Global Renewables

National Benefits of Implementation of UR-3R Process®

A Triple Bottom Line Assessment

July, 2004

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Document History and Status

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1-1	Draft Report	2 June 2004	Hannes Partl	Barry Nicholls, Hannes Partl, Leanne Philpott, Bruno Schacher
1-2	Final Draft	16 July 2004	Hannes Partl	Bruno Schacher
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Disclaimer

Environmental life cycle and financial data used to undertake this assessment has been derived from a number of sources, including local and international literature, consultant reports, proprietary software packages, environmental impact assessments, and information obtained directly from Global Renewables. With respect to assumed resource recovery, OGM generation and residue to landfill from the UR-3R Process®, Nolan-ITU has applied – and verified to the extent possible - data provided directly by Global Renewables. The degree to which these parameters reflect actual performance will only be able to be verified once UR-3R Facilities have been constructed and fully commissioned. The first Global Renewables processing facility, the Eastern Creek UR-3R Facility, is scheduled to be commissioned during the second half of 2004.

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EXECUTIVE SUMMARY

Introduction

GRL Investments Pty Limited ("Global Renewables") is owned by Australian companies GRD and Hastings Funds Management. Global Renewables' stated mission is:

> *"to provide innovative technological solutions to the growing problem of municipal solid waste in order to significantly reduce emissions, and to contribute to a sustainable environment for the benefit of all"*

Global Renewables is currently constructing the first Urban Resource - Reduction, Recovery and Recycling (UR-3R) Facility in Sydney, Australia, with a roll-out of facilities planned throughout Australasia soon after. The design philosophy of the UR-3R Process® is the recovery of materials to their highest net resource value i.e. to conserve embodied energy as much as possible and minimise / avoid emissions of all types (i.e. solid, liquid, gaseous).

Global Renewables has commissioned Nolan-ITU to prepare a Triple Bottom Line assessment report on the performance of its UR-3R Process®. In commissioning the project, Global Renewables requested it be conducted as an independent study. The study was commissioned to identify and communicate the economic, environmental and social benefits of the UR-3R Process® with both simplicity and rigour. The objectives of this study are:

- To assess, quantify and substantiate the overall environmental life cycle benefits of the UR-3R Process® in accordance with international standards; and
- To report the overall net welfare benefits of UR-3R Process® in a true Triple Bottom Line (TBL) sense, incorporating economic, environmental and social impacts.

UR-3R Facilities in Australia

For the purpose of this study Global Renewables' UR-3R Facilities have been assumed to be implemented in each major population centre around the country. A threshold population of 300 000 was applied to determine whether a population centre was assumed to be served by a UR-3R Facility(ies).

Identified population centres are: Sydney, Melbourne, Brisbane, Perth, Adelaide, Canberra, Newcastle, and Gold Coast. The total population that would be served by UR-3R Facilities is 13.1M, or 67% of the national population of 19.6M.

[Note: Global Renewables is developing UR-3R Facilities suitable for smaller population centres however, for the purpose of this study, a threshold population of 300 000 was adopted.]

Resource Recovery

The UR-3R Process® incorporates a range of process steps that result in the recovery of dry recyclable materials from incoming mixed waste, the production of Organic Growth Media (OGM) and the generation of electricity. The incoming mixed waste can comprise mixed putrescible wastes from domestic, Council (e.g. litter) and/or commercial and industrial sources.

When applied to the domestic garbage from each population centre and summed over all centres an estimated 353 000 tonne/yr of dry recyclable materials would be diverted from landfill and recovered for recycling by the UR-3R Process®. The estimated quantity of recyclables currently recovered through kerbside recycling from the population centres modelled is 847 000 tonne/yr (excluding contamination). The processing of mixed waste through UR-3R Facilities would therefore increase Australia's recovery of dry recyclable materials by an estimated 42% (i.e. from 847 000 tonne/yr to 1.20 Million tonne/yr).

Organic Growth Media (OGM) generated by the UR-3R Process® will be marketed for a range of landscaping and agricultural applications. OGM will be produced following ISKA® Percolation, enclosed composting, maturing and refining of the separated organics stream. When summed over all population centres, an estimated 670 000 tonnes/yr of OGM would be generated for beneficial reuse.

In addition, approximately 320 GWh of electricity (renewable energy) would be generated annually.

The UR-3R Process® achieves a landfill diversion rate of around 80%. When summed over all the population centres, an estimated 2.6 Million tonnes/yr of domestic waste would be diverted from landfill.

Waste Data

Each of the identified population centres differ in domestic waste generation as well as types of waste and recycling services offered. To account for these differences domestic waste generation data was collated for each centre using Nolan-ITU's inhouse national database of Council waste management systems as well as published literature and studies. For each centre a review of existing garbage and recycling services was made to determine the most common systems in operation, and the associated diversion rates. The identified most common waste management system was then assumed as the default system for each population centre with all collected garbage delivered to a disposal point (either landfill or Global Renewables' UR-3R Facility) and all kerbside recyclables delivered to a centralised Materials Recovery Facility.

The review found that for each population centre the most common kerbside recycling system is fortnightly collection using 240 L Mobile Garbage Bins (MGBs). Quantities collected from Councils employing this system were extracted from the database and aggregated to determine typical quantities if the system was applied across the whole population centre. The proportion of containers and paper in the kerbside recycling stream was also collated for each population centre, as well as total losses (contamination and sorting) for the most common system.

Resultant derived total domestic waste generation, garbage and kerbside recycling quantities (assuming 240 L MGB fortnightly collections) are shown in Figure I.

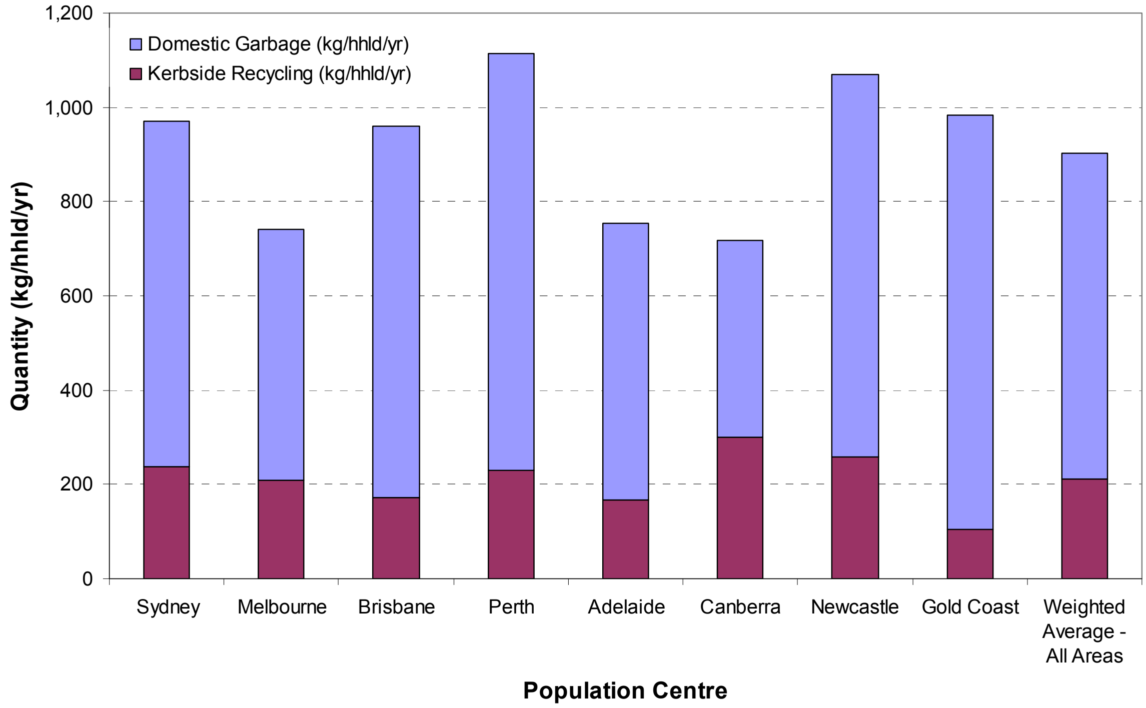


Figure I: Domestic Waste Generation for each Population Centre (kg/hhld/yr)

Financial Costs

For each population centre a representative landfill gate fee was determined based on typical gate fees at existing facilities and/or Council costs for disposal at existing facilities.

Landfill costs have risen considerably in recent years. In the Sydney Metropolitan Area for example, the costs to dispose one tonne of domestic waste to landfill was $18 in 1990. The equivalent 2003/2004 cost is $77 (exclusive of GST). Landfill costs are likely to continue to rise as air space becomes scarcer and disposal levies increase. The rate of rise is highly dependent on pressure from competing landuses as well as the availability of suitable disposal locations. These factors vary significantly between population centres.

The adopted gate fee for Global Renewables' UR-3R Facilities is $90/tonne (exclusive of GST). As will be the case for the Eastern Creek UR-3R Facility, the gate fee for processing at these facilities has been assumed to be exempt from landfill levies.

Future gate fees at Global Renewables' UR-3R Facilities will likely increase at a much lower rate than landfill disposal fees, as the UR-3R Facility gate fee is exempt from disposal levies and amenity and environmental impacts are significantly lower. In addition, the processing of domestic garbage at UR-3R Facilities is much less dependent on the availability of disposal air space, with around 20% (by mass) of the input material requiring disposal, with the residue (potentially) able to be disposed at non-putrescible as well as putrescible landfills.

System costs have been estimated using financial modelling software for the most common collection system (i.e. fortnightly kerbside recycling collection using 240 L MGBs and weekly garbage collection) with separate analyses conducted assuming garbage is delivered to landfill and to UR-3R Facilities. An additional assessment was conducted assuming monthly paper only kerbside recycling with garbage delivered to UR-3R Facilities. Figure II presents a summary of estimated system costs for each of the systems investigated and for each population centre.

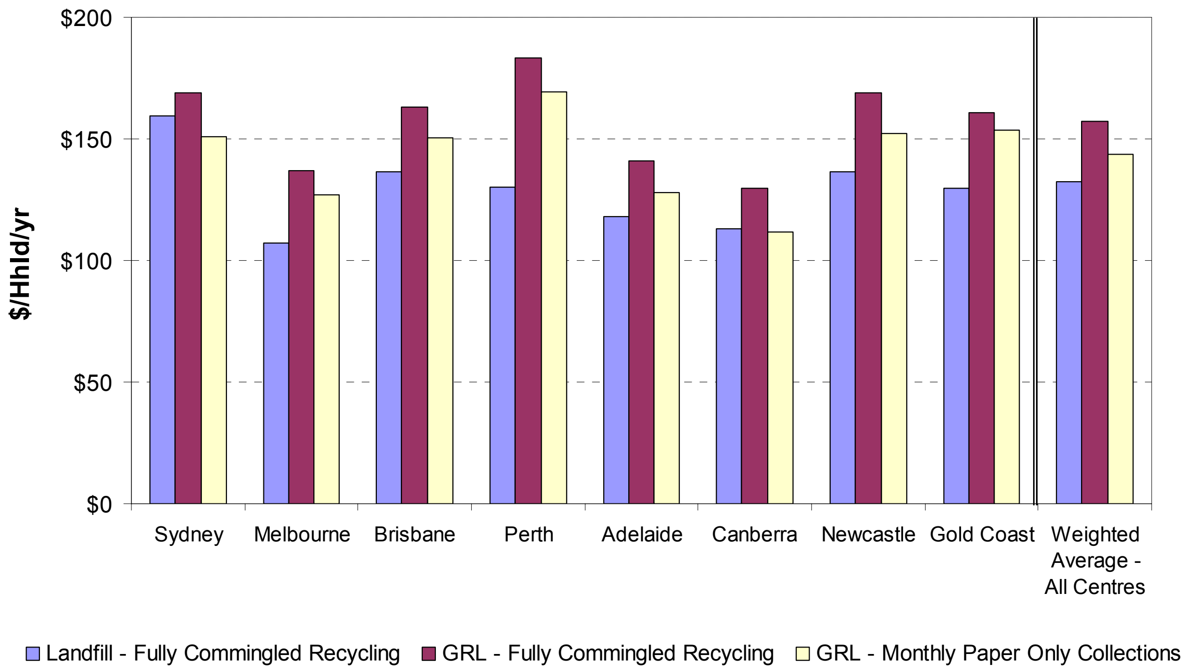


Figure II: Summary of Estimated Waste Management Costs

For the base case system (240 L MGB fortnightly fully commingled kerbside recyclables collection and weekly garbage collection), the replacement of landfill disposal of garbage with processing at a Global Renewables' UR-3R Facility increases domestic waste management costs by an estimated $24/hhld/yr, to $157/hhld/yr (weighted national average). For population centres where current landfill fees are high (e.g. Sydney), the increase is much lower ($9/hhld/yr), while in areas with low landfill gate fees the marginal financial cost is higher.

The introduction of the UR-3R Process® for processing garbage and recyclable containers, in combination with a reduction of the recyclables collection frequency from fortnightly to monthly together with reducing the mix of recyclables to paper/cardboard only (i.e. with residents placing all recyclable containers in the garbage bin), would increase the annual costs to households over the base case system by $11/hhld/yr, to $144/hhld/yr (weighted national average). The cost difference over the base case varies considerably across population centres, depending on a range of factors including current landfill costs, existing recyclables recovery, etc. For some population centres (i.e. Sydney and Canberra), the introduction of the UR-3R Process® for processing garbage and recyclable containers in combination with monthly paper only recycling is estimated to be cheaper than the base case.

The cost difference between the landfill disposal scenario (i.e. base case system) and the UR-3R Facility scenarios will reduce over time as landfill disposal costs are expected to increase more rapidly than UR-3R Facility gate fees.

Life Cycle and Environmental Assessment

The life cycle and environmental analysis component of this study has been conducted within the broader framework of an economic assessment. It aims to define and value the environmental externalities (or non-financial costs and benefits) associated with various management strategies for municipal solid waste.

The environmental analysis is based on Life Cycle Assessment (LCA) and Environmental Economic Valuation. This method quantifies material and energy inputs and outputs to the waste management system and then values these flows using established economic values. Pollutant loads within impact categories are assigned monetary values based on existing and published cost benefit studies by Australian regulatory agencies. The net environmental impact/benefit is then expressed in dollar terms, or "Eco$".

The four steps in the assessment approach are summarised in Figure III. The assessment involved the development of new LCA inventory data for Australian landfills and for the UR-3R Process®. In addition, an expanded methodology for Environmental Economic Valuation was developed and applied to the analysis. This is the first time in Australia that such a complete approach to waste systems assessment has been applied, and it highlights the importance of landfill avoidance and municipal waste pre-treatment.

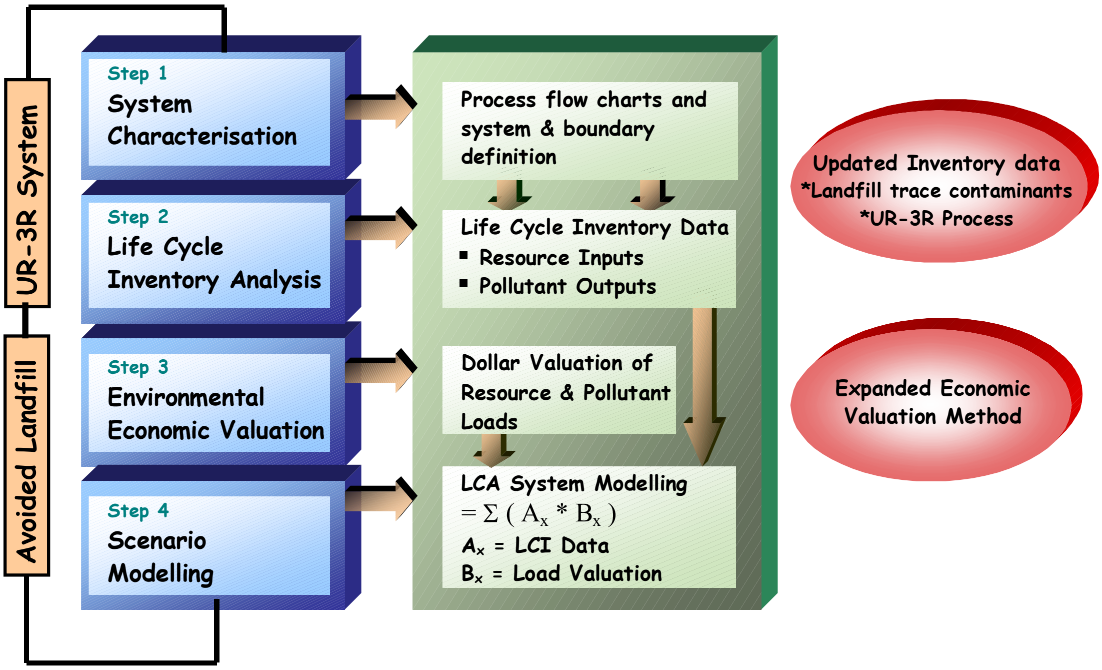


Figure III: Assessment Methodology

The systems assessed including the boundaries set is illustrated in Figure IV.

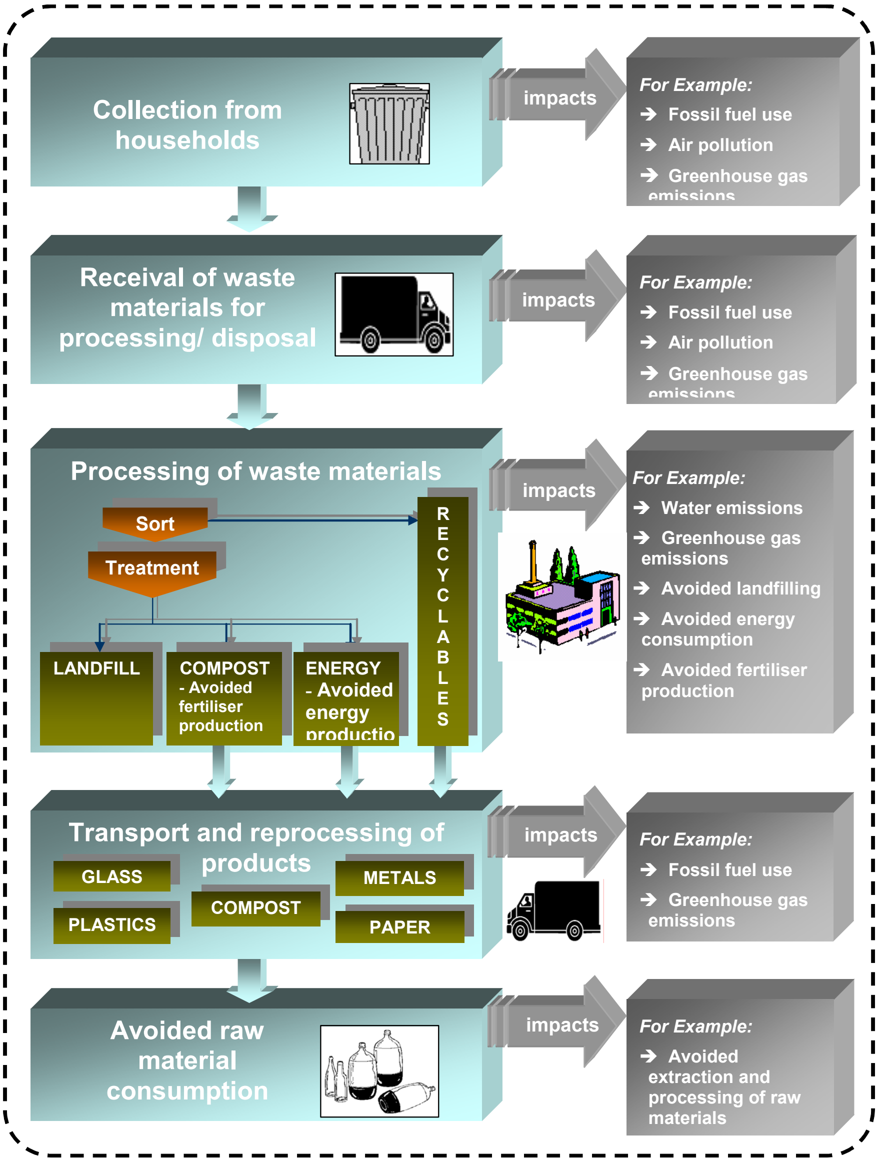
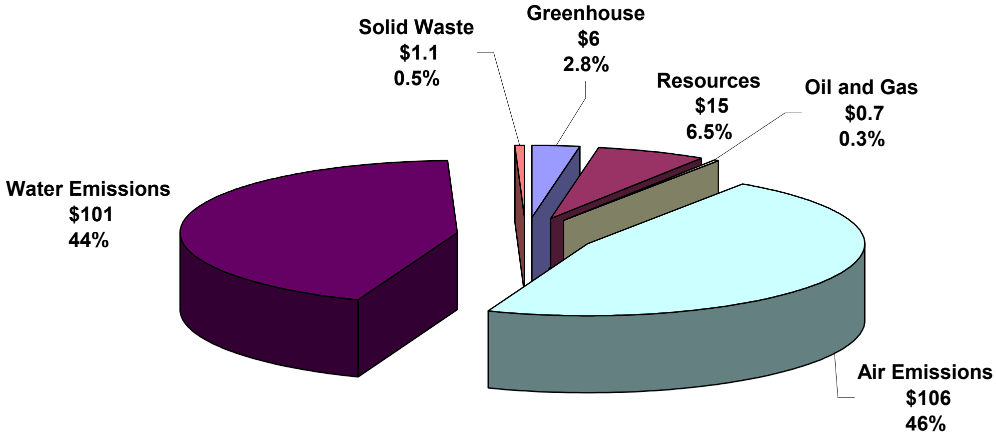


Figure IV: System Boundary

Based on the analysis, the net environmental benefit of the UR-3R Process® over landfill disposal, expressed as a weighted average across Australian population centres, amounts to Eco$159 per household per year, or $741M per year nationally.

The difference between the various population centres (refer Figure V) is a reflection of domestic waste generation as well as the recovery rates currently achieved through the kerbside recycling systems. For example, less domestic waste generation means less additional resources recovered, less avoided landfill etc. Figure VI depicts the environmental benefits for each impact category on a *per tonne of waste input* basis.

Figure V: Net Environmental Benefit by Population Centre
UR-3R Process® versus Landfill Disposal – Base Case (Eco$/hhld/yr)



Total Environmental Benefit = $230/tonne input

Figure VI: Impact Contribution per Tonne of Waste Input

The net benefit of the UR-3R Process® over landfilling is attributable not only to the avoided impacts from landfilling untreated garbage, but also from the credits associated with beneficial re-use from recovered resources, in particular recovery of Dry Recyclable Materials and OGM. The respective contribution by treatment and recovery process to the net environmental benefit is illustrated on a *per tonne* (of facility input) basis in Figure VII.

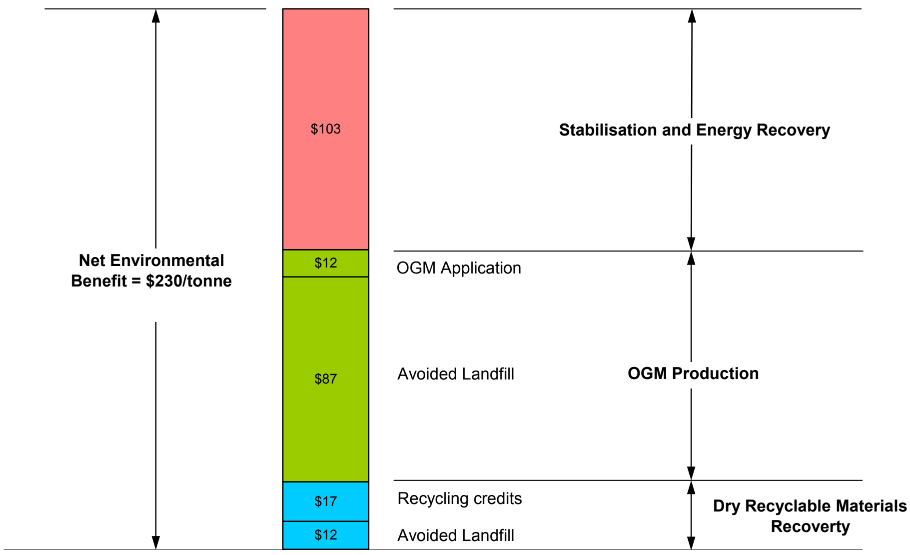


Figure VII: Net Environmental Benefit UR-3R Process® versus Landfill Disposal Contribution by Process, *per tonne of Input*

A range of sensitivity analyses was carried out which indicate the assessment results are not altered significantly by changing key parameters. The only exception is when a lower standard landfill than the Base Case landfill is assumed. This would increase the net environmental benefit of the UR-3R Process® by more than 30%.

Cost Benefit Analysis

Figure VIII shows the results of the cost benefit analysis when comparing the UR-3R Process® scenario with the landfill disposal scenario, assuming 240 L MGB fortnightly fully commingled kerbside recyclables collection and weekly garbage collection.

The financial costs (garbage and recycling collection, transport, disposal and/or recovery) have been expressed as the difference between the calculated system costs where garbage is processed at a UR-3R Facility(ies) and the scenario where garbage is disposed of to landfill. Environmental benefits of the system incorporating the UR-3R Process® over the system where garbage is disposed to landfill have been expressed in dollar terms.

When comparing the financial *costs* with the environmental *benefits*, the processing of garbage at a UR-3R Facility(ies) results in an estimated *net benefit* of $134/hhld/yr over directing garbage to landfill. When summed over the total number of households in the population centres modelled (i.e. 4.66 Million households), the estimated annual net benefit is $624M, not including macro economic benefits.

The processing of garbage at a UR-3R Facility(ies) together with monthly paper/cardboard only kerbside recycling results in an estimated net benefit of $146/hhld/yr over the system with landfill disposal of garbage and 240 L MGB fortnightly fully commingled kerbside recycling. When summed over the total number of households in the population centres modelled the estimated annual net benefit is $678M.

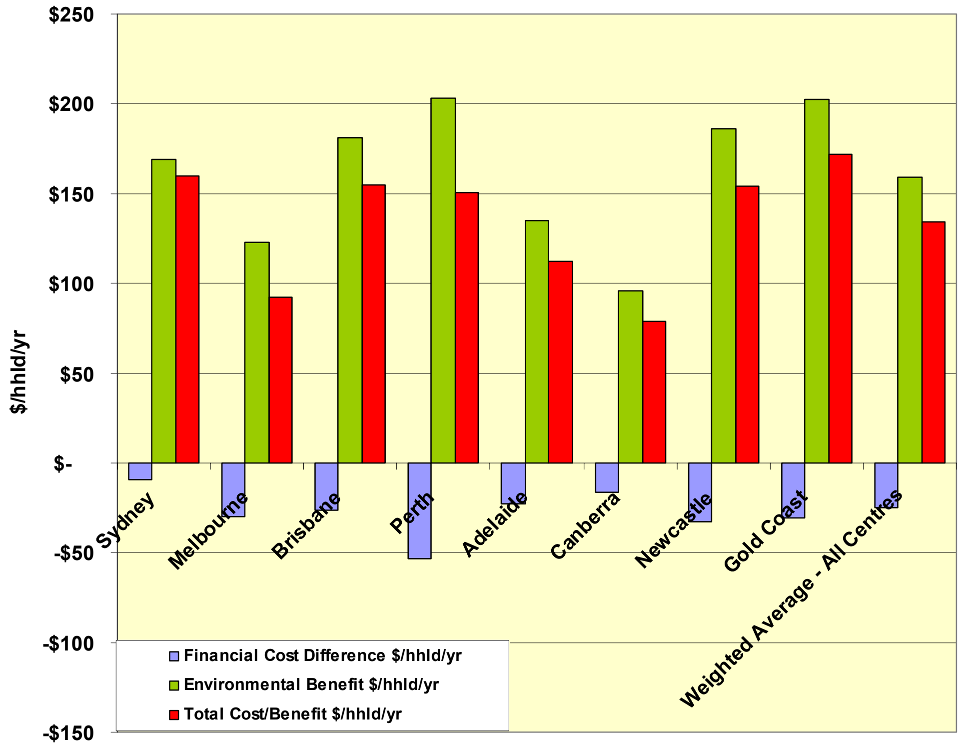


Figure VIII: Cost-Benefit Summary: UR-3R Process® versus Landfill Disposal (both with current kerbside recycling system)

Social Impact Assessment

As part of the TBL assessment, a strategic level Social Impact Assessment (SIA) has been undertaken to determine whether the inclusion of the social impacts, at a broad level, alters the thrust of the results of the cost-benefit analysis. As a starting point, the project team considered a standard set of social impact categories commonly used when conducting SIA as suggested by the widely recognised Guidelines and Principles for Social Impact Assessment developed by US Government agencies (1994)[1].

