohibiting any discharge of pollutants to waters including wetlands.

### *Air emissions*

The EU directive is simply that nuisance emissions and hazards should be minimised. The UK regulation refers to the application of regional operating permits. The USA regulation also refers to the application of State permits.

### *Landfill gas management*

The EU directive specifies that accumulation and migration of landfill gas “shall” be controlled and that landfill gas shall be collected, treated and used to produce energy. If the gas cannot be used to produce energy (usually due to scale) then it must be flared. The UK guideline is similarly clear and directive. The USA requirement is that the concentration of methane does not exceed 25% of the lower explosive limit for methane in the landfill.

## Landfill Operating Requirements

### *Waste acceptance*

EU and UK specify that procedures must be implemented to control waste acceptance to ensure that only wastes for which the landfill is licensed are accepted. Both require compliance testing and the UK regulation specifies that details of all waste description and origin are maintained. The USA requirement is similar, with particular emphasis on preventing acceptance of hazardous wastes.

### *Resource recovery and pre-treatment*

The EU and UK both specify that all waste must be treated in an appropriate way prior to landfilling. Treatment possibilities covered include reuse or recycling (for dry waste), and composting or anaerobic digestion for putrescible waste. The USA regulations are silent on resource recovery and pre-treatment, leaving specification of requirements to the States.

### *Litter, odour and dust control*

The EU requirement is simply that nuisance emissions and hazards should be minimised. The UK regulation refers to the application of regional operating permits. The USA regulation requires application of six inches (300mm) of earthen material at the end of each operating day or more frequently, as necessary.

### *Disease vector control and landfill cover*

The EU requirement is simply that nuisance emissions and hazards should be minimised. The UK regulation requires that nuisance and risk to health or the environment must be prevented. The USA requirement is that landfill operators must prevent or control on-site populations of disease vectors to protect human health and the environment.

### *Monitoring and reporting*

The EU requirement is for annual reporting of quantities and types of waste received, and on the annual results of the monitoring program. The monitoring program is to cover issues associated with leachate, surface water, landfill gas, and groundwater. The UK regulation specifies the same level of monitoring, with monthly or quarterly reporting to the Environment Agency.

## Table 8-1 Planning and Waste Minimisation Requirements - USA

| Landfill Classifications | Planning and Siting Considerations | Waste Minimisation |
|---|---|---|
| At the federal level, the EPA controls municipal solid waste landfills and hazardous waste landfills, setting minimum standards for design and operation.<br><br>The Resource Conservation and Recovery Act requires each State to have a Solid Waste Management Plan which establishes any standards above the federal requirements.<br><br>The States also establish standards for industrial, residual and construction and demolition facilities. Open dumps are Illegal at all levels. | Planning constraints relate to airport safety, floodplains, wetlands, fault areas, seismic impact zones, unstable areas and issues that address hydrogeologic setting, water quality, transportation and related topics. | State or regional plan is required for each state under the Solid Waste Disposal Act. Targets for recycling are established at up to 50% by municipality. |

Source: *Resource Conservation and Recovery* Act 1976 and Regulations.

## Table 8-2 Planning and Waste Minimisation Requirements – European Union

| Landfill Classifications | Planning and Siting Considerations | Waste Minimisation |
|---|---|---|
| All landfills are classified in one of the following classes:<br>• Inert waste.<br>• Non-hazardous waste.<br>• Hazardous waste.<br><br>Member states are required to implement procedures to ensure that landfills accept only the class of wastes permitted.<br><br>Some exceptions are permitted for isolated settlements. | A permit to operate can only be granted if no serious environmental risk is predicted. Key considerations are:<br>• distance from boundary to residential and recreational areas, water bodies, other agricultural or urban sites;<br>• groundwater, coastal or nature protection zones in the area;<br>• geological and hydrogeological conditions;<br>• flooding, subsidence, landslides or avalanche risk;<br>• protection of culture and heritage. | On a 1995 baseline, reduction in the amount of biodegradable MSW going to landfill must be achieved as follows:<br>• 25% reduction by 2006.<br>• 50% reduction by 2009.<br>• 65% reduction by 2016.<br><br>States which landfilled >80% of their MSW in 1995 were permitted to delay the above dates by 4 years. |

Source: Council Directive 99/31/EC the *Landfill of Waste* 1999 (the Landfill Directive).

## Table 8-3 Planning and Waste Minimisation Requirements – United Kingdom

| Landfill Classifications | Planning and Siting Considerations | Waste Minimisation |
|---|---|---|
| Landfills are classified:<br>• Inert waste<br>• Non-hazardous waste<br>• Hazardous waste<br><br>Landfills may not accept wastes outside their classification. The landfill classifications impose different engineering and operational standards.<br><br>The waste classifications for inert and hazardous wastes are defined by a series of regulations and depend on detailed chemical and leachability criteria. Non-hazardous wastes, which include municipal solid wastes, are all wastes that are neither inert nor hazardous. | Landfill planning is undertaken on a regional basis by waste planning authorities (Councils and groups of Councils) who are tasked with planning for integrated waste management. Waste Regional Plans outline the projected need for facilities and consider appropriate locations (based on projected need and EU requirements and Government policy – eg, more sustainability, more recycling, less landfilling).<br><br>Obtaining development approval for a facility that is clearly not a part of a Waste Regional Plan's requirement is extremely difficult, but ultimately is at the discretion of the Waste Planning Authority.<br><br>New landfills and landfill extensions generally require Environmental Impact Statements.<br><br>Landfill siting is controlled by the permitting process as well as the planning process, since a landfill permit cannot be issued unless it is demonstrated that no risk to water resources exists. In practice this normally means:<br>• The landfill base must be above the water table.<br>• A landfill may not be situated on a major aquifer (classified for significant contribution to drinking water resource).<br>• A landfill may not be situated on any other aquifer which provides significant base flow to an important water course or an ecologically sensitve area. | It is UK Government policy to seek reduction in waste generation in all areas, and reduction in the amount of waste landfilled. This is tackled via a number of measures, not all directly concerning the landfill operators. Most are driven by EU requirements (see EU section).<br><br>UK landfill tax is designed to make non-landfill alternatives more attractive. It currently sits at £40 ($80) per tonne, rising to £48 ($96) per tonne from April 2010. There is no exemption for MSW landfilled by Councils from public collections. |

Source: *Landfill (England and Wales) Regulations* 2002.

## Table 8-4 Design and Construction Requirements - USA

| Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|
| Composite Liner System: The upper component must consist of a minimum 30mm flexible membrane liner (FML), and the lower component must consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than $1\times10^{-7}$ cm/sec.<br><br>FML components consisting of high density polyethylene (HDPE) shall be at least 60mm thick.<br><br>The FML component must be installed in direct and uniform contact with the compacted soil component. | Maintain less than 300mm head of leachate on any point of the liner system. | MSW landfills shall not:<br>• Cause a discharge of pollutants into waters, including wetlands, that violates any requirements of the Clean Water Act, including, but not limited to, the National Pollutant Discharge Elimination System (NPDES) requirements, pursuant to section 402.<br>• Cause the discharge of a nonpoint source of pollution to waters of the United States, including wetlands, that violates any requirement of an area-wide or State-wide water quality management plan that has been approved under section 208 or 319 of the Clean Water Act, as amended. | Owners or operators of MSW landfills must ensure that the facilities do not violate any applicable requirements developed under a State Implementation Plan approved or promulgated by the Administrator pursuant to section 110 of the Clean Air Act, as amended.<br><br>Open burning of solid waste, except for the infrequent burning of agricultural wastes, silvicultural wastes, land clearing debris, diseased trees, or debris from emergency cleanup operations, is prohibited at all MSW landfill facilities. | Owners or operators of all MSW landfills must ensure that:<br>• The concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components).<br>• The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary. |

Source: *Resource Conservation and Recovery* Act (1976) and Regulations.

