Department of the Environment, Water, Heritage and the Arts

Australian landfill capacities into the future

Final report – amended and revised

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Department of the Environment, Water, Heritage and the Arts

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CONTENTS

Appendices

Glossary of acronyms

C&D	construction and demolition (waste)
C&I	commercial and industrial (waste)
DEWHA	Department of the Environment, Water, Heritage and the Arts
EPA	Environment(al) Protection Authority (Agency)
WMAA	Waste Management Association of Australia

Executive summary

The Department of the Environment, Heritage, Water and the Arts (DEWHA) commissioned Hyder Consulting (Hyder) to study landfill capacities across Australia to 2030. The study is intended to inform the development of a national waste policy and to complement the Hyder (2008a) report *Waste and Recycling in* Australia. In particular, DEWHA intends to use the report in assessing the potential capacity of landfills to contribute to waste management policies.

The core of the project was a modelling exercise to project the depletion of existing landfill capacity at major population centres in Australia. This involved collecting data on landfill capacity and subtracting, year by year, the projected quantity of material sent to landfill.

The model covered Adelaide, the Australian Capital Territory, Brisbane, Cairns, Darwin, Geelong, Gold Coast, Hobart, Launceston, Melbourne, Newcastle, Perth, Sydney, Toowomba, Townsville and Wollongong. Where sufficient data was available, the model involved the following steps for a population centre:

1 construct a profile of 2007 waste tonnages sent to landfill and recycled for municipal solid waste (MSW), commercial and industrial (C&I) waste and construction and demolition (C&D) waste

2 project future waste generation for each of the three source sectors under high and low growth scenarios

3 project future resource recovery rates for each of the three source sectors under high and low scenarios

4 subtract the annual waste quantity projection from available landfill space to estimate the year when depletion is estimated to occur.

Putrescible and inert landfill space was modelled separately where applicable and where there was sufficient information. Population centres were divided into high, mid-range and lower categories for resource recovery rates and future recovery rates were estimated for each. Data was obtained in relation to:

- current and projected populations in each centre
- MSW, C&I and C&D waste sent to landfill and recycled
- landfill capacity data for putrescible and inert landfills
- the proportions of C&I landfilled waste sent to inert landfills.

Data was obtained from available reports, websites, consultations with relevant government representatives and liaison with the Waste Management Association of Australia, which was undertaking a survey of landfills concurrent with this project. In general, the data obtained was of low quality — this applied to waste quantity data in many cases and landfill capacity data in most cases. Collection and collation of capacities data by jurisdictional authorities would be a simple way to improve landfill planning.

Most of the population centres have sufficient approved landfill capacity to last many years. Those with only a few years of approved capacity appear to have lined up additional airspace. No evidence was found of any critical shortage of landfill capacity at any of the population centres.

However, this does not mean landfill space is unconstrained. As landfills close they are generally replaced by sites that are further away, so that the cost and environmental impact of transport is greater (e.g. Cairns). The availability of holes for landfilling is limited by regulatory constraints (e.g. Melbourne south and east). Community objections to landfills are a real, significant and increasing constraint on supply — and experience demonstrates that problems increase when communities are asked to accept waste from other areas (e.g. Mildura). In addition, advanced waste technologies and recycling plants produce significant waste streams that require landfilling, and so the economics of these operations can be linked to the availability of local landfill (e.g. Sydney).

The analysis indicates the potential for waste reduction and recycling to extend the lifespan of existing capacity by many years.

In summary, the study finds that:

- the data to enable modelling of the consumption of landfill capacity is weak (so the results should be viewed in that light)
- there appears to be more than 15 years of landfill capacity in most of the major population centres, and additional potential capacity is apparently available in those where the supply is most constrained
- there are nevertheless good reasons to consider the available supply of landfill to be a scarce resource that should be used conservatively, and political risks if it is not.

1 Introduction

The Department of the Environment, Heritage, Water and the Arts (DEWHA) commissioned Hyder Consulting (Hyder) to study landfill capacities across Australia to 2030. The study is intended to inform the development of a national waste policy and to complement the Hyder (2008a) report *Waste and Recycling in* Australia. In particular, DEWHA intends to use the report in assessing the potential contribution of landfills to waste management policies.

The core of the project was a modelling exercise to project the depletion of existing landfill capacity at major population centres in Australia. This involved collecting data on landfill capacity and subtracting, year by year, the projected quantity of material sent to landfill. Although this is conceptually simple, there are a host of difficulties with definitions, data and uncertainty for the model and this report to take into account. The outcomes include estimates of the available landfill capacity in major Australian population centres and when it is likely to be depleted. Knowledge gaps in relation to landfill capacity and waste quantities are identified and the implications of landfill capacity depletion are discussed.

The method was clarified after submission of an initial report was submitted in mid-February. It was resolved that, notwithstanding significant gaps in the available data, a quantitative assessment of landfill airspace availability and consumption should be undertaken. This should use best available data and estimates, and should identify gaps. It was agreed that social and political issues are significant factors in landfill availability and potential scarcity, and that the nature and manifestations of these issues should be emphasised in the report.

At the same time as this project was being prepared, the Waste Management Association of Australia (WMAA) was undertaking an updated survey of landfills. The survey included queries about expected closure date and waste quantities. After submission of the draft report, WMAA's findings — aggregated to maintain commercial confidentiality — were examined to fill data gaps in Hyder's initial work.

Following this introduction, in Section 2 we discuss some general issues related to landfilling in Australia. In Section 3 we describe the modelling process and the results. Section 4 comprises a brief discussion and conclusions.

2 Landfill airspace in Australia

Landfilling is the most common method of disposing of solid waste in Australia. Landfills tend to be of three main types:

- putrescible sites accept household and other wastes containing organic materials such as food and garden waste
- inert sites accept material that is not biologically active, mainly construction and demolition waste
- hazardous sites accept material that is classified by the authorities as requiring a higher level of management due to risks to human health or the environment.

These types of site are not mutually exclusive in terms of the wastes they accept. Some population centres have no separate inert landfill. Putrescible landfills may receive some inert wastes even where there are local inert landfills, though generally in low quantities because the standards — and therefore the price — of putrescible landfills are higher. Some facilities accept only hazardous waste; others receive a mixture of hazardous and other wastes.

Landfills are generally developed in existing holes, usually formed by quarrying operations. Unlike other waste management facilities, landfill lifespans are inherently finite.

Putrescible landfills are typically managed to prevent the ingress of water, which promotes the generation of leachate, gases and odours. This ‘dry tomb’ approach has been criticised as potentially leaving a problem for future generations, and more recently there has been a move towards promoting the degradation of landfilled waste in so-called bioreactor landfills.

In the following two sections we briefly discuss how landfills are developed, as well as the availability of, and constraints on, landfill development. The significance of these issues becomes apparent in the subsequent section reporting on the modelling.

2.1 Landfill development processes

Because of environmental risks and impacts, landfilling is regulated by environmental and planning agencies. The methods of regulation vary between jurisdictions and between landfill types and sizes. Typically, a putrescible landfill will need both planning approval from the local authority and works approval or similar from the state environmental regulator. There may be a pre-approval scheduling in a regional waste management plan. At large sites, state environmental regulators are often reluctant to provide blanket approval for airspace that is not expected to be needed for many years. Consequently even when regulators and planners expect a site to be used for decades, it is possible that only a few years of capacity has received full formal approval. This is a fundamental difference between landfills and other waste facilities, which are generally fully approved for the long-term.

The process for establishing landfill capacity can be lengthy — it includes investigation design, approvals development, approvals consideration, community consultation, and construction phases[1]. For a new site, industry operators often think in terms of five years from the start of the process to opening.

[1] The process for establishing AWTs can also be lengthy.

2.2 Landfill airspace availability and constraints

A number of factors determine and constrain the availability of landfill airspace.

Generally, landfilling within quarry and mining holes is preferred by operators and regulators. This provides a means of rehabilitating sites, minimises the visual impact of the landfill and reduces litter and dust. The availability of landfill is therefore linked to the availability of holes.