A workshop was held to identify and assess the social impacts. Information from the community consultation process for the Eastern Creek UR-3R Facility in Sydney was provided to the project team and the workshop included personnel from Blacktown City Council and the NSW EPA who have been involved in /aware of the Eastern Creek Project to date.

The key results of the SIA are:

- The analysis of social indicators provides a clear result – the UR-3R Process® is undoubtedly preferred to the landfill disposal in terms of social indicators;
- Whilst some additional education effort will be required initially to inform the community of the new technology, performance of the UR-3R Process® for all the other social indicators is positive (or equivalent) in comparison to landfill disposal.
- No weighting of the impacts is required as the result is unambiguous.

Macro-Economic Impacts

Wider macro-economic benefits are generated from projects of this nature, although some economists believe it is not appropriate to directly add these to dollar values in the cost-benefit analysis. Gross economic impacts of the project are summarised in Table I.

Table I: Gross Economic Impacts (per annum over 20 years)

Economic Impact	Direct	Indirect	Total
Gross Output ($ million)	250	275	525
Employment (Full Time Equivalents)	1,150	630	1,780
Note: Construction period jobs and capital expenditures have been converted to annual equivalents across the 20 year period			

[1] US Interorganizational Committee – *Guidelines and Principles for Social Impact Assessment* (May 1994)

With national implementation, the project is expected to create the equivalent of 1,780 jobs overall and annual expenditure of $525 million over 20 years.

The impacts from national implementation of the project on Gross Domestic Product (GDP) is shown in Table II.

Table II: Impact on Gross Domestic Product ($ Million/yr)

Economic Impact	Total
Gross Output	525
Net Output (adjusted for transfers)	390
Value Added (GDP)	140

A national GDP impact of $140 Million per year represents an increase in Australian GDP by 1/10 of 1%, attributable to this project. It represents around 50% of the direct expenditure associated with the project.

Conclusion

The net environmental benefit of the UR-3R Process®, when expressed as a weighted average across Australia's main population centres, amounts to Eco$159 per household per year, or $741M per year nationally. Table III summarises the quantifiable net benefits of a national implementation of the UR-3R Process®.

Table III: Summary of Quantifiable Benefits Through UR-3R Process® Implementation

Item	$ per household per year	$ per tonne of domestic garbage	$ nationally per year
Financial Cost (increase over landfill disposal)	$25 (11)	$36 (14)	$117M (51M)
Environmental Benefit	$159 (157)	$230 (201)	$741M (732M)
Net Benefit	$134 (146)	$194 (187)	$620M (680M)
Macro Economic Benefit	-	-	$140M 1)
1) plus 1,780 jobs Figures in parentheses indicate respective costs/benefits if existing kerbside recycling systems were replaced by monthly paper only recycling (with containers recycled through waste sorting at UR-3R Facilities)			

The following impacts have been examined in the TBL evaluation for the national implementation of the UR-3R Process®:

- Financial Impacts – estimated in $ values as part of the cost benefit analysis
- Environmental Impacts - estimated in $ values as part of the cost benefit analysis
- Social Impacts – examined in qualitative terms
- Macro-economic Impacts – estimated in terms of value added output and employment.

To provide an overall assessment of the project it is necessary to combine these different elements. The following key results are presented for the project option relative to the "without project" Base Case:

- The cost benefit analysis, encompassing dollar valuation of the financial costs and revenues as well as the environmental benefits, indicates a very significant net benefit to the community of $130-$150 per household per annum, depending on the waste collection scenario.
- When summed over the total number of households in the population centres modelled, the estimated annual net benefit for Australia is estimated at $620-$680 million per annum
- The analysis of social indicators provides a positive result – the UR-3R Process® is clearly preferred to the Base Case in terms of social indicators.
- Macro economic benefits are also significant on a national basis, with the UR-3R Process® potentially providing 1,780 full time equivalent jobs and contributing $140 million in value added to the national economy.

In summary national implementation of the UR-3R Process® provides the following benefits:

Financial / Environmental	↔	**Significantly Positive**
Social	↔	**Significantly Positive**
Macro-economic	↔	**Positive**

1 INTRODUCTION

GRL Investments Pty Limited ("Global Renewables") is owned by Australian companies GRD and Hastings Funds Management. Global Renewables' mission is to provide innovative technological solutions to the growing problem of municipal solid waste in order to significantly reduce emissions, and to contribute to a sustainable environment for the benefit of all.

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- To assess, quantify and substantiate the overall environmental life cycle benefits of the UR-3R Process® in accordance with international standards; and
- To report the overall net welfare benefits of the UR-3R Process® in a true TBL sense, incorporating economic, environmental and social impacts.

The main tasks of this assessment were:

- To undertake a full Life Cycle Assessment (LCA) of the UR-3R Process® based on the mass balance of the Optimised Flow Sheet currently being used to establish the UR-3R Facility at Eastern Creek, in accordance with the ISO 14000 series;
- To convert all environmental benefits (and impacts) into "eco-dollars" in accordance with Nolan-ITU's environmental economic model originally developed for the *Independent Assessment of Kerbside Recycling in Australia*, conducted for the National Packaging Covenant (NPC) Council, and further developed in the recent study *Assessment of Alternative Domestic Waste and Recycling Systems* for the NSW Jurisdictional Recycling Group under the NPC, and Publishers National Environment Bureau;
- To estimate, verify and report on the financial costs of the UR-3R Process®;
- To combine the financial and environmental costs and benefits and report on the outcomes in a manner consistent, compatible and comparable with the NPC;
- To develop and assess indicators for social performance, and to incorporate these into the assessment; and
- To prepare a TBL assessment report stating the combined net economic welfare benefits of implementing Global Renewables' UR-3R Process® in Australia.

2 ASSUMED EXTENT OF UR-3R FACILITIES

2.1 Population Centres Serviced by UR-3R Facilities

For the purpose of this study Global Renewables' UR-3R Facilities have been assumed to be implemented in each major population centre around the country. A threshold population of 300 000 was applied to determine whether a population centre was assumed to be served by a UR-3R Facility(ies).

[Note: Global Renewables is developing UR-3R Facilities suitable for smaller population centres however, for the purpose of this study, a threshold population of 300 000 was adopted.]

Identified population centres are: Sydney, Melbourne, Brisbane, Perth, Adelaide, Canberra, Newcastle, and Gold Coast. Population and dwelling numbers for each centre as sourced from Australian Bureau of Statistics data are shown in Table 2.2. Based on the analysis, the total population served by UR-3R Facilities would be 13.1M, or 67% of the national population of 19.6M.

Table 2.1 lists the number of UR-3R Facilities assumed across the country. The average UR-3R Facility size was assumed to be 200,000 t/yr of waste input, with a base capacity of 175,000 t/yr and a maximum capacity of 266,000 t/yr. The total quantity of waste processed at the 16 facilities would be 3.22 Million t/yr.

Table 2.1: Number of UR-3R Facilities by State

State	No of UR-3R Facilities
Victoria	3
New South Wales	6
ACT	1
Queensland	3
South Australia	1
Western Australia	2
Total	16

The number of UR-3R Facilities has been estimated assuming receival and processing of Council-collected domestic wastes only (i.e. garbage). It is noted however that the UR-3R Process® is suitable for processing other wastes, such as putrescible commercial and industrial wastes and some Other Council wastes (e.g. litter).

2.2 Waste Generation

2.2.1 Systems Analysis and Quantities Generated

Each of the identified population centres differ in domestic waste generation as well as types of waste and recycling services offered. To account for these differences domestic waste generation data was collated for each centre using Nolan-ITU's in-house national database of Council waste management systems as well as published literature and studies. For each centre a review of existing garbage and recycling services was made to determine the most common systems in operation, and the associated diversion rates. The identified most common waste management system was then assumed as the default system for each population centre with all collected garbage delivered to a disposal point (either landfill or UR-3R Facility) and all kerbside recyclables delivered to a centralised Materials Recovery Facility (MRF).

The review found that for each population centre the most common kerbside recycling system is fortnightly collection using 240 L Mobile Garbage Bins (MGBs). Quantities collected from Councils employing this system were extracted from the database and aggregated to determine typical quantities if the system was applied across the whole population centre. The proportion of containers and paper in the kerbside recycling stream was also collated for each population centre, as well as total losses (contamination and sorting) for the most common system.

Resultant derived total domestic waste generation, garbage and kerbside recycling quantities (assuming 240 L MGB fortnightly collections) are shown in Table 2.3 and Figure 2.1.

Table 2.2: Population and Dwelling Numbers for Identified Population Centres

Item		Population Centre									Australia Total
		Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Total*	
Population [1]		4,167,002	3,513,051	1,643,423	1,411,618	1,113,765	321,134	496,990	439,374	*13,106,357*	19,640,979
Dwellings [2]	Separate Houses	907,195	919,704	481,333	396,368	323,102	87,617	149,862	100,208	*3,365,389*	5,327,309
	Semi detached, row or terrace houses and townhouses	162,320	127,810	39,686	66,427	57,076	14,947	13,597	27,436	*509,299*	632,176
	Flats, units or apartments	343,518	177,579	69,886	42,670	45,397	11,016	13,187	37,833	*741,086*	923,139
	Other dwellings	11,896	9,099	6,542	3,029	2,167	379	3,247	3,140	*39,499*	134,274
	Total Dwellings	1,424,929	1,234,192	597,447	508,494	427,742	113,959	179,893	168,617	*4,655,273*	7,016,898
Persons per household		2.9	2.8	2.8	2.8	2.6	2.8	2.8	2.6	*2.8*	2.8

1) Population data for 30 June 2002 sourced from ABS catalogue 1379.0.55.001
2) Dwelling information from 2001 census sourced from ABS cat. no. 2001.0

Table 2.3: Total Domestic Waste Generation, Garbage and Kerbside Recycling for Identified Population Centres

Item	Population Centre								
	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average*
Total Domestic Waste (kg/hhld/yr)	970	742	959	1,115	754	717	1,068	983	*902*
Domestic Garbage (kg/hhld/yr)	733	534	788	885	588	417	811	880	*691*
Kerbside Recycling (kg/hhld/yr)	237	208	171	230	166	300	257	103	*211*
% Containers	34%	40%	44%	34%	28%	29%	39%	58%	*37%*
% Paper	48%	49%	49%	47%	58%	58%	56%	35%	*49%*
% Total losses (contamination & sorting)	17%	12%	7%	19%	14%	13%	5%	7%	*14%*
Total Tonnages (both containers and paper recovered through kerbside recycling)									
Domestic Garbage	1,045,000	659,000	471,000	450,000	252,000	47,000	146,000	148,000	*3,218,000*
Kerbside Recycling (240 L MGB fortnightly collections, commingled containers and paper)	338,000	257,000	102,000	117,000	71,000	34,000	46,000	17,000	*982,000*
Total Tonnages (containers included in garbage stream – paper separately recovered)									
Domestic Garbage	1,182,000	773,000	519,000	498,000	275,000	59,000	165,000	159,000	*3,630,000*
Kerbside Recycling (240 L MGB monthly collections, paper only)	194,000	141,000	54,000	66,000	47,000	23,000	27,000	7,000	*559,000*

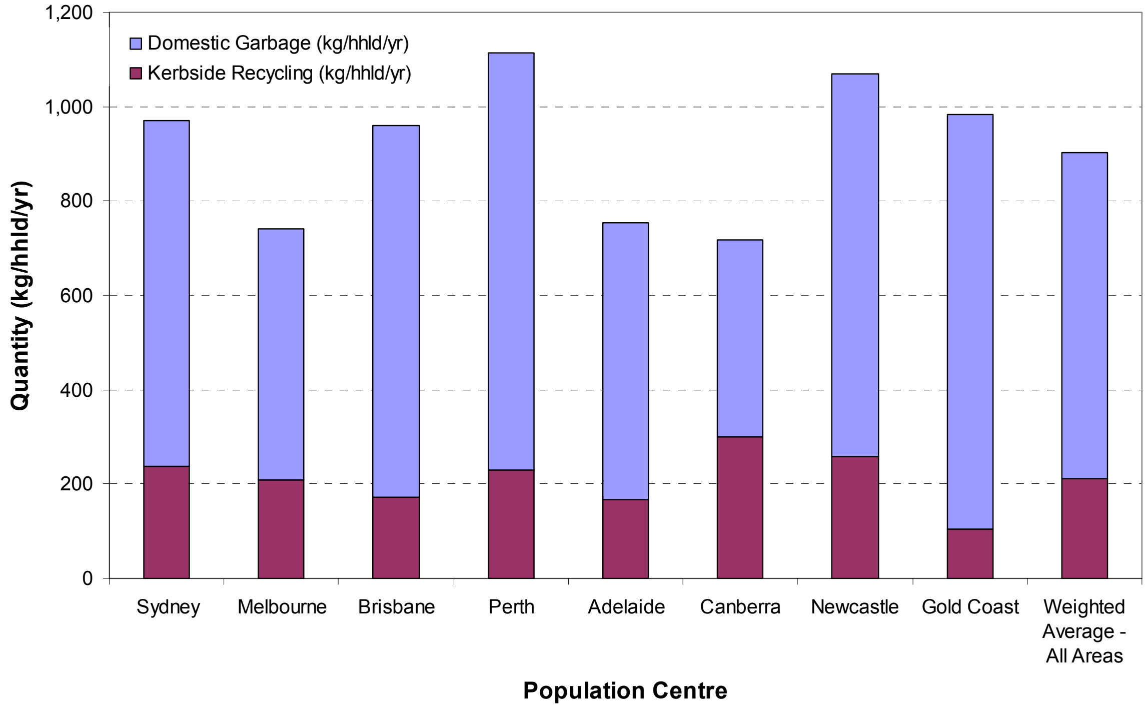

Figure 2.1: Domestic Waste Generation for each Population Centre (kg/hhld/yr)

2.2.2 Composition

a) Domestic Garbage

The derived composition of collected domestic garbage was based on collation of numerous bin-based audits conducted over the last 2 – 3 years for Councils with the same or similar collection arrangements to the adopted system for this study, as well as published reports and studies (Nolan-ITU; 2004; GRD Minproc; 2002). While some variations in garbage composition would occur from state to state, this variation would not significantly alter the outcomes in the context of the whole study. Each population centre was therefore assigned the same domestic garbage composition. The adopted composition is shown in Figure 2.2.

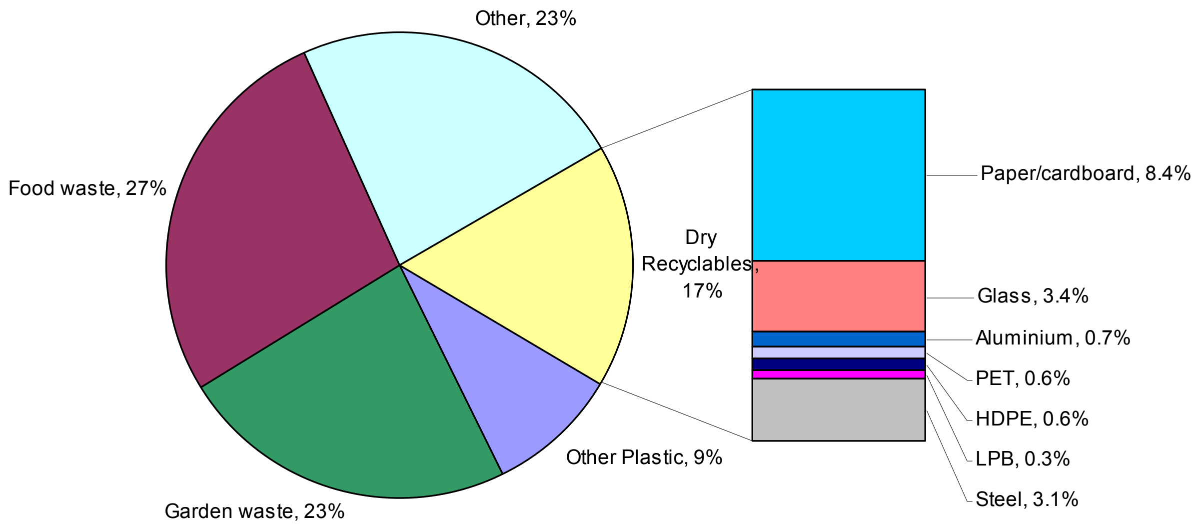

Figure 2.2: Adopted Garbage Composition

b) Kerbside Recyclables

For the most common kerbside recycling system (fortnightly MGB collection) the proportion of paper, containers and contamination was found to vary across population centres. Results are summarised in Figure 2.3. These variations in composition were then used as input to both the financial and environmental modelling.

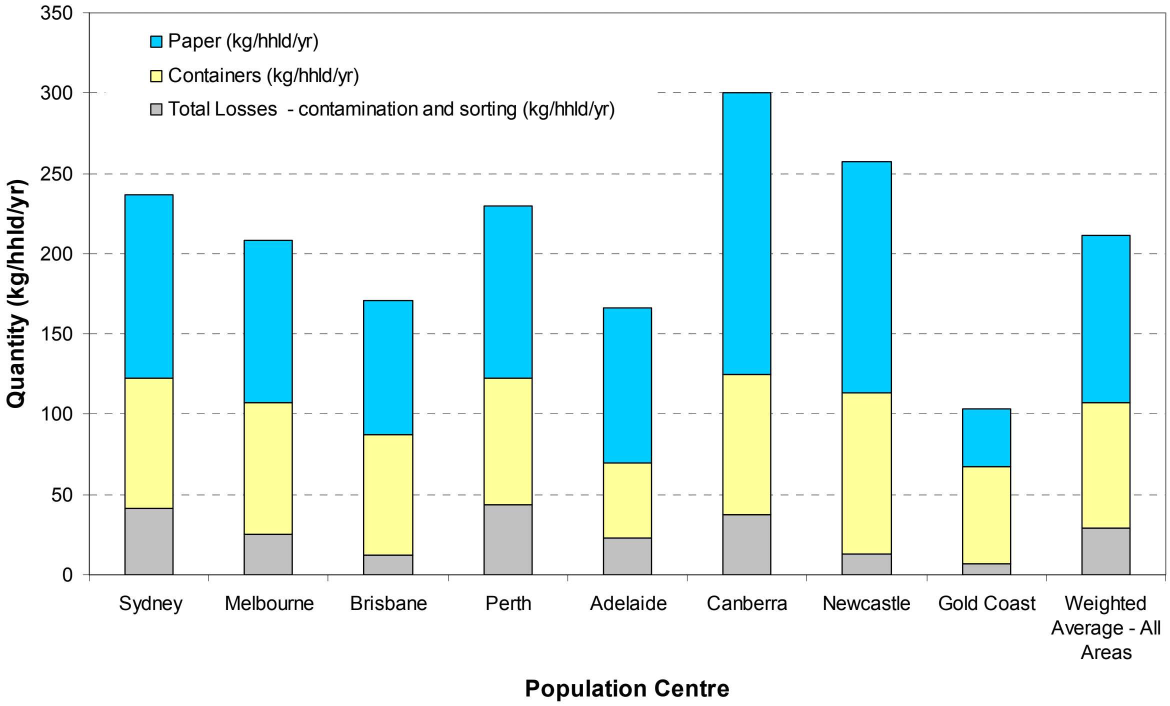

Figure 2.3: Domestic Kerbside Recyclables for each Population Centre (kg/hhld/yr)

3 RESOURCE RECOVERY BY UR-3R PROCESS®

The UR-3R Process® incorporates a range of process steps that result in both the recovery of dry recyclable materials from incoming mixed waste as well as the production of Organic Growth Media (OGM) and renewable energy. In this section, the quantities of resources recovered from incoming wastes by the UR-3R Process® are estimated at a national level.

a) Dry Recyclable Materials Recovery

Dry recyclable materials are those materials normally recovered through kerbside recycling collection programs. The most common materials recovered are: newsprint, mixed paper and cardboard, liquid paperboard, glass bottles, aluminium, PET, HDPE and steel.

Within the waste stream separation unit process incorporated in the UR-3R Process® dry recyclable materials are recovered from incoming mixed wastes using a combination of automatic equipment and manual sorting. The recovery rates that are assumed to be achieved through the UR-3R Process®, as advised by Global Renewables, are listed in Table 3.1. When applied to the garbage streams generated in each population centre assumed to be served by UR-3R Facilities and summed over all centres an estimated 353 000 tonne/yr of dry recyclable materials would be diverted from landfill and recovered for recycling.

Table 3.1: Dry Recyclables Recovery - UR-3R Process®

Material	Recovery Rate of Dry Recyclable Materials through UR-3R Process® (%)	Quantity Present in Mixed Waste (tonne/yr)	Additional Material Recovery (tonne/yr)
Paper & Cardboard	60%	269,000	161,400
Glass	60%	104,000	62,400
Plastics (PET & HDPE)	80%	28,000	22,400
Metals (Aluminium and Steel)	88%	121,000	106,600
Other	0%	2,696,000	0
Total		3,218,000	352,800

By comparison, if the kerbside recycling system of 240 L MGB fortnightly fully commingled collections was in place in each population centre, the estimated quantity of recyclables that would be recovered is 847 000 tonne/yr (excluding contamination). The processing of mixed waste through UR-3R Facilities would therefore increase the recovery of dry recyclable materials by an estimated 42% (i.e. from 847 000 tonne/yr to 1.20 Million tonne/yr).

b) Production of Organic Growth Media

OGM generated by the UR-3R Process® will be marketed for a range of landscaping and agricultural applications. The OGM will be produced following ISKA® Percolation, enclosed composting, maturing and refining of the separated organics stream.

The quantity of OGM to be produced and marketed represents 21% of the incoming mixed wastes. When summed over all population centres, an estimated 670 000 tonnes/yr of OGM would be generated for beneficial reuse.

c) Production of Renewable Energy

The UR-3R Process® is designed to generate 100kWh of electricity per tonne of input (however, the technology also requires energy for its operation). Projected over the population centres served by the UR-3R Process®, an estimated 320 GWh of electricity would be generated annually.

d) Reduction in Waste to Landfill

Residuals from the processing of mixed domestic waste through the UR-3R Process® comprise rejects from waste separation, screening and refining processes. These include plastic films, wood, textiles, and inert materials. Approximately 20% of incoming mixed domestic waste is generated as residual material requiring landfilling. The UR-3R Process® therefore achieves a diversion rate of around 80%. When summed over all the population centres, an estimated 2.6 Million tonnes/yr of domestic waste would be diverted.

[Note: Outputs from the Eastern Creek UR-3R Facility include an additional output known as Alternative Daily Cover (ADC) which will be used as cover material at the adjacent landfill. The ADC and process residuals for this facility together amount to 28% of the input material. It is understood that Global Renewables will be implementing additional systems to eliminate ADC production at future UR-3R Facilities and increase resource recovery, with total residuals to landfill reducing to around 20% of input.]

4 FINANCIAL ASSESSMENT

4.1 Modelling Approach

4.1.1 Introduction

The estimation of the costs for collection, sorting and material delivery for the different systems was made using the *Australian Waste and Recycling Cost Model* developed by the Cooperative Research Centre for Waste Management and Pollution Control in association with EcoRecycle Victoria and Recycle 2000 to allow organisations to evaluate existing and alternative collection systems to see the effect they have on yields and costs. Amongst other information, the model calculates and reports on the following:

Total garbage collected: The amount of garbage collected represents the mass of material ending up in landfill or some other processing option. It includes contaminated materials produced from recycling sorting processes. The amount of material disposed is therefore a function both of the assumed rate of contamination and the rate of recycling.

Total recyclables recovered and reprocessed: The amount of recyclables collected and / or sorted is, by definition, all materials not going to landfill or some other disposal option. It is important to consider this not the same as the amount of material collected, but the amount of material which is separated through the collection and sorting process and is recovered for some kind of re-use.

Cost of garbage collection and disposal: These values represent the cost of collecting and landfilling/disposing of garbage. System costs includes the value of trucks, fuel, provided bins, landfilling, haulage and other associated expenditure.

Cost of recycling: This represents the cost of collecting, sorting and/or treating recycled materials. It does not include the transportation of materials beyond a MRF, although it can include the delivery of sorted materials to a beneficiation plant or some other buyer. As a rule, post-MRF transport costs are reflected in the price per tonne offered for the recovered materials. The calculated cost of recycling also includes the cost of sorting and disposing of contaminants, which should be considered as part of the recycling process.

Total cost of garbage and recycling services: This value is the aggregation of the recycling and garbage disposal costs.

4.1.2 Key Operational Parameters

To estimate costs, a range of key operational parameters was sourced to provide the input to the model. Parameters have been based on collated industry data. They include:

- Crew size and labour costs;

- Truck capacities;
- Truck pick-up times;
- Collection area characteristics;
- Landfill disposal cost and gate fees for alternative waste treatment facilities;
- MRF sorting costs;
- Set out rates.

These are discussed in the following sections.

a) Crew Size and Labour Costs

Crew sizes for systems collecting materials from MGBs are generally either driver only or driver plus one runner. For modelling purposes both garbage and kerbside recyclables collections were assumed to be provided using a driver only arrangement, with garbage collected in separate vehicles to kerbside recyclables.

Labour costs for drivers, including wages and other on costs, i.e. WorkCover, insurances, superannuation, etc have been varied across population centres as shown in Table 4.1.

Table 4.1: Labour Costs for Drivers
($/hr, including OHS, WorkCover, insurances, etc)

Population Centre	Labour Costs for Driver Only Collections ($/hr)
Sydney	$26
Melbourne	$24
Brisbane	$23
Perth	$26
Adelaide	$23
Canberra	$26
Newcastle	$26
Gold Coast	$23

b) Truck Capacities

Both domestic garbage and recyclables collections have been assumed to be carried out using single compartment compaction trucks with nominal 18 m^3 bodies.

c) Truck Collection Times

The truck collection time input to the model represents the time taken per bin lift including transport between adjacent properties. The collection time is based on metropolitan households where the distance between households is not a significant influencing factor. The adopted times are shown in Table 4.2.

Table 4.2: Truck Collection Run Times (seconds per lift)

Truck Type	Crew Size	Collection Run Times (seconds per lift)	Collections per day (assuming 6 hrs collecting)
Single compaction truck	1	27	800

For movement of collection vehicles while not collecting (i.e. between depots and collection areas, haulage to delivery points) an average truck speed of 30 km/hr has been assumed.

d) Collection Area Characteristics

Assumed collection area characteristics in relation to traffic, housing density, and street width are presented in Table 4.3.

Table 4.3: Collection Area Characteristics

Traffic	Housing Density	Street Width
Moderate – significant interference during collection	Standard suburb	Slight impediment due to hilly or narrow streets

e) Landfill disposal cost and gate fees for UR-3R Facilities

For each population centres a representative landfill gate fee was determined based on typical gate fees at existing facilities and/or Council costs for disposal at existing facilities, with GST removed (Table 4.4).

Table 4.4: Landfill Disposal Cost
($/tonne, includes landfill levies where applicable but excludes GST)

Population Centre	2003/2004 Landfill Levy[1] ($/tonne)	Landfill Disposal Cost Including Levy ($/tonne)
Sydney	$19.80	$77
Melbourne	$5.00	$34
Brisbane	$0.00	$56
Perth	$3.00	$30
Adelaide	$10.09	$51
Canberra	$0.00	$50
Newcastle	$11.40	$50
Gold Coast	$0.00	$55

[1] The amount of levy varies by state – many states (e.g. NSW, Vic WA) are in the process of increasing or considering increasing the levy (refer Table 4.5).

Landfill costs have risen considerably in recent years. In the Sydney Metropolitan Area for example, the costs to dispose one tonne of domestic waste to landfill was $18 in 1990. The equivalent 2003/2004 cost is $77 (exclusive of GST). The increase has arisen partly due to the impact of the government landfill levies and the increasing financial allocation for rehabilitation and ongoing post-closure environmental management of landfill sites. The change in putrescible waste disposal costs in the period 1990 to the present is shown in Figure 4.1. Also shown is the corresponding increase in CPI using the 1990 disposal charges as a starting point.