## Table 8-5 Design and Construction Requirements – European Union

| Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|
| Base and sides shall have a mineral layer 1m thick, K = 1 x $10^{-9}$ m/s. An artificial sealing liner is also required.<br><br>The liner must achieve the required level of protection for soils and groundwater (which is specified for groundwater in considerable detail).<br><br>The States may elect to amend the above in specific circumstances if they consider that required environmental protection can be achieved by other means. | Leachate drainage layer 0.5m thick, designed to minimise leachate head on the liner.<br><br>The States may elect to amend the above in specific circumstances if they consider that required environmental protection can be achieved by other means. | Control precipitation water from entering the landfill body.<br><br>Prevent surface water and groundwater from entering the landfilled waste.<br><br>Collect and treat contaminated water to the standard required for discharge (standard set by states). | Measures shall be taken to minimise nuisances and hazards. | Measures shall be taken to control accumulation and migration of landfill gas.<br><br>Landfill gas shall be collected from all landfills receiving biodegradable waste, and the gas must be treated and used. If the gas cannot be used to produce energy, it must be flared.<br><br>The collection and treatment of landfill gas shall be carried out in a way that minimises damage to or deterioration of the environment and risk to human health |

Source: Council Directive 99/31/EC the *Landfill of Waste* 1999 (the Landfill Directive).

## Table 8-6 Design and Construction Requirements – United Kingdom

| Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|
| For MSW landfills (non-hazardous) an 'artificial sealing liner' is required in all cases (generally this will be 2mm double welded HDPE).<br><br>There must also be a 'geological' barrier providing the equivalent of 1m thickness at 1x10-9m/s hydraulic conductivity. This can be natural, but if the natural ground is insufficient (usually the case) compacted clay is required. Lining requirements apply to base and sides.<br><br>Risk assessment modelling to prove liner design is required (stability and groundwater protection). | Leachate accumulation must be minimised. A 500mm leachate drainage layer is required in all cases (usually 20mm single size gravel with perforated piping network).<br><br>Many operating permits specify no more than a 1m head of leachate on the liner, however the actual requirement is site specific.<br><br>Best practice guidance is given in technical guidance notes. | Surface and groundwater must be prevented from entering the waste. Sub-water table landfills are no longer permitted.<br><br>Water management is controlled on a site specific basis by the operating permit. Any contaminated water must be collected and treated.<br><br>Discharge of uncontaminated stormwater to waterways is normally permitted providing monitoring results do not indicate problems. | Emissions standards for landfill gas engines are set in operating permits, and typical values given in best practice technical guidance.<br><br>Health risk assessment of predicted emissions from landfill gas and gas engine stacks is required as part of application for an operating permit. | All landfills accepting biodegradable waste must collect landfill gas. It must be used if this is possible, or alternatively flared.<br><br>Collection and treatment of landfill gas must be carried out in such a way as to prevent risk to health or nuisance.<br><br>Detailed technical guidance is provided in best practice guidance documents.<br><br>Landfill gas engines of 50MW or over are required to have permits to operate (which may be separate from the landfill permit). |

Source: *Landfill (England and Wales) Regulations* 2002.

## Table 8-7 Operational Requirements – USA

| Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|
| Owners or operators of all MSW landfills must implement a program at the facility for detecting and preventing the disposal of regulated hazardous wastes and polychlorinated biphenyls (PCB) wastes.<br><br>This program must include, at a minimum:<br>• Random inspections of incoming loads unless the owner or operator takes other steps to ensure that incoming loads do not contain regulated hazardous wastes or PCB wastes;<br>• Records of any inspections;<br>• Training of facility personnel to recognize regulated hazardous waste and PCB wastes. | N/A | The owners or operators of all MSW landfills must cover disposed solid waste with six inches ( approx 150mm) of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control fires, odours, blowing litter, and scavenging. | The owners or operators of all MSWLF units must cover disposed solid waste with six inches ( approx 150mm) of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors.<br><br>Owners or operators of all MSW landfills must prevent or control on-site populations of disease vectors (any rodents, flies, mosquitoes, or other animals, including insects, capable of transmitting disease to humans) using techniques appropriate for the protection of human health and the environment. | A groundwater monitoring system is required, including notification and recording of any activities associated with the system.<br><br>Upon exceedance of methane levels in landfill gas, recording of subsequent levels, notification of the State Director, and implementation of a remediation plan are required.<br><br>If a regulated hazardous waste or PCB waste is discovered at the facility the State Director of authorized States under Subtitle C of RCRA or the EPA Regional Administrator of unauthorized States must be notified. |

Source: *Resource Conservation and Recovery* Act (1976) and Regulations.

## Table 8-8 Operational Requirements – European Union

| Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|
| Member states shall implement procedures to ensure control over wastes accepted.<br><br>Procedures are required for :<br>• Basic characterisation of each waste accepted<br>• Compliance testing to ensure that the waste meets the characterisation established above.<br>• On-site verification to check that every load meets the characterisation in so far as is possible at the gate.<br><br>Landfilling of liquids, whole tyres, clinical wastes, and wastes that are oxidising, corrosive or flammable is banned. | Only waste that has been treated shall be landfilled. Exemption is available for waste where there is no possible treatment that would contribute to the objective of reducing the impact of landfilling on the environment, human health and greenhouse gas production. | Measures shall be taken to minimise nuisances and hazards. | Measures shall be taken to minimise nuisances and hazards. | At least annual reporting on the quantities and types of waste, and on the monitoring programme is required.<br><br>Monitoring (monthly, quarterly and 6 monthly requirements):<br>• Leachate volume and composition at each point it is extracted from the landfill<br>• Surface water upstream and downstream<br>• Landfill gas monitoring must be representative for each section of the landfill<br>• Groundwater minimum 1 upgradient and 2 downgradient.<br><br>Sampling is required on three occasions before landfilling commences is required. |

Source: Council Directive 99/31/EC the *Landfill of Waste* (1999) (the Landfill Directive).

## Table 8-9 Operational Requirements – United Kingdom

| Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|
| All landfills must have procedures to ensure that only wastes covered by their operating permit are accepted. These procedures are part of the permit requirement.<br><br>Typically, MSW landfills weigh in all loads at a weighbridge. Each load is accompanied by a transfer note incorporating waste description and origin. The landfill is required to keep transfer notes at least 2 years.<br><br>Nature and quantity of wastes are specified by the landfill operating permit.<br><br>Liquids, tyres, clinical wastes and those which are explosive, oxidising or flammable are prohibited in all landfills. | All wastes must be pretreated prior to landfilling. Pretreatment includes all standard methods for reuse and recycling of MSW, eg, sorting (kerbside or by MRF-type centralised), composting, anaerobic digestion.<br><br>There are legally binding targets (see EU section) on the reduction of biodegradable wastes going to landfill. | Litter, odour and dust are controlled on a site specific basis by conditions in the operating permit.<br><br>Typically measures to prevent nuisance and escape of litter beyond the boundary are required. More stringent provisions are required of sites in sensitive locations, or with a history of problems.<br><br>Best practice is given in technical guidance documents; compliance with these is generally expected but deviations may be negotiated with the Environment Agency. | Nuisance and risk to health or the environment must be prevented (legislative requirement).<br><br>Best practice guidance provides detailed methods and compliance is generally expected.<br><br>Requirements are enforced by means of site operating permits. | Minimum monitoring requirements are listed below. In practice considerably more than the minimum is generally required – best practice is detailed in technical guidance and compliance is enforced via operating permits.<br>• Leachate level.<br>• Leachate volume.<br>• Leachate composition.<br>• Surface water composition.<br>• Groundwater levels.<br>• Groundwater compositions.<br>• Gas composition in-waste and in perimeter boreholes.<br>• Gas and atmospheric pressures.<br><br>These measurements are generally required monthly or quarterly and reports must be issued to the Environment Agency.<br>Annual reporting on waste inputs is also required. |

Source: *Landfill (England and Wales) Regulations* 2002.

## REFERENCES


Waste Management Association of Australia. *Landfill Survey*, 2007.

Waste Management Association of Australia. *Landfill Survey*, 2009.

Environment Protection Authority NSW. *Environmental Guidelines: Solid Waste Landfills,* 1996.

EPA Victoria. *Siting, Design, Operation and Rehabilitation of Landfills,* 2001.

Environment Protection Agency. *Guideline ERA 75 Waste Disposal,* 2006.

Environment Protection Authority South Australia. *Environment Management of Landfill Facilities (municipal solid waste, and commercial and industrial general waste)* 2007.

Department of Primary Industries, Water, and Environment (Environment Division) Tasmania. *Landfill Sustainability Guide,* 2004.

EPA Northern Territory, *Guidelines for the Siting, Design, and Management of Solid Waste Disposal Sites in the Northern Territory,* 2003.