Sites need to be accessible to waste transport trucks. However, beyond the distance that is viably serviced by collection vehicles, distance is not a strong constraint. This is because of the low cost per tonne kilometre of transferring compacted waste in large trucks — an increase in the transport distance of 50km would add only around $10/t to the disposal cost. Waste is sometimes transported large distances in search of cheaper landfill space. Around 400,000 tonnes of waste per year is sent by rail from Sydney to Veolia's Woodlawn landfill, some 250km from the city. Waste is trucked from Perth to Dardanup, a round trip exceeding 300 km.

Landfilling is constrained by environmental requirements. In recent years, environmental standards in relation to lining, leachate management and groundwater monitoring have made smaller operations unviable. The number of landfills has been declining as waste streams are consolidated in larger, regional sites. In terms of siting, the most important environmental constraint is probably the buffer requirements set by regulators to protect sensitive uses such as housing. Buffer distance requirements of 200m to 500m are common. In addition, landfilling below the average groundwater level is not allowed in some jurisdictions because the ingress of water promotes degradation and leachate loss to the environment. No further landfill development is expected in Melbourne's east and south-east, for example, because the depth to groundwater is only a few metres. Landfilling in Perth's Swan Coastal Plain is widely considered too risky because of its combination of sandy soils and high quality groundwater, and consequently an unofficial moratorium exists on new landfills in the catchment.

Landfills are typically established near the edges of cities, areas that are also subject to development pressures. Development close to a landfill can constrain its growth in order to maintain buffer distances. Recent problems with dangerously high methane concentrations in a Victorian housing estate (Cranbourne) occurred after a planning appeals tribunal granted permission for housing development almost to the edge of a landfill site.

Local politics is a further significant constraint. Resistance to local landfill development is evident in many landfill proposals. Fifteen thousand people attended a community meeting in Werribee, Victoria in the mid-1990s that helped defeat a proposal for a local hazardous waste landfill. A subsequent decade long search for an alternative site culminated in a proposed facility near Mildura — which also collapsed amidst vociferous local opposition. This is not only an issue for hazardous waste sites. There is often strong opposition to putrescible or inert landfill sites — for example the proposed Skye landfill south-east of Melbourne (ABC 2005).

The effect of local opposition is that waste tends to remain within localities that are accustomed to it. Extending a landfill is politically easier than establishing a new one[2]. Founding a landfill in an area with existing landfills is generally easier than one in a new area. Closed landfills often provide safe locations for waste transfer stations or other waste infrastructure. The political difficulty in establishing greenfields landfills is an important driver for the establishment of alternatives including advanced waste technologies that variously stabilise waste, reduce its volume and generate recyclable products, energy and compost-like materials.

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[2] There are nevertheless many examples of local resistance to landfill extensions – for example the proposed Devilbend landfill extension on the Mornington Peninsula.

3 Modelling the depletion of landfill airspace

In this section we describe the method and results of a modelling exercise to estimate how long available landfill airspace will last. An overview of the model is followed by a section on the methods used for collecting and collating the required data. A third section discusses the limitations of the data and the modelling process. The fourth and final section describes the modelling results.

3.1 Overview of the model

A model was constructed in Microsoft Excel to project future quantities of waste to landfill and subtract these from landfill capacity to the year 2030. In this way, the timeframe in which existing capacity is likely to be depleted could be identified.

The model covered Adelaide, the Australian Capital Territory, Brisbane, Cairns, Darwin, Geelong, Gold Coast, Hobart, Launceston, Melbourne, Newcastle, Perth, Sydney, Toowomba, Townsville and Wollongong. This list was based on population size. Melbourne was broken into two 'catchments' that were separately analysed, because this fits the general pattern of waste disposal in the city and because adequate data was available. All other population centres were treated as single catchments[3].

Where sufficient data was available, the model involved the following steps for a population centre:

1 construct a profile of 2007 waste tonnages sent to landfill and recycled for municipal solid waste (MSW), commercial and industrial (C&I) waste and construction and demolition (C&D) waste

2 project future waste generation for each of the three source sectors under high and low growth scenarios

3 project future resource recovery rates for each of the three source sectors under high and low scenarios

4 subtract the annual waste quantity projection from available landfill space to estimate the year when depletion is estimated to occur.

Putrescible and inert landfill space was modelled separately where applicable and where there was sufficient information. Hazardous waste space was excluded due to lack of data and management variability[4].

3.2 Projecting change in waste and its management

Based on a review of the literature and available data (see Appendix A), the rate of growth in waste generation was assumed to lie between 1.04 and 1.00 times the projected rate of population growth.

In projecting resource recovery rates we divided the population centres into three categories based on a review of current and targeted rates of resource recovery (as described in Appendix B). The assumed peak recovery rates in each category of population centre were as specified in

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[3] Sydney was modelled as a single catchment because the limited number of landfills would allow competitor companies to calculate each other's reported waste receipts and airspace availability.

[4] For example, some hazardous wastes can be sent to normal putrescible landfills, but the types vary from state to state.

Table 1. These rates were assumed to be reached through increases of 2% per year from 2007 rates, reflecting the trend in gradually increasing resource recovery rates in most jurisdictions over the past two decades (Hyder Consulting 2006, 2008a). Where the current recovery rate in a population centre exceeded the projected figure for that recovery rate category, then the current rate was assumed to remain constant (this applied in a small number of cases).

Table 1 Peak resource recovery rates assumed for the assessment (low and high range models)

Recovery rate category	Population centres*	MSW		C&I		C&D	
		low	high	low	high	low	high
Higher category	ACT, Adelaide, Melbourne, Sydney	60%	80%	60%	80%	70%	90%
Mid-range category	Brisbane, Geelong, Gold Coast, Newcastle, Perth, Wollongong	50%	70%	50%	70%	55%	75%
Lower category	Cairns, Darwin, Hobart, Launceston, Toowomba, Townsville	40%	60%	40%	60%	40%	60%

* Full quantity breakdowns of recovered material by sector were not available for Brisbane, Cairns, Darwin, Gold Coast, Hobart, Launceston or Wollongong

We were unable to obtain data on quantities of recycled waste for some population centres and consequently could not use the above step-by-step framework. In most of these cases we had access to data on waste to landfill so we were able to project this value based on the assumption that changes in waste to landfill would be similar across population centres in the same resource recovery category (see Table 1). The average projected change in landfill quantities within population centres in the same category was calculated and used as a multiplier.

3.3 Data collection and collation

The following categories of data were sought:

- current and projected populations in each centre
- MSW, C&I and C&D waste sent to landfill and recycled, preferably in 2006/07
- landfill capacity data for putrescible and inert landfills, preferably in m^3 and in 2006/07
- the proportions of C&I landfilled waste sent to inert landfills.

In the following sections we report on the data used in the model in each of the categories listed above.

3.3.1 Population data and projections

Population data and annual growth estimates were derived from a range of sources (ABS 2001, ABS 2008a, ABS 2008b, DIP Qld 2008, DoP NSW 20008, DSE Victoria 2008, OESR Qld 2008). ABS data and projections were preferred but were not available for all locations. Where available, high and low projections were applied. In some cases, interpolation between years was needed. Where the available data was for other years, we adjusted it to 2006/07 estimates based on projected growth rates. The assumed population and growth estimates are tabulated below. Full details of the assumptions made in projecting population figures are given in Table A3 in Appendix C.

Table 2 Population data and 2030 projections

	2007 data	2030 projections	
		High or only projection	Low projection
Adelaide	1,145,812	1,454,613	1,423,901
ACT	334,119	483,722	375,606
Brisbane	1,819,762	3,094,937	2,553,834
Cairns	151,474	219,744	n/a
Darwin	114,362	201,989	145,448
Geelong	269,988	367,865	n/a
Gold Coast	541,224	977,692	803,563
Hobart	205,481	276,729	229,642
Launceston	99,710	99,843	n/a
Melbourne E & SE	1,948,640	2,500,311	n/a
Melbourne N & W	1,857,563	2,738,513	n/a
Newcastle	523,700	647,700	n/a
Perth	1,518,748	2,613,802	2,193,230
Sydney	4,281,988	5,693,443	5,507,208
Toowomba	154,183	225,235	n/a
Townsville	170,188	267,533	n/a
Wollongong	280,200	328,300	n/a

3.3.2 Current quantities of waste landfilled and recycled

Data on waste quantities sent to landfill and recovered[5] was sought through two methods:

- Firstly we carried out a review of relevant waste-related reports (Barwon RWMG 2008, Cardno 2008, DECC NSW 2007, EPA Qld 2008a, EPA Qld 2008b, EPA SA 2008, Hyder Consulting 2008a, State Government of Victoria 2008, WA and CS 2007, ZWSA 2008).
- Secondly we attempted to fill the gaps from the first phase through telephone and email consultations with relevant government representatives (see Table 3). Our consultations also covered landfill capacities (discussed in the following sub-section).