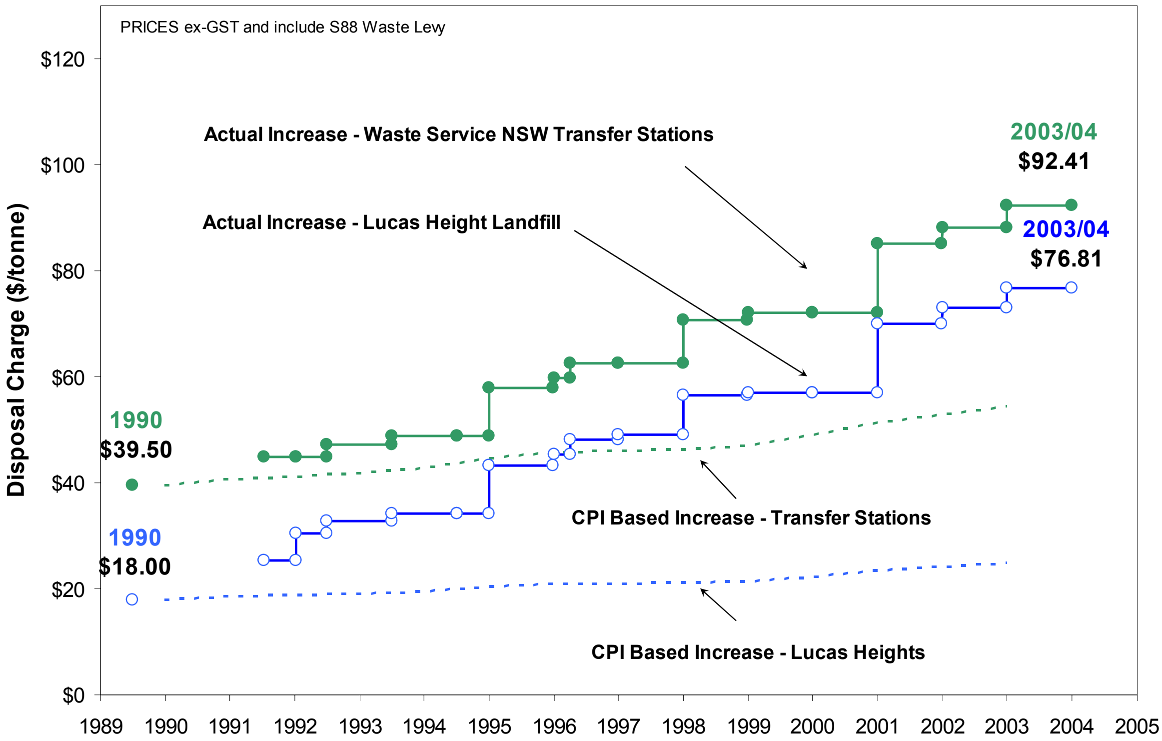

Figure 4.1: Historical Landfill Disposal Charges – Metropolitan Sydney

Landfill costs are likely to continue to rise as air space becomes scarcer, disposal levies increase and landfill environmental regulations become stricter. The rate of rise is highly dependent on pressure from competing land uses as well as the availability of suitable disposal locations. These factors vary significantly between population centres. In relation to disposal levies, these are determined and administered by state and territory environmental agencies, with some yet to introduce a levy (i.e. Queensland and ACT). The current level of the levy for each population centre is shown in Table 4.4. Identified future increases in landfill levies are shown in Table 4.5.

Table 4.5: Future Landfill Levies

Population Centre	2003/2004 Landfill Levy ($/tonne)	Future Landfill Levy	
		Amount ($/tonne)	Date applicable
Sydney	$19.80	$25	July 2009
Melbourne	$5.00	$9	July 2007
Perth	$3.00	$6	Under consideration
Newcastle	$11.40	$25	July 2012

(1) Levies are typically raised annually in equal increments. Actual amount of future levy may be higher than indicated as some states include CPI adjustment

The adopted gate fee for Global Renewables' UR-3R Facilities is $90/tonne (exclusive of GST). As is the case for the Eastern Creek UR-3R Facility, the gate fee for processing at these facilities has been assumed to be exempt from landfill levies.

Gate fees for UR-3R Facilities will likely increase at a much lower rate than landfill disposal fees, as the UR-3R Facility gate fee is exempt from disposal levies and amenity and environmental impacts are significantly lower. In addition, the processing of domestic garbage at UR-3R Facilities is much less dependent on the availability of disposal air space, with typically only 20% or less (by mass) of the input material requiring disposal, with the residue (potentially) able to be disposed at non-putrescible as well as putrescible landfills.

For population centres in excess of 500,000 people (Sydney, Melbourne, Brisbane, Adelaide and Perth) it has been assumed that a network of transfer stations is in place for inner suburban Councils to deliver collected domestic garbage. Gate fees at transfer stations were assumed to be $17/tonne higher than the applicable disposal fee. For these centres half of the collection catchment was assumed to be served by transfer stations with garbage from the remaining assumed to be direct-hauled to the disposal point.

f) Material Recovery Facility (MRF) Sorting Costs

MRF sorting costs depend on the scale of the facility, and are material specific. In general, based on collated industry data, MRF sorting costs range from $80 - $140/tonne depending on MRF size and configuration. To derive a MRF gate fee, material commodity prices are subtracted from sorting costs.

Gate fees applicable at MRFs depend also on costs for disposal of residuals (i.e. transport, acceptance and, in some instances, burial to prevent litter) which vary from state to state. As part of this study, discussions were held with a number of recycling industry and Council representatives to identify typical charges applied at MRFs for receival and processing of fully commingled streams and associated influencing factors. Based on these MRF gate fees have been estimated for each population centre and applied to the financial modelling (Table 4.6)

Table 4.6: MRF Gate Fees for Acceptance of Commingled Recyclables

Population Centre	MRF Gate Fee (Commingled Recyclables, $/tonne)
Sydney	$45
Melbourne	$30
Brisbane	$35
Perth	$30
Adelaide	$35
Canberra	$35
Newcastle	$35
Gold Coast	$35

Penalties for contamination are sometimes applied at MRF's to cover increased costs for disposal and reduced revenue from sale of materials. For this study cost penalties in the form of increased MRF gate fees were applied for population centres with high contamination rates (Table 4.7). Also shown are adopted gate fees for receival of source separated paper and cardboard streams. The cost penalties as well as paper and cardboard acceptance fees shown are the same as those derived in the recently completed study of alternative domestic waste and recycling systems (Nolan-ITU; 2004), which included consultative sessions with Councils and industry and agreement from the project steering committee on the rates shown.

Table 4.7: MRF Fees and Penalties vs Contamination Levels

<table>
<tr><th>Contamination % of Recyclables Stream (weight basis)</th><th>MRF Gate Fee Cost Penalty, Fully Commingled Recycling Stream</th><th>MRF Gate Fee, Source Separated Paper and Cardboard Stream</th></tr>
<tr><td>0% - 8%</td><td rowspan="2">$0/t</td><td>-$30/t</td></tr>
<tr><td>8% to 15%</td><td>$-15/t</td></tr>
<tr><td>15% to 25%</td><td>$10/t</td><td>$-5/t</td></tr>
<tr><td>> 25%</td><td>$20/t</td><td>$5/t</td></tr>
</table>

g) Set-Out Rates

Bin set out rates (% of collections that bins are set out) have been sourced from those reported in surveys based on industry evidence, and in-house data sources. In general, the greater the collection frequency, the lower the set out rate. For garbage collections, a bin set out rate of 95 % was assumed for all cases. For the kerbside recyclables collections a bin set out rate of 80% was assumed.

4.2 Results

The following sections show the results of the financial modelling for each of the systems modelled and each population centre. The average proportions of garbage and recyclables streams (including contamination) are also shown.

The results represent *average costs* for each population centre. The averages mask a wide variation in estimated system costs: within each system category, across different areas; and at the operational level, where local influences are important. The average data have been used to draw broad conclusions, but at the local level cost variations from these averages may be significant. Detailed results by population centre can be found in Appendix A.

System costs are presented on a $/hhld per year basis separately for the garbage component and kerbside recyclables component, then as a total.

4.2.1 Fully Commingled Recycling, Landfill Disposal of Garbage

Average estimated domestic waste (garbage and kerbside recycling) costs, assuming 240 L MGB fortnightly commingled recyclables collection and weekly garbage collection with disposal to landfill, vary from a minimum of $107/hhld/yr (Melbourne) to a maximum of $160/hhld/yr (Sydney). The main reasons for the cost differences are variations in:

- Landfill disposal fees;
- Waste generation; and
- MRF processing fees (which are linked to disposal fees and contamination levels).

Across Australia, the weighted average annual cost of this system is estimated at $133 per household. Estimated costs for this system are presented for each population centre in Table 4.8 and Figure 4.2.

For the assumed kerbside recycling system the estimated total quantity of recyclables recovered for the population centres modelled is 847 000 tonne/yr (excluding contamination).

Table 4.8: Estimated Waste Management Costs ($/hhld/yr)
Fortnightly Fully Commingled Recycling, Garbage to Landfill

System Component	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Garbage Collection/Transport	$52	$48	$51	$56	$49	$48	$53	$52	*$51*
Garbage Disposal/Processing	$63	$22	$51	$34	$35	$21	$41	$48	*$42*
Recyclables Collection/Transport	$32	$31	$29	$32	$28	$34	$34	$26	*$31*
Recyclables Processing	$13	$6	$6	$9	$6	$11	$9	$4	*$9*
Total System Cost	$160	$107	$137	$130	$118	$113	$136	$130	*$133*

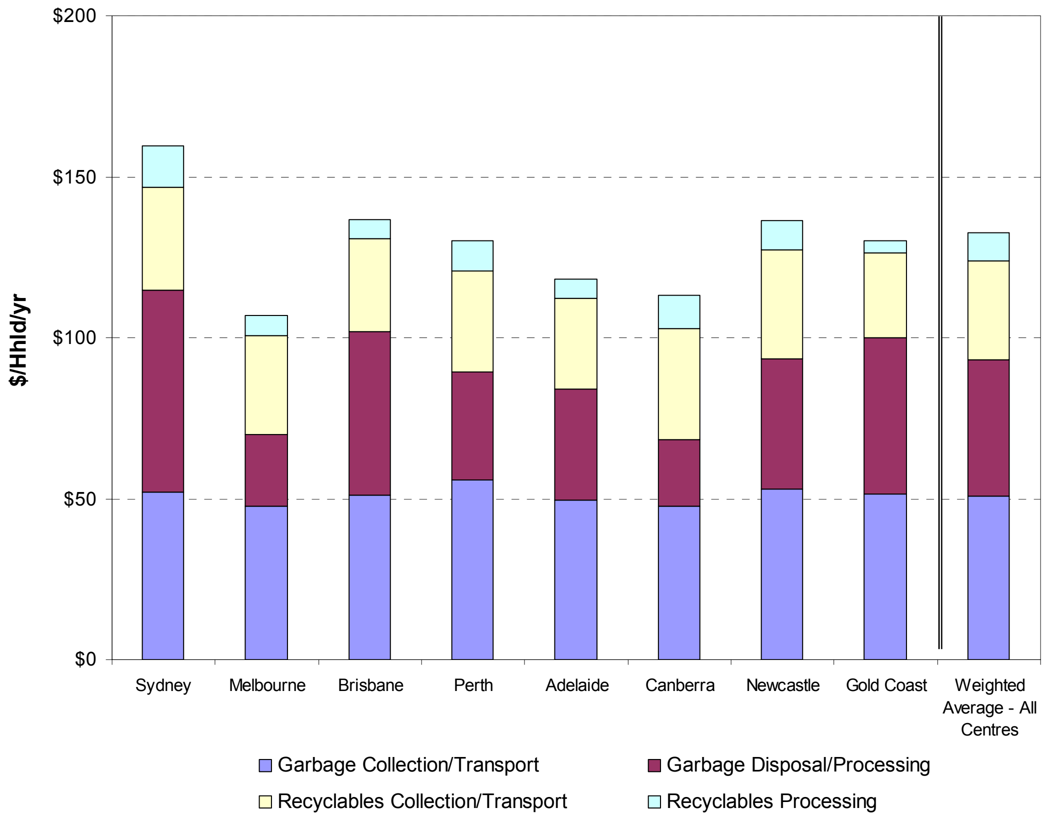

Figure 4.2: Estimated Waste Management Costs
Fortnightly Fully Commingled Recycling, Garbage to Landfill

4.2.2 Fully Commingled Recycling, Processing of Garbage at UR-3R Facilities

Average estimated domestic waste (garbage and kerbside recycling) costs, assuming 240 L MGB fortnightly commingled recyclables collection and weekly garbage collection with delivery to a UR-3R Facility, vary from a minimum of $130/hhld/yr (Canberra) to $183/hhld/yr (Perth).

When averaged across all population centres, the average cost of this system is estimated at $157/hhld/yr, or $24/hhld/yr higher than the landfill disposal scenario.

For this scenario, the only difference to the previous scenario from a financial perspective is the gate fee for garbage processing/disposal. Costs for garbage collection, recyclables collection and recyclables processing remain unchanged. Estimated costs for each population centre are shown in Table 4.9 and Figure 4.3.

For this system, the UR-3R Process® would recover an additional 353 000 tonne/yr of dry recyclable materials from the garbage stream when summed over all the population centres, bringing the total estimated recovery of dry recyclable materials to 1.20 Million tonne/yr.

Table 4.9: Estimated Waste Management Costs ($/hhld/yr)
Fortnightly Fully Commingled Recycling, Garbage to UR-3R Facility

System Component	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Garbage Collection/Transport	$52	$48	$51	$56	$49	$48	$53	$52	*$51*
Garbage Disposal/Processing (1)	$72	$52	$77	$87	$58	$38	$73	$79	*$67*
Recyclables Collection/Transport	$32	$31	$29	$32	$28	$34	$34	$26	*$31*
Recyclables Processing	$13	$6	$6	$9	$6	$11	$9	$4	*$9*
Total System Cost	$169	$137	$163	$183	$141	$130	$169	$161	*$157*

(1) Garbage processing costs (expressed in $/hhld/yr) vary across population centres depending on assumed transfer arrangements and garbage generation rate. For centres with low garbage generation (e.g. Canberra), garbage processing costs per household are lower.

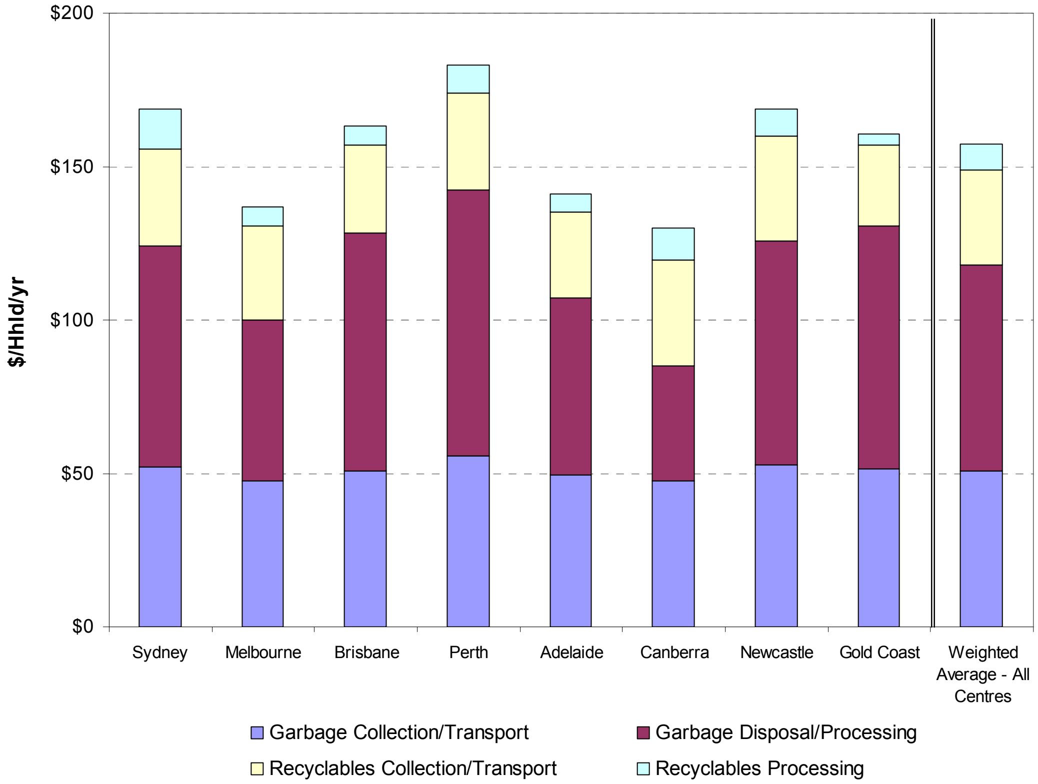

Figure 4.3: Estimated Waste Management Costs
Fortnightly Fully Commingled Recycling, Garbage to UR-3R Facility

4.2.3 Paper Only Recycling, Processing of Garbage at UR-3R Facilities

Average estimated domestic waste (garbage and kerbside recycling) costs, assuming 240 L MGB monthly paper-only kerbside recycling and weekly garbage collection with delivery to a UR-3R Facility vary from a minimum of $112/hhld/yr (Canberra) to a maximum of $169/hhld/yr (Perth). For this system containers that were previously collected in commingled form with paper are mixed with the garbage stream and recovered through sorting and separation operations at the UR-3R Facility.

When averaged across all population centres, the cost of this system is estimated at $144/hhld/yr, or $11/hhld/yr higher than the landfill disposal scenario with fully commingled fortnightly recycling (paper and containers).

For this system, removal of containers from the recycling stream and the reduction in recycling collection frequency from fortnightly to monthly results in an estimated saving of $13/hhld/yr (plus potentially further uncosted benefits from reduced road damage from collection vehicles on residential streets).

For this system, the estimated total quantity of paper recovered from monthly kerbside collection is 497 000 tonne/yr across all population centres. The UR-3R Process® would recover an estimated additional 580 000 tonne/yr of dry recyclable materials from the garbage stream, bringing the total estimated recovery of dry recyclable materials to 1.08 Million tonne/yr.

Estimated costs for this system for each population centre are shown in Table 4.10 and Figure 4.4.

Table 4.10: Estimated Waste Management Costs
Monthly Paper-Only Recycling, Garbage to UR-3R Facility

System Component	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Garbage Collection/Transport	$53	$50	$52	$56	$50	$49	$56	$54	*$52*
Garbage Disposal/Processing (1)	$81	$61	$85	$96	$63	$47	$82	$85	*$76*
Recyclables Collection/Transport	$18	$17	$17	$17	$17	$20	$19	$16	*$17*
Recyclables Processing	($2)	($2)	($3)	($1)	($2)	($3)	($5)	($1)	*($2)*
Total System Cost	$151	$127	$151	$169	$128	$112	$152	$154	*$144*

(1) Garbage processing costs (expressed in $/hhld/yr) vary across population centres depending on assumed transfer arrangements and garbage generation rate. For centres with low garbage generation (e.g. Canberra), garbage processing costs per household are lower.

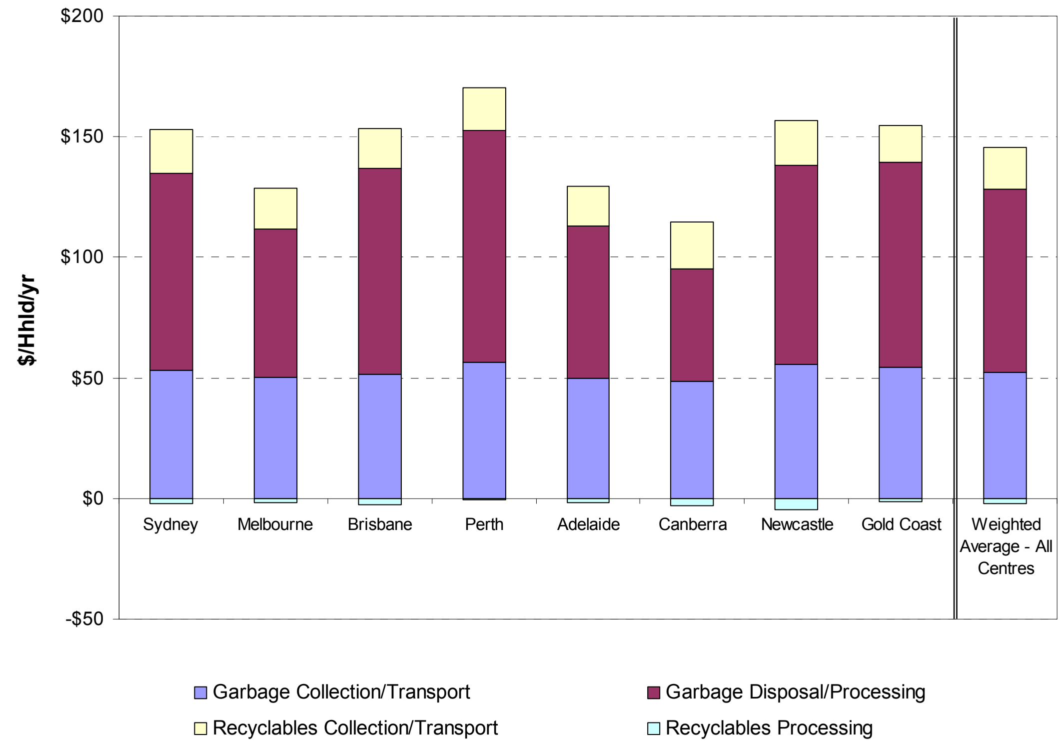

Figure 4.4: Estimated Waste Management Costs Monthly Paper Only Recycling, Garbage to UR-3R Facility

4.3 Summary

Table 4.11 and Figure 4.5 present a summary of estimated system costs for each of the systems investigated and for each population centre.

For the base case system (240 L MGB fortnightly fully commingled kerbside recyclables collection and weekly garbage collection, garbage to landfill) the estimated cost of providing garbage and recycling collection and processing/disposal services is $133/hhld/yr (weighted national average).

The replacement of landfill disposal of garbage with processing at a Global Renewables' UR-3R Facility increases waste management costs by an estimated $24/hhld/yr, to $157/hhld/yr (weighted national average). For metropolitan areas where current landfill fees are high (e.g. Sydney), the increase is much lower ($9/hhld/yr), whereas in areas with low gate fees at landfills the marginal financial cost is higher.

The introduction of the UR-3R Process® for processing garbage and recyclable containers, in combination with a reduction of the recyclables collection frequency from fortnightly to monthly together with reducing the mix of recyclables to paper/cardboard only (i.e. with residents placing all recyclable containers in the garbage bin), would increase the annual costs to households over the base case system by $11/hhld/yr, to $144/hhld/yr (weighted national average). The cost difference over the base case varies considerable across population centres, depending on a range of factors including current landfill costs, existing recyclables recovery, etc. For some population centres (i.e. Sydney and Canberra), the introduction of the UR-3R Process® for processing garbage and recyclable containers in combination with monthly paper only recycling is estimated to be cheaper than the base case.

The cost difference between the landfill disposal scenario (i.e. base case system) and the UR-3R Facility scenarios will reduce over time as landfill disposal costs are expected to increase more rapidly than UR-3R Facility gate fees.

Table 4.11: Summary of Estimated Waste Management Costs ($/hhld/yr)

Scenario	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Base Case: Fortnightly Fully Commingled Recycling, Garbage to Landfill									
Total System Cost	$160	$107	$137	$130	$118	$113	$136	$130	*$133*
Fortnightly Fully Commingled Recycling, Garbage to UR-3R Facility									
Total System Cost	$169	$137	$163	$183	$141	$130	$169	$161	*$157*
Difference over Base Case	+$9	+$30	+$26	+$53	+$23	+$17	+$32	+$31	*+$24*
Monthly Paper/Cardboard Only Recycling, Garbage to UR-3R Facility									
Total System Cost	$151	$127	$151	$169	$128	$112	$152	$154	*$144*
Difference over Base Case	-$9	+$20	+$14	+$39	+$10	-$2	+$16	+$24	*+$11*

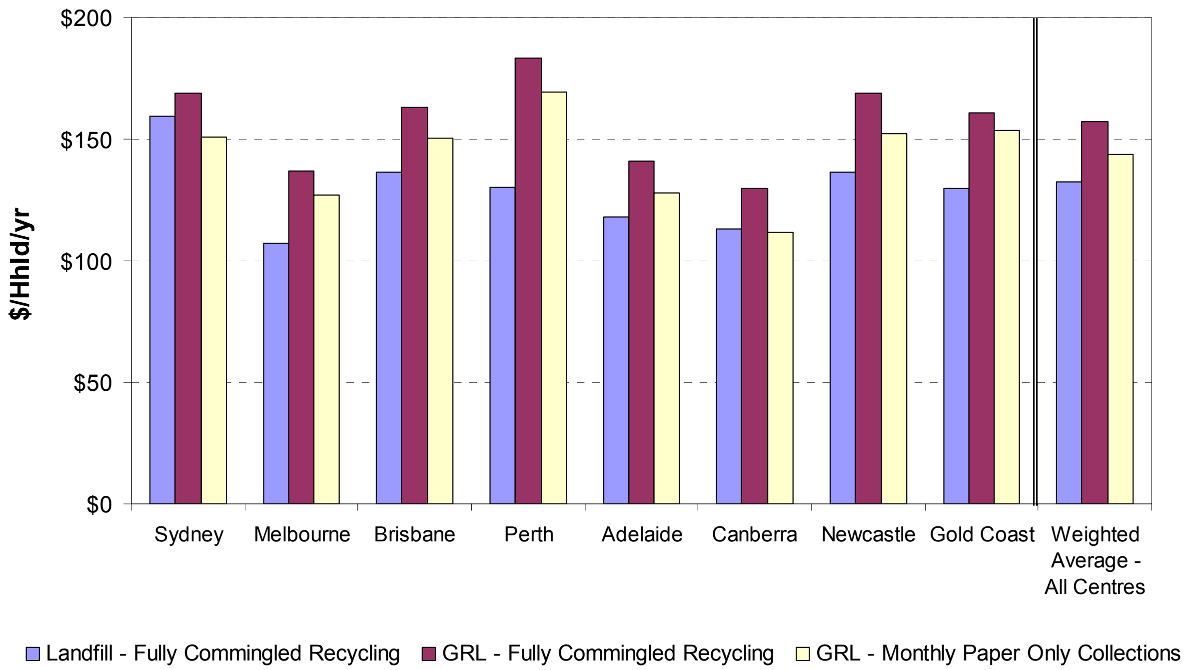

Figure 4.5: Summary of Estimated Waste Management Costs

Total estimated quantities of dry recyclable materials recovered for the three systems modelled are listed in Table 4.12.

Table 4.12: Estimated Dry Recyclables Recovery – All Population Centres (tonne/yr)

System	Quantity Recovered from Kerbside recycling (excl. contamination) (tonne/yr)	Quantity Recovered by UR-3R Process® (tonne/yr)	Total Recovered (tonne/yr)
Base Case: Fortnightly Fully Commingled Recycling, Garbage to Landfill	847 000	0	847 000
Fortnightly Fully Commingled Recycling, Garbage to UR-3R Facility	847 000	353 000	1 200 000
Monthly Paper/Cardboard Only Recycling, Garbage to UR-3R Facility	497 000	580 000	1 077 000

5 ENVIRONMENTAL ASSESSMENT

5.1 Modelling Approach

5.1.1 Overview

The environmental assessment has been conducted within the broader framework of an economic assessment. It aims to define and value the environmental externalities (or non-financial costs and benefits) associated with various management strategies for municipal solid waste.

The environmental assessment is based on LCA and environmental economic valuation. The assessment method quantifies material and energy inputs and outputs to the waste management system and then values these flows using established economic values as depicted below. The four steps in the assessment approach are summarised below in Figure 5.1. As indicated, the assessment involved the development of new LCA inventory data for Australian Landfills and for the UR-3R Process®. In addition, an expanded methodology for Environmental Economic Valuation was developed and applied for the analysis. This is the first time in Australia that such a more complete approach to waste systems assessment was applied, and it highlights the importance of landfill avoidance and municipal waste pre-treatment (see Section 5.1.2 for discussion).