European Commission. Council Directive 99/31/EC, *Landfill of Waste,* 1999. (The Landfill Directive).

Environment Agency England and Wales. *Statutory Instrument 2002 No 1559 Landfill (England and Wales) Regulations,* 2002.

US EPA. *Resource Conservation and Recovery* Act 1976, and *Regulations Subtitle D*.

# Appendix A. Summary of Landfill Performance Indicators

In this Appendix to the report, details from the interrogation and analysis of the Waste Management Association of Australia National Landfill Survey and database are presented.

The material has been collated for presentation as follows:

- summary tables on the likelihood of compliance with requirements on a jurisdiction basis – Table A-1 Design and Construction Requirements and Table A-2 Operational Requirements; and
- an analysis for each aspect or requirement, covering the parameters selected when interrogating the database and a chart of the frequency of occurrence, from which likely compliance levels were assessed.

## Table A-1 Compliance with Design and Construction Requirements

| Jurisdiction | Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|---|
| NSW | A majority of large and medium landfills have some lining.<br>A majority of small landfills have no lining. | Leachate collection is reportedly high in all size landfills, but efficacy should be questioned in small and medium landfills. | Stormwater management practice is reportedly high across all size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills in respect of dust and odour. Small landfill management of litter and odour is reportedly high. | Landfill gas capture and utilisation is low across large and medium size landfills and virtually absent at small size landfills. |
| Victoria | A majority of all landfills have some lining. | Leachate collection is reportedly high, and efficacy should be reasonable in all size landfills. | Stormwater management practice is reportedly moderate to high across all size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills in respect of dust and odour. Small landfill management of litter and odour is reportedly high. | Landfill gas capture and utilisation is low across large and medium size landfills and virtually absent at small size landfills. |
| Queensland | A majority of large and medium landfills have some lining.<br>A majority of small landfills have no lining. | Leachate collection is reportedly high in all large and medium size landfills, but efficacy should be questioned in small and medium landfills. | Stormwater management practice is reportedly high large and medium size landfills, but less prevalent in small size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills. | Landfill gas capture and utilisation is low across large size landfills and virtually absent at and medium small size landfills. |
| WA | A majority of large landfills have some lining.<br>A majority of medium and small landfills have no lining. | Leachate collection is reportedly low across all size landfills. | Stormwater management practice is reportedly moderate across all size landfills. | Management controls for dust, litter and odour are reportedly moderate to high for large and medium size landfills, but low for small size landfills. | Landfill gas capture and utilisation is low across large size landfills and virtually absent at and medium small size landfills. |

| Jurisdiction | Liner | Leachate Collection | Water Management | Air Emissions | Landfill Gas |
|---|---|---|---|---|---|
| SA | A majority of large and medium landfills have some lining.<br>A majority of small landfills have no lining. | Leachate collection is reportedly high in large size landfills, but low in small and medium size landfills. | Stormwater management practice is reportedly high large size landfills, but less prevalent in medium and small size landfills. | Management controls for dust, litter and odour are reportedly moderate to high for large and medium size landfills, but moderate to low for small size landfills. | Landfill gas capture and utilisation is low across large and medium size landfills and virtually absent at small size landfills. |
| Tasmania | A majority of all landfills have some lining. | Leachate collection is reportedly high, and efficacy should be reasonable in all size landfills. | Stormwater management practice is reportedly high across all size landfills. | Management controls for dust, litter and odour are reportedly high for all size landfills. | Landfill gas capture and utilisation is low across all size landfills. |

## Table A-2 Compliance with Operational Requirements

| Jurisdiction | Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|---|
| NSW | Waste checking is reportedly moderate to high across all size landfills. | Resource recovery is reportedly moderate to high across all size landfills, while resource recovery infrastructure is only moderate to low at all size landfills.<br>Pre-treatment is low or non-existent across all size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills in respect of dust and odour. Small landfill management of litter and odour is reportedly high. | Control of vermin is reportedly high across all size landfills. | A comprehensive monitoring practice is reportedly high at large size landfills, moderate to high at medium size landfills and low to high at small size landfills. |
| Victoria | Waste checking is reportedly moderate to high across all size landfills. | Resource recovery is reportedly moderate across all size landfills, while resource recovery infrastructure is only moderate to low at all size landfills.<br>Pre-treatment is low or non-existent across all size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills in respect of dust and odour. Small landfill management of litter and odour is reportedly high. | Control of vermin is reportedly high across all size landfills. | A comprehensive monitoring practice is reportedly high at large size landfills, moderate to high at medium size landfills and low to high at small size landfills. |
| Queensland | Waste checking is reportedly moderate to high across large and medium size landfills, but low at small size landfills. | Resource recovery is reportedly moderate across all size landfills, while resource recovery infrastructure is only moderate to low at all size landfills.<br>Pre-treatment is low or non-existent across size landfills. | Management controls for dust, litter and odour are reportedly high for large and medium size landfills, but moderate to low for small size landfills. | Control of vermin is reportedly high at large and medium size landfills but low to moderate at small size landfills. | A comprehensive monitoring practice is reportedly high at large size landfills, moderate to high at medium size landfills and low to high at small size landfills. |

| Jurisdiction | Acceptance | Resource Recovery and Pre-treatment | Litter, Odour and Dust Control | Disease Vector Control and Cover | Monitoring and Reporting |
|---|---|---|---|---|---|
| WA | Waste checking is reportedly moderate to high across large and medium size landfills, but low at small size landfills. | Resource recovery is reportedly moderate to low across all size landfills, while resource recovery infrastructure low at all size landfills.<br>Pre-treatment is virtually non-existent across size landfills. | Management controls for dust, litter and odour are reportedly moderate to high for large and medium size landfills, but low for small size landfills. | Control of vermin is reportedly moderate at large and medium size landfills but low at small size landfills. | A comprehensive monitoring practice is reportedly moderate at large and medium size landfills, and low at small size landfills. |
| SA | Waste checking is reportedly moderate to high across large and medium size landfills, but low at small size landfills. | Resource recovery is reportedly moderate to low across all size landfills, while resource recovery infrastructure low at all size landfills.<br>Pre-treatment is moderate at large landfills and virtually non-existent at medium and small size landfills. | Management controls for dust, litter and odour are reportedly moderate to high for large and medium size landfills, but moderate to low for small size landfills. | Control of vermin is reportedly high across all size landfills. | A comprehensive monitoring practice is reportedly high at large size landfills, moderate to high at medium size landfills and low to high at small size landfills. |
| Tasmania | Waste checking is reportedly moderate to high across large and medium size landfills, but low at small size landfills. | Resource recovery is reportedly moderate to high across all size landfills, while resource recovery infrastructure is only moderate to low at all size landfills.<br>Pre-treatment is non-existent across all size landfills. | Management controls for dust, litter and odour are reportedly high for all size landfills. | Control of vermin is reportedly high across all size landfills. | A comprehensive monitoring practice is reportedly high at all size landfills. |

## Analyses of Specific Requirements for Compliance

The Waste Management Association National Landfill Survey and associated database presents a summary of operating practices and infrastructure arrangements at landfills in all most jurisdictions, covering in excess of 95 percent of all landfills in the country.

As a tool for assessing the likelihood of compliance with regulatory requirements and expectations in operating and design and construction areas, the database was interrogated using a series of parameters for each interrogation. The parameters selected represented a set of practices, systems and infrastructure that if implemented and applied would most likely see the specific requirement met.