Waste quantity data was not directly available in all categories for most population centres. In these cases assumptions were needed to split regional data into population centres, divide industrial waste by type or similar. Where the available data was for other years, we adjusted it to 2006/07 estimates based on population changes. Data net of recycling at the tip face was applied. Where it was not clear whether the data was net of recycling we assumed that it was. Full recycling data could not be derived for seven of the modelled centres.

[5] This is defined to include source-separated 'hard' recyclables, processed organics, materials recovered from advanced waste technologies and mass losses during organics processing.

Table 3 Details of the consultations with officers from the states and territories

Organisation	Officer
ACT NoWaste	Graham Mannall (Acting Manager)
Cairns Regional Council	Nigel Crumpton (Waste Technical Officer)
City of Greater Geelong	Ray Stratton (Waste Services Officer) Steve Adams (Coordinator Special Projects & Strategic Development)
Darwin City Council	Tony Scherer (Environment Officer) Shelley Inglis (Environment Officer) Pam Robinson (Manager Climate Change and Environment)
Dept Environment & Conservation WA	Michael Reid (Assistant Manager, Waste Management Branch)
Dept Environment & Climate Change NSW	Stephen Hartley Julian Thompson (Unit Head)
Dept Planning NSW	Felicity Greenway
EPA Qld	Kylie Hughes (Assistant Manager Waste Policy) Faiz Kahn (Environmental Scientist)
EPA SA	Marina Wagner (Manager Waste & Resources)
EPA Tasmania	Mark Cretney (Senior Environment Officer)
EPA Victoria	Colin MacIntosh
Gold Coast City Council	Kevin Quantick
Newcastle City Council	Mark Johnson
NT government	Nigel Green
Toowoomba Regional Council	John Harper
Townsville Regional Council	Ian Kuhl (Manager – Waste Operations: Disposal)
Wollongong City Council	Lindsay Dawson

EPA = Environment(al) Protection Authority/Agency

Full details of the assumptions made in estimating current waste quantities are given in Table A4 in Appendix C. The resulting estimated waste profile for each population centre is tabulated below.

Table 4 Estimated waste profiles, 2006/07 (data in kt to two significant figures)

	Landfill			Recycling / Recovery		
	MSW	C&I	C&D	MSW	C&I	C&D
Adelaide	290	220	410	350	740	980
ACT	88	88	31	270	68	230
Brisbane	630	400	500	280	dna	dna
Cairns	70	33	200	dna	dna	dna
Darwin	44	57	51	29	dna	dna
Geelong	47	70	67	45	46	88
Gold Coast	170	230	260	89	dna	dna
Hobart	99	82	8.1	dna	dna	dna
Launceston	55	48	5.9	dna	dna	dna
Melbourne E & SE	600	390	420	360	840	990
Melbourne N & W	580	370	400	350	810	960
Newcastle	51	82	92	18	7.7	4.6
Perth	710	830	2,100	380	870	400
Sydney	1,000	3,100	280	620	410	480
Toowomba	41	40	10	8.1	12	12
Townsville	79	26	15	50	5.6	54
Wollongong	58	47	61	16	dna	dna

dna = data not available

3.3.3 Current landfill capacities

The initial phase of the investigation applied the methods used in obtaining data on current quantities of waste landfilled and recycled. Landfill capacity data was sought through a review of reports and through consultations with government representatives (as listed and tabulated in the preceding sub-section).

A second phase in the investigation of landfill capacities was liaison with the Waste Management Association of Australia (WMAA) in relation to landfill capacities. During the course of this consultancy it became evident that WMAA was undertaking a further survey of landfills in Australia, following up on its earlier 2006/2007 survey. Given the close nature of that survey and the current work, DEWHA and WMAA agreed to accelerate the WMAA work to ensure that the results were available to this consultancy. WMAA was able to produce estimates based on aggregated responses to their landfills survey, which helped to fill gaps in the capacities data from the first two phases and acted as a check on the original data.

We describe both of these phases below. Full details of the assumptions made in estimating current landfill capacities are given in Table A5 in Appendix C. The results of each phase and the method by which we selected the most appropriate data for modelling are described in Appendix D.

Initial phase of the investigation

In the initial phase of the work, putrescible landfill airspace data was directly available in cubic metres in only seven cases. In most others data was available only in terms of the estimated number of years of remaining capacity. It was assumed that these estimates were carried out on the basis of an unchanging waste stream: that is, based on current receipts. Waste was assumed to be compacted to an average density of $1t/m^3$. This is the figure that the Victorian EPA (2002) requires landfill operators to use calculating their landfill levy returns[6].

Where applicable it was assumed that 15% of airspace would be taken by cover material and 10% by liner and drainage layer. These are considered typical figures for most jurisdictions. These proportions were subtracted from the relevant capacity estimates. It was assumed that waste data included any virgin natural excavated material received that was additional to the requirements for cover material.

Where available, estimates were obtained on the quantity of expected, but not yet approved, landfill airspace. Where the data was for years other than 2006/07, we made adjustments based on estimated waste receipts.

Only 10 of the population centres have dedicated inert landfills — the remainder use their putrescible sites for the disposal of inert waste. Data on capacity at inert sites was more difficult to obtain because the sites are often privately owned and managed. No data on inert capacity could be obtained in four cases, but in only in one case did it prove impossible to obtain a capacity estimate for putrescible airspace.

The results of this initial phase of the landfill capacity investigation are set out in Appendix D.

Liaison with WMAA

In its 2009 survey of all landfills, WMAA surveyed many aspects of site operation. WMAA gave commitments to respondents that the results will be kept confidential, and so was only able to

[6] In reality densities vary signficantly from site-to-site (depending on equipment) and between waste streams.

provide aggregated information to Hyder to help this study. Among the survey questions were inquiries about the tonnes of material received and the expected number of years of approved capacity remaining at the site. The product of these figures produces an estimate of landfill capacity[7].

We requested data from WMAA on total landfill capacity servicing a population centre. Since the survey did not ask which population centre(s) their sites serve, this was not a straightforward task.

Unfortunately a significant number of landfills — including some large sites — did not respond to the WMAA survey. For this reason, no usable data was available for Darwin, Geelong, Hobart, Melbourne and Perth. WMAA was unable to provide data for some population centres for confidentiality reasons because there was a small number of respondents. This meant data was unavailable in relation to putrescible sites servicing the Gold Coast and from inert sites servicing Adelaide, the ACT, the Gold Coast, Launceston, Toowoomba and Townsville.

The WMAA data obtained is presented in Appendix D.

The data to be used in the analysis

The WMAA data were compared with the Hyder data from the initial phase of the investigation. Where data was available from both sources, a case-by-case assessment was made as to which data was better and should be used for the analysis. The assessment is given in Appendix D.

Table 5 Estimated landfill capacities used in the analysis (data in Mt to two significant figures)

	Current approved capacity		Incl. additional expected capacity	
	Putrescible	Inert	Putrescible	Inert
Adelaide	43	0		
ACT	1.4	0	5.2	
Brisbane	26	*8.0*		
Cairns	0	*0.23*		
Darwin	1.5	0	7.5	
Geelong	2.8	0.60		
Gold Coast	7.0	0.23		
Hobart	3.3	0	9.5	
Launceston	0.76	0	2.9	
Melbourne E & SE	13	11		
Melbourne N & W	95	6.1		
Newcastle	1.4	0.16	12	
Perth	24	11		
Sydney	40	*4.7*		
Toowomba	0.34	dna	1.1	
Townsville	5.6	0		
Wollongong	0.20	0.04	3.3	20

dna = data not available

Data obtained via the WMAA survey are presented in italics

[7] It was assumed that when operators reported on the number of years until approved capacity is exhausted, they gave this estimate with reference to current waste receipts.