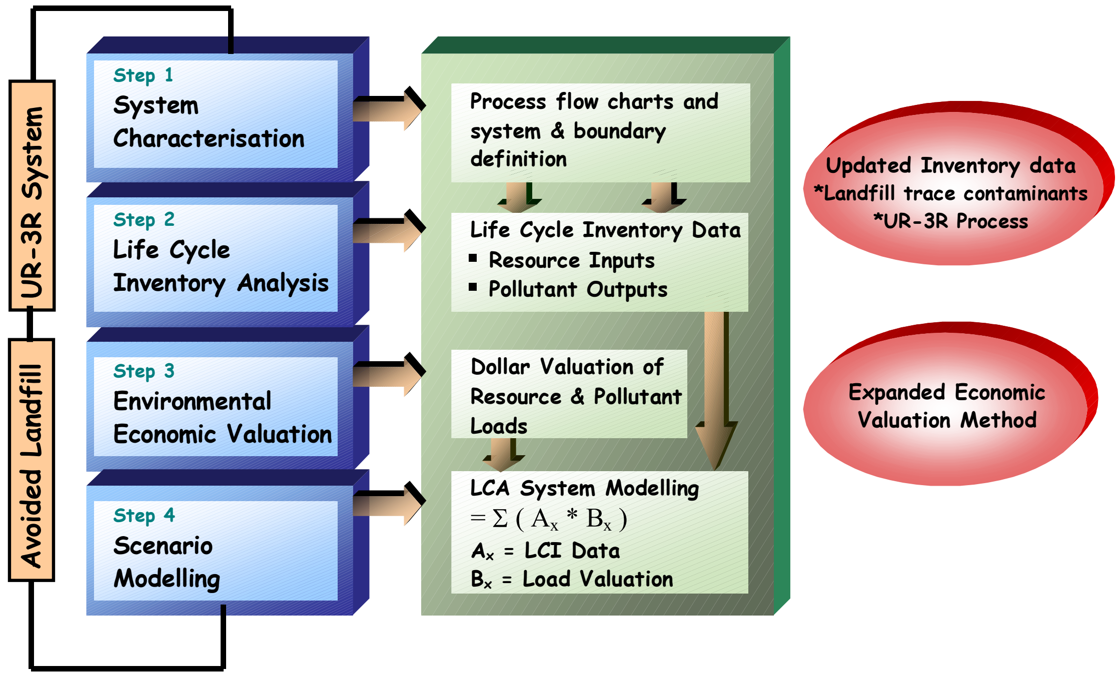

Figure 5.1 Assessment Methodology

a) Step 1: System Characterisation

The analysis incorporates the entire life cycle system of domestic waste and recycling systems in Australia, and the UR-3R Process®, from cradle to grave. All inputs to, and outputs from, the system are recorded from the point of waste collection, through the various processing steps and on to the management of residuals and products from the UR-3R Facility. All unit processes within the system are defined and have been examined from a mass balance perspective.

This included detailed consideration of any avoided systems, notably:

- Avoided landfill;
- Avoided energy production;
- Avoided commodity material stages associated with materials recovery and recycling; and
- Benefits from production and land application of OGM.

The lack of detailed, local LCA data on landfill meant that the landfill system required detailed characterisation. Data review and collection was required to ensure that the UR-3R Process® configuration was fully understood and that the avoided landfill system was representative of current and future management practices across Australian capital cities and cities with a population of over 300,000 people.

The system assessed including the boundaries set is illustrated in Figure 5.2.

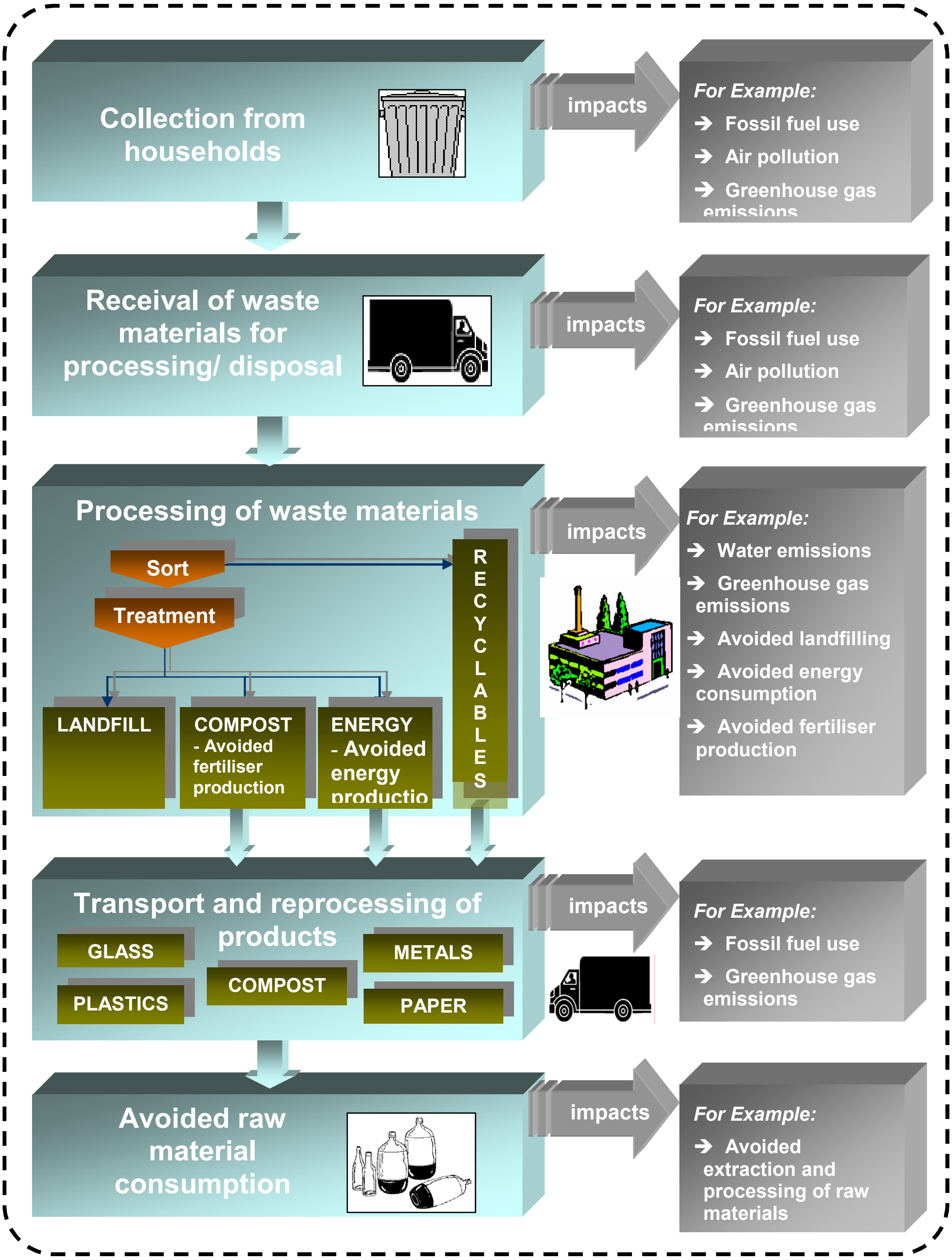

Figure 5.2: System Boundary

b) Step 2: Life Cycle Inventory Data

Life Cycle Inventory Data on the resource inputs and pollutant outputs to the system were developed or referenced from existing published studies. The range of resource inputs and pollutant outputs was extensive and exceeded 15 raw material inputs, greenhouse gases and more than 100 substances emitted to air and water that spanned general and toxic pollutants including heavy metals and chlorinated and aromatic hydrocarbons, including dioxins and furans.

New life cycle inventory data sets were developed for the UR-3R Process® and for trace contaminants from landfill in Australia.

One of the key challenges of this study was to consolidate the databases for the various processes and materials, and to combine the material specific emissions from landfill (from LCA data bases) with generic emissions from landfill (from 'real world' emissions as monitored and reported) in order to predict changing emissions (through different waste compositions, quantities and stabilisation levels) with the highest possible degree of certainty.

c) Step 3: Environmental Economic Valuation

Existing Environmental Economic Valuation Model

The Australian-based, environmental economic valuation method (Nolan-ITU, 2001; 2004) was applied in order to derive a monetary cost benefit assessment. The method uses environmental economic values that have been either directly sourced, or derived from published government sources within Australia. Where the values are "derived", scientific equivalence factors have been used to relate a known base pollutant to the derived value in accordance with Life Cycle Impact Assessment characterisation approaches (Heijungs, 2001). This approach was used and internationally peer reviewed for valuation of pollutants for previous policy advice to the National Packaging Covenant Council (Nolan-ITU, 2001).

The impact categories assessed are:

- Greenhouse Gases;
- Air Emissions;
- Water Emissions;
- Resource Conservation (with 'Oil & Gas' as separate (sub-)category); and
- Solid Waste (reflecting non-chemical impacts of landfilling (EPA NSW, 1997).

Short Description of Impact Categories

The derivation of the original environmental economic values for each impact category (Nolan-ITU, January 2001) was a detailed assignment. A summary of the approach is described below and further information is provided in Appendix D. For a more complete understanding of the approach, please refer to the *Independent Assessment of Kerbside Recycling in Australia, National Packaging Covenant Council (2001)*.

Water and Air Pollutant Valuation

Pollutant emissions from the inventory are classified as Water Pollution or Air Pollution if they have the potential to affect human health or the environment. Environmental economic values from published government sources are used where possible to assign economic values to pollutants on a per tonne basis. If values are not available from government sources, scientific equivalence factors are used to scale the economic values for known pollutants in order to derive the unknown pollutant values.

Equivalence factors are derived from local regulations including the NSW EPA (1997) Proposed Clean Air (Plant and Equipment) Regulation 1997 and the NSW EPA (1998) Load Based Licensing Scheme and published international LCIA references including the Themes Approach of the Centre of Environmental Science (CML) Leiden University, Netherlands.

Greenhouse Gases

Greenhouse Gases or global warming pollutants are common to all inventory data sets including the UR-3R Facility, landfill and energy inventories.

The Climate model as developed by the Intergovernmental Panel on Climate Change (IPCC) has been used to provide equivalence factors to assess pollutants. These are expressed in terms of carbon dioxide equivalence and an economic value of $20.00 per tonne of carbon dioxide is used. A limited range of greenhouse gases has been considered.

Resource Conservation

The resources modelled are the most significant resources by weight in the inventories used: They include a range of mineral, forest and soil and water resources.

Resource values have been referenced from published Australian valuation studies or estimated based on the application of international scientific ranking systems to Australian valuation data.

Solid Waste

Solid Waste is assessed in order to include the non-chemical environmental and social impacts of landfills. These are predominantly established by the EPA NSW for land value loss and loss of amenity (NSW EPA, 1997).

Expanded Environmental Economic Valuation Model

For this study, a revised and more comprehensive environmental economic valuation approach has been used for the first time in Australia. Trace contaminants to air and water have been assigned a specific environmental economic cost and applied to waste management scenarios.

Economic valuation is praised for its ability to aggregate complex information in a meaningful way. It is also criticised for providing a simple and definitive assessment of systems that are dynamic and indeterminate. The approach is increasingly used for environmental decision making and is recommended by the European Commission as being rigorous and scientific, and "providing the basis for improved policy decision making", Philippe Busquin, EC Member for Research, Ref. *External Costs* (2003) European Commission EUR20198 Project.

d) Step 4: System Modelling

Once the data sets were established they were entered into the SimaPro LCA software along with considerable data on various collection and management systems for Municipal Solid Waste. The inventory data was then aggregated into models according to flow charts for each scenario and system and then the inventory results were assessed based on the impact valuation data.

5.1.2 Environmental Assessment - Detailed Methodology

a) Broad System Characterisation

The first step in the assessment is the detailed analysis and characterisation of the UR-3R Process® system including avoided systems such as landfill and energy production as depicted below. The life cycle, systems-based boundary was established to ensure that all significant impacts and benefits associated with the UR-3R Process® are captured. This required consideration of the avoided landfill background system, as well as the process system from the point of waste receival through to the emissions that arise from the landfilling of UR-3R Facility residues and any impacts and benefits arising from UR-3R Facility outputs. The broad system is depicted in Figure 5.3.

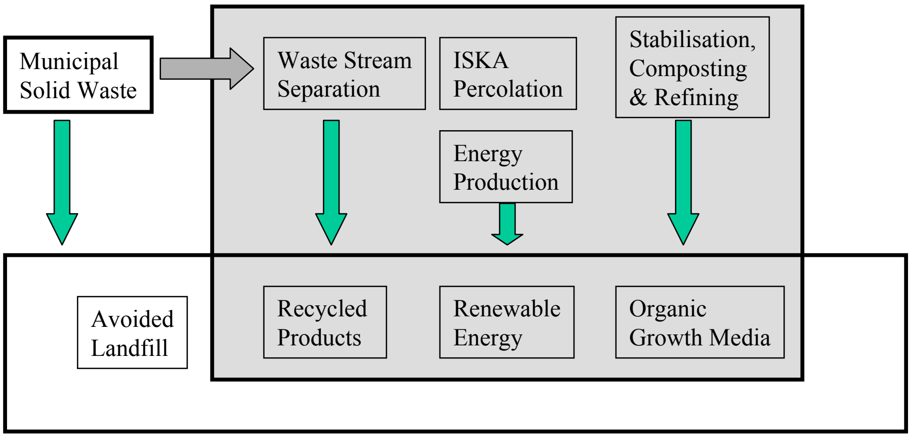

Figure 5.3 UR-3R Process® System including Avoided Landfill

b) The UR-3R Process® System

Description

This UR-3R (Urban Resource - Reduction, Recovery and Recycling) Facility, employs a Mechanical Biological Treatment (MBT) technology for the processing of domestic garbage and commercial wastes into a range of end products.

The UR-3R Process® has been developed by Global Renewables and incorporates a range of unit processes for which the company has obtained licence agreements from overseas technology suppliers.

Waste processing and resource recovery is via four unit processes, as depicted in Figure 5.4 below:

- Waste Stream Separation;
- ISKA® Percolation;
- Composting and Refining; and
- Energy Production

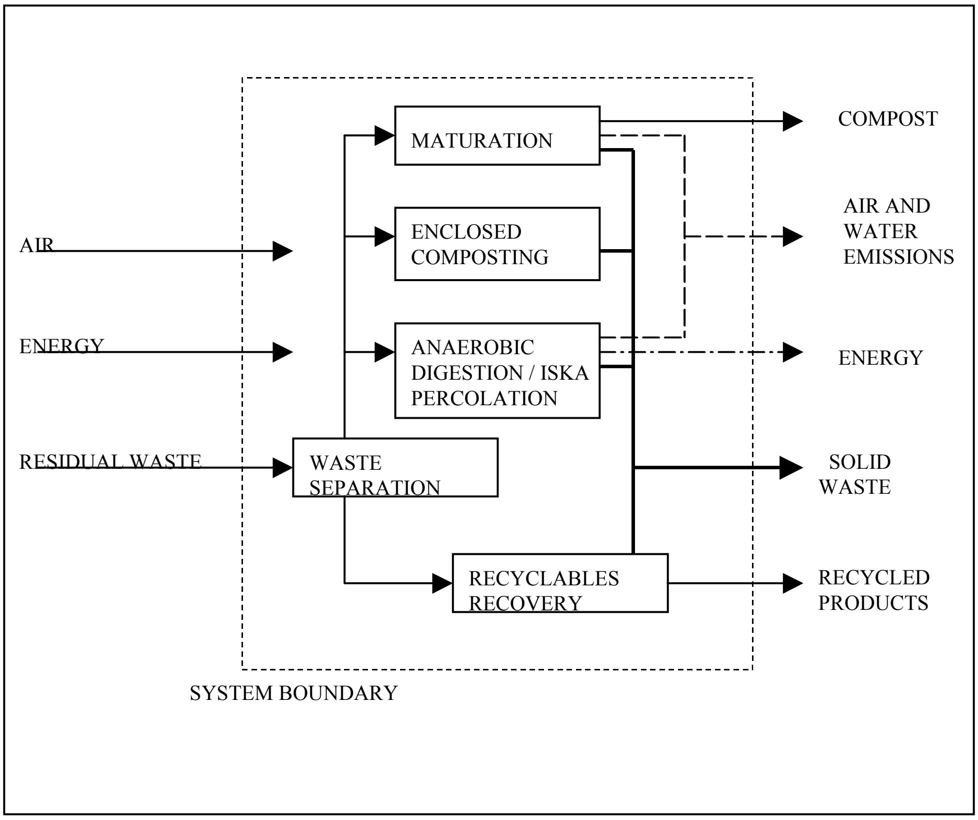

Figure 5.4: Simplified Flow Chart of the UR-3R Process®

A description of the unit processes to be employed at the UR-3R Facility follows:

Waste Stream Separation

The UR-3R Facility's waste stream separation process takes mixed residential and/or commercial waste and separates it into homogenous streams of:

Paper;	Glass;
Plastics;	Metals;
Organics;	Other

The separation technology uses a combination of automatic equipment (conveyors, screens, and air, magnetic and eddy current separators) as well as manual sorting to separate homogenous streams of material from incoming mixed waste.

ISKA® Percolation

The ISKA® Percolation process includes a percolator vessel, anaerobic digester, sand separator and sludge screens, dewatering press and water denitrifier. The process breaks down and mobilises volatile (i.e. readily biodegradable) organics present in screened mixed solid waste in a percolator vessel using a washing action with warm acidic water. Within the percolator waste is periodically turned whilst water is sprinkled over its surface. The water permeates through the waste before being collected at the percolator base. Sand and sludge is removed from collected water before it is treated through an anaerobic digester to yield biogas. Discharged solid material from the percolator is suitable for enclosed composting.

Composting and Refining

Aerobic composting of the percolate solid material is undertaken in an enclosed building to convert it into an OGM. Maturing and refining processes are utilised following enclosed composting to stabilise the product, remove visual contaminants as well as screen the material for required end-uses.

Energy Recovery

Biogas generated by the ISKA® Percolation process is combusted at the UR-3R Facility to produce electricity. The resultant electricity is used to power the operation of the UR-3R Facility, whilst the excess will be available for sale.

Key Environmental Performance Criteria

The key performance criteria for Global Renewables' UR-3R Process® are presented in Section 3. Only additional assumptions relevant for the environmental assessment are discussed below.

Recyclables Material Recovery

Recyclable materials that are not picked up in kerbside recycling collection schemes enter the UR-3R Facility as part of the garbage stream. Through a combination of mechanical and manual sorting processes, a certain proportion of these materials is recovered for reprocessing. Table 3.1 lists the assumed recovery rates. For materials recovered at the UR-3R Facility, a similar recycling path has been assumed as for recyclables recovered at MRF's. The one exception is paper where it as been assumed that only 15% of newsprint is being recycled into newsprint, with all other paper/cardboard going to local production of Kraftliner Brown.

Organic Growth Media (OGM)

The UR-3R Process® separates organic material early in the process. These organics are directed to the ISKA® Percolation area. From there, the percolate solution including the volatile organic component of the waste is processed through the anaerobic digestion circuit to generate renewable energy. The solid organic material is directed to the composting process.

Organic material not captured though the initial separation undergoes a similar process of composting however, for this material the process is predominantly used for stabilisation of residues prior to landfilling. At the Eastern Creek UR-3R Facility, part of this material is being refined and used as ADC. Solutions are presently being designed to minimise the production of ADC and maximise the yield of organic material used to produce OGM.

The modelling assumes that OGM produced amounts to approximately 20% of UR-3R Facility input. Concentrations of heavy metals in OGM have been assumed to be at the threshold values of the Draft Composting Guidelines (EPA NSW; 2002). Nitrate emissions to water have been assumed at 1.125 g/kg of compost. In the sensitivity analysis, assumed heavy metal concentrations were increased to actually measured MSW-derived compost values from conventional MBT facilities[2], which are between "Grade B" and "Grade C" (EPA NSW, 2002) depending on substance (for more details see Section 5.4).

The separation and composting of organic materials (including food waste) to produce OGM achieves two significant environmental benefits. These are:

1) Avoided Landfill Benefits

Organic material is the dominant factor in generating emissions from landfills. A reduction of organic materials to landfill reduces emissions (Greenhouse Gases, air and water pollutants) significantly.

2) Benefits from Application of Organic Growth Media (OGM) to Soils

The environmental value for compost application includes *resource savings* as well as the full range of environmental impact categories associated with avoided product (fertilisers, pesticides and some application energy) credits, including air and water emissions and global warming potential. The net benefits account for transport to application. The predominant *application* benefits arise from improved moisture retention in soil and the fertiliser value of nutrients in compost. However, the most significant benefits of OGM production are achieved through avoided landfill impacts (for details refer to Section 5.3.3 and Appendix D).

Compost *application* benefits considered in this study include:

- Improved Water Retention Capacity;
- Soil Structure Improvement;
- Reduced Acidification and Salinity;
- Avoided phosphate depletion;
- Avoided Urea (N);
- Avoided KCl (K);
- Reduced Nitrous Oxide Emissions;

[2] Conventional MBT facilities have been in operation for several decades and, in this context, do not feature combinations of advanced technology modules ("hybrid system") such as incorporated in the UR-3R Process®

- Increased crop yield;
- Reduced pesticide application; and
- Carbon Soil Sequestration.

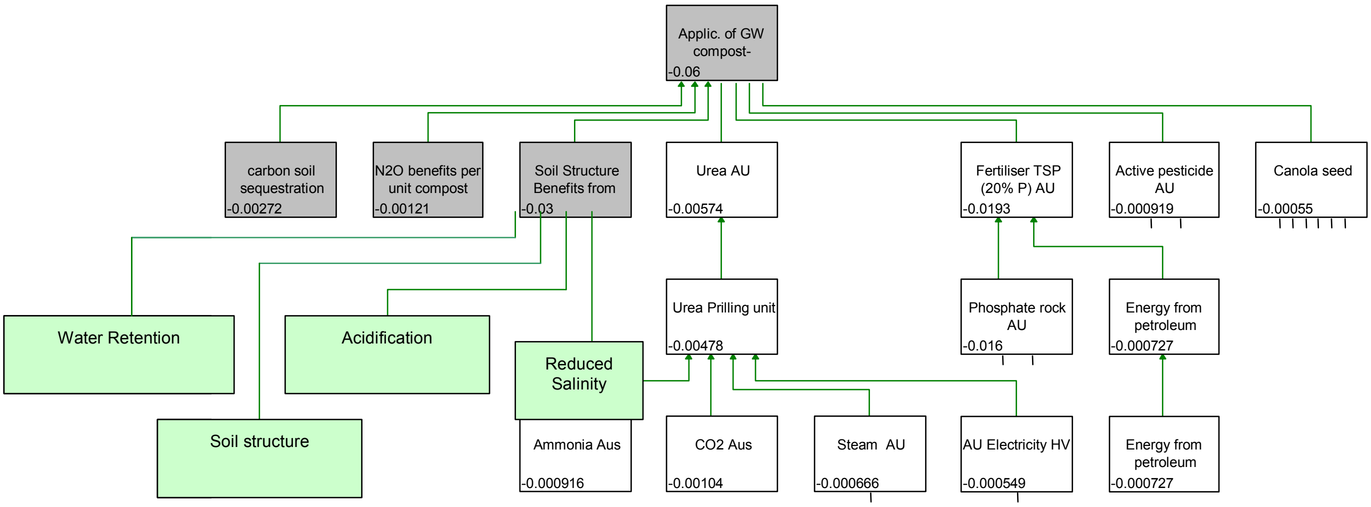

Figure 5.5: Simplified Example of Model for Derivation of OGM Application Benefits

In this study considerable effort has been made to derive (where not available) and apply economic values for the various benefits of OGM. However quantification and valuation of all benefits has not been possible. A good example of this is the medium and long term benefits of OGM application on the (micro)organism communities within soils ('soil health'). Some environmental cost benefits of compost application that remain unvalued by this approach are listed in Table 5.1.

Table 5.1: Environmental Cost Benefits of OGM that remain External

External Benefits
Pollutant retention and assimilation
Soil conditioning – porosity and aeration
Improved soil health and fertility
Micronutrient supply
Reduced Risk of Flooding

Energy Generation

The organic fraction of the facility input is being directed towards the ISKA® Percolation module where easily degradable organic substances are being separated into a liquid phase which subsequently goes to the digesters. There, biogas is produced for energy generation. The UR-3R Facility is designed to produce 17,500 MWh of electricity per year. This output is considered renewable energy and, consequently, yields Renewable Energy Certificates (RECs). For the LCA, the electricity generated by the UR-3R Facility is modelled to replace electricity from conventional power plants. A typical South East Australian electricity mix (with the associated mix of coal grades) has been assumed (Grant et al, 2001). The energy demand of the UR-3R Process® is assumed to be 85 kWh/t of electrical energy and 1 L/t of fuel.

Process water from the digesters generating biogas is stripped of ammonia. In this step, the ammonia is converted to ammonium sulphate. The ammonia stripping unit is expected to generate approximately 300 t/yr of nitrogen from ammonium sulphate. The environmental benefits (fertiliser replacement) of this nitrogen have been incorporated into the LCA modelling through calculating its urea replacement potential. However, the contribution to the overall benefits is less than 1%.

Waste Reduction and Stabilisation of Residues

As is well known and documented in international literature, all Alternative Waste Treatment (AWT) facilities improve the environmental performance of waste management systems predominantly through the pre-treatment of (mainly putrescible) wastes prior to landfilling. One major technology group within AWT, Mechanical Biological Treatment (MBT) facilities, are commonly characterised as reducing the weight of waste requiring disposal by 35-70%, mainly through evaporation and decomposition of organic material (CO2 losses). Measured by volume, the gains are even greater through the higher density achievable in landfills with MBT residues compared with untreated wastes.

An additional – and even more important - benefit arises through the stabilisation of wastes through the process. The decomposition of organic matter in combination with water losses leads to a much more 'stable' matrix in the landfill. A number of international studies have been conducted that show landfill gas and leachate production (over the active life of the landfill) with the associated emissions to air and water are reduced substantially.

For this study, it was assumed that landfill gas and leachate generation is reduced by 90% (Binner et al, 2001). The mass balance of the UR-3R Facility currently being established at Eastern Creek in Sydney has been assumed. ADC has therefore been modelled as stabilised material in landfill.

Waste Profile and Transport Impacts

Waste profiles have been developed and used for each metropolitan area assessed. This included composition and quantities of both garbage and kerbside recycling streams. Transport and transfer assumptions are described in Section 4.1. It has been assumed that the UR-3R Facility is located adjacent to a landfill hence the transport of residues and ADC from the UR-3R Facility to the final disposal was considered negligible. Transport of recovered dry recyclables to reprocessing plants has been modelled based in Sydney conditions. The transport of recyclables has also been modelled individually for WA (with substantial quantities being shipped offshore for reprocessing) and was found to contribute less than 1% to total environmental performance of the systems modelled. Transport infrastructure impacts are included in the modelling.

UR-3R Facility Emissions

UR-3R Facility emissions have been modelled based on a number of sources. For air emissions, three distinct data sources have been used.

Air emissions from the power generator sets have been based on the Supplementary Report to the Environmental Impact Statement (EIS) (NECS, 2001) and Statement of Environmental Effects (SEE) (NECS, 2002), (Global Renewables, undated).

Air emissions from the aerobic stabilisation, composting and digestion processes have been derived as median values from a range of studies, consolidated by Nolan-ITU in co-operation with RMIT and internationally peer reviewed for the LCA of Waste Management Options in Victoria (ERV, 2003). The amount of material passing through the aerobic stages of the UR-3R Process® has been based on the mass balance of the UR-3R Facility at Eastern Creek, Sydney.

Water emissions (ISKA® Percolation and digestion)

The UR-3R Process® is designed to operate without process water discharge. Water used in the digestion process is partially recirculated. Any excess water is used for maintaining an optimal moisture content in the stabilisation/composting modules. It is noted however that, whilst water emissions from the UR-3R Process® are zero, emissions to water from a number of materials and processes have been accounted for. Examples are (treated) leachate discharge from landfilling of residues, emissions to water from manufacturing paper and packaging materials, and reprocessing of recyclables (and credits for avoided manufacturing emissions).