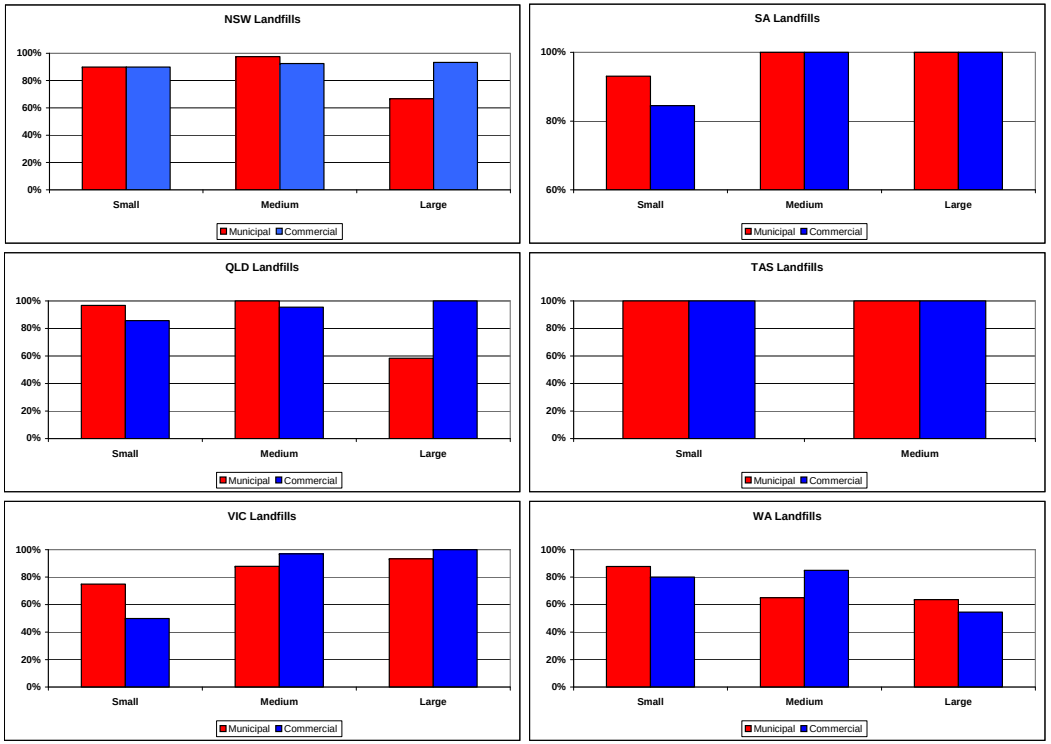
Each interrogation yielded a quantification of the number of landfill on the database, in the three size-classes selected, that employed the various parameters. On the basis of the frequency with which the parameters were evident an interpretation was made on the likelihood of compliance.

In the following pages, a brief summary of each requirement tested, with the associated parameters used to interrogate the database, is presented, accompanied by a chart of frequency of implementation of each parameter for each of the six states.

### (a) Receipt of Potentially Putrescible Waste

In the first instance, the percent of landfill sites receiving municipal and commercial waste is presented to identify the extent to which landfills across the country might be subject to the environmental management pressures brought about through handling putrescible wastes.

**Landfills Receiving Municipal & Commercial Waste**

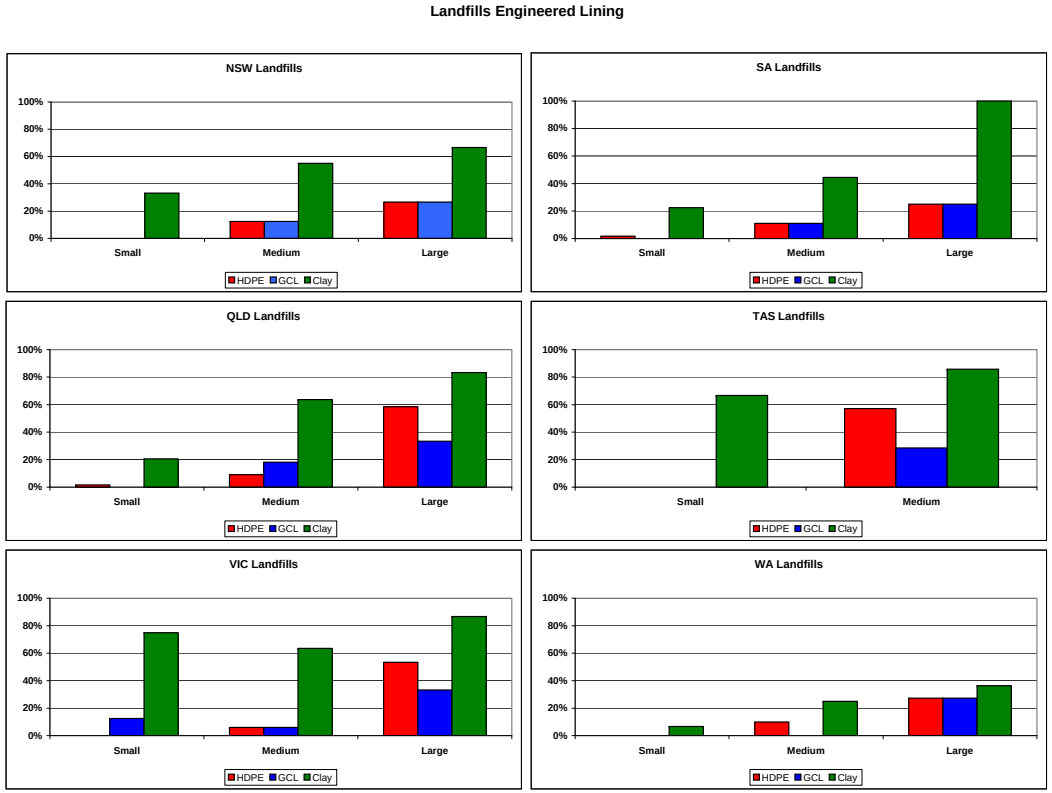



From this data it is very evident that the vast majority of landfills of all size-class and across all jurisdictions receive municipal and commercial waste, which in most instances might be considered as potentially putrescible, liable to produce leachate, landfill gas emissions etc. and therefore require a fair degree of management to minimise impacts and perform as per the expectations of the regulatory agencies in the jurisdictions.

## (b) Containment of Leachate

The database contains data on three types of engineered lining system – high density polyethylene (HDPE), geo-synthetic clay (GCL) and natural clay (CLAY) as means for preventing the loss of leachate from the landfill into the surrounding strata and water. These liners are variously installed on the base and sides of the landfill as a whole, or around individual cells within a landfill complex. There may be instances where a landfill uses more than one liner system to prevent leakage of leachate.

In the plots below, the percent of landfills with engineered liner systems is presented.



In interpreting this particular set of data, it is important to recognise that the percentage figures may be cumulative – i.e. it may not be necessary to have both a clay liner **and** one of the synthetic liners, in which case a majority of large size landfills in all jurisdictions may well have an engineered liner system.

However, it is quite evident, that in the small size class, and to a lesser extent in the medium size class, engineered lining systems are not common.

Containment of leachate is a precursor management system to effective collection and disposal of leachate.

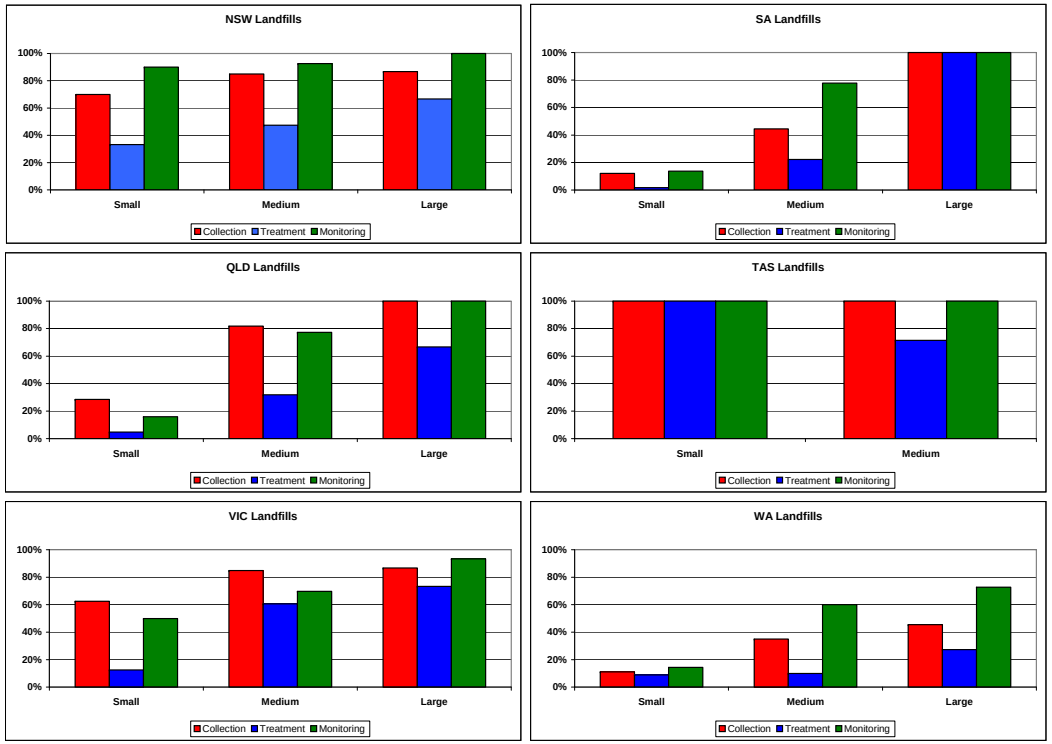
### (c) Capture of Leachate

Leachate management can involve a significant number of practice areas, including stormwater management to keep stormwater away from waste and out of the landfill. However, in this instance the practice of capture and management of leachate is taken to be represented by:

- the physical capture of the leachate,
- treatment of the leachate, and
- leachate monitoring.