3.3.4 Waste to inert landfills

It was assumed that all MSW is sent to putrescible sites and that all C&D waste is sent to inert sites where these are available. In relation to C&I waste, respondents were asked about the split between inert and putrescible landfills. The responses are presented in Table 6 in terms of the percentage to inert landfills.

Table 6 Proportions of C&I waste to landfill sent to inert landfill

% C&I to inert landfill	Population centres
None	Adelaide, ACT, Brisbane, Cairns, Darwin, Gold Coast, Hobart, Launceston, Perth, Toowoomba, Townsville
Half	Geelong, Melbourne
Data not available	Newcastle, Sydney, Wollongong

3.4 Limitations to the data and modelling

There are a number of weaknesses in the data and the modelling process that limit the quality of the results. The principle weakness is that, in general, the quality of the available data is fairly low. The modelling process itself is robust in principle but also has some limitations.

Data and modelling limitations are discussed in five subsections below. In each case, we assess the impact of these limitations on the accuracy of the model results.

3.4.1 Population data

The quality of the population data was generally reasonable, to the extent that government population projections are accurate. Some data and projections were a little old e.g. Launceston data was from 2001.

Estimated impact of these limitations on the accuracy of the results: Small

3.4.2 Waste to landfill and recycling

As a whole, the quality of the landfill and recycling quantity data was fairly low. A full data set for the correct year was available for only two of the population centres. In some cases there was uncertainty whether the recycling information included green waste. In some cases, we were not certain whether the landfill data was net or gross, but this is not significant since the extent of recycling at the landfill tip face is generally small. Data on C&I and C&D waste was difficult to obtain in some cases because it is not routinely collected by the relevant jurisdiction. In 12 centres, assumptions were needed that introduce an error margin. Adelaide, for example, has a good data set but recycling data was available only for the whole state, so we assumed the proportion of SA's recyclables that Adelaide generates (85%). There were many data gaps, representing 20% of the data elements sought.

Estimated impact of these limitations on the accuracy of the results: Significant in some cases

3.4.3 Landfill capacity data

The landfill airspace data set was, on the whole, of low quality and contained a number of gaps. None of the jurisdictional regulators appear to routinely collect and collate landfill capacity data. In general, landfill data was more difficult to obtain for private landfills and particularly private inert landfills.

In Hyder's data collection, the extent to which volumetric estimates included or excluded cover, liner, drainage and capping materials was not always clear. There was also considerable uncertainty over the waste densities needed to convert volumetric information to mass — these can vary widely depending on management techniques and the waste types received. We applied a 1 t/m^3 average based on the conversion factor required by EPA Victoria (2002) for their landfill levy estimates. Several of the reported capacity figures were calculated from estimates of number of years of remaining capacity. In most of these cases the volumetric estimate relied on knowledge of current waste quantities, which were themselves sometimes uncertain.

The WMAA data proved useful only in filling three gaps in the Hyder data. Estimates were unavailable for more than half of the data elements sought. Confidence in the data was undermined by less than 100% response rates, uncertainty about response rates, and uncertainty about whether the postcode list provided to WMAA encompassed all the sites (and only the sites) that serviced a given population centre.

In addition, as discussed in Section 2.1, approval processes sometimes have multiple levels (local government planning, regional waste planning and environmental approval) and these processes vary from one jurisdiction to another. Some sites may have had approval on one level but not another. Throughout the data gathering we were not always able to be certain that partially approved capacity was dealt with consistently.

Estimated impact of these limitations on the accuracy of the results: Significant in some cases

3.4.4 The proportions of landfilled waste sent to inert landfills

We consider the data quality on waste to inert landfills to be generally fairly low. The assumptions that MSW all goes to putrescible sites is sound, and the assumption that C&D waste all goes to inert sites where these are available[8] will not introduce a large error. However, jurisdictional representatives typically know less about inert sites and industrial waste streams than they do about putrescible sites and domestic wastes. Given that authorities report that half of C&I waste goes to inert sites in Victoria it seems unlikely that none goes to the inert sites in Brisbane, the Gold Coast, Perth and Toowoomba. No information was available from NSW.

The model examined landfill depletion as a whole as well as via putrescible and inert landfill separately, so weaknesses in the data on waste to inert landfills did not prevent a reasonable outcome.

Estimated impact of these limitations on the accuracy of the results: Small

3.4.5 Modelling limitations

The model assumes that future quantities of waste to landfill can be estimated by projecting future waste generation and resource recovery rates using the methods outlined in Section 3.1. Error is minimised by providing a fairly large range of values. There are differences between the jurisdictions in methods for classifying recycled waste and for classifying what materials must go to what type of site, but these are unlikely to have a large impact.

Another assumption in the model is that nominated capacity services a defined population centre. In reality there may be transfer of waste from population centres to landfills some distance away that accept material from other population centres. These transfers may vary over time. It is likely that some capacity that is used in this way is not accurately represented in

[8] There are no inert sites at Adelaide, the ACT, Darwin, Hobart, Launceston and Townsville.

the model i.e. that capacity that has not been included in the analysis is being used for waste that is being included, or that capacity has been included that is being used for waste from other centres. As well, some capacity may be allocated to the wrong population centre — for example, an unknown proportion of industrial waste from Geelong is transferred to the Werribee landfill, the capacity of which was allocated to Melbourne north and west.

Estimated impact of these limitations on the accuracy of the results: Significant in some cases

3.5 Results

The results are expressed in terms of the expected year in which landfill depletion is likely to occur. To the extent that the data was available, estimates were generated for total landfill capacity[9], putrescible landfill capacity and inert landfill capacity. In each case, estimates were provided under two scenarios:

- rapid consumption — based on high waste generation and low resource recovery
- slow consumption — based on low waste generation and high resource recovery.

The resultant date ranges for depletion of approved capacity are summarised in Table 7.

Table 7 Expected depletion date range for approved landfill airspace at major Australian population centres

	All capacity		Putrescible capacity		Inert capacity	
Consumption rate:	Rapid	Slow	Rapid	Slow	Rapid	Slow
Adelaide	>2030	>2030	>2030	>2030	n/a	n/a
ACT	2013	2015	2013	2015	n/a	n/a
Brisbane	2025	>2030	2026	>2030	2021	2028
Cairns	2009	2009	n/a	n/a	2009	2009
Darwin	2017	2020	2017	2020	n/a	n/a
Geelong	2021	>2030	2028	>2030	2013	2015
Gold Coast	2018	2021	2026	>2030	2009	2009
Hobart	2021	2030	2021	2030	n/a	n/a
Launceston	2014	2016	2014	2016	n/a	n/a
Melbourne E & SE	2021	>2030	2022	>2030	2021	>2030
Melbourne N & W	>2030	>2030	>2030	>2030	2016	2025
Newcastle	2015	2016	2022	2029	2010	2010
Perth	2017	2020	2020	2030	2013	2014
Sydney	2017	2020	2019	2022	2012	2012
Toowoomba	dna	dna	2012	2013	dna	dna
Townsville	>2030	>2030	>2030	>2030	n/a	n/a
Wollongong	2010	2010	2010	2010	2009	2009

dna = data not available
n/a = not applicable: there is no landfill of this type
rapid consumption: based on high waste generation estimates and low resource recovery estimates
slow consumption: based on low waste generation and high resource recovery estimates.

The likely dates of expiration of approved landfill airspace vary widely. The best data set was for putrescible waste sites, for which there is a result for all applicable population centres. The

[9] Total capacity depletion is assessed on the basis that putrescible sites can accept inert waste when inert capacity is depleted, but the converse does not apply.

difference between the depletion estimates under rapid and slow airspace consumption scenarios widens with the quantity of capacity available, stretching to almost a decade for centres where expected depletion is subsequent to 2020.

Of the putrescible waste sites, four are projected to deplete existing approved capacity within five years under a rapid consumption scenario (ACT, Launceston, Toowoomba and Wollongong). Quantities of additional expected capacity (i.e. planned but not approved) were reported by respondents at each of these as well as Adelaide, Hobart and Newcastle, allowing the model to be re-run with the additional capacity. This extended the expected depletion year past 2025 for all the population centres under the rapid depletion scenario, other than Toowoomba (2018).