Main Data Sources

The main data sources used for the environmental assessment are listed below.

- GRL/GRD (2003): Mass Balances from Optimised Flow Sheet and Bankable Feasibility Study Update, Final.
- Nolan-ITU (2004): TBL Assessment of Alternative Domestic Waste and Recycling Systems in NSW.
- RMIT & Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria (including Energy from Waste).

- DEC (2003): Alternative Waste Treatment Technologies Assessment Methodology and Handbook. Prepared by Nolan-ITU.
- Greenpeace, TBU and Eunomia (2003): Cool Waste Management – A State-of-the-Art Alternative to Incineration of Residual Municipal Waste.
- Nolan-ITU (2004): Decision Support System for the Assessment of Integrated Resource Recovery, Western Australian Local Government Association.
- Eriksson, O., Björklund, A. (2002): Municipal Solid Waste Model.
- Finnveden *et al*. (2002): Energy from waste.
- Nolan-ITU and SKM (2001): Independent Assessment of Kerbside Recycling in Australia.
- Grant *et al* (2001): Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Stage 1 & 2 Report. Melbourne. For Eco Recycle Victoria.
- CRC WMPC (1998): Life Cycle Inventories for Transport, Energy and Commodity Materials.
- Australian Greenhouse Office, Greenhouse Inventory Update
- Sundqvist, J.-O. (1998): Landfilling and incineration in LCA and systems analyses. Proceedings of Systems Engineering Models for Waste Management, International workshop in Göteborg, Sweden, 25-26 February 1998.
- White, P. (1999): IWM-2 An LCI computer model for solid waste management – model guide
- COWI - Consulting Engineers and Planners for the European Commission, DG Government (October 2000): A study on the economic valuation of environmental externalities from landfill disposal and incineration of waste.
- Eunomia Research and Consulting, (2002): Appendices to final report – economic analysis of options for managing biodegradable municipal waste
- Published industry data
- SimaPro 5.1 Inventory Data.

Impacts from the construction of the UR-3R Facility have not been considered as is common practice. However, the proportional impacts of transport infrastructure such as roads etc. have been incorporated.

5.1.3 The Avoided Landfill System

Solid waste landfills are dynamic systems and the pollutant loads carried by landfill gas and leachate vary considerably over time and in accordance with a range of local variables such as landfill design and management, waste composition and local hydrology. In this context, LCA inventory data for the landfilling of MSW attempts to quantify the total pollutant load to air and water over the life of landfill. The landfill LCA data treats the landfill process as it does any waste treatment process, with the emissions to air and water recorded and assessed for their environmental impact, and credits assigned for electricity generation.

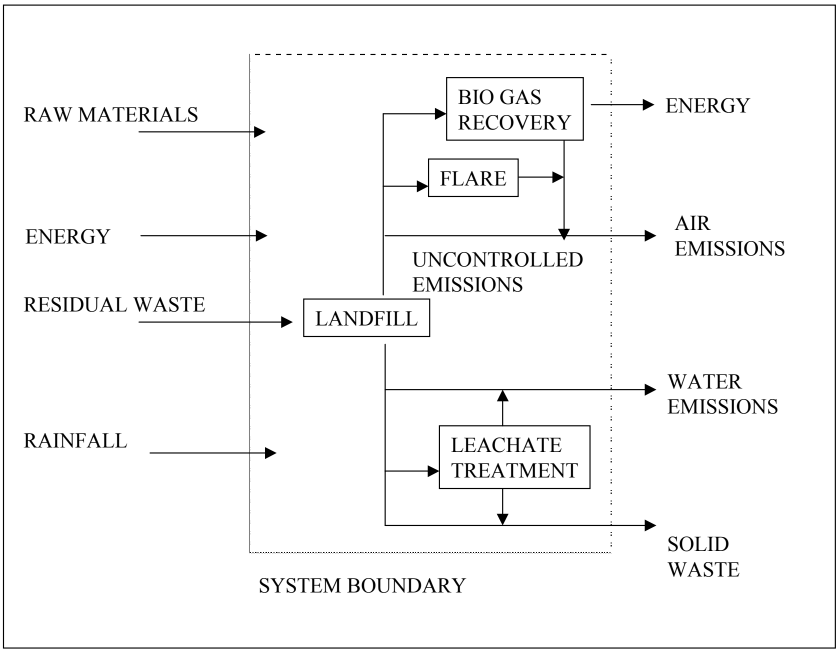

Figure 5.6: Landfill System

Best practice landfill for Australian conditions is assumed. This is a conservative assumption as, in practice, not all landfills currently serving the population centres modelled achieve the assumed best practice standard. In modelling the landfill system, average data from the landfill life is allocated to a unit of waste, in this case one tonne of MSW landfilled. A 30 year time frame has been selected as this time period covers the "active" phase of the landfill, when most of the decomposition and chemicophysical changes occur. The appropriateness of this time period varies for different pollutant loads. While some pollutants are predominantly active within the first three years of the landfill only (Moore, 1992), others are released over very long time periods. Results from geochemical landfill modelling (Hellweg, 2000) suggest that heavy metals are released over a very long time period, ranging from a few thousand years to more than 100,000 yrs.

In theory, only the infinite time frame is compatible with the LCA framework, since all emissions should be included in an LCA (Finnveden, 1999). However, a 30 year time frame was selected for this study for two reasons: 1) Data is available for modelling; and 2) A short time period selected for landfill is a conservative estimate when comparing with an alternative technology.

a) Derivation and source of data

The calculation of LCA data requires that concentration based data be converted to load based data per tonne of waste landfilled. Recognising that landfill data is dependant on many factors, concentration peaks and lows over an assumed active life of 30 years are considered, the arithmetic mean is calculated and then applied to the volume of gas or leachate as calculated for Australian Capital Cities. A similar methodological approach has been used previously for LCA of landfill as the basis of policy advice to the European Union and the UK Environment Agency (COWI, 2000; Eunomia, 2002; NSCA 2002).

An extensive review of data was conducted on landfill leachate and gas emissions (Qasim, S.R. and Chiang,W., 1994; Christensen et al, 1994; Ehrig, 1989; Carra and Cossu, 1990; COWI, 2000; White et al, 1995; Neilson, P, 2001; National Society for Clean Air and Environmental Protection (UK), 2002; SimaPro LCA Software, 2004). Local data was also sought from the University of New South Wales and the NSW Waste Recycling and Processing Corporation. The modelling of the base line landfill scenario accounts for carbon sequestration in the landfill from a range of materials in the waste/residual streams being disposed.

Landfill Leachate

Leachate generation (included contaminated run-off) is calculated to be 187.6 l/tonne over 30 years. This is based on weighted average rainfall data for Australian capital cities.

Prior to discharge to sewer, it is assumed that the following landfill leachate treatment steps are taken:

1. Leachate equalisation;
2. Metals precipitation;
3. Organic load reduction;
4. Denitrification; and
5. Clarification and decanting.

Leachate equalisation involves the mixing of leachate in a holding tank to prevent shock loading of the biological system through the introduction of “fresh” leachate which may contain high concentrations of pesticides or other chemicals contained in newly deposited waste.

Metals precipitation is achieved through lowering the pH of leachate by dosing leachate with lime. The precipitate is settled and circulated back to landfill.

Organic load reduction is achieved using an activated sludge process or using a sequencing batch reactor. These are both biological processes which rely on micro-organisms to consume the organic matter contained in leachate. After the organic load has been reduced, the treated leachate is allowed to settle thereby clarifying the liquid. The clear liquid is then decanted to sewer.

Landfill Gas

After detailed analysis of the available landfill data, it was decided to use a mix of both material specific and generic process data. Material specific emissions are calculated based on the material composition of waste in landfill and generic data is process and technology specific. After comparison of the performance of data sets in the modelling of scenarios and the accuracy of data, it was agreed that material specific data would be used for common pollutants, including the Greenhouse Gases of CO_2, CH_4 and N_2O, and generic data would be used for trace contaminants including chlorinated and aromatic hydrocarbons and heavy metals.

Information relating to landfill management practices in national capital cites across Australia was applied to determine the extent of fugitive emissions, and emissions post flaring or engine combustion. Both data sets assume best practice landfill is adopted and that landfill gas capture is in place in 80% of landfills and that 20% operate without landfill gas collection facilities. Where collection is in place, 55% of gas is effectively collected for combustion. Of this 55%, 75% results in electricity production and the remaining 25% is flared.

Generic Process Data

Concentration based data was converted to load based emissions using conventional landfill engineering methods. Landfill gas generation is assumed to be 250 Nm3/t.

Material specific data

Material specific emission data relate to the likely generation of gases from materials. These are assumed to be not dependant on local variables and existing data is used (EcoRecycle Victoria, 2001).

The issue of double counting was assessed for trace contaminants within the material specific data. In the final adjusted model used here, the 'overlap' between the generic and the material specific data was less than 1%. This was considered to be not significant enough, with respect to the impact on the final results, to warrant further work.

Greenhouse gas emissions

Conservative estimates of landfill gas production are assumed in order to cater for likely landfill management improvements over the coming 5 years. Gas capture and treatment assumptions are described above. Methane oxidation at the landfill surface and subsurface is assumed to be 10% (AGO, 2004).

Greenhouse Gas emissions are highly sensitive to effective gas capture rates, and to the inclusion or exclusion of carbon sequestration benefits (which have been included in this study). Should landfill management practices not advance as expected, the avoided greenhouse gas impact associated with landfill would increase.

5.1.4 Environmental Valuation

a) Description

The Australian-based, environmental valuation method (Nolan-ITU, 2001; 2004) has been applied in order to derive a cost benefit assessment.

Pollutant values have been derived based on equivalence relationships established by Human Toxicity Factors used in human toxicity assessments within Life Cycle Impact Assessment under the widely applied Themes method developed by the Centre of Environmental Studies (CML) Leiden University, Netherlands (Heijungs, 2001). These factors are used to relate base valuations derived from published government sources within Australia to the unvalued trace contaminants.

It is important to note that the final dollar valuation is not intended to represent financial transaction costs for environmental impacts but rather to indicate the relative significance of the different environmental loads and impacts. The main aim is to ensure the LCA results are more meaningful to more people.

b) Uncertainties

While the valuation approach has been expanded, original environment economic values have not been revalued. Some of the trace air pollutant values were dependant on economic values obtained from the NSW EPA in their Clean Air Act (NSW EPA, 1997) and for the application of Load Based Licensing in NSW (NSW EPA, 1998). These valuations have subsequently been critiqued as being significant too low by CSIRO atmospheric research scientist Tom Beer (Beer, 2002). The best estimate valuation proposed by Beer for PM_{10} is A$147,400 per tonne. This is significantly higher than the range offered by the original model which sets fine particulates at $18,500 per tonne, coarse particulates at 1,810 per tonne and undifferentiated particulates at $9,400 per tonne. Consequently, if de Beer's figure were applied, the valuation of environmental benefits for the system assessed in this report would increase substantially. Revising the equivalence relationships between pollutant values in order to better reflect the information presented by Beer on the health effects of particulates is beyond the scope of the study. In light of the uncertainty raised by the Beer paper, the expanded pollutant valuation undertaken for this study has not referenced PM_{10} or the other pollutants that he critiqued.

c) Trace Contaminant Valuation

In order to derive the environmental economic values for the expanded pollutant list, a base pollutant has been referenced and an equivalence relationship relating to Human Toxicity Potentials has been applied. The base valuation is obtained for environmental economic pollutant values from published Australian Government sources according to the original valuation method (Nolan-ITU, 2001) and the equivalence relationship is referenced after a review of the best available scientific methodology for Life Cycle Impact Assessment. The revised Themes approach for human toxicity potential assessment has been used (CML, 2001).

The CML Themes method from the Netherlands is one of 2 methods that have dominated the LCIA debate internationally. It is the most scientific of the methods and uses only scientific relationships to derive equivalence values, where as political and social weightings have influenced other methods. The CML Themes method has influenced the development of the International Standard for Life Cycle Impact Assessment (ISO 14 042) and the progress of LCIA in the peak scientific body for LCA, the Society for Environmental Toxicology and Chemistry (SETAC). The use of the method has sometimes produced results that have caused anomalies in the results. These anomalies are assigned proxy values and highlighted in Appendix C. They have been corrected using another LCIA equivalence relationship or other means as indicated in the Appendix. The base pollutant value for air is SO_2 and for water is Lead.

5.2 LCA Results

The interpretative phase of LCA involves classification of inventory data under a consistent set of impact categories. For each impact category, inventory data is converted to a single unit using conversion factors using an established method. In this report an environmental economic valuation method developed by Nolan-ITU has been used to convert inventory data to dollar values under the impact categories of: greenhouse, resources, oil and gas, air emissions, water emissions, and solid waste.

In this section, LCA results are expressed using a different method to the environmental economic valuation method used elsewhere in this report, namely the CML method (developed by the CML (Centre of Environmental Science), Leiden University, Netherlands) adapted for use in Australia by RMIT Centre for Design, for individual impact categories. Using this method, inventory data has been interpreted to express impacts under the following categories: resource depletion/savings; human toxicity; and photochemical oxidation (smog).

5.2.1 Resource Depletion/Saving

The resource depletion/saving indicator shows the depletion (or saving) of non-living (abiotic) resources and fossil fuels from the environment taking account of the abundance of these resources and current usage patterns. The issue of resource depletion may also be seen partly as a social issue of intergenerational equity in that any resource use today restricts resource use for future generations. Direct environmental implications of resource use may also arise from more intensive production techniques required to find and exploit lower grade energy sources, as the higher grade reserves are depleted.

The Abiotic Depletion Factor is determined for each extraction of minerals and fossil fuels (kg antimony (Sb) equivalents/kg extraction) based on concentration reserves and rate of deaccumulation.

Figure 5.7 presents the resource savings for each population centre of the UR-3R Process® and landfill disposal for the base case collection arrangement (*240 L MGB fortnightly commingled recyclables collection and weekly garbage collection*). The difference in results per population centre is a reflection of differences in waste generation by population centre (refer Figure 2.1). It is noted that the positive outcome of the 'landfill disposal' (base case) scenario stems predominantly from the kerbside recycling activities undertaken (and to a very limited extent from the energy recovery from landfills).

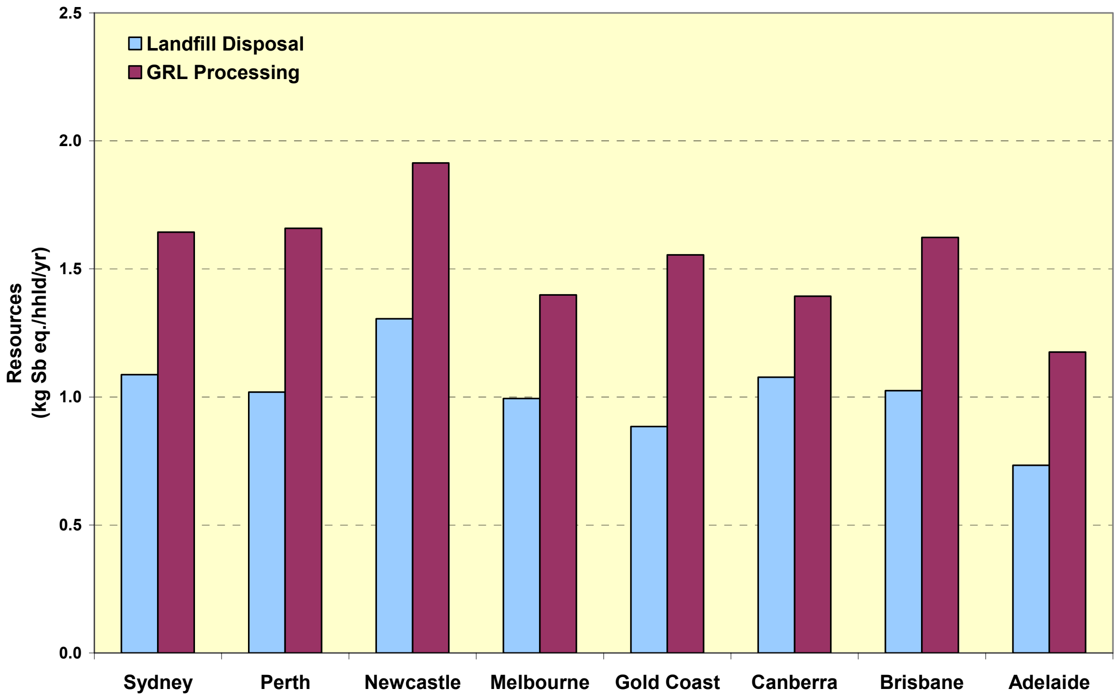

Figure 5.7: Resource Savings, UR-3R Process® versus Landfill Disposal (kg Sb eq/hhld/yr, CML method adapted for use in Australia)

5.2.2 Human Toxicity

The human toxicity savings of the UR-3R Process® over landfill are presented Figure 5.8 for the various population centres. In the CML method, characterisation factors, expressed as Human Toxicity Potentials (HTP), are calculated with USES-LCA (a model that describes fate, exposure and effects of toxic substances) for an infinite time horizon. For each toxic substance HTP's are expressed as 1,4-dichlorobenzene equivalents/ kg emission.

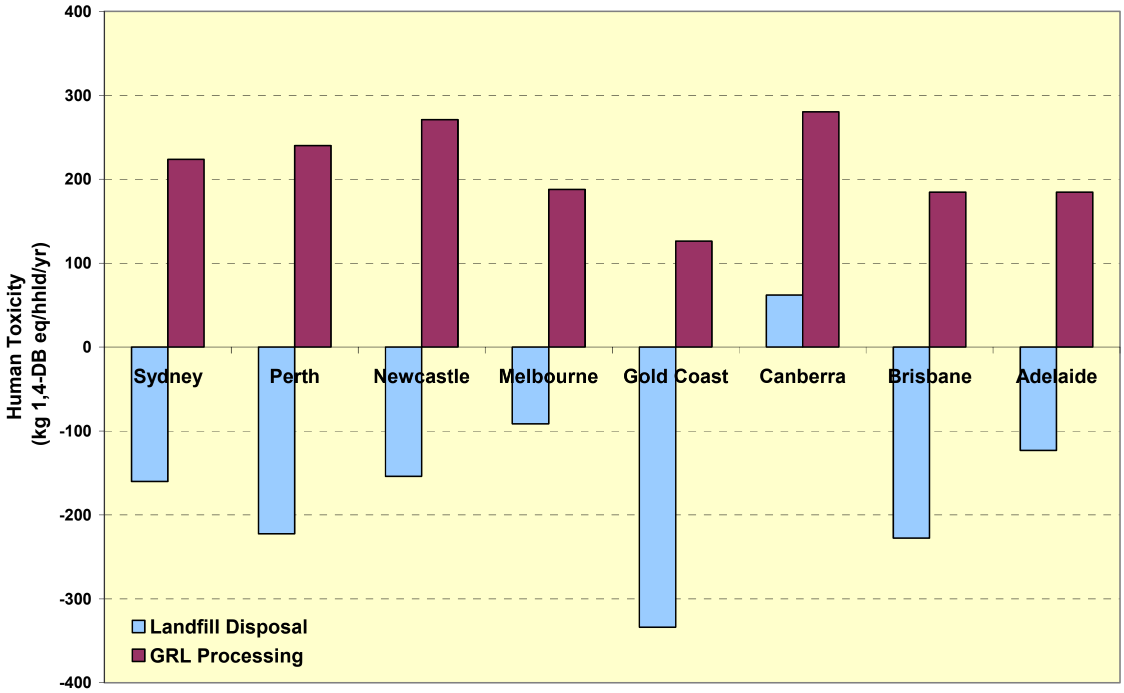

Figure 5.8: Human Toxicity Savings, UR-3R Process® versus Landfill Disposal (kg 1,4-DB eq/hhld/yr, CML method adapted for use in Australia)

5.2.3 *Photochemical Oxidation (Smog)*

Figure 5.9 presents the savings in photochemical oxidation (smog) potential of the UR-3R Process® over landfill disposal. The main contributing substances to photochemical oxidation are NO_x, CO, methane and non-methane VOC's. Photochemical oxidation (smog) potential for emission of substances to air is calculated with the UNECE Trajectory model (including fate), and expressed in kg ethylene equivalents/kg emission.

Savings in photochemical smog potential arise from the recovery of dry recyclables and energy through the UR-3R Process® as well as from avoiding landfill gas emissions. These sources together overwhelm emissions from additional transport (e.g. of recyclate to markets, compost transport and application) that would otherwise be expected to contribute to photochemical oxidants.

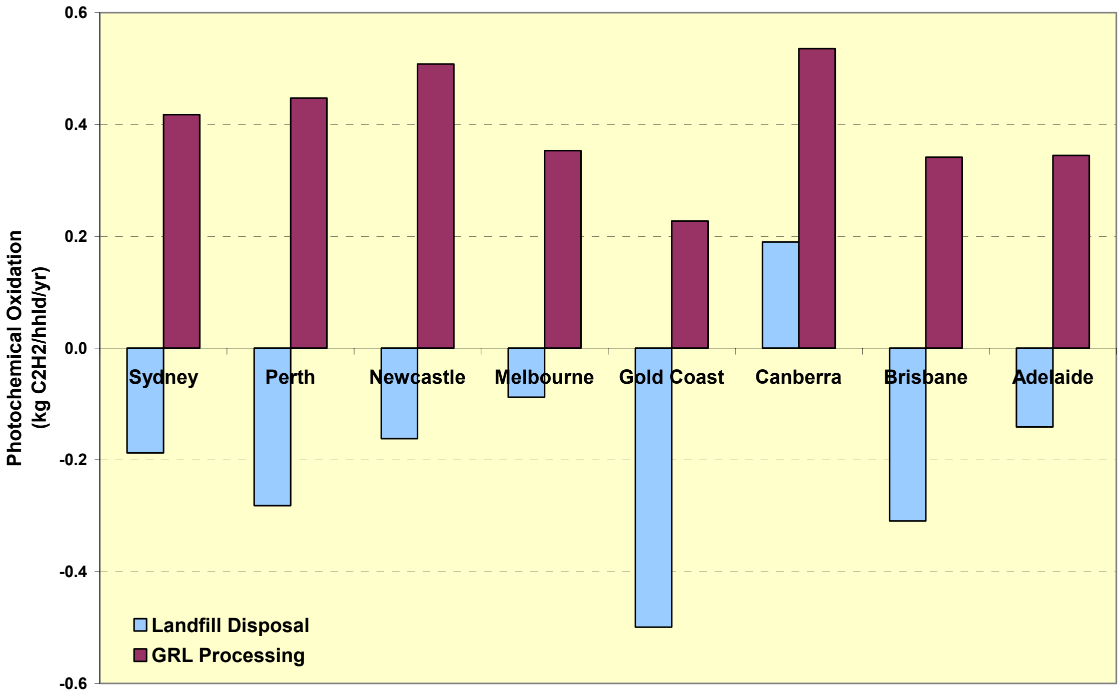

Figure 5.9: Net Photochemical Oxidation Savings Potential, UR-3R Process® versus Landfill Disposal (kg C2H2/hhld/yr, CML method adapted for use in Australia)

5.3 Environmental Economic Assessment Results

This Section presents and discusses the key results of the environmental assessment. As described above, environmental impacts and benefits from a number of impact categories have been combined through the Environmental Economic Model. This model allows expressing the environmental performance as one single indicator and is based on Australian conditions, economics and regulations. Considering the range of process steps, impact categories, localities, and the fact that the results of this study component are to be used in a TBL assessment, only results expressed as "Eco dollars" (i.e. this specific single indicator) are shown. All results are normalised against the base line landfill, i.e. base line landfill is set at zero.

5.3.1 Net Environmental Benefit by Population Centre

The net environmental benefit of the UR-3R Process®, as a weighted average across Australian metropolitan areas, amounts to Eco$159 per household and year, or $741M per year nationally.

The difference between the various population centres (refer Figure 5.10) is a reflection of domestic waste generation as well as the recovery rates currently achieved through the kerbside recycling systems. For example, less domestic waste generation means less additional resources recovered, less avoided landfill etc. The correlation with the waste data is clearly visible when comparing the results with Figure 2.1.

Figure 5.10: Net Environmental Benefit by Population Centre UR-3R Process® versus Landfill Disposal – Base Case (Eco$/hhld/yr)

5.3.2 Net Environmental Benefit by Impact Category

The contribution of the various impact categories to the overall result (expressed in dollar terms) is shown in this Section. At the same time, the influence of an alternative kerbside recycling system on the overall environmental performance is shown.

a) Fully Commingled Recycling

As described in Section 4, a fully commingled kerbside recycling system is the most prevalent system used in the country and has therefore been modelled as part of both the base case (landfill) and the UR-3R Facility scenario. The environmental benefits of the UR-3R Process® over and above those of the base case (including the kerbside recycling scheme) are shown in Figure 5.11. The dominant contributors to the overall benefits are clearly avoided emissions to air and water. As with the other categories, these benefits come partially from additional avoided product credits through recovery of additional recyclables, partially through compost and energy generation, and partially through avoided impacts of landfill. The contributions of the various process stages are discussed in Section 5.3.3.

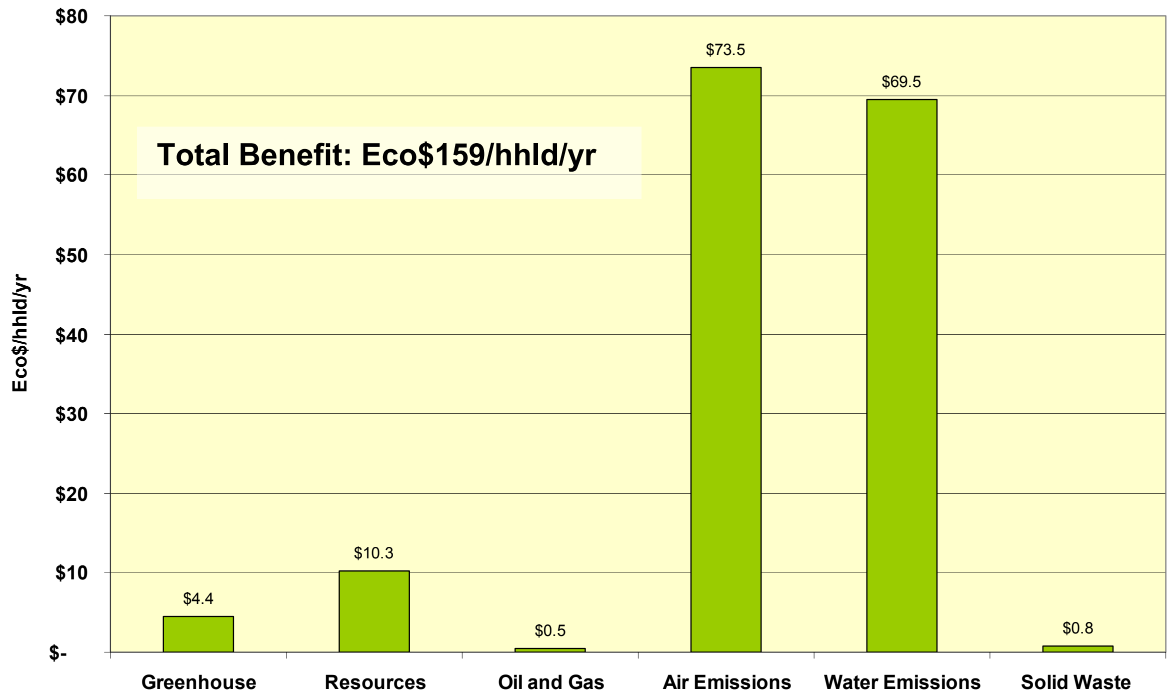

Figure 5.11: Net Environmental Benefit by Impact Category (Eco$/hhld/yr) UR-3R Process® versus Landfill Disposal - Weighted Average All Centres - Fully Commingled Recycling

Figure 5.12 depicts the environmental benefits for each impact category on a *per tonne* of waste input basis.