From the WMAA National Landfill Database the following statistics for leachate management practice are reported.

**Landfills Leachate Management**

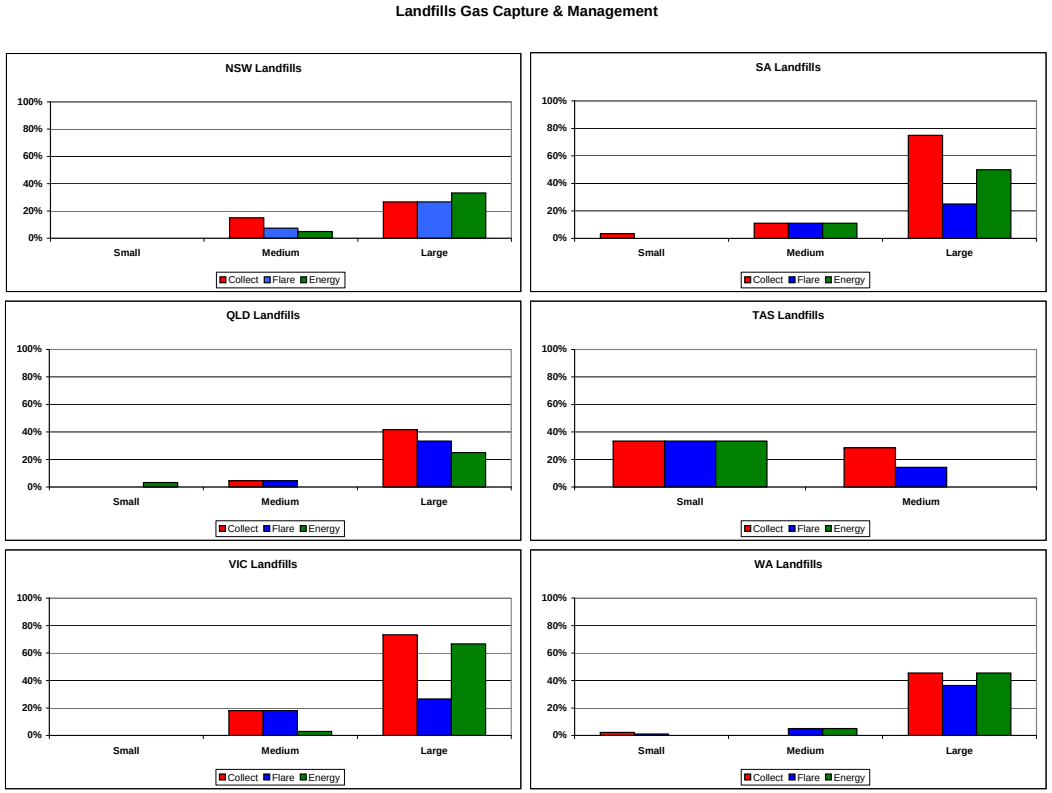



From this data it is evident that the level of leachate management practice is reported to be high across all jurisdictions and all three size classes of landfills. However, if read in conjunction with the previous chart on landfill engineered liner practice, the efficacy of the leachate capture at many of the, particularly small, landfills should be questioned.

## (d) Capture of Landfill Gas

Greenhouse gas emissions from landfill are a significant issue for the waste management sector today and for the future. Therefore, the degree to which landfill gas is captured from landfill receiving potentially putrescible wastes, and that the gas is either flared or used in energy generation, is an indicator of greenhouse performance for the sector.

In respect of landfill gas, the database contains statistics on landfill gas capture, gas flaring and energy generation. Capture of landfill gas is a necessary precursor to either flaring or energy generation.



In general terms, the degree of landfill gas capture and combustion, either through flaring or energy generation, is relatively low in Australian landfills that accept waste that is likely to be putrescible. Not only does this result in unsatisfactory greenhouse gas emissions today, but it commits Australia to a long-term legacy of such emissions as the current batch of landfills progressively age and stabilise, since retrofitting gas capture and harnessing is a costly exercise that is unlikely to be funded for the majority of landfills.

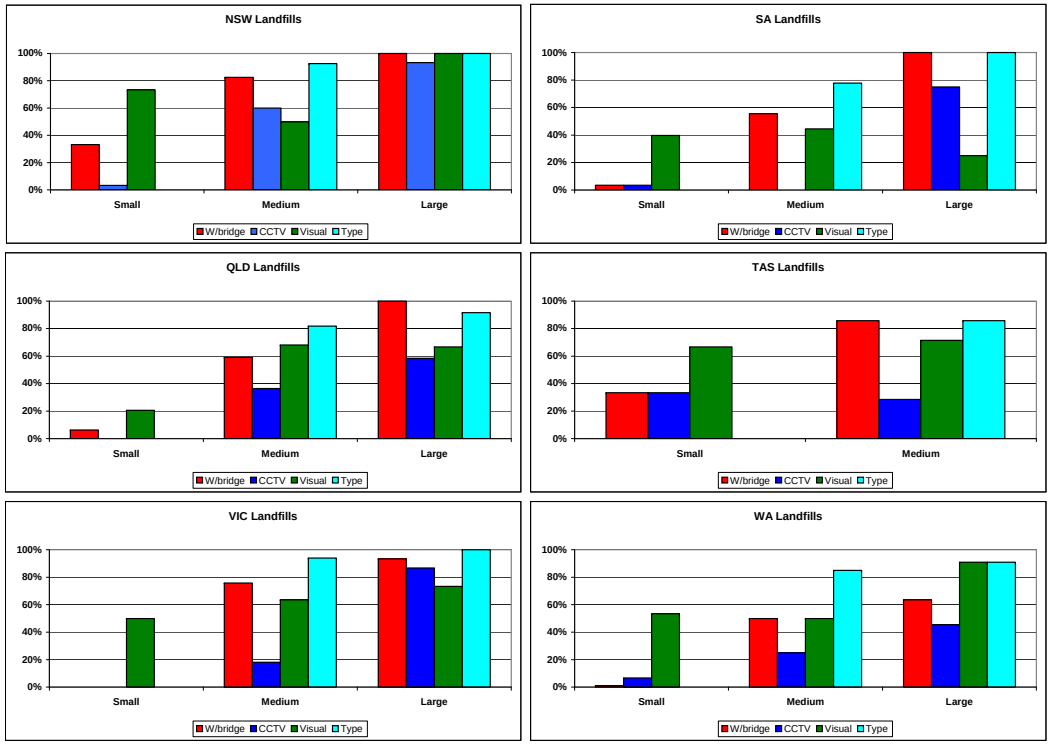
### (e) Monitoring of Waste Acceptance

For landfill operators to comply with licence conditions relating to the types of waste permitted for acceptance at a facility, various forms of waste acceptance tests can be undertaken. On the database, four techniques are identified –

- a weighbridge station where visual checks and questions are possible,
- closed circuit TV monitors observing vehicles enter,
- visual inspections on unloading, and
- asking for and recording the type of waste in loads.

Landfills with these acceptance checking systems are plotted on the charts below.