Table 8 Expected depletion date range for landfill airspace at major Australian population centres including expected as well as approved capacity

	All capacity		Putrescible capacity		Inert capacity	
Consumption rate:	Rapid	Slow	Rapid	Slow	Rapid	Slow
ACT	2025	>2030	2025	>2030	n/a	n/a
Darwin	>2030	>2030	>2030	>2030		
Hobart	>2030	>2030	>2030	>2030	n/a	n/a
Launceston	2027	>2030	2027	>2030	n/a	n/a
Newcastle	>2030	>2030	>2030	>2030	2010	2010
Toowomba	dna	dna	2018	2022	n/a	n/a
Wollongong	>2030	>2030	2030	>2030	>2030	>2030

The sites that currently service Cairns are expected to run out of capacity this year. Cairns composts its waste using a ‘Bedminster’ system and so does not need a true putrescible site. Residues from the Bedminster operation are expected to be transferred to the Mareeba landfill some 65 km from Cairns.

4 Discussion and conclusions

This is the first assessment and attempt to quantify national landfill capacities. The process of undertaking the project revealed significant uncertainty and variability in the available data. Waste quantity data are generally poor, especially outside the major centres. State and territory jurisdictions generally do not hold aggregated data on landfill capacities.

It is surprising that jurisdictions do not closely monitor aggregated landfill capacity given firstly that operators are typically already required to report annually to the regulator, and secondly that the supply of landfill capacity is an essential service that jurisdictions must ensure is provided. Collection and collation of capacities data by jurisdictional authorities would be a simple way to improve landfill planning.

The results of the analysis paint a picture of possible scenarios for landfill depletion under high and low recycling scenarios. Most of the population centres have sufficient approved landfill capacity to last many years. Those with only a few years of approved capacity appear to have lined up additional airspace. We found no evidence of any critical shortage of landfill capacity at any of the population centres. In most centres there is no shortage of quarry holes — typically they are being created faster than they are filled.

However, this does not mean landfill space is unconstrained. As landfills close they are generally replaced by sites that are further away, so that the cost and environmental impact of transport is greater (e.g. Cairns). The cost will rise further as a price for carbon is introduced. The availability of holes for landfilling is limited by regulatory constraints (e.g. Melbourne south and east). Community objections to landfills are a real, significant and increasing constraint on supply — and experience demonstrates that problems increase when communities are asked to accept waste from other areas (e.g. Mildura). While hazardous waste landfills give rise to particularly strong concerns, there are hazardous materials in general waste which can cause ‘licence to operate’ challenges. Communities objecting to landfill generally point to waste reduction and recovery as alternatives — if programs in these areas are weak these arguments are strengthened. In addition, advanced waste technologies and recycling plants produce significant waste streams that require landfilling, and so the economics of these operations can be linked to the availability of local landfill (e.g. Sydney).

Long-term problems with landfill capacity are likely in two of Australia’s major urban centres — Melbourne’s south-east and metropolitan Sydney

The analysis indicates the potential for waste reduction and recycling to extend the lifespan of existing capacity by many years. Under a ‘rapid depletion’ scenario, new putrescible landfill space is needed before 2030 in 13 of the 16 centres that have putrescible sites. Only nine centres need new putrescible space under the slow depletion scenario. A key difference between these scenarios is investment in advanced waste treatment facilities. Industry sources suggest that landfill space typically costs around $\$15/m^3$ to buy, $\$10/m^3$ to develop and $\$15/m^3$ to operate and close. Establishment of a one million cubic metre facility would typically cost around $25 million so delaying this expenditure for a year produces an economic return of around $1.5 million per year.

In summary, the study finds that:

- the data to enable modelling of the consumption of landfill capacity is weak (so the results should be viewed in that light)
- there is sufficient landfill capacity for the medium term in most of the major population centres, and additional potential capacity is apparently available in those where the supply is most constrained

- there are nevertheless good reasons to consider the available supply of landfill to be a scarce resource that should be used conservatively, and political risks if it is not.

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Appendix A

Projecting changes in waste generation

Projecting changes in waste generation

We considered future waste generation rates through reference to reviews of the literature, the data, and state commitments. These are addressed in turn in the following sub-sections.

Literature review

At the large-scale and long-term levels, future waste quantities have often been estimated based on population and economic growth projections. Other variables are sometimes applied such as construction activity, resource consumption, demographic variables and the impacts of government waste reduction programs. Before proposing methods for projecting future Australian waste quantities it is necessary to understand these various approaches.

A number of authors have attempted to identify the underpinnings or explanatory factors for waste generation, often using regression analysis or similar methods (Niessen and Alsobrook 1972, Grossman *et al*. 1974, McBean and Fortin 1993, Duchin and Lange 1998, Katsamaki *et al*. 1998, Chen and Chang 2000, Navarro-Esbri *et al*. 2002). Common variables shown to affect waste generation per capita are economic activity growth, social indicators, age structure, living density and household size. These types of study are mostly designed to provide useful predictions only over the short-term or in similar localities when the factors change little. Australia-wide metrics to link demographics and waste quantities are not available, nor are demographic projections necessarily reliable.

Econometric models such as Chang *et al*. (1993) and Bruvoll and Ibenholt (1997) are more sophisticated, incorporating predictions about the explanatory factors and their relationships. The latter study modelled waste from Norwegian manufacturing between 1994 and 2010, and projected increases in waste that are "far higher than estimated growth in domestic product", as a continuing relative decline in material costs outweighs projected resource efficiency gains. However, the highly theoretical underpinnings and narrowness of scope in these models exclude them from usefulness in assessing the best projection factors for Australian waste quantities.

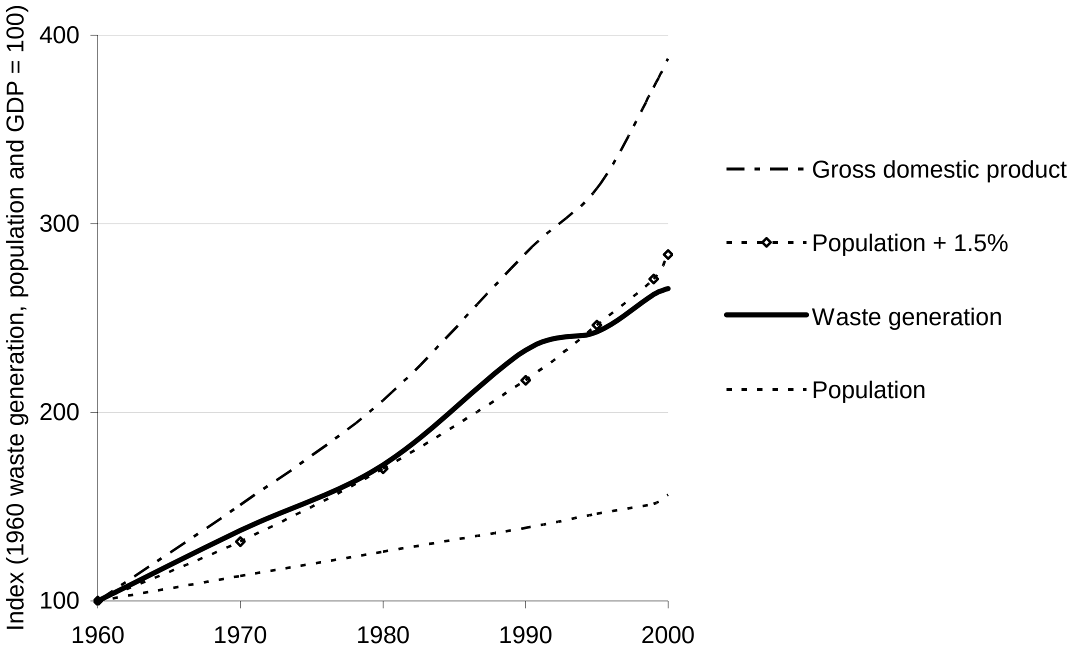
Christiansen and Fischer (1999) develop a model for the European Environment Agency to help member states predict future waste quantities by tracing a link between waste and consumption trends. But over the longer term it is not clear that predicting consumption trends is much easier than predicting than waste quantities directly. For example, there is much dispute about the extent to which material consumption is 'decoupling' from economic growth (Cleveland and Ruth 1998, de Bruyn 2002).