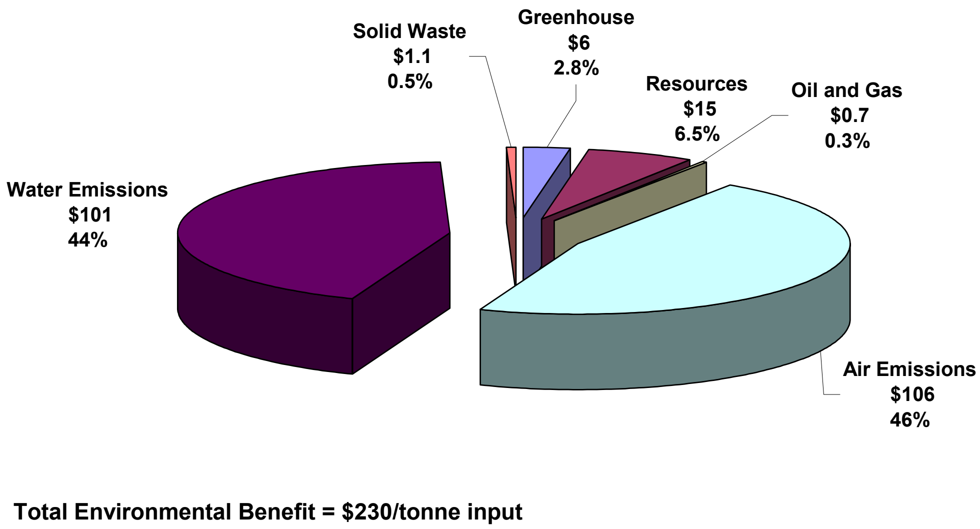

Figure 5.12: Impact Contribution per Tonne of Waste Input

[Note: Net environmental benefit for Sydney is Eco$169/hhld/yr (see Figure 5.10). Sydney domestic garbage generation is 733 kg/hhld/yr (Table 2.3). Hence net environmental benefit on a *per tonne* basis is Eco$230/tonne]

b) Monthly Paper Only Recycling

Figure 5.13 illustrates the contribution of individual impacts for a scenario where only paper is assumed to be collected separately from the kerbside on a monthly basis, with all containers assumed to be part of the garbage stream.

The relative contribution of impact categories has not changed. The overall result is almost identical (Eco$157 compared with Eco$159 for fully commingled kerbside recycling system).

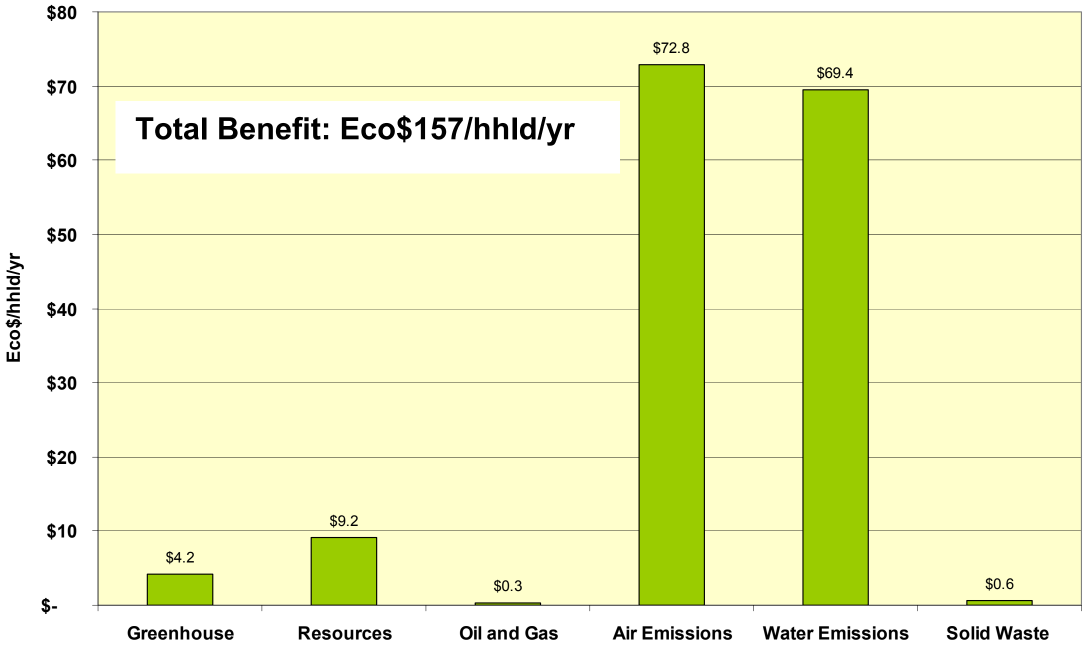

Figure 5.13: Net Environmental Benefit by Impact Category (Eco$/hhld/yr) UR-3R Process® versus Landfill Disposal - Weighted Average All Centres - Monthly Paper Only Recycling

5.3.3 Environmental Benefit by Process

The net benefit of the UR-3R Process® over landfilling is attributable not only to the avoided impacts from landfilling untreated garbage, but also from the credits associated with beneficial re-use from recovered resources, in particular recovery of Dry Recyclable Materials and OGM. The respective contribution to the total net environmental benefit through treatment and recovery has been illustrated for the Sydney population centre in Figure 5.14. It becomes clear that the predominant benefit is achieved through avoided landfill impacts. These are achieved through reduced impacts of stabilised residues requiring final (landfill) disposal plus energy recovery (Eco$75), diversion and composting of predominantly organic materials (Eco$64) and the avoided landfill impacts of dry recyclables recovery (Eco$9). Figure 5.15 presents the same results on a *per tonne* (of facility input) basis (instead of per household per year).

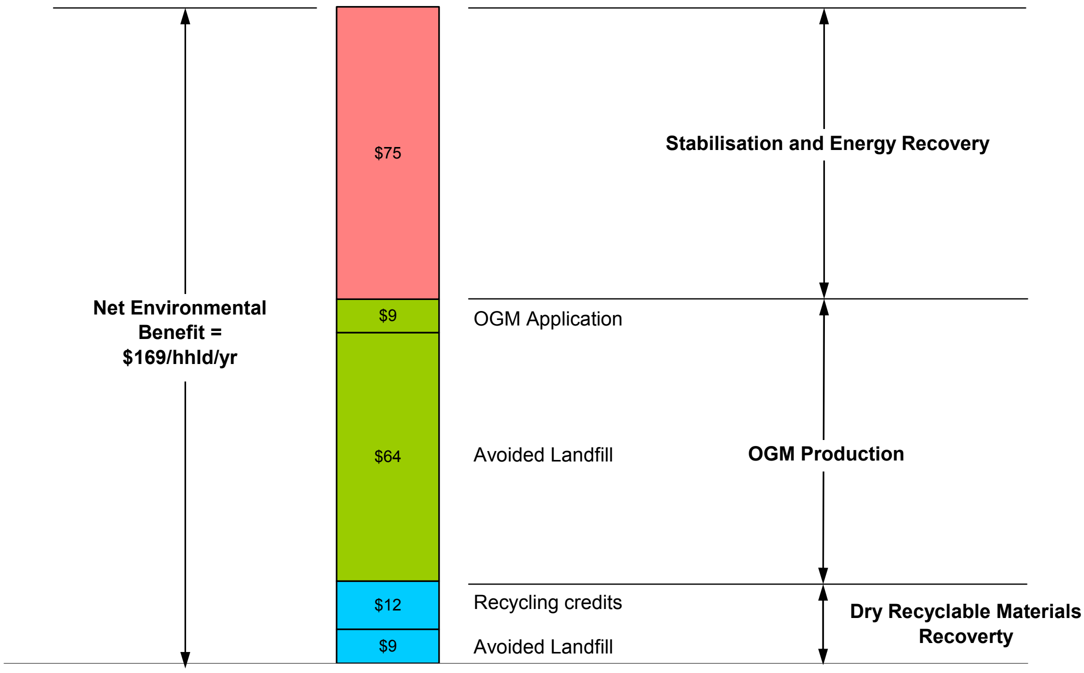

Figure 5.14: Net Environmental Benefit UR-3R Process® versus Landfill Disposal Contribution by Process, Sydney, *per Household per Year*

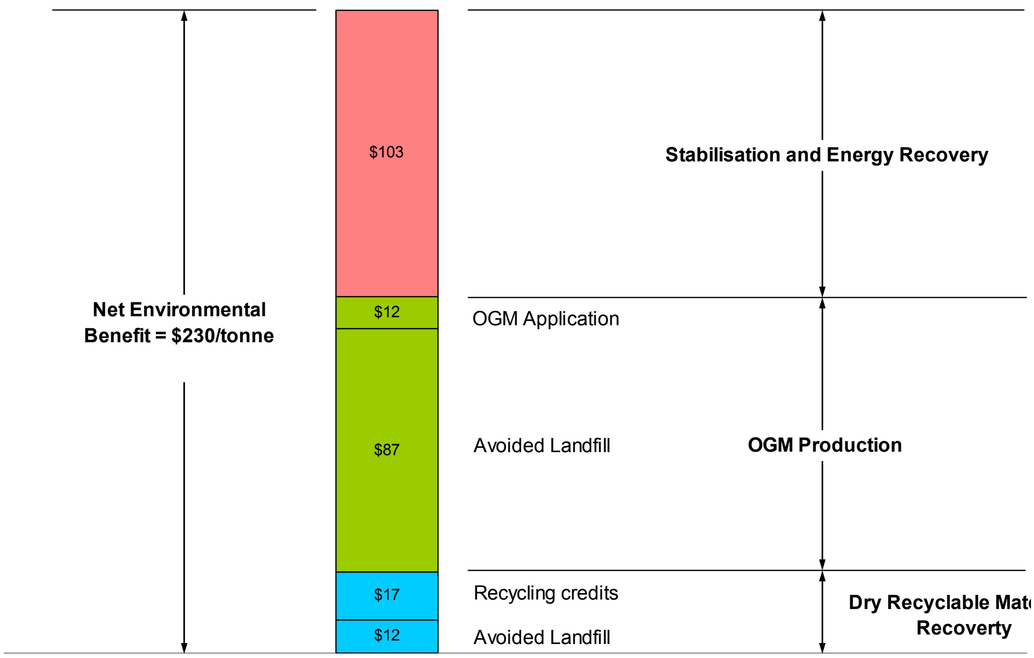

Figure 5.15: Net Environmental Benefit UR-3R Process® versus Landfill Disposal Contribution by Process, *per Tonne of Input*

5.4 Sensitivity Analysis

Four sensitivities were tested, based on the Sydney scenario. Assumptions and results are discussed below and illustrated in Figure 5.16.

5.4.1 Sensitivity Analysis 1: Production of low grade compost

No environmental benefits of compost application have been assumed other than carbon sequestration, i.e. no avoided fertiliser, pesticide, crop yield, water savings or other environmental benefits have been included in this analysis.

The production of a low grade compost reduces the overall environmental performance of an integrated waste management system employing the UR-3R Process® by just over Eco$4/hhld/yr, or around 2.5%. In this context, the authors note that, based on the current level of knowledge, the benefits from (high grade) compost application are still low compared to the avoided landfill credits.

5.4.2 Sensitivity Analysis 2: Reduced electricity generation

Electricity generation was assumed to be reduced to 50% of the designed power output for the UR-3R Process®. The effect on the overall performance is very small (around Eco$3/hhld/yr, or 2%).

5.4.3 Sensitivity Analysis 3: Landfill without energy recovery

The landfill was modelled assuming no electricity is generated from the collected gas (i.e. only flaring of gas without energy recovery). As the total amount of electricity generated at a landfill is small (compared with the magnitude of other impacts), the difference is again not highly significant (Eco$5/hhld/y or 3%).

5.4.4 Sensitivity Analysis 4: Landfill without gas capture

For this analysis it was assumed that landfill gas is not actively managed. Here, the environmental benefits of the implementing the UR-3R Process® are much more significant. This is due to the higher greenhouse gas and other air emissions occurring from landfill under these assumptions. Greenhouse gas benefits of the UR-3R Process® over landfill would triple, and the overall environmental benefit would amount to Eco$215/hhld/yr, an increase of around 30%.

In summary, this sensitivity analysis indicates that the environmental performance results do not change significantly through an adjustment of parameters. The main reason for this is that the majority of benefits are due to avoided landfill impacts. Although a wider range of LCI data has been used to model these, the calculations as well as the environmental economic valuation have been undertaken based on conservative estimates, and are comparable with earlier studies where expanded pollutant and impact ranges have been considered.

5.4.5 Sensitivity Analysis 5: Recyclables and Organics Recovery at UR-3R Facility halved

Recovery of dry recyclable materials such as paper and beverage containers is assumed to be 50% of the designed recovery. Similarly, it has been assumed that the OGM quantity produced is only 50% of that designed, and that the remainder will be disposed of to landfill as stabilised material. The net environmental benefit drops to Eco$157/hhld/yr, a reduction of Eco$12/hhld/yr or 7%. The main reason for the relatively small reduction in net environmental benefit is that composted material has significant avoided landfill emission credits even if landfilled (mass and polluting potential reduction), and that the overall net contribution from dry recyclables is not as high as other environmental performance aspects.

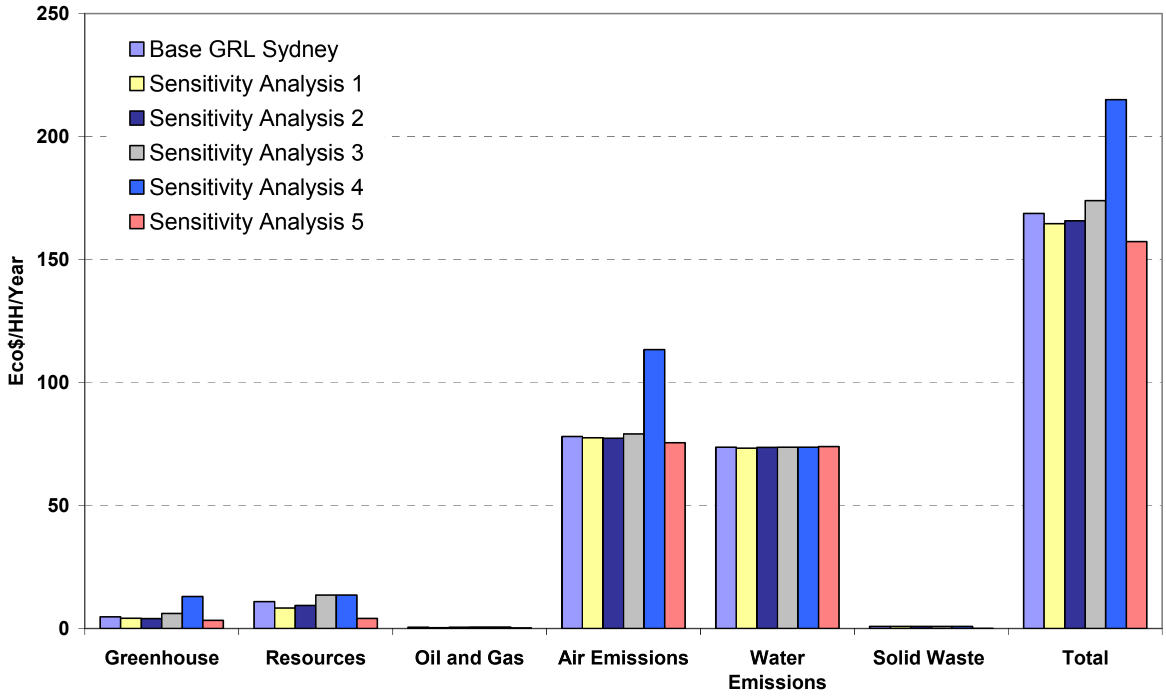

Figure 5.16: Sensitivity Analysis Results

6 COST BENEFIT ANALYSIS

This section presents the outcomes of a cost-benefit analysis of scenarios from the perspective of financial and environmental costs (expressed in dollar terms). Social costs have not been determined in dollar terms (other than as per EPA NSW, 1997) and hence have not been included here because there is insufficient literature and research conducted in Australia that would allow a robust monetary valuation of the full range of social factors.

6.1 Fully Commingled Recycling, Processing of Garbage at UR-3R Facilities

Table 6.1 shows the results of the cost benefit analysis when comparing the Global Renewables' UR-3R Process® scenario with the landfill disposal scenario, assuming 240 L MGB fortnightly fully commingled kerbside recyclables collection and weekly garbage collection.

The financial costs (garbage and recycling collection, transport, disposal and/or recovery as per Section 4) have been expressed as the difference between the calculated system costs where garbage is processed at a UR-3R Facility(ies) and the scenario where garbage is disposed of to landfill. Environmental benefits of the system incorporating the UR-3R Process® over the system where garbage is disposed to landfill have been expressed in dollar terms (for details refer to Section 5.3).

Figure 6.1 shows the costs and benefits whereby the landfill disposal scenario costs have been set at zero.

Table 6.1: Cost-Benefit Summary of Processing of Garbage using UR-3R Process® Compared to Landfilling - Base Case System

Scenario	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Financial Cost Difference $/hhld/yr	-$9	-$30	-$26	-$53	-$23	-$17	-$32	-$31	*-$25*
Environmental Benefit $/hhld/yr	$169	$123	$181	$203	$135	$96	$186	$203	*$159*
Net Cost/Benefit $/hhld/yr	$160	$93	$155	$150	$112	$79	$154	$172	*$134*

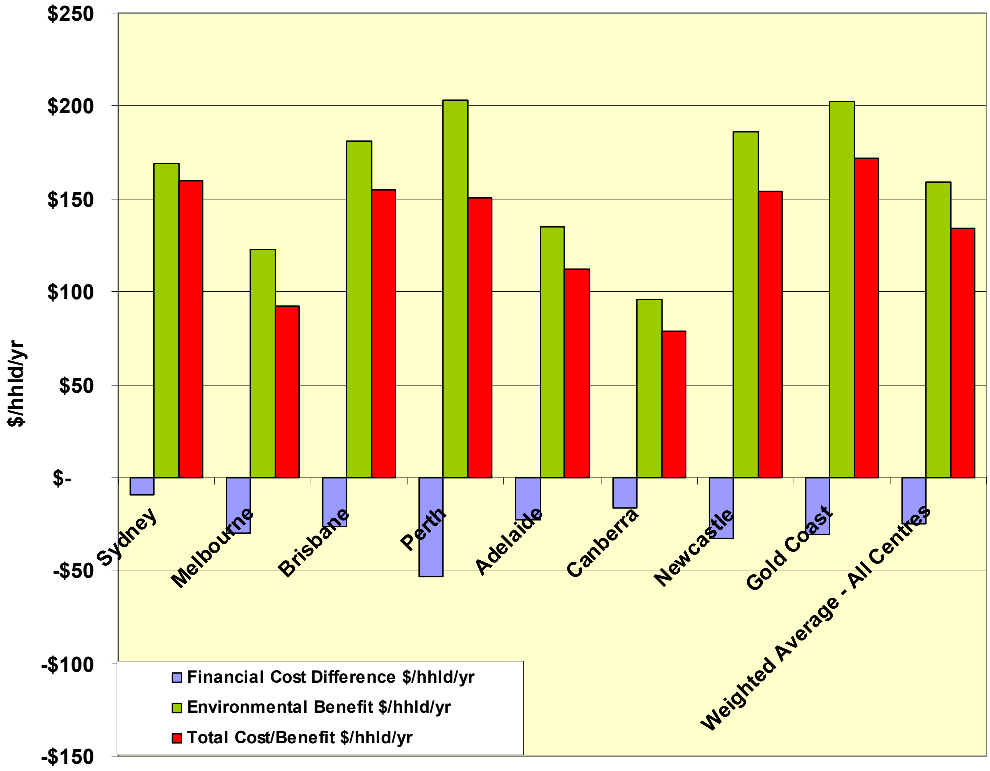

Figure 6.1: Cost-Benefit Summary: UR-3R Process® versus Landfill Disposal

When comparing the financial *costs* with the environmental *benefits* expressed in dollar terms, the processing of garbage at a UR-3R Facility(ies) results in an estimated *net benefit* of $134/hhld/yr over directing garbage to landfill. When summed over the total number of households in the population centres modelled (i.e. 4.66 Million households), the estimated annual net benefit is $624M, not including macro economic benefits (refer Section 8).

6.2 Paper Only Recycling, Processing of Garbage at UR-3R Facilities

Table 6.2 and Figure 6.2 show the results of the cost benefit analysis when comparing the scenario processing of garbage at a UR-3R Facility with monthly paper/cardboard kerbside recycling with the base case scenario of landfill disposal of garbage with 240 L MGB fortnightly fully commingled kerbside recycling.

Table 6.2: Cost-Benefit Summary of Processing of Garbage at UR-3R Facility with Monthly Paper/Cardboard Only Recycling *versus* Landfill Disposal of Garbage with Fortnightly Fully Commingled Recycling

Scenario	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	*Weighted Average - All Centres*
Financial Cost Difference $/hhld/yr	$9	-$20	-$14	-$39	-$10	$2	-$16	-$24	*-$11*
Environmental Benefit $/hhld/yr	$166	$120	$179	$201	$134	$93	$183	$201	*$157*
Net Cost/Benefit $/hhld/yr	$175	$100	$165	$161	$124	$94	$167	$177	*$146*

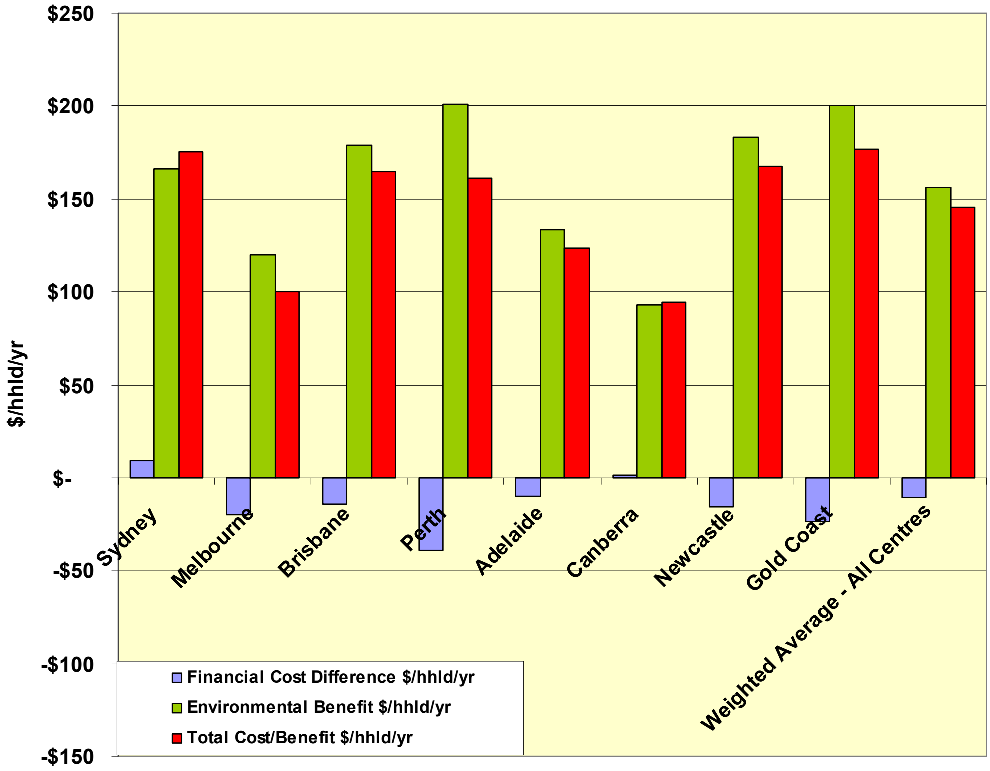

Figure 6.2: Cost-Benefit Summary: Processing of Garbage at UR-3R Facility with Monthly Paper/Cardboard Only Recycling *versus* Landfill Disposal of Garbage with Fortnightly Fully Commingled Recycling

When comparing the financial costs with the environmental benefits expressed in dollar terms, the processing of garbage at a UR-3R Facility(ies) together with monthly paper/cardboard only kerbside recycling results in an estimated net benefit of $146/hhld/yr over the system with landfill disposal of garbage and 240 L MGB fortnightly fully commingled kerbside recycling.

For this scenario the weighted average environmental *benefits* of $157/hhld/yr are slightly lower than the $159/hhld/yr for the system involving 240 L MGB fortnightly commingled recycling, with processing of garbage at a UR-3R Facility(ies). The net financial *costs* over the landfill base case for this system are however considerably lower, i.e. $11/hhld/yr for monthly paper only recycling versus $25/hhld/yr for the system involving 240 L MGB fortnightly commingled recycling. The net benefit of this scenario, taking account of both the financial cost and environmental benefit, of $146 hhld/yr is therefore higher than for the system with 240 L MGB fortnightly commingled recycling ($134/hhld/yr).

When summed over the total number of households in the population centres modelled the estimated annual net benefit is $678M (not including macro economic benefits (refer Section 8).

7 SOCIAL IMPACT ASSESSMENT

7.1 Social Context

As part of the TBL assessment of the national implementation of the UR-3R Process®, a strategic level social impact assessment has been undertaken to determine whether the inclusion of the social impacts, at a broad level, alters the thrust of the results of the quantified analysis presented earlier in this report. If the results are significantly altered, then it is usually recommended that a more detailed Social Impact Assessment (SIA) be undertaken. If the results are not significantly altered by their inclusion, the level of social impact analysis conducted here is seen as "fit for purpose".

A project team workshop was held on 10th May 2004 to identify and assess the social impacts. It should be noted that this workshop should not be interpreted as community consultation for the Eastern Creek UR-3R project. However, previous information from the community consultation process for the Eastern Creek UR-3R Facility in Sydney was provided to the project team and the workshop included personnel from Blacktown City Council and the NSW EPA who have been involved in /aware of the Eastern Creek project to date.

Waste and recycling collection and treatment systems have social costs and benefits in addition to their economic and environmental costs and benefits. At one end of the spectrum, an efficient and regular waste management system significantly contributes to social capital through the provision of health and amenity benefits – benefits largely taken for granted in the contemporary era. At the other end of the spectrum, it is unfortunately the case that waste management can adversely affect the prevailing social fabric of a community, particularly in terms of the divisiveness that can be associated with the siting of some waste management infrastructure. It is therefore important – in considering optimal waste and recycling collection and treatment system options – to also consider their social ramifications.

Within the social context, the increasing challenge for waste managers is to meet their direct objectives - such as safe and sanitary disposal of waste and increased resource recovery - while minimising implications of waste management activities on communities and involving those communities as active partners. Because of waste management's inherent social implications, it is important at the planning and decision-making phases to carefully consider and weigh up the different social costs and benefits of alternative waste management collection and treatment systems.

For this TBL Study the social impacts have been identified and compared for both the Base Case (continuation of current systems) and the Development Option – that is the implementation of the UR-3R Process® and its associated facilities throughout Australia.

The national implementation of the UR-3R Process® would involve an estimated 16 facilities similar in scale to the Eastern Creek UR-3R Facility (refer Section 2).

For the purposes of analysis it has been assumed that there are no cumulative social impacts of implementation across Australia (employment impacts, which are cumulative, are considered as part of the macro-economic impacts rather than social impacts). In other words, the social impacts are generally localised in nature. Hence the consideration of social impacts can be conducted at the local level – for example as for the Eastern Creek UR-3R Facility. There may be specific locality issues in each case, but at the level of analysis undertaken here, the broad social impacts are taken to be fairly similar in the different locations.

7.2 Impact Identification

As a starting point, the project team considered a standard set of social impact categories commonly used when conducting SIA as suggested by the widely recognised Guidelines and Principles for Social Impact Assessment developed by US Government agencies (1994)[3].

Additionally, with appropriate modifications to reflect a system-wide analysis as opposed to a technology-specific analysis, it was appropriate to maintain a consistency with past precedents, including the social impact categories in the NSW Department of Environment and Conservation's *Alternative Waste Treatment Technologies Assessment Methodology and Handbook* (DEC, 2003) and the NSW Government's *Alternative Waste Management Technologies and Practices Inquiry Report* (2000).

The role of perceptions needs to be stressed in social impact analysis. A perceived impact can in effect be a real impact for the recipient (e.g. NIMBY effect). There have certainly been situations in NSW where a community has negatively perceived a certain system or its proponents. In developing an impact assessment, it would be unrealistic to ignore this reality and therefore there needs to be a perceptions-based category of analysis, i.e. (as per the DEC AWT Handbook) - *Individual Amenity* impacts (perceived). The *Residential Amenity* impact category covers the real physical impacts.