**Landfills Waste Acceptance Checks**



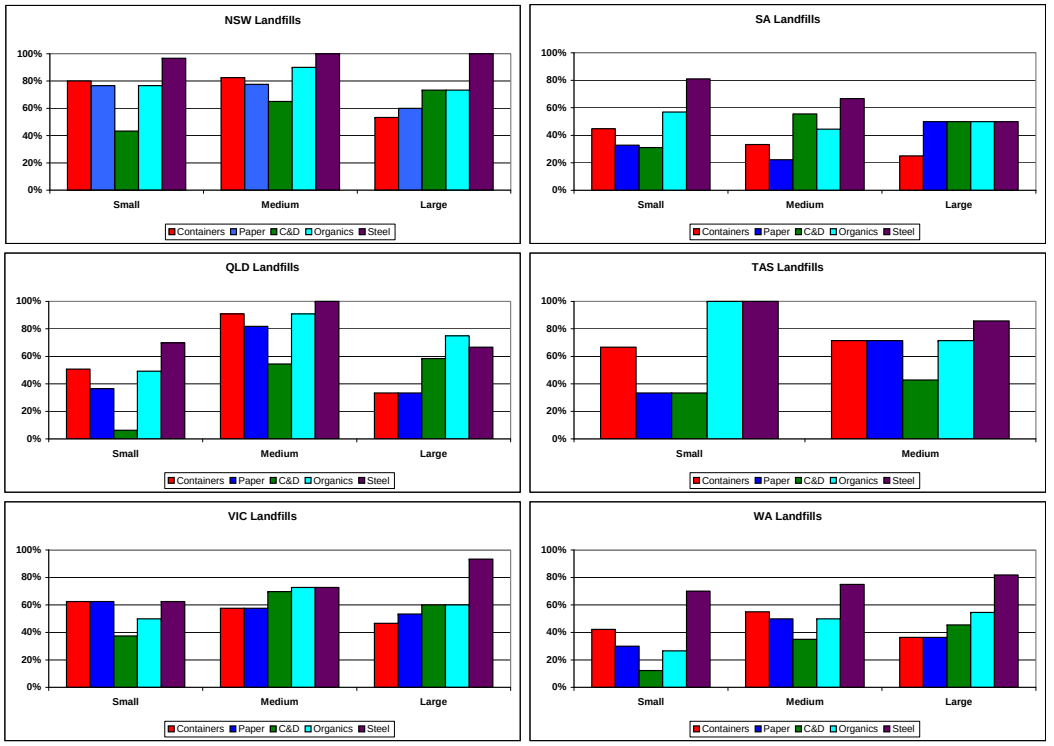

In broad terms, at both the large and the medium sized landfills, a significant majority of facilities have in place at least three systems for load acceptance checking, with many having all four systems. The relatively low level of load checking at the very large number of small sized landfills must be of concern, given the potential for un-checked dumping of hazardous and dangerous wastes.

### (f) Resource Recovery

Indicators of resource recovery at landfills can be glimpsed through the degree to which specific material streams are either accepted source separated or streamed on arrival, for dedicated aggregation and possible further beneficial processing. From the database five relatively commonly recovered material streams have been selected for plotting:

- containers – bottles and cans,
- paper and cardboard,
- building wastes – concrete and bricks
- organic wastes – garden organics, and
- steel.

**Landfills Resource Recovery Activities**



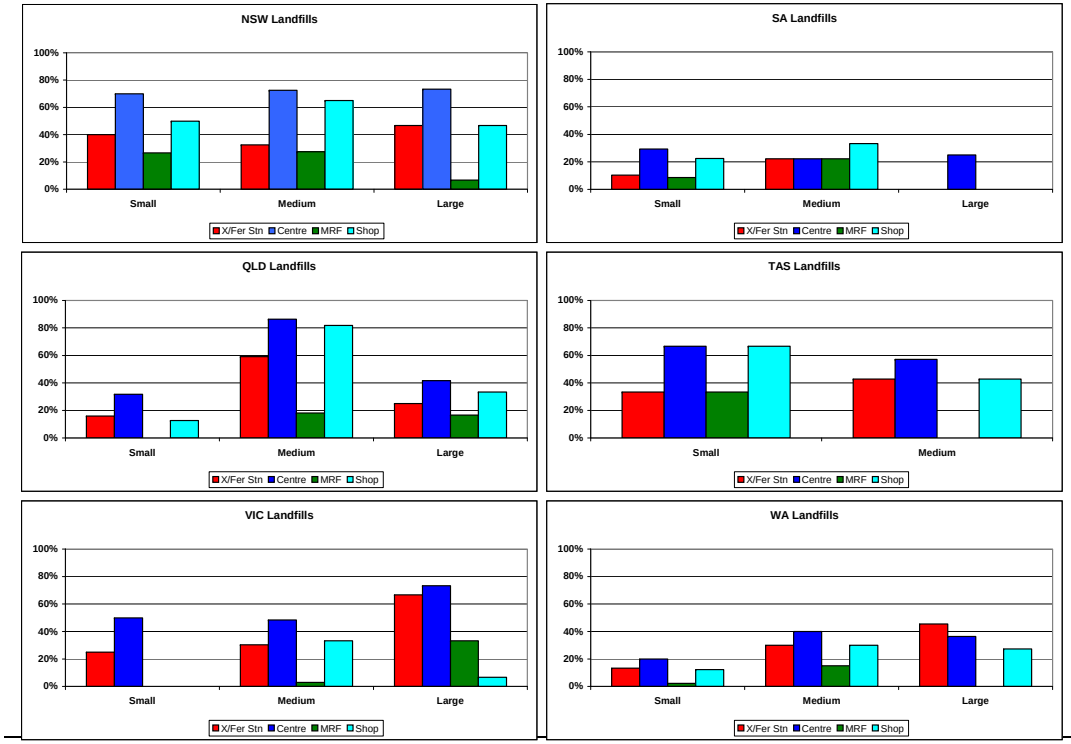

Clearly recovery of these common recyclable materials is prevalent across most landfills of all sizes in all jurisdictions.

## (g) Resource Recovery Infrastructure

A further indicator of resource recovery intention and commitment is the presence at landfills of infrastructure or facilities to intercept wastes and secure them for recovery, re-use, recycling or beneficial processing. In this instance, the following items of infrastructure have been selected:

- small vehicle transfer station,
- recycling centre,
- a materials recovery facility, and
- re-use shop on site.

**Landfills Resource Recovery Infrastructure**



This data is not particularly conclusive, perhaps with the exception that at medium sized landfills – which would be presumably be located at large regional towns – resource recovery infrastructure would appear to be more common than at either the larger or the smaller facilities. This observation may support a views that:

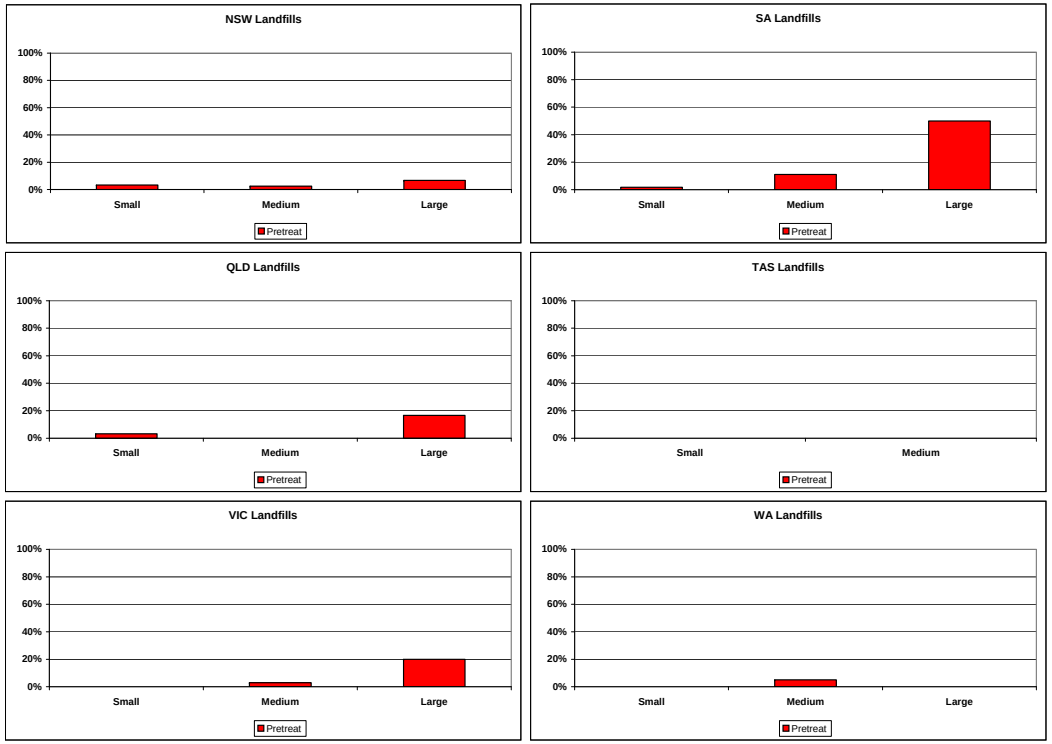
- larger capital city landfills are not places commonly visited by people in small vehicles with loads for resource recovery and re-sale, and
- smaller landfills are typically not equipped or manned to facilitate resource recovery.