Other studies have examined the link between waste and economic output. Comparative international data suggests that richer countries produce more waste, but not much more (Beede and Bloom 1995). Jensen and Pipatti (2002) plot data on GNP per capita against waste per capita from multiple country surveys, finding a strong link with r^2=0.983. On the other hand, no significant relationship between per capita income and waste generation was identified in an evaluation of different US States (Bruvoll 2001). One interpretation of these apparently inconsistent findings is that the level of economic activity influences waste quantities in comparisons between distinct economies, but is less important within particular economies. A study across four industrialised countries indicated that the relationship between waste and economic activity is changing over time with a decoupling of waste growth from economic growth (Matthews *et al.* 2000). Waste quantities, it was found, are more closely linked with population.

Data review

Figure A1 is derived from US EPA data, and shows the relative changes in waste, economic activity and population in the US between 1960 and 2000. Waste generation increased slower than gross domestic product, faster than population, and close to population + 1.5%. Some decoupling of waste from economic growth is apparent from around 1990.

Figure A1 Comparisons in the growth of population, economic activity and municipal waste generation – United States of America



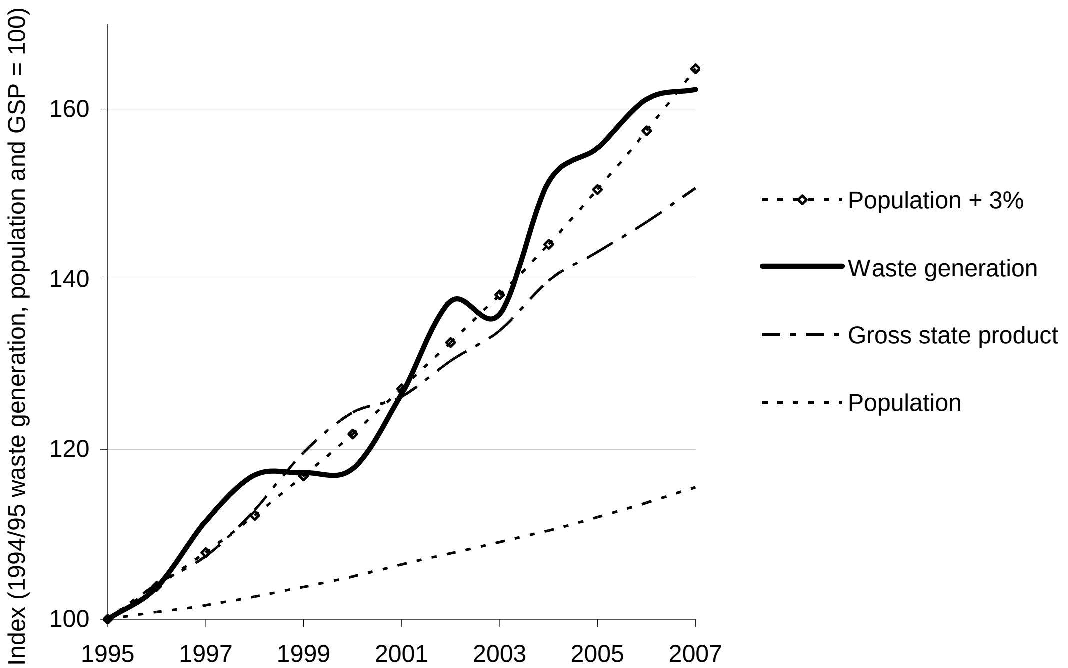
Source: *US EPA website*
Note: *The US category 'municipal waste' is equivalent to Australian MSW plus most C&I waste*

Solid waste quantity trends have been less well tracked in Australia. Data in Hyder Consulting (2008) suggests growth of 28% in only four years. The best records are probably from Victoria but extend back only to mid-1990s. This data is plotted in Figure A2 together with gross state product and population. Unlike the longer-term US data, there is no evidence of decoupling of waste generation and economic growth. Indeed, the increase in waste generation exceeds that of economic growth and is close to population + 3%.

It is possible that some of the apparent difference in the trends between the Victorian and US data is attributable to the C&D stream, which is included only in the Victorian data. Perhaps this waste stream is more prone to 'boom and bust' cycles related to demolition activity. Short to medium term forecasts of construction activity are available, and some authors have used these to estimate C&D waste. We are unaware, however, of any Australian analyses that firmly demonstrate a link between construction activity and C&D waste.

The data does not provide a reasonable split of the waste generation trends between the MSW, C&I and C&D streams, or (more relevant to this study) between putrescible and inert streams. Some commentators believe that MSW is better linked to population and other streams to economic growth.

Figure A2 Comparisons in the growth of population, economic activity and waste generation - Victoria



Sources: EcoRecycle Victoria, Sustainability Victoria, Australian Bureau of Statistics
Notes:
1. *The pre-1997 total is extrapolated from measurements in Melbourne and major centres*
2. *Waste comprises MSW, C&I, C&D. It excludes prescribed waste, quarantine waste and residues from agriculture, mining and forestry.*

State targets

Some of the states have set targets for their future waste generation rates. Victoria's *Towards Zero Waste* strategy (State Government of Victoria 2005 p.18) aims for "a reduction from 44 to 34 tonnes per million dollars of gross state product" by 2014. Figure A2 indicates that 'waste intensity' is moving in the opposite direction. The NSW strategy (DECC 2007) set a goal of "holding level the total amount of waste generated over a five-year period". It reports an increase in Sydney's waste from 8.5 to 8.9 million tonnes between 2002/03 and 2004/05 suggesting that the target will not be achieved.

We conclude that for the purposes of this modelling state waste reduction commitments can be ignored.

Conclusions

Projecting waste quantities can be done using a range of variables and approaches. We propose that for the purposes of this project it is adequate to generate estimates with reference to population growth. The Victorian data shown in Figure A2 suggests that population + 3% is the most appropriate measure. The data may be anomalous given that waste growth has exceeded economic growth — contradicting the evidence in several other countries (Matthews *et al.* 2000). We therefore propose that the Victorian figure be considered close to a 'high growth' case, which should be set at population + 4%. For the low growth case we propose that waste growth at the rate of population only i.e. somewhat below the US average and consistent with a low economic growth scenario.

Appendix B

Projecting changes in resource recovery rates

Projecting resource recovery rates

Resource recovery occurs either through source separation (e.g. of demolition concrete or kerbside recyclables) or through residuals processing (e.g. through advanced waste technology treatment of municipal garbage).

Recovery rates have been increasing across Australia for around 20 years, driven by a mix of community demand, technological development, improved systems, subsidies, industry restructuring and, until recently, favourable commodity prices. Rates are highest in urban areas where the economics are best and in jurisdictions that have made the most policy effort. We may therefore obtain reasonable guidance on potential future recovery rates from current Australian recovery rates across and jurisdictional policy goals. This information is summarised in Table A1.

Table A1 – Current jurisdictional recovery targets

Sources: Hyder Consulting (2008a, 2008b)

Jurisdiction	Recently recorded diversion rate			Target recovery rate			Target date
	MSW	C&I	C&D	MSW	C&I	C&D	
ACT	76%	43%	92%	90-95%			No date given
NSW	33%	38%	61%	66%	63%	76%	2014
Northern Territory	1%			No quantitative targets set			N/A
Queensland	44%	57%	30%	No quantitative targets set			N/A
South Australia	54%	64%	79%	75% of all kerbside	30% increase	50% increase	2010
Tasmania	6%	unknown	unknown	No quantitative targets set			N/A
Victoria	38%	69%	72%	65%	80%	80%	2014
Western Australia	29%	60%	17%	Strategy under development			N/A

The years of interest to this assessment are 2020 and 2030. None of the jurisdictions have targets for within this timeframe. The ACT target appears ambitious given that recovery processes generate waste streams that generally require landfill disposal — at materials recovery facilities this typically represents 10% of inputs, whereas at some advanced waste technologies it may easily reach 40%. The NSW and Victorian target recovery rates seem achievable based on current performance and trajectories. Perth has no formal targets as yet but has several advanced waste technologies and others planned. However, the data is for entire jurisdictions rather than for the key population centres, where recovery rates would be much higher due to the higher population size and density. There are some differences across the jurisdictions in relation to waste type definitions, so the rates are not wholly comparable[10].