However, a system or its proponents should not be unnecessarily or unfairly affected by perceptions-based approaches. Therefore, an additional category of *community relations* has been included, whereby a system or its proponents are given the opportunity to show good will and have their overall assessment adjusted accordingly.

As mentioned, another input into the impact identification process was the outcomes of the community consultation process undertaken for the Eastern Creek site in Sydney (firstly as part of the EIS for the proposed landfill extension and then for the UR-3R Facility itself). Summary documentation of meetings held and copies of the information given to the relevant local community have been provided to the consultants project team by Global Renewables[4]. Relevant generic impacts from this documentation were fed into the assessment process.

[3] US Interorganizational Committee – *Guidelines and Principles for Social Impact Assessment* (May 1994)

[4] Various documentation provided by Global Renewables

A number of social impacts overlap with environmental impacts and economic impacts. For example, the generation of employment has both social and economic dimensions; improved residential amenity can be associated with improved environmental outcomes. Indeed some social impacts overlap with other social impacts. A TBL assessment should avoid, where possible, the double counting of any of these impacts, although some overlap is unavoidable. We have endeavoured to keep these impact overlaps to a minimum and do not believe they are significant.

The list of social impacts to be assessed – as developed by the project team – is shown in Table 7.1.

Table 7.1: Social Impact Identification

Impact Group	Specific Impacts
Individual and Family Amenity Impacts - degree of potential ***public perception*** of risk to health, safety and/or amenity from a waste management system;	▪ Landfill – reflecting the degree to which the amount of waste sent to landfill affects the disamenity associated with landfills by local residents ▪ Reprocessing Facility – the impost on the amenity in local communities of reprocessing facilities. ▪ Acceptability of Technology – the degree to which the community accepts the required technology and any associated risks
Residential Amenity., degree of ***physically measurable*** amenity impacts	▪ Physical measures of noise , odour, dust and traffic impacts
Householder Convenience, e.g. potential for system to be convenient and accessible to householders.	▪ Convenience Factor Measure: This will be relevant if the new technology changes the convenience relative to the existing systems (e.g. waste collection systems)
Equity	▪ Inter-generational Equity – the degree to which the option improves inter-generational equity, (i.e. future environments) in line with Ecologically Sustainable Development (ESD) principles.
Natural and Cultural Heritage Impacts	▪ Assessed Impacts if not accounted for in Environmental Assessment
Safety	▪ OH&S– the occupational, health and safety issues associated with each technology / option ▪ Community – any adverse impacts on community safety
Labour Relations	▪ Likelihood of disruptive industrial action
Community Relations, e.g. inherent potential of the system to be used to foster community relations and social cohesion such as leveraging desirable community behaviours.	▪ Sense of well-being - The likely sense of well-being for the community in addressing problem ▪ Reinforcement Effect – how the option reinforces the community's knowledge of the link between solid waste and the environment ▪ Education Effort – the amount of additional effort required in education of the community to implement the new technology ▪ Consultation Required – the amount of community consultation that would be required prior to implementation
Employment, i.e. job creation	▪ this is not assessed as a social impact – it is accounted for in the macro-economic analysis (Section 8)

7.3 Assessment of Impacts

The impacts were all assessed during the workshop in the following way:

- against the Base Case – the Base Case is represented by the most prevalent solid waste management systems in place now, including kerbside recycling and disposal at landfill. The Base Case could involve, as was the situation for the Eastern Creek UR-3R Facility, the need to extend existing landfill sites, as they become full over time.
- using the following impact scale, according to whether an impact is positive (beneficial) or negative (adverse):

Negative Impact Significance	Positive Impact Significance	Score (1 is best outcome, 7 is worst)
Very Low	Very High	1
Low	High	2
Low / Medium	Medium / High	3
Medium	Medium	4
Medium / High	Low / Medium	5
High	Low	6
Very High	Very Low	7

A weighting system for the social impacts has not been employed on the basis that a wider consultation program would be required to assign weights to the impacts with any degree of certainty. This, however, does not imply lack of clarity from the assessment of social impacts.

If a clear distinction between the Base Case and the development option can be made in regard to overall social impacts without weighting, then weighting is superfluous to the analysis. Indeed, a clear result under these circumstances is, a priori, more robust than a weighted result (due to subjectivity included in the weights). Our analysis attempts to determine if a clear result is achieved without weighting.

For the rest of the TBL assessment (the economic and environmental components), two scenarios for the implementation of the UR-3R Process® are being analysed:

- Scenario 1 – with UR-3R Facilities being added to the most prevalent existing systems for kerbside collections. The UR-3R Facilities will be used to separate the recyclables that remain in the garbage stream, remove and process organic materials (as compost), generate renewable energy and reduce the environmental impact of residuals going to landfill; and

- Scenario 2 – with kerbside collections simplified to “garbage” and monthly paper collections only, using the UR-3R Facilities to separate out the recyclable containers.

For the purposes of the SIA being undertaken, there will be very little difference between the significance of impacts between the two scenarios, particularly in comparison with the Base Case (i.e. landfill disposal). The impact difference will be minor, e.g. slightly more education effort possibly required under Scenario 2 as householders will need to “unlearn” some source separation habits.

Therefore the assessment of social impacts is presented as the same for both UR-3R Facility scenarios.

The assessment is presented in Table 7.2. For each social indicator the preferred option (Base Case or UR-3R Facility Scenario) is shown by the scoring system and shading in the relevant cell).

One caveat to the assessment is that the analysis has been undertaken on the basis that the UR-3R Process® is implemented in line with the “bankable” feasibility study (GRD Minproc; 2002) i.e. the systems work as designed and risks are addressed in line with operating procedures.

Further analysis of the social impacts would be required were this not to be the case as the community would be faced by a different set of risk factors.

The key results of the SIA are:

- The analysis of social indicators provides a clear result – the UR-3R Process® is undoubtedly preferred to the Base Case in terms of social indicators.

- Whilst some additional education effort will be required initially to inform the community of the new technology, performance of UR-3R Process® for all the other social indicators is positive (or equivalent) in comparison to the Base Case.

- No weighting of the impacts is required as the result is unambiguous.

Table 7.2: Assessment of Social Impacts

Impact Category	Specific Impact	Base Case	UR-3R Facility Scenarios	Comment / Explanation
Individual Amenity	Landfill Locality Disamenity	6	4	Landfill extensions/new landfills are not desired by the community. Community perceptions favour a lower emissions based technology. Will take a number of years to reap benefits from less intensive landfill activity
	Reprocessing Facility Disamenity	4	2	A more controlled reprocessing regime under the UR-3R Facility scenarios will reap perceived benefits for the community in terms of locational issues in the medium term
	Community Acceptability of Technology	4	2	Biological process basis of the UR-3R Process® has good community acceptance. The facilities need to be built "in character" with local surrounds.
	Residential Amenity – Noise/Odour/Dust and Traffic	5	3	Enclosed, controlled facility so no direct unmitigated additional impacts from the UR-3R Facility scenarios. Reduction in waste to landfill ("face size") should allow lesser occurrence, or easier amelioration, of negative landfill impacts The UR-3R Facilities will generate some noise and additional traffic for product transport, but worsening Base Case for traffic and odour impacts.

Impact Category	Specific Impact	Base Case	UR-3R Facility Scenarios	Comment / Explanation
Convenience	Householder Convenience in Waste Management	4	4	Little difference to householder input. Process for householder could be simpler under the UR-3R Facility scenarios but re-education issue offsets this.
Equity	Inter-generational Equity	5	2	Clear advantage to UR-3R Facility scenarios achieving much higher (80%) waste diversion from landfill and reducing period of landfill impacts to less than one generation.
Cultural	Natural / Cultural Heritage Impacts	4	3	Site Specific – Impacts would be covered in EIS process with avoidance/mitigation mechanisms. Risks from footprint of extended landfills are higher than under UR-3R Facility scenarios.
Safety	Occupational Health and Safety	4	3	Likely to be slightly better OH&S with new technology based systems, although more contact with waste streams requires proper management
	Community Safety (e.g. groundwater)	4	2	Less community risks from enclosed processes. Less waste to open landfill (albeit lined landfill)
Labour Relations	Track Record in Industrial Relations / Risk of Industrial Disputes	2	2	Risks are considered low, given proper OH&S Management Plans

Impact Category	Specific Impact	Base Case	UR-3R Facility Scenarios	Comment / Explanation
Community Relations	Community Well-Being	4	2	Better environmentally and locational impacts under the UR-3R Facility scenarios.
	Solid waste and Environment Reinforcement Effect	4	3	Higher waste diversion seen as achievable by community. Under UR-3R Facility scenarios co-collection of specific materials could increase the benefit
	Education Effort Required	3	4	More effort initially required to explain new technology based option. Scenario 2 would also require re-education of community for recycling process.
	Consultation Effort Required	4	2	Given higher education effort required (above), the UR-3R Facility scenarios should reduce consultation issues once benefits identified. Strong opposition to new landfills
Other Impacts	Local Employment	4	2	Positive impact on employment (after transfer effects) in implementing new technology – economic benefit measured elsewhere in assessment. Social dimension of employment in local communities seen as an important benefit of national implementation.

8 MACRO-ECONOMIC IMPACTS

8.1 Introduction

Wider macro-economic benefits are generated from projects of this nature, although it is not possible to fully "add" them directly to dollar values in the economic evaluation. Where such impacts on the overall economy are significant, they can be important in gaining stakeholder support and / or attracting funding for projects.

The implementation of the UR-3R Process® nationally in Australia constitutes a significant infrastructure project – with capital expenditure in the order of $1.3 billion. The macro-economic benefits that are associated with such a project include:

- Job creation;
- Initial direct capital investment (measured on the cost side of the cost benefit equation) plus flow on impacts in the rest of the economy;
- Operational expenditures and indirect impacts in supply and downstream industries;
- Potential additions to state and national Gross Domestic Product, if the project is not displacing others, nor replacing a component of existing activity (the "transfer" impact – which in this project involves some downsizing of landfill activities as the resource recovery stream increases);
- Catalyst to emissions trading and resource recovery certificate trading schemes (e.g. RECs);
- Provides impetus for investment/adoption of sustainable eco-infrastructure projects in other areas (e.g. water, salinity, energy); and
- Potential impacts on the balance of trade – depending on the import and export composition of the investments and operational activities.

Clearly, the costs and benefits have to be identified at two related levels: costs/benefits that are a direct result of changes to the waste and affiliated industries; and costs/benefits that are secondary by nature, e.g. flow-on implications for the overall economy. The former are included in the cost benefit component of the TBL; the latter will be identified and documented in the overall assessment.

8.2 Quantifying the macro-economic benefits

8.2.1 Direct Expenditure

Table 8.1 shows the direct expenditure impact from the project over a 20 year period. It is assumed that the project involves 16 UR-3R Facilities nationally.

Table 8.1: Direct Expenditure Impact

Expenditure Category	$ Million (2004 prices)
Per UR-3R Facility Capital Expenditure per facility	$80
Operational Expenditure (per year)	$12
16 Facilities Capital Expenditure	$1,280
Operational Expenditure (per year)	$190
Total Expenditure (20 years)	$5,080
Present Value (20 years @ 10% real discount rate)	$2,650
Source: Global Renewables and Nolan-ITU estimates	

8.2.2 Direct Employment

Direct employment could be estimated from the direct expenditure on the project during the 20 year period using employment factors from ABS Input Output data. However, this type of data is, by its aggregated nature, prone to significant error margins, so it is preferable to use industry estimates of the jobs created (on a Full Time Equivalent basis - FTE), if these are available.

The workforce required for each UR-3R Facility's operation is a combination of unskilled, semi-skilled and experience personnel (NECS, 2002), and as such should usually be able to be sourced within local regions for each UR-3R Facility. Global Renewables has advised that, based on staff levels at the Eastern Creek UR-3R Facility, 80 FTE jobs will be created to operate each facility. In total, for the 16 facilities, this would equate to 1,280 FTE jobs nationally. However, it should be remembered that there will be some reduction in the FTE jobs in the waste management processes that this technology is replacing – e.g. landfilling, and possibly in collection and sorting. It is difficult to estimate what that reduction is likely to be due to the "fixed" components of activities (irrespective of volumes).

It would be prudent therefore to account for potential transfer impacts by reducing the direct job creation estimates by 10 % to provide the net impact. This reduction results in a job creation estimate of 1,150 FTE jobs nationally.

In addition, employment will be created during the construction period. Assuming an average construction period to full operation of 18 months, and using average employment factors from ABS input-output data for the construction sector, the average employment created for the construction phase would be 210 FTE jobs per UR-3R Facility. Nationally this would translate to 3,360 FTE jobs in Australia during the construction phase (this assumes that all jobs created are filled within Australia).

8.2.3 Indirect Impacts

Flow-on impacts from direct project expenditures and employment creation occur due to the interrelation of sectors within the economy both from suppliers and downstream industries. The waste management sector has, relatively, lower cross sector interdependencies due to:

- Its "end of pipe" or residual activity nature – many of the prior activities are for other uses (e.g. packaging is primarily for product consumption)

- Downstream sectors are relatively limited in process activities (e.g. resource recovery).

Multiplier analysis (using input-output data) is traditionally used to estimate the "flow-on" or indirect impacts from the direct data. For the economy as a whole the indirect impacts represent a multiple of 1.75[5] compared to the direct impacts (i.e. direct multiplied by 2.75 gives total output).

Given the above discussion, however, the waste management sector tends to have significantly lower "multipliers" than the average at a national level. Previous analysis of the ABS waste Management data by members of the project team, indicates the national sectoral multipliers are of the order of 2.1 (i.e. $1 in direct expenditure leads to indirect expenditure of $1.10). Applying these average sectoral factors to the direct expenditure results in total impact estimates as shown in Table 8.2.

For analytical purposes the construction period expenditures and employment generation have been converted to annual equivalence over a 20 year period.

5 ABS Catalogue 5209.0 Australian National Accounts: Input-Output Tables 1996-97

Table 8.2: Gross Economic Impacts (per annum over 20 years)

Economic Impact	Direct	Indirect	Total
Gross Output ($ million)	250	275	525
Employment (Full Time Equivalents)	1,150	630	1,780
Note: Construction period jobs and capital expenditures have been converted to annual equivalents across the 20 year period			

With national implementation, the project is expected to create the equivalent of 1,780 jobs overall (FTE) and annual expenditure of $525 million over 20 years.

In addition, the UR-3R Process® has the potential to drive end producer responsibility which will deliver materials/energy efficiency.

The UR-3R Process® will increase diversion of hazardous / toxic wastes (e.g. containers of hazardous wastes as well as batteries) for proper treatment, hence avoiding pollution from landfill disposal of these materials. Diversion and treatment of these and other materials is likely to stimulate economic activity in a form consistent with current Extended Producer Responsibility (EPR) initiatives and may link into industry EPR programs.

8.2.4 Overall GDP Impacts

The nation's production capability is currently measured by Gross Domestic Product (GDP) at a state or national level. GDP comprises the sum of the "value added" outputs of each sector (direct and indirect impacts). The value added of a sector is a proportion (generally 20-60%) of a sector's gross output. There is no available data to accurately estimate the value added share in the solid waste management sector. Therefore we have assumed that the sector achieves the "average value added share" of 35% from this project.

The gross output figures already presented also have to be adjusted for the "transfer impact" – as was applied to the employment figures. This represents the offset to additional production due to the lower level of activity required in certain other waste management activities. This factor is assumed at 25%.

Applying both these factors results in impacts from national implementation of the project on GDP is shown in Table 8.3.

Table 8.3: Impact on Gross Domestic Product ($ Million/yr)

Economic Impact	Total
Gross Output	525
Net Output (adjusted for transfers)	390
Value Added (GDP)	140

A national GDP impact of $140 million per year represents an increase in Australian GDP by 1/10 of 1%, attributable to this project. It represents around 50% of the direct expenditure associated with the project.

8.2.5 Trade Impacts

The trade impacts of the project will be mainly dependent on the following two areas:

- Imports required for the construction activities; and
- Exports of recyclable products from the project.

There is insufficient data available to estimate these components. However, given Australia's general trade patterns and export potential from this project (e.g. recycled paper/card products), it appears likely that the impact on the trade balance could be slightly negative. With an import propensity in the construction sector of 20% and assuming an export propensity of 15%, the impact on the trade balance could be of the order of (negative) $7 million per annum. Clearly these are indicative figures, but the trade impact is not expected to be a significant factor in the overall costs and benefits of the project.

The project is consistent with international trends in reducing the quantity and pollution potential of waste to landfill (e.g. European Landfill Directive; Council of The European Union (1999)). Failure by Australia to match the environmental standards required by its trading partners in their own countries may potentially be grounds for trade barriers to be imposed. The implementation of the project and other projects similar in nature could reduce this risk.

9 SUMMARY AND CONCLUSIONS

Global Renewables is currently constructing its first Urban Resource - Reduction, Recovery and Recycling (UR-3R) Facility in Sydney, Australia, with a roll-out of facilities planned throughout Australasia soon after. The design philosophy of the UR-3R Process® is the recovery of materials at their highest net resource value i.e. to conserve embodied energy as much as possible and minimise / avoid emissions of all types (i.e. solid, liquid, gaseous).

Global Renewables has commissioned Nolan-ITU to prepare a TBL assessment report on the performance of their UR-3R Process®. The report has been commissioned to identify and communicate the economic, environmental and social benefits of the technology with both simplicity and rigour. In commissioning the project, Global Renewables requested it be conducted as an independent study.

For the purpose of the study Global Renewables' UR-3R Facilities have been assumed to be implemented in each major population centre around the country. A threshold population of 300 000 was applied to determine whether a population centre was assumed to be served by a UR-3R Facility(ies). Based on the analysis, the total population served by UR-3R Facilities would be 13.1M, or 67% of the national population of 19.6M.

When applied to the garbage from each population centre and summed over all centres an estimated 353 000 tonne/yr of dry recyclable materials would be diverted from landfill and recovered for recycling by the UR-3R Process®. The recovery of dry recyclable materials would increase by an estimated 42% (i.e. from 847 000 tonne/yr to 1.20 Million tonne/yr).

OGM generated by the UR-3R Process® will be marketed for a range of landscaping and agricultural applications. When summed over all population centres, an estimated 670 000 tonnes/yr of OGM would be generated for beneficial reuse.

In addition, approximately 320 GWh of electricity would be generated annually.

The UR-3R Process® achieves a landfill diversion rate of around 80%. When summed over all the population centres, an estimated 2.6 Million tonnes/yr of domestic waste would be diverted from landfill.

The environmental analysis component of the study is based on LCA and Environmental Economic Valuation. This method quantifies material and energy inputs and outputs to the waste management system and then values these flows using established economic values. The assessment involved the development of new LCA inventory data for Australian Landfills and for the UR-3R Process®. In addition, an expanded methodology for Environmental Economic Valuation was developed and applied for the analysis. This is the first time in Australia that such a complete approach to waste systems assessment has been applied, and it highlights the importance of landfill avoidance and municipal waste pre-treatment.

The net environmental benefit of the UR-3R Process, when expressed as a weighted average across Australia's main population centres, amounts to Eco$159 per household per year, or $741M per year nationally. Table 9.1 summarises the quantifiable net benefits of a national implementation of the UR-3R Process®.

Table 9.1: Summary of Quantifiable Benefits Through UR-3R Process® Implementation

Item	$ per household per year	$ per tonne of domestic garbage	$ nationally per year
Financial Cost (increase over landfill disposal)	$25 (11)	$36 (14)	$117M (51M)
Environmental Benefit	$159 (157)	$230 (201)	$741M (732M)
Net Benefit	$134 (146)	$194 (187)	$620M (680M)
Macro Economic Benefit	-	-	$140M [1)]

[1)] plus 1,780 jobs

Figures in parentheses indicate respective costs/benefits if existing kerbside recycling systems were replaced by monthly paper only recycling (with containers recycled through waste sorting at UR-3R Facilities)

The following impacts have been examined in the TBL evaluation for the national implementation of the UR-3R Process®:

- Financial Impacts – estimated in $ values as part of the cost benefit analysis
- Environmental Impacts - estimated in $ values as part of the cost benefit analysis
- Social Impacts – examined in qualitative terms
- Macro-economic Impacts – estimated in terms of value added output and employment.

To provide an overall assessment of the project it is necessary to combine these different elements. The following key results are presented for the project option relative to the "without project" Base Case:

- The **cost benefit** analysis, as presented in Section 6, encompassing dollar valuation of the financial costs and revenues as well as the environmental benefits, indicates a very significant net benefit to the community of $130-$150 per household per annum, depending on the waste collection scenario.
- When summed over the total number of households in the population centres modelled, the estimated annual net benefit for Australia is estimated at $620-$680 million per annum

- The analysis of **social indicators** provides a positive result – the UR-3R Process® is clearly preferred to the Base Case in terms of social indicators.

- **Macro economic** benefits are also significant on a national basis, with the UR-3R Process® potentially providing 1,780 full time equivalent jobs and contributing $140 million in value added to the national economy [Note: Some economists believe it is not appropriate to directly add these to dollar values in the cost-benefit analysis].

In summary, the national implementation of the UR-3R Process® provides the following benefits:

Financial / Environmental	↔	**Significantly Positive**
Social	↔	**Significantly Positive**
Macro-economic	↔	**Positive**

As all the categories have a positive net benefit there is no need to undertake weighted summation of the different impacts – a significantly positive overall net benefit outcome will result irrespective of any weightings applied.

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Appendix A

Financial Modelling

Detailed Results by Population Centre

GRL
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WRCM Results Summary

Landfill - Fully Commingled Recycling

Item	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	Weighted Average - All Centres
$ per Household per Year									
Garbage Collection/Transport	$52	$48	$51	$56	$49	$48	$53	$52	$51
Garbage Disposal/Processing	$63	$22	$51	$34	$35	$21	$41	$48	$42
Recyclables Collection/Transport	$32	$31	$29	$32	$28	$34	$34	$26	$31
Recyclables Processing	$13	$6	$6	$9	$6	$11	$9	$4	$9
Total System Cost	$160	$107	$137	$130	$118	$113	$136	$130	$133
Cost if only Weekly Garbage Service Offered	$139	$82	$116	$100	$95	$88	$111	$108	$109
Net Cost of Recycling	$20	$25	$21	$30	$23	$25	$26	$21	$23
% Garbage	76%	72%	82%	79%	78%	58%	76%	90%	77%
% Recyclables (incl contamination)	24%	28%	18%	21%	22%	42%	24%	10%	23%

GRL - Fully Commingled Recycling

Item	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	Weighted Average - All Centres
$ per Household per Year									
Garbage Collection/Transport	$52	$48	$51	$56	$49	$48	$53	$52	$51
Garbage Disposal/Processing	$72	$52	$77	$87	$58	$38	$73	$79	$67
Recyclables Collection/Transport	$32	$31	$29	$32	$28	$34	$34	$26	$31
Recyclables Processing	$13	$6	$6	$9	$6	$11	$9	$4	$9
Total System Cost	$169	$137	$163	$183	$141	$130	$169	$161	$157
Cost if only Weekly Garbage Service Offered	$151	$124	$148	$167	$125	$117	$153	$143	$142
Net Cost of Recycling	$17	$13	$15	$16	$16	$13	$15	$18	$16
% Garbage	76%	72%	82%	79%	78%	58%	76%	90%	77%
% Recyclables (incl contamination)	24%	28%	18%	21%	22%	42%	24%	10%	23%

GRL - Monthly Paper Only Collections

Item	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	Weighted Average - All Centres
$ per Household per Year									
Garbage Collection/Transport	$53	$50	$52	$56	$50	$49	$56	$54	$52
Garbage Disposal/Processing	$81	$61	$85	$96	$63	$47	$82	$85	$76
Recyclables Collection/Transport	$18	$17	$17	$17	$17	$20	$19	$16	$17
Recyclables Processing	($2)	($2)	($3)	($1)	($2)	($3)	($5)	($1)	($2)
Total System Cost	$151	$127	$151	$169	$128	$112	$152	$154	$144
Cost if only Weekly Garbage Service Offered	$151	$124	$148	$167	$125	$117	$153	$143	$142
Net Cost of Recycling	($1)	$3	$2	$3	$3	($5)	($1)	$11	$2
% Garbage	86%	85%	91%	88%	85%	72%	86%	96%	87%
% Recyclables (incl contamination)	14%	15%	9%	12%	15%	28%	14%	4%	13%

Summary

Scenario	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Newcastle	Gold Coast	Weighted Average - All Centres
Total System Costs ($/hhld/yr)									
Landfill - Fully Commingled Recycling	$160	$107	$137	$130	$118	$113	$136	$130	$133
GRL - Fully Commingled Recycling	$169	$137	$163	$183	$141	$130	$169	$161	$157
GRL - Monthly Paper Only Collections	$151	$127	$151	$169	$128	$112	$152	$154	$144

GRL
Triple Bottom Line Assessment
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WRCM Results Summary - Fully Commingled Kerbside Recycling

Item	Unit	Sydney		Melbourne		Brisbane	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	26,179	26,179	19,061	19,061	28,149	28,149
Recyclables Collected	t/yr	8,464	8,464	7,441	7,441	6,110	6,110
Waste Collected	t/yr	34,643	34,643	26,502	26,502	34,259	34,259
Garbage Collection Cost		$ 1,863,031	$ 1,863,031	$ 1,700,824	$ 1,700,824	$ 1,820,044	$ 1,820,044
Garbage Disposal Cost		$ 2,236,416	$ 2,565,560	$ 798,217	$ 1,867,946	$ 1,814,855	$ 2,758,621
Recyclables Collection Cost		$ 1,137,496	$ 1,137,496	$ 1,099,632	$ 1,099,632	$ 1,030,809	$ 1,030,809
Recyclables Processing/Revenue		$ 465,520	$ 465,520	$ 223,232	$ 223,232	$ 213,839	$ 213,839
Total System Cost		$ 5,702,463	$ 6,031,607	$ 3,821,905	$ 4,891,634	$ 4,879,546	$ 5,823,312
Cost if only weekly garbage service offered		$ 4,973,764	$ 5,409,324	$ 2,932,114	$ 4,419,453	$ 4,143,862	$ 5,292,469
Net cost of recycling		$ 728,699	$ 622,283	$ 889,791	$ 472,180	$ 735,684	$ 530,843
Garbage Collection Cost	$/t	71	71	89	89	65	65
Garbage Disposal Cost	$/t	85	98	42	98	64	98
Recyclables Collection Cost	$/t	134	134	148	148	169	169
Recyclables Processing/Revenue	$/t	55	55	30	30	35	35
Garbage Collected	kg/hhld/yr	733	733	534	534	788	788
Recyclables Collected	kg/hhld/yr	237	237	208	208	171	171
Waste Collected	kg/hhld/yr	970	970	742	742	959	959
Garbage Collection Cost	$/hhld/yr	$ 52	$ 52	$ 48	$ 48	$ 51	$ 51
Garbage Disposal Cost	$/hhld/yr	$ 63	$ 72	$ 22	$ 52	$ 51	$ 77
Recyclables Collection Cost	$/hhld/yr	$ 32	$ 32	$ 31	$ 31	$ 29	$ 29
Recyclables Processing/Revenue	$/hhld/yr	$ 13.0	$ 13.0	$ 6.3	$ 6.3	$ 6.0	$ 6.0
Total System Cost	$/hhld/yr	$ 160	$ 169	$ 107	$ 137	$ 137	$ 163
Cost if only weekly garbage service offered	$/hhld/yr	$ 139	$ 151	$ 82	$ 124	$ 116	$ 148
Net cost of recycling	$/hhld/yr	$ 20	$ 17	$ 25	$ 13	$ 21	$ 15
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	1510.34	1510.34	1099.66	1099.66	1623.99	1623.99
per week	t/wk	503.45	503.45	366.55	366.55	541.33	541.33
per annum	t/yr	26179.22	26179.22	19060.71	19060.71	28149.23	28149.23
per household per week	kg/hhld/wk	14.10	14.10	10.26	10.26	15.16	15.16
per household per year	kg/hhld/yr	733	733	534	534	788	788
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	2110.12	2110.12	1976.72	1976.72	1715.99	1715.99
per week	t/wk	162.77	162.77	143.10	143.10	117.49	117.49
per annum	t/yr	8464.01	8464.01	7441.08	7441.08	6109.68	6109.68
per household per week	kg/hhld/wk	4.56	4.56	4.01	4.01	3.29	3.29
per household per year	kg/hhld/yr	236.99	236.99	208.35	208.35	171.07	171.07
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	78835.57	85165.27	48058.50	68630.25	69901.95	88051.31
per annum	$/yr	4099449.72	4428593.87	2499041.83	3568772.76	3634901.47	4578668.26
per tonne	$/t	156.59	169.16	131.11	187.23	129.13	162.66
per household per week	$/hhld/wk	2.21	2.38	1.35	1.92	1.96	2.47
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	30827.08	30827.08	25439.56	25439.56	23935.41	23935.41
per annum	$/yr	1603008.37	1603008.37	1322857.07	1322857.07	1244641.27	1244641.27
per tonne	$/t	189.39	189.39	177.78	177.78	203.72	203.72
per household per week	$/hhld/wk	0.86	0.86	0.71	0.71	0.67	0.67
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	109662.66	115992.35	73498.06	94069.80	93837.36	111986.72
per annum	$/yr	5702458.09	6031602.24	3821898.90	4891629.83	4879542.74	5823309.53
per household per week	$/hhld/wk	3.07	3.25	2.06	2.63	2.63	3.14
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	93290.07	101666.22	55703.26	84305.98	77415.63	99504.23
per annum	$/yr	4851083.55	5286643.36	2896569.30	4383910.82	4025612.51	5174220.20
per household per week	$/hhld/wk	2.61	2.85	1.56	2.36	2.17	2.79
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	16372.59	14326.13	17794.80	9763.83	16421.74	12482.49
per annum	$/yr	851374.54	744958.88	925329.60	507719.01	853930.23	649089.32
per household per week	$/hhld/wk	0.46	0.40	0.50	0.27	0.46	0.35