### (h) Waste Pre-Treatment

Instances of waste pre-treatment at landfills prior to disposal are few in number in Australia. The database indicates that a total of 16 landfills (some 3.6% of all landfills) pre-treat waste prior to disposal.

The distribution of those landfills across the jurisdictions is shown in the following chart.

**Landfills Pre-Treating Waste**




The data for South Australia includes waste baling as a pre-treatment. It is evident from this data that pre-treatment of wastes for the purpose of stabilisation or sorting before disposal is not common in Australia.

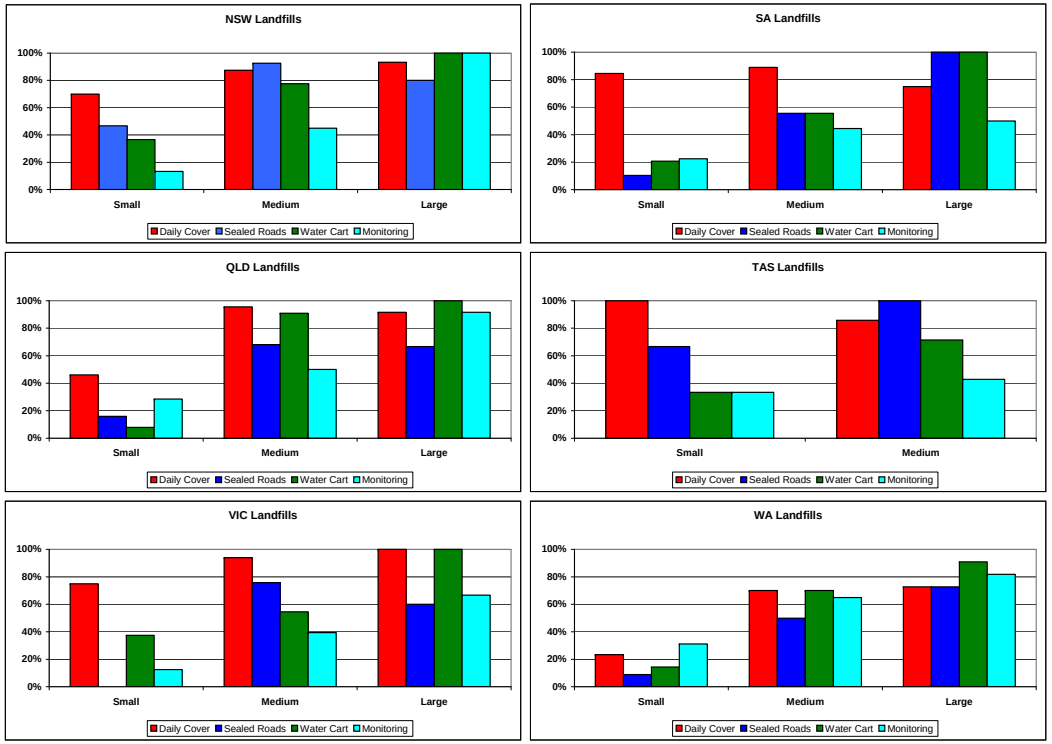
### (i) Dust Control

For dust control at a landfill the database identifies four management practices that if applied properly can have beneficial impact:

- daily cover,
- sealed roads,
- water cart on site, and
- monitoring dust.

The frequency with which these practices are implemented at Australian landfills is presented in the chart below.

**Landfills Dust Management Practices**




Significantly, the majority of both large and medium sized landfills are well equipped in this regard and there is a high level of reporting that these practices are in place. And the

relatively high proportion of small sized landfills with some or all of these practices in place is also a good sign.

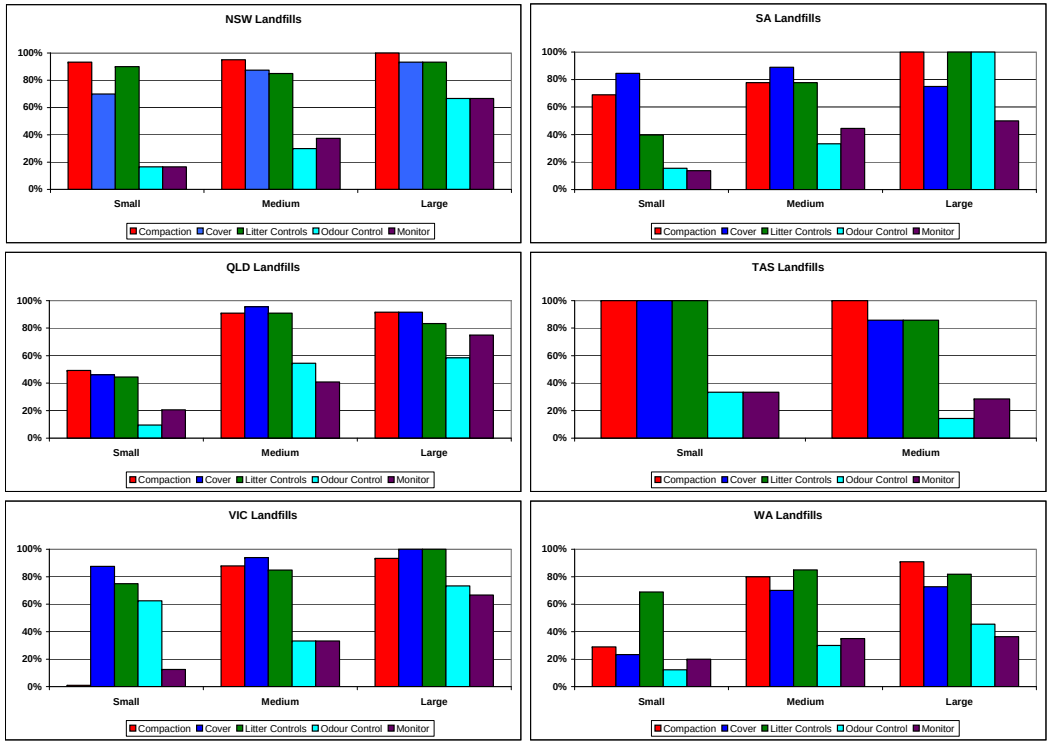
### (j) Litter & Odour Control

Five management practices recorded on the database relate to good control of litter and odour, these are:

- waste compaction,
- daily cover,
- active liter controls,
- active odour controls, and
- odour monitoring.

In the chart below, the prevalence of these management practices at Australian landfill sites is presented.

**Landfills Litter & Odour Management Practices**




With the exception of active odour controls and odour monitoring, the group of relevant practices is relatively well implemented across landfills of all three sizes. And with

compaction and daily cover both well established practices, odour should be partially catered for even without active odour controls.