Given the level of the uncertainty in the data (particularly over landfill capacity), it will be sufficient to consider future recovery rates on the basis of broad estimates. It is highly likely that the political drivers for increased recovery will continue, so increases in recovery rates should be expected. However, we see no clear basis for distinguishing between estimates for 2020 and

[10] For example, the Victorian definition of recycled metal has included all recovered metals whereas the NSW definition ignores metals that have always been recycled.

2030 — in other words, we consider that estimates for 2020 are applicable to 2030. We propose to set assumptions based on three groups of population centres — higher rate, mid-range rate and lower rate centres. Allocations to these groups are based on a mix of performance factors including current levels of resource recovery, level of jurisdictional policy commitment to recycling and level of access to large recyclables markets.

- high resource recovery rate category: ACT, Adelaide, Melbourne, Sydney
- mid-range resource recovery rate category: Brisbane, Geelong, Gold Coast, Newcastle, Perth, Wollongong
- lower resource recovery rate category: Cairns, Darwin, Hobart, Launceston, Toowomba, Townsville.

To these groups we propose to apply two recovery rates (low and high) as set out in Table A2. In the mid-range and higher recovery categories, achievement of the high rate would depend on significant investment in advanced waste technologies.

Table A2 Proposed recovery rates to be assumed for the assessment

Recovery rate category	MSW	C&I	C&D
Higher category	60% - 80%	60% - 80%	70% - 90%
Mid-range category	50% - 70%	50% - 70%	55% - 75%
Lower category	40% - 60%	40% - 60%	40% - 60%

Appendix C

Data sources and assumptions

Table A3 Data sources and assumptions – population projections

Population centre	Data source(s)	Assumption(s)
Adelaide, ACT, Brisbane	ABS (2008): series A (high projection); series C (low projection)	
Cairns	Qld DIP projections, http://www.dip.qld.gov.au/population-forecasting/population-projections.html	Growth rates are constant across the mulit-year intervals for which data is provided
Darwin	ABS (2008): series A (high projection); series C (low projection)	
Geelong	Victoria in Future 2008; http://www.dse.vic.gov.au/DSE/dsenres.nsf/LinkView/B9023E3BAACA5A6ACA256EF60019E55806C7DF80826B65674A256DEA002C0DCA	
Gold Coast	Queensland Government Office of Economic and Statistical Research, http://www.oesr.qld.gov.au/queensland-by-theme/demography/population/tables/pop-proj-high/proj-pop-five-year-age-group-gcs-sd/index.shtml	
Hobart	ABS (2008): series A (high projection); series C (low projection)	
Launceston	ABS (2001)	Growth rates are constant across the mulit-year intervals for which data is provided
Melbourne (all)	Victoria in Future 2008; http://www.dse.vic.gov.au/DSE/dsenres.nsf/LinkView/B9023E3BAACA5A6ACA256EF60019E55806C7DF80826B65674A256DEA002C0DCA	Growth rates after 2026 continue at the rate of 2025/26
Newcastle	NSW Dep't Planning Population and Housing Projections, http://www.planning.nsw.gov.au/programservices/population.asp	
Perth, Sydney	ABS (2008): series A (high projection); series C (low projection)	
Toowomba, Townsville	Qld DIP projections, http://www.dip.qld.gov.au/population-forecasting/population-projections.html	Growth rates are constant across the mulit-year intervals for which data is provided.
Wollongong	NSW Dep't Planning Population and Housing Projections, http://www.planning.nsw.gov.au/programservices/population.asp	

Table A4 Data sources and assumptions – waste quantities

Population centre	Data source(s)	Assumptions and calculation methods in relation to …	
		Waste to landfill	Recycling
Adelaide	(a) EPA SA, 2007-08 landfill quantities. (b) WA & CS (2007) c) ZWSA (2008)	Breakdown of waste between sectors was sourced from (b) and applied to data from source (a)	MSW: green waste included. Total SA recovery figure used. Assumed 85% comes from Adelaide C&I / C&D: Total SA recovery figure used. Assumed 85% comes from Adelaide
ACT	(a) Graham Mannall, ACT No waste, pers. comm. 04/02/09	Source (a) used	MSW: Green waste assumed to be included
Brisbane	(a) EPA Qld (2008a) (b) EPA Queensland 2007–08 private sector landfill data.	MSW: From source (a): includes kerbside waste collected and household waste dropped off. assume that 90% of drop off is land filled C&I: From source (a), local government data on C&I waste received (2% is recycled), plus data provided by EPA on private waste collection in SE Qld (source b), adjusted for population of Gold Coast. C&D: local government data from source (a) (52.5% of C&D waste received is recycled) plus data provided by EPA on private waste collection in SE Qld (source b), adjusted for population of Gold Coast	MSW: Source (a), includes paper and packaging material collected, plus estimated proportion of household drop off waste recycled. Green waste is included.
Cairns	EPA Qld (2008a) EPA Qld 2007–08 private sector landfill data.	MSW: inert residual from waste composting operation (treating MSW and C&I). Data adjusted to 06/07. C&I / C&D: Total C&I waste to landfill from the private and public sectors in Queensland, corrected for population.	
Darwin	(a) Shelley Inglis, Darwin City Council, pers comm.. 17/08/09 (b) Darwin City Council (2008b) National Environment Protection (Used Packaging) Measure data, Annual Report by Local Government Authorities (Darwin City Council) for the reporting period 01/07/06 – 30/06/07	Waste to landfill quantities and breakdown from waste between sectors was sourced from (a)	Recycling quantities were sourced from (b). Green waste reprocessed was provided in metres cubed and converted to tonnes using a conversion factor of 0.15 tonnes/m^3 (Waste Wise Events volume to weight conversion ratios used).
Geelong	BRWMG (2008)	Total MSW / industrial / C&D waste to landfill in the Barwon	MSW: Mixed recycling and green waste produced per

Population centre	Data source(s)	Assumptions and calculation methods in relation to …	
		Waste to landfill	Recycling
		region multiplied by the proportion going to Corio and Drysdale Landfills. .	ratable property multiplied by number of ratable properties. C&I: Total recyclables collected in the COGG plus mixed recyclables and green waste collected by the private sector (assumed this mainly includes Geelong) less MSW recovery. Total soil and rubble recovered in the Barwon Region.
Gold Coast	(a) EPA Qld (2008a) (b) EPA Qld 2007–08 private sector landfill data.	MSW: from source (a), includes kerbside waste collected and household waste dropped off, assume that 90% of drop off is landfilled C&I: local government data on C&I waste received (2% is recycled) from source (a), plus data provided by EPA on private waste collection in SE Qld (source b), adjusted for population. C&D: local government data from source (a) (24.9 % of C&D waste received is recycled) plus data provided by EPA on private waste collection in SE Qld (source b), adjusted for population.	Source (a). Includes paper and packaging material collected. Plus estimated proportion of household drop off waste recycled. Green waste incl.
Hobart, Launceston	Mark Cretney, EPA Tasmania, pers comm. 05/02/09		
Melbourne (all)	State Government of Victoria (2008)	MSW: waste landfilled in metropolitan Melbourne adjusted for population. Estimated Vic-wide C&I / C&D split applied to total industrial waste landfilled	MSW recycled in metropolitan Melbourne adjusted for population Tonnes of C&I and C&D recovered is based on recovery rate.
Newcastle	Mark Johnson, Newcastle City Council, pers comm. 02/03/09	Data adjusted to 06/07	Data adjusted to 06/07 MSW: includes kerbside collectables and domestic green waste C&I: includes commercial green waste ferrous, non ferrous, glass, paper and plastic C&D: includes self haul C&D waste from the ‘commercial’ sector
Perth	Cardno (2008)		
Sydney	DECC NSW (2007)	Data adjusted to 06/07	Data adjusted to 06/07