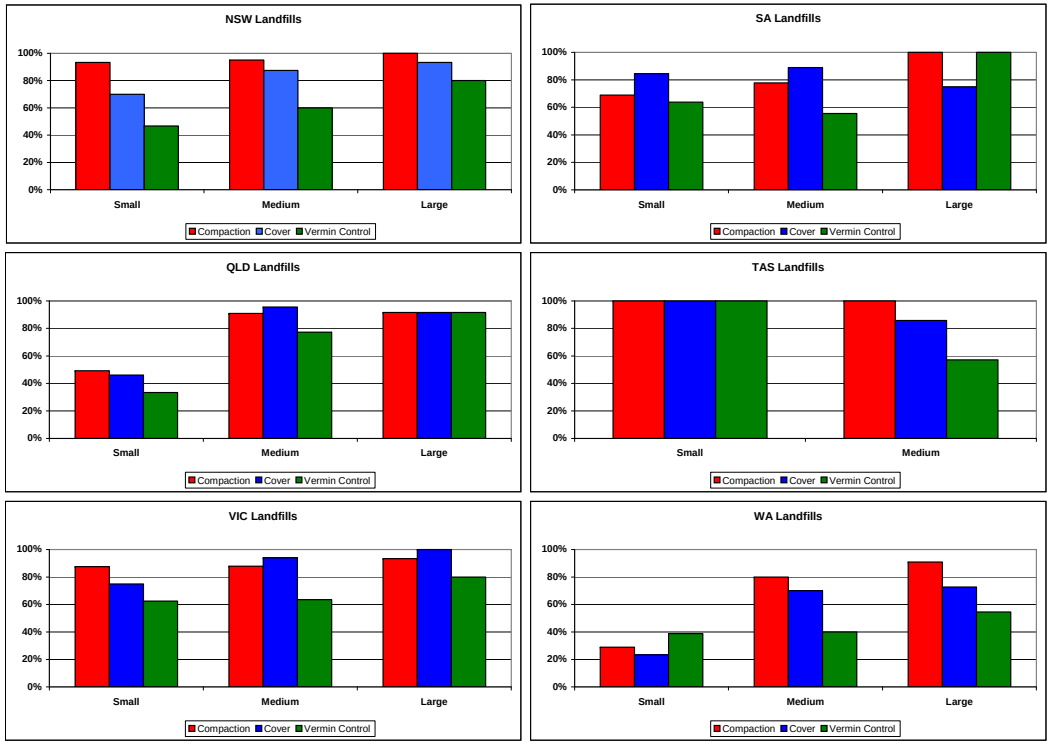
### (k) Disease, Vermin & Vector Control

The three key management practices typically used to manage potential spread of disease, and infestation of vermin and other vectors are:

- waste compaction,
- daily cover, and
- active vermin controls.

The prevalence of these management practices at Australian landfills is shown in the following chart.

**Landfills Vermin Management Practices**




With few exceptions, the implementation of these practices is well established across all three size classes of landfill, including active vermin control measures.

## (I) Surface Water Management Practice

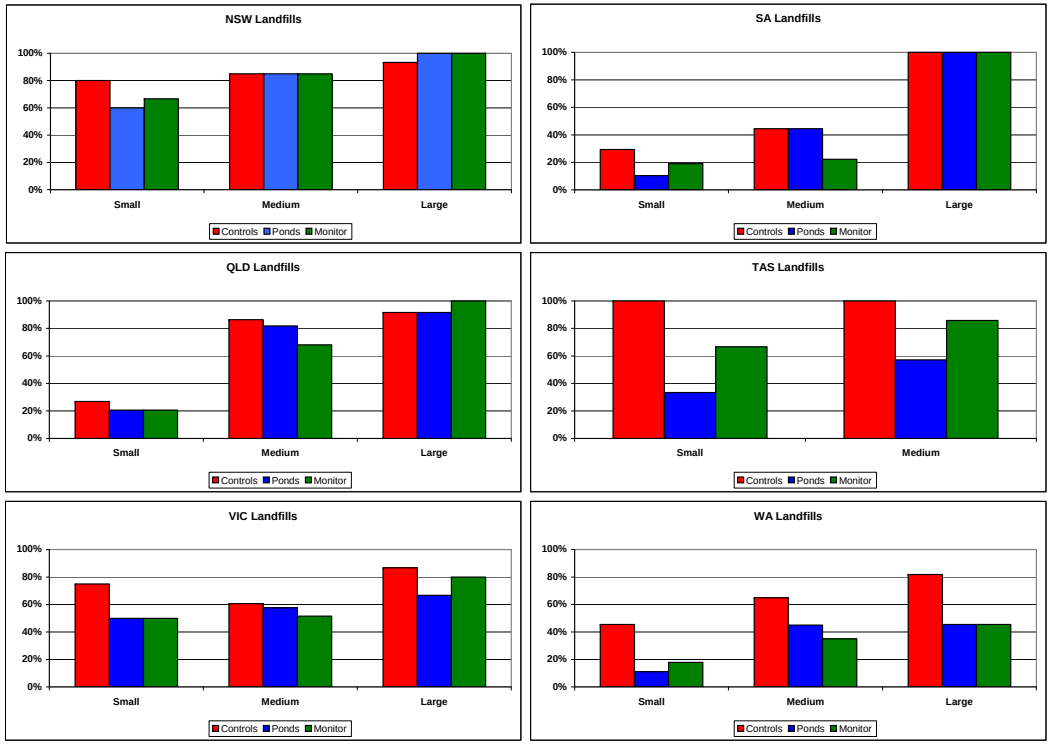
Management of surface water, with particular attention to stormwater control has many ramifications for landfill operators – especially maintaining surface water away from all areas where waste is handled and out of contact with waste to eliminate the potential for that water to be classified and treated as leachate. Given the potential for large and sudden inundation with surface and stormwater, this management approach can pay significant dividends in reducing leachate volumes.

The WMAA National Landfill Database records three key measures for managing stormwater:

- active stormwater controls,
- stormwater ponds, and
- monitoring stormwater quality.

In the chart below the prevalence of these practices is shown.

**Landfills Surface Water Management Practices**




In the majority of jurisdictions, implementation of stormwater management practice is at a relatively high level, particularly in the large and medium sized landfills.

## (m) Environmental Monitoring Performance

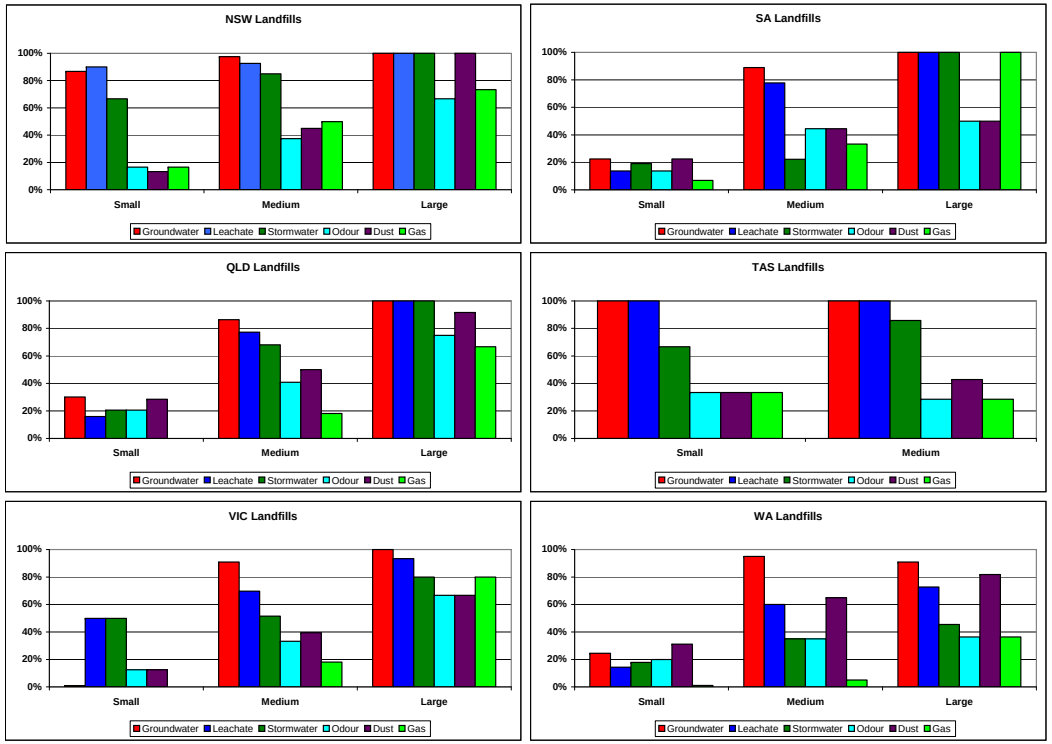
Various monitoring aspects of landfill management have already been reported on in some of the foregoing charts, however, in each case the monitoring was used as an indicator to the management practice for a specific environmental impact issue.

Here, six monitoring parameters are grouped and reported on for all landfills across Australia to develop a picture of the extent to which a comprehensive monitoring regime has been built into landfill management practice. The six monitoring activities reported here are:

- groundwater – water bores around the site,
- leachate,
- stormwater,
- odour,
- dust, and
- landfill gas.

These are presented on the following chart.

**Landfills Environmental Monitoring Practices**




From this data there are clear differences in the extent of the monitoring regime implemented across both jurisdictions and landfill size classes. It is interesting to note that the database does not report on noise management and monitoring practice at landfills.