Population centre	Data source(s)	Assumptions and calculation methods in relation to …	
		Waste to landfill	Recycling
Toowomba	John Harper, Toowoomba Regional Council, pers comm. 26/02/09		Total green waste recycled was assumed to come equally from MSW, C&I and C&D sectors.
Townsville	Ian Kuhl, Townsville Regional Council, pers comm. 02/03/09	MSW land filled includes green waste	Assume recycled MSW includes green waste
Wollongong	(a) Lindsay Dawson, Wollongong City Council, pers comm. 25/02/09 (b) DECC NSW (2007)	Source (a) used for MSW and C&I,, data adjusted to 06/07. Source (b) used for C&D, data adjusted to 06/07	Assume MSW recyclables include green waste

Table A5 Data sources and assumptions – landfill capacities (Hyder inquiries)

Population centre	Data source(s)	Assumption(s)
Adelaide	Marina Wagner, EPA SA (2009), pers comm 24/02/09	Liner and cap not taken into account in data provided.
ACT	Graham Mannall, ACT No waste, pers comm. 04/02/09	Based on source estimate of years of capacity remaining and current waste to landfill data.
Brisbane	Environmental Protection Authority Queensland (2009), pers comm Kylie Hughes (12/02/08)	Based on MSW and C&I to landfill and source estimate of remaining life (in years) at one facility.
Cairns	(a) Nigel Crumpton, Cairns Regional Council, pers comm. 26/02/09; (b) Data provided by WMAA, 22/6/09, based on survey of landfill operators	Source (a) for putrescible capacity, source (b) for inert landfill capacity
Darwin	SMEC Consultants (2008) Shoal Bay waste disposal site long term feasibility plan, prepared for Darwin City Council	Current approved capacity is based years of capacity remaining and current waste to landfill data. Assumed net density is not accounted for in potential future capacity figures.
Geelong	Barwon Regional Waste Management Group (2006), Barwon Regional Waste Management Plan 2006, prepared by Meinhardt Infrastructure and Environment	Assumed net density is not accounted for in data provided.
Gold Coast	Kevin Quantick, Gold Coast City Council, pers comm. 11/03/09	Capacity estimates based on current generation rates and estimate by source of years remaining. Assume all C&D waste goes to inert landfill.
Hobart, Launceston	Mark Cretney, EPA Tasmania, pers comm. 05/02/09	Capacity estimates based on current generation rates and estimate by source of years remaining.
Melbourne (all)	State Government of Victoria (2008)	Liner and cap not taken into account in data provided.
Newcastle	Mark Johnson, Newcastle City Council, pers comm. 02/03/09	Liner and cap not taken into account in data provided.
Perth	Cardno (2008)	Liner and cap not taken into account in data provided.
Sydney	Unpublished preliminary results from NSW Department of Planning, Strategic review of putrescible landfill demand and capacity for the Sydney region	Liner and cap not taken into account in data provided.
Toowomba	John Harper, Toowoomba Regional Council, pers comm. 26/02/09	None
Townsville	Ian Kuhl, Townsville Regional Council, pers comm. 02/03/09	Capacity estimates based on current waste generation rates, estimate by source of years remaining for each landfill and estimate by source of split of waste between landfills.
Wollongong	Lindsay Dawson, Wollongong City Council, pers comm. 25/02/09	Liner and cap not taken into account in data provided.

Appendix D

Landfill capacity data from Hyder investigations and WMAA survey – presentation, comparison and selection for analysis

Hyder provided its data request to WMAA in one of two ways. Where we knew the names of all the landfills servicing a population centre, we asked WMAA to provide an estimate for those sites. In most cases, however, we did not have this information to a high degree of confidence. Instead, we provided WMAA with a list of postcodes falling within (or mostly within) a 50 km radius of the population centres, and asked them to sum the landfill capacity within these postcodes. The resultant data is recorded and assessed below.

Table A6 Estimated landfill capacities, 2006/07, putrescible and inert, from both Hyder and WMAA data sources (in millions of tonnes to two significant figures)

Population centre	Hyder data *(based on reports & gov't consultations)* Current approved capacity		Incl. additional expected capacity		WMAA data of current approved capacity *(based on survey of landfill operators)*		Comparison and assessment of the data from both sources	Decision on data to be used
	Putresc	Inert	Putresc	Inert	Putresc	Inert		
Adelaide	43	0			13	dna	Putrescible data exclude Adelaide's largest landfill, which did not complete WMAA survey. WMAA provided no data on inert landfill capacity. Hyder is reasonably confident about the quality of its data for this population centre.	Use Hyder data
ACT	1.1	0	5.2		1.5	dna	Putrescible data similar to Hyder data. WMAA provided no data on inert landfill capacity. Hyder is reasonably confident about the quality of its data for this population centre.	Use Hyder data
Brisbane	26	dna			5.6	8.0	WMAA putrescible data different from Hyder data, possibly due to low level WMAA survey response (24% of known sites within nominated postcodes did not complete the survey). No Hyder data available for inert sites.	Use Hyder data for putrescible sites and WMAA data for inert.
Cairns	0	dna			0.51	0.23	Hyder is reasonably confident of its datum that Cairns is not serviced by any putrescible sites – discrepancy probably because postcode list provided to WMAA encompassed a site servicing other (small) population centre(s). No Hyder data available for inert sites.	Use Hyder data for putrescible sites and WMAA data for inert.
Darwin	1.5	0	7.5		adna	adna	The available WMAA data was not usable because one or more major sites did not respond to the WMAA survey.	Use Hyder data
Geelong	2.8	0.60			adna	adna	The available WMAA data was not usable because one or more major sites did not respond to the WMAA survey.	Use Hyder data
Gold Coast	7.0	0.23			dna	dna	WMAA was unable to provide data due to confidentiality concerns	Use Hyder data
Hobart	3.3	0	9.5		adna	adna	The available WMAA data was not usable because one or more major sites did not respond to the WMAA survey.	Use Hyder data

Population centre	Hyder data *(based on reports & gov't consultations)*				WMAA data of current approved capacity *(based on survey of landfill operators)*		Comparison and assessment of the data from both sources	Decision on data to be used
	Current approved capacity		Incl. additional expected capacity					
	Putresc	Inert	Putresc	Inert	Putresc	Inert		
Launceston	0.76	0	2.9		3.8	dna	WMAA putrescible data similar to Hyder 'current + potential' data. Assume this additional capacity is not fully approved. WMAA was unable to provide data on inert capacity due to confidentiality concerns.	Use Hyder data
Melbourne E & SE	13	11			adna	adna	The available WMAA data was not usable because one or more major sites did not respond to the WMAA survey.	Use Hyder data
Melbourne N & W	95	6.1						
Newcastle	1.4	0.16	12		3.1	0.04	WMAA putrescible data similar but Hyder inert data much higher. WMAA data is based on postcodes list - Hyder data considered to be more accurate.	Use Hyder data
Perth	24	11			adna	adna	The available WMAA data was not usable because one or more major sites did not respond to the WMAA survey.	Use Hyder data
Sydney	40	dna			11	4.7	21% of known sites did not respond to WMAA survey. Hyder is reasonably confident about the quality of its data on putrescible waste capacity for this population centre. No Hyder data available for inert sites.	Use Hyder data for putrescible sites and WMAA data for inert.
Toowomba	0.34	dna	1.1		0.47	dna	WMAA and Hyder putrescible data similar. WMAA data is based on postcodes list - Hyder data considered to be more accurate. WMAA was unable to provide data on inert capacity due to confidentiality concerns.	Use Hyder data
Townsville	5.6	0			0.18	dna	WMAA data (based on postcode list) much lower than Hyder data - Hyder data considered to be more accurate. WMAA was unable to provide data on inert capacity due to confidentiality concerns.	Use Hyder data
Wollongong	0.20	0.04	3.3	20	1.0	0.27	WMAA putrescible data considerably higher and inert data considerably lower. WMAA data apparently based on postcode list. 25% of known sites did not respond. Hyder data considered to be more accurate.	Use Hyder data

dna = data not available

adna = adequate data not available because some major landfills did not provide input to the WMAA landfill survey