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WRCM Results Summary - Fully Commingled Kerbside Recycling

Item	Unit	Sydney		Melbourne		Brisbane	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Garbage							
Number of Trips Required	trips	84	84	62	62	91	91
Hours Taken to Collect		359	359	340	340	369	369
Hours Taken per Trip		4.28	4.28	5.48	5.48	4.05	4.05
Number of trucks required		10	10	9	9	10	10
Truck capital cost per annum		734357	734357	660921	660921	734357	734357
Truck collection cost per annum		877562	877562	788791	788791	834576	834576
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		1863031	1863031	1700824	1700824	1820044	1820044
Truck capital cost per household per annum		20.56	20.56	18.51	18.51	20.56	20.56
Truck collection cost per household per annum		24.57	24.57	22.09	22.09	23.37	23.37
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		52.17	52.17	47.62	47.62	50.96	50.96
Proportion of time truck spent collecting		75%	75%	81%	81%	74%	74%
Proportion of time truck spent in transit to depot or landfill		18%	18%	14%	14%	19%	19%
Proportion of time truck spent unloading		7%	7%	5%	5%	7%	7%
System 2 - Recycling							
Number of Trips Required		118	118	110	110	96	96
Hours Taken to Collect		395	395	383	383	365	365
Hours Taken per Trip		3.35	3.35	3.48	3.48	3.80	3.80
Number of trucks required		6	6	6	6	5	5
Truck capital cost per annum		403896	403896	403896	403896	367179	367179
Truck collection cost per annum		482489	482489	444625	444625	412519	412519
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		1137496	1137496	1099632	1099632	1030809	1030809
Truck capital cost per household per annum		11.31	11.31	11.31	11.31	10.28	10.28
Truck collection cost per household per annum		13.51	13.51	12.45	12.45	11.55	11.55
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		31.85	31.85	30.79	30.79	28.86	28.86
Proportion of time truck spent collecting		58%	58%	60%	60%	63%	63%
Proportion of time truck spent in transit to depot or landfill		31%	31%	30%	30%	27%	27%
Proportion of time truck spent unloading		11%	11%	10%	10%	9%	9%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52	52	52
System 2		26	26	26	26	26	26
System 3		0	0	0	0	0	0
Truck Visits Per property Per Year		78	78	78	78	78	78
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128	1857128	1857128
System 2		928564	928564	928564	928564	928564	928564
System 3		0	0	0	0	0	0
Total		2785692	2785692	2785692	2785692	2785692	2785692
Truck hours per collection (WRCM Output)							
Garbage		359	359	340	340	369	369
System 2		395	395	383	383	365	365
Total Truck Hours per year							
Garbage		18680	18680	17655	17655	19174	19174
System 2		10271	10271	9952	9952	9477	9477
Total		28951	28951	27607	27607	28651	28651
Truck hours per 1000 property visits		10.39	10.39	9.91	9.91	10.28	10.28
Fuel Consumption (L/hr)		12	12	12	12	12	12
Total Fuel consumption per 1000 visits		124.7	124.7	118.9	118.9	123.4	123.4
Garbage							
Collection (min/m3)		10.72	10.72	14.92	14.92	10.04	10.04
Unloading Garbage (min/m3)		1.00	1.00	1.01	1.01	1.01	1.01
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		6.56	6.56	6.97	6.97	8.07	8.07
Unloading Recyclables (min/m3)		1.21	1.21	1.20	1.20	1.21	1.21
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		4167002	4167002	3513051	3513051	1411618	1411618
Total Households		1424929	1424929	1234192	1234192	597447	597447

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WRCM Results Summary - Fully Commingled Kerbside Recycling

Item	Unit	Perth Landfill	Perth GRL	Adelaide Landfill	Adelaide GRL	Canberra Landfill	Canberra GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	31,597	31,597	21,009	21,009	14,881	14,881
Recyclables Collected	t/yr	8,215	8,215	5,931	5,931	10,714	10,714
Waste Collected	t/yr	39,813	39,813	26,939	26,939	25,595	25,595
Garbage Collection Cost		$ 1,987,289	$ 1,987,289	$ 1,765,369	$ 1,765,369	$ 1,699,438	$ 1,699,438
Garbage Disposal Cost		$ 1,200,692	$ 3,096,523	$ 1,237,794	$ 2,058,851	$ 744,042	$ 1,339,275
Recyclables Collection Cost		$ 1,127,806	$ 1,127,806	$ 1,007,094	$ 1,007,094	$ 1,224,920	$ 1,224,920
Recyclables Processing/Revenue		$ 328,615	$ 328,615	$ 207,567	$ 207,567	$ 374,997	$ 374,997
Total System Cost		$ 4,644,402	$ 6,540,232	$ 4,217,823	$ 5,038,880	$ 4,043,397	$ 4,638,630
Cost if only weekly garbage service offered		$ 3,565,111	$ 5,953,865	$ 3,396,987	$ 4,449,819	$ 3,147,199	$ 4,171,000
Net cost of recycling		$ 1,079,291	$ 586,368	$ 820,835	$ 589,061	$ 896,198	$ 467,630
Garbage Collection Cost	$/t	63	63	84	84	114	114
Garbage Disposal Cost	$/t	38	98	59	98	50	90
Recyclables Collection Cost	$/t	137	137	170	170	114	114
Recyclables Processing/Revenue	$/t	40	40	35	35	35	35
Garbage Collected	kg/hhld/yr	885	885	588	588	417	417
Recyclables Collected	kg/hhld/yr	230	230	166	166	300	300
Waste Collected	kg/hhld/yr	1115	1115	754	754	717	717
Garbage Collection Cost	$/hhld/yr	$ 56	$ 56	$ 49	$ 49	$ 48	$ 48
Garbage Disposal Cost	$/hhld/yr	$ 34	$ 87	$ 35	$ 58	$ 21	$ 38
Recyclables Collection Cost	$/hhld/yr	$ 32	$ 32	$ 28	$ 28	$ 34	$ 34
Recyclables Processing/Revenue	$/hhld/yr	$ 9.2	$ 9.2	$ 5.8	$ 5.8	$ 10.5	$ 10.5
Total System Cost	$/hhld/yr	$ 130	$ 183	$ 118	$ 141	$ 113	$ 130
Cost if only weekly garbage service offered	$/hhld/yr	$ 100	$ 167	$ 95	$ 125	$ 88	$ 117
Net cost of recycling	$/hhld/yr	$ 30	$ 16	$ 23	$ 16	$ 25	$ 13
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	1822.92	1822.92	1212.04	1212.04	858.51	858.51
per week	t/wk	607.64	607.64	404.01	404.01	286.17	286.17
per annum	t/yr	31597.21	31597.21	21008.72	21008.72	14880.87	14880.87
per household per week	kg/hhld/wk	17.01	17.01	11.31	11.31	8.01	8.01
per household per year	kg/hhld/yr	885	885	588	588	417	417
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	2029.29	2029.29	1448.39	1448.39	2649.23	2649.23
per week	t/wk	157.99	157.99	114.05	114.05	206.04	206.04
per annum	t/yr	8215.38	8215.38	5930.48	5930.48	10714.20	10714.20
per household per week	kg/hhld/wk	4.42	4.42	3.19	3.19	5.77	5.77
per household per year	kg/hhld/yr	230.03	230.03	166.05	166.05	300.00	300.00
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	61307.35	97765.67	57753.16	73542.76	46990.04	58436.86
per annum	$/yr	3187982.45	5083814.92	3003164.49	3824223.64	2443481.85	3038716.67
per tonne	$/t	100.89	160.89	142.95	182.03	164.20	204.20
per household per week	$/hhld/wk	1.72	2.74	1.62	2.06	1.32	1.64
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	28007.94	28007.94	23358.74	23358.74	30767.42	30767.42
per annum	$/yr	1456412.84	1456412.84	1214654.32	1214654.32	1599905.85	1599905.85
per tonne	$/t	177.28	177.28	204.82	204.82	149.33	149.33
per household per week	$/hhld/wk	0.78	0.78	0.65	0.65	0.86	0.86
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	89315.29	125773.61	81111.90	96901.50	77757.46	89204.28
per annum	$/yr	4644395.29	6540227.76	4217818.81	5038877.96	4043387.70	4638622.51
per household per week	$/hhld/wk	2.50	3.52	2.27	2.71	2.18	2.50
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	67477.49	113415.09	64645.07	84891.86	59821.22	79509.74
per annum	$/yr	3508829.45	5897584.86	3361543.50	4414376.51	3110703.66	4134506.47
per household per week	$/hhld/wk	1.89	3.18	1.81	2.38	1.68	2.23
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	21837.80	12358.52	16466.83	12009.64	17936.23	9694.54
per annum	$/yr	1135565.83	642642.90	856275.32	624501.45	932684.04	504116.04
per household per week	$/hhld/wk	0.61	0.35	0.46	0.34	0.50	0.27

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WRCM Results Summary - Fully Commingled Kerbside Recycling

Item	Unit	Perth		Adelaide		Canberra	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Garbage							
Number of Trips Required	trips	102	102	68	68	48	48
Hours Taken to Collect		380	380	345	345	322	322
Hours Taken per Trip		3.73	3.73	5.07	5.07	6.72	6.72
Number of trucks required		11	11	10	10	9	9
Truck capital cost per annum		807793	807793	734357	734357	660921	660921
Truck collection cost per annum		928385	928385	779900	779900	787406	787406
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		1987289	1987289	1765369	1765369	1699438	1699438
Truck capital cost per household per annum		22.62	22.62	20.56	20.56	18.51	18.51
Truck collection cost per household per annum		25.99	25.99	21.84	21.84	22.05	22.05
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		55.64	55.64	49.43	49.43	47.58	47.58
Proportion of time truck spent collecting		71%	71%	79%	79%	84%	84%
Proportion of time truck spent in transit to depot or landfill		21%	21%	15%	15%	11%	11%
Proportion of time truck spent unloading		8%	8%	6%	6%	4%	4%
System 2 - Recycling							
Number of Trips Required		113	113	81	81	148	148
Hours Taken to Collect		387	387	344	344	437	437
Hours Taken per Trip		3.43	3.43	4.24	4.24	2.95	2.95
Number of trucks required		6	6	5	5	6	6
Truck capital cost per annum		403896	403896	367179	367179	440614	440614
Truck collection cost per annum		472798	472798	388804	388804	533194	533194
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		1127806	1127806	1007094	1007094	1224920	1224920
Truck capital cost per household per annum		11.31	11.31	10.28	10.28	12.34	12.34
Truck collection cost per household per annum		13.24	13.24	10.89	10.89	14.93	14.93
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		31.58	31.58	28.20	28.20	34.30	34.30
Proportion of time truck spent collecting		59%	59%	67%	67%	53%	53%
Proportion of time truck spent in transit to depot or landfill		30%	30%	24%	24%	35%	35%
Proportion of time truck spent unloading		11%	11%	8%	8%	12%	12%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52	52	52
System 2		26	26	26	26	26	26
System 3		0	0	0	0	0	0
Truck Visits Per property Per Year		78	78	78	78	78	78
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128	1857128	1857128
System 2		928564	928564	928564	928564	928564	928564
System 3		0	0	0	0	0	0
Total		2785692	2785692	2785692	2785692	2785692	2785692
Truck hours per collection (WRCM Output)							
Garbage		380	380	345	345	322	322
System 2		387	387	344	344	437	437
Total Truck Hours per year							
Garbage		19762	19762	17917	17917	16761	16761
System 2		10064	10064	8932	8932	11350	11350
Total		29827	29827	26850	26850	28111	28111
Truck hours per 1000 property visits		10.71	10.71	9.64	9.64	10.09	10.09
Fuel Consumption (L/hr)		12	12	12	12	12	12
Total Fuel consumption per 1000 visits		128.5	128.5	115.7	115.7	121.1	121.1
Garbage							
Collection (min/m3)		8.93	8.93	13.47	13.47	18.96	18.96
Unloading Garbage (min/m3)		1.01	1.01	1.01	1.01	1.01	1.01
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		6.80	6.80	9.56	9.56	5.22	5.22
Unloading Recyclables (min/m3)		1.20	1.20	1.21	1.21	1.21	1.21
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		1411618	1411618	1113765	1113765	321134	321134
Total Households		508494	508494	427742	427742	113959	113959

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WRCM Results Summary - Fully Commingled Kerbside Recycling

Item	Unit	Newcastle		Gold Coast		Weighted Average - All Centres	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact	Fortnightly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	28,966	28,966	31,420	31,420	24682	24682
Recyclables Collected	t/yr	9,188	9,188	3,684	3,684	7541	7541
Waste Collected	t/yr	38,154	38,154	35,104	35,104	32223	32223
Garbage Collection Cost		$ 1,886,853	$ 1,886,853	$ 1,840,668	$ 1,840,668	$ 1,815,215	$ 1,815,215
Garbage Disposal Cost		$ 1,448,299	$ 2,606,938	$ 1,728,104	$ 2,827,806	$ 1,510,735	$ 2,397,905
Recyclables Collection Cost		$ 1,213,067	$ 1,213,067	$ 943,202	$ 943,202	$ 1,098,748	$ 1,098,748
Recyclables Processing/Revenue		$ 321,588	$ 321,588	$ 128,931	$ 128,931	$ 310,360	$ 310,360
Total System Cost		$ 4,869,807	$ 6,028,446	$ 4,640,905	$ 5,740,607	$ 4,735,059	$ 5,622,229
Cost if only weekly garbage service offered		$ 3,948,725	$ 5,474,893	$ 3,874,595	$ 5,103,228	$ 3,903,098	$ 5,064,346
Net cost of recycling		$ 921,082	$ 553,553	$ 766,309	$ 637,379	$ 831,961	$ 557,883
Garbage Collection Cost	$/t	65	65	59	59	74	74
Garbage Disposal Cost	$/t	50	90	55	90	61	97
Recyclables Collection Cost	$/t	132	132	256	256	146	146
Recyclables Processing/Revenue	$/t	35	35	35	35	41	41
Garbage Collected	kg/hhld/yr	811	811	880	880	691.1	691.1
Recyclables Collected	kg/hhld/yr	257	257	103	103	211.1	211.1
Waste Collected	kg/hhld/yr	1068	1068	983	983	902.3	902.3
Garbage Collection Cost	$/hhld/yr	$ 53	$ 53	$ 52	$ 52	50.8	50.8
Garbage Disposal Cost	$/hhld/yr	$ 41	$ 73	$ 48	$ 79	42.3	67.1
Recyclables Collection Cost	$/hhld/yr	$ 34	$ 34	$ 26	$ 26	30.8	30.8
Recyclables Processing/Revenue	$/hhld/yr	$ 9.0	$ 9.0	$ 3.6	$ 3.6	8.7	8.7
Total System Cost	$/hhld/yr	$ 136	$ 169	$ 130	$ 161	132.6	157.4
Cost if only weekly garbage service offered	$/hhld/yr	$ 111	$ 153	$ 108	$ 143	109.3	141.8
Net cost of recycling	$/hhld/yr	$ 26	$ 15	$ 21	$ 18	23.3	15.6
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	1671.12	1671.12	1812.70	1812.70	1424.0	1424.0
per week	t/wk	557.04	557.04	604.23	604.23	474.7	474.7
per annum	t/yr	28966.01	28966.01	31420.11	31420.11	24682.5	24682.5
per household per week	kg/hhld/wk	15.60	15.60	16.92	16.92	13.3	13.3
per household per year	kg/hhld/yr	811	811	880	880	691	691
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	2523.54	2523.54	1121.49	1121.49	1947.9	1947.9
per week	t/wk	176.70	176.70	70.84	70.84	145.0	145.0
per annum	t/yr	9188.24	9188.24	3683.73	3683.73	7540.6	7540.6
per household per week	kg/hhld/wk	4.95	4.95	1.98	1.98	4.1	4.1
per household per year	kg/hhld/yr	257.27	257.27	103.15	103.15	211.1	211.1
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	64137.58	86419.12	68630.27	89778.42	63960.6	81021.6
per annum	$/yr	3335153.92	4493794.43	3568774.26	4668477.95	3325952.4	4213123.6
per tonne	$/t	115.14	155.14	113.58	148.58	136.0	173.0
per household per week	$/hhld/wk	1.80	2.42	1.92	2.51	1.79	2.27
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	29512.42	29512.42	20617.86	20617.86	27098.1	27098.1
per annum	$/yr	1534646.00	1534646.00	1072128.95	1072128.95	1409101.2	1409101.2
per tonne	$/t	167.02	167.02	291.04	291.04	190.1	190.1
per household per week	$/hhld/wk	0.83	0.83	0.58	0.58	0.76	0.76
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	93650.00	115931.55	89248.14	110396.29	91058.7	108119.7
per annum	$/yr	4869799.92	6028440.43	4640903.21	5740606.90	4735053.6	5622224.8
per household per week	$/hhld/wk	2.62	3.25	2.50	3.09	2.5	3.0
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	73484.73	102834.16	72213.90	95841.48	73488.3	95820.1
per annum	$/yr	3821206.17	5347376.21	3755122.88	4983757.20	3821394.1	4982644.0
per household per week	$/hhld/wk	2.06	2.88	2.02	2.68	2.1	2.7
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	20165.26	13097.39	17034.24	14554.80	17570.4	12299.6
per annum	$/yr	1048593.75	681064.22	885780.33	756849.70	913659.4	639580.8
per household per week	$/hhld/wk	0.56	0.37	0.48	0.41	0.49	0.34

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Item	Unit	Newcastle		Gold Coast		Weighted Average - All Centres	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Garbage							
Number of Trips Required	trips	93	93	101	101		
Hours Taken to Collect		369	369	378	378		
Hours Taken per Trip		3.97	3.97	3.74	3.74		
Number of trucks required		10	10	10	10		
Truck capital cost per annum		734357	734357	734357	734357		
Truck collection cost per annum		901385	901385	855200	855200		
Bin cost (amortized) per annum		218357	218357	218357	218357		
Total cost per annum		1886853	1886853	1840668	1840668		
Truck capital cost per household per annum		20.56	20.56	20.56	20.56		
Truck collection cost per household per annum		25.24	25.24	23.95	23.95		
Bin cost per household per annum		7.03	7.03	7.03	7.03		
Total cost per household per annum		52.83	52.83	51.54	51.54		
Proportion of time truck spent collecting		73%	73%	72%	72%	76%	76%
Proportion of time truck spent in transit to depot or landfill		19%	19%	20%	20%	17%	17%
Proportion of time truck spent unloading		8%	8%	8%	8%	7%	7%
System 2 - Recycling							
Number of Trips Required		141	141	63	63		
Hours Taken to Collect		427	427	320	320		
Hours Taken per Trip		3.03	3.03	5.07	5.07		
Number of trucks required		6	6	5	5		
Truck capital cost per annum		440614	440614	330461	330461		
Truck collection cost per annum		521341	521341	361630	361630		
Bin cost (amortized) per annum		218357	218357	218357	218357		
Total cost per annum		1213067	1213067	943202	943202		
Truck capital cost per household per annum		12.34	12.34	9.25	9.25		
Truck collection cost per household per annum		14.60	14.60	10.13	10.13		
Bin cost per household per annum		7.03	7.03	7.03	7.03		
Total cost per household per annum		33.97	33.97	26.41	26.41		
Proportion of time truck spent collecting		54%	54%	73%	73%	61%	61%
Proportion of time truck spent in transit to depot or landfill		34%	34%	20%	20%	29%	29%
Proportion of time truck spent unloading		12%	12%	7%	7%	10%	10%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52		
System 2		26	26	26	26		
System 3		0	0	0	0		
Truck Visits Per property Per Year		78	78	78	78		
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128		
System 2		928564	928564	928564	928564		
System 3		0	0	0	0		
Total		2785692	2785692	2785692	2785692		
Truck hours per collection (WRCM Output)							
Garbage		369	369	378	378	356	356
System 2		427	427	320	320	382	382
Total Truck Hours per year							
Garbage		19188	19188	19647	19647		
System 2		11098	11098	8308	8308		
Total		30285	30285	27955	27955		
Truck hours per 1000 property visits		10.87	10.87	10.04	10.04		
Fuel Consumption (L/hr)		12	12	12	12		
Total Fuel consumption per 1000 visits		130.5	130.5	120.4	120.4		
Garbage							
Collection (min/m3)		9.69	9.69	8.95	8.95	11.46	11.46
Unloading Garbage (min/m3)		1.00	1.00	1.00	1.00	1.00	1.00
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		5.48	5.48	12.41	12.41	7.13	7.13
Unloading Recyclables (min/m3)		1.21	1.21	1.21	1.21	1.20	1.20
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		496990	496990	439374	439374	12874552	12874552
Total Households		179893	179893	168617	168617	4655273	4655273

GRL
Triple Bottom Line Assessment
4075-08
WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Sydney		Melbourne		Brisbane	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	29,700	29,700	22,400	22,400	31,055	31,055
Recyclables Collected	t/yr	4,943	4,943	4,102	4,102	3,204	3,204
Waste Collected	t/yr	34,643	34,643	26,502	26,502	34,259	34,259
Garbage Collection Cost		$ 1,899,098	$ 1,899,098	$ 1,791,473	$ 1,791,473	$ 1,839,323	$ 1,839,323
Garbage Disposal Cost		$ 2,537,211	$ 2,910,624	$ 938,065	$ 2,195,212	$ 2,002,188	$ 3,043,371
Recyclables Collection Cost		$ 646,716	$ 646,716	$ 609,301	$ 609,301	$ 592,303	$ 592,303
Recyclables Processing/Revenue		-$ 74,144	-$ 74,144	-$ 61,524	-$ 61,524	-$ 96,122	-$ 96,122
Total System Cost		$ 5,008,880	$ 5,382,293	$ 3,277,315	$ 4,534,461	$ 4,337,693	$ 5,378,876
Cost if only weekly garbage service offered		$ 4,973,764	$ 5,409,324	$ 2,932,114	$ 4,419,453	$ 4,143,862	$ 5,292,469
Net cost of recycling		$ 35,116	-$ 27,031	$ 345,201	$ 115,008	$ 193,831	$ 86,407
Garbage Collection Cost	$/t	64	64	80	80	59	59
Garbage Disposal Cost	$/t	85	98	42	98	64	98
Recyclables Collection Cost	$/t	131	131	149	149	185	185
Recyclables Processing/Revenue	$/t	-15	-15	-15	-15	-30	-30
Garbage Collected	kg/hhld/yr	832	832	627	627	870	870
Recyclables Collected	kg/hhld/yr	138	138	115	115	90	90
Waste Collected	kg/hhld/yr	970	970	742	742	959	959
Garbage Collection Cost	$/hhld/yr	$ 53	$ 53	$ 50	$ 50	$ 52	$ 52
Garbage Disposal Cost	$/hhld/yr	$ 71	$ 81	$ 26	$ 61	$ 56	$ 85
Recyclables Collection Cost	$/hhld/yr	$ 18	$ 18	$ 17	$ 17	$ 17	$ 17
Recyclables Processing/Revenue	$/hhld/yr	-$ 2.1	-$ 2.1	-$ 1.7	-$ 1.7	-$ 2.7	-$ 2.7
Total System Cost	$/hhld/yr	$ 140	$ 151	$ 92	$ 127	$ 121	$ 151
Cost if only weekly garbage service offered	$/hhld/yr	$ 139	$ 151	$ 82	$ 124	$ 116	$ 148
Net cost of recycling	$/hhld/yr	$ 1	-$ 1	$ 10	$ 3	$ 5	$ 2
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	1713.48	1713.48	1292.32	1292.32	1791.63	1791.63
per week	t/wk	571.16	571.16	430.77	430.77	597.21	597.21
per annum	t/yr	29700.39	29700.39	22400.27	22400.27	31054.96	31054.96
per household per week	kg/hhld/wk	15.99	15.99	12.06	12.06	16.72	16.72
per household per year	kg/hhld/yr	832	832	627	627	870	870
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	1478.85	1478.85	1280.82	1280.82	1039.75	1039.75
per week	t/wk	95.06	95.06	78.88	78.88	61.62	61.62
per annum	t/yr	4942.95	4942.95	4101.63	4101.63	3204.06	3204.06
per household per week	kg/hhld/wk	2.66	2.66	2.21	2.21	1.73	1.73
per household per year	kg/hhld/yr	138.40	138.40	114.85	114.85	89.71	89.71
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	85313.87	92494.92	52491.24	76667.29	73875.41	93898.25
per annum	$/yr	4436321.09	4809735.98	2729544.32	3986699.17	3841521.08	4882709.11
per tonne	$/t	149.37	161.94	121.85	177.98	123.70	157.23
per household per week	$/hhld/wk	2.39	2.59	1.47	2.15	2.07	2.63
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	11010.90	11010.90	10534.09	10534.09	9541.89	9541.89
per annum	$/yr	572566.59	572566.59	547772.42	547772.42	496178.43	496178.43
per tonne	$/t	115.84	115.84	133.55	133.55	154.86	154.86
per household per week	$/hhld/wk	0.31	0.31	0.29	0.29	0.27	0.27
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	96324.76	103505.82	63025.32	87201.38	83417.30	103440.14
per annum	$/yr	5008887.68	5382302.57	3277316.75	4534471.59	4337699.50	5378887.54
per household per week	$/hhld/wk	2.70	2.90	1.76	2.44	2.34	2.90
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	93290.21	101666.39	55703.29	84306.14	77415.73	99504.41
per annum	$/yr	4851090.93	5286652.15	2896571.33	4383919.10	4025617.71	5174229.13
per household per week	$/hhld/wk	2.61	2.85	1.56	2.36	2.17	2.79
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	3034.55	1839.43	7322.03	2895.24	6001.57	3935.74
per annum	$/yr	157796.75	95650.42	380745.42	150552.49	312081.80	204658.41
per household per week	$/hhld/wk	0.08	0.05	0.21	0.08	0.17	0.11

GRL
Triple Bottom Line Assessment
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WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Sydney Landfill	Sydney GRL	Melbourne Landfill	Melbourne GRL	Brisbane Landfill	Brisbane GRL
Summary Information for Reporting							
Garbage							
Number of Trips Required	trips	96	96	72	72	100	100
Hours Taken to Collect		374	374	347	347	377	377
Hours Taken per Trip		3.90	3.90	4.82	4.82	3.77	3.77
Number of trucks required		10	10	10	10	10	10
Truck capital cost per annum		734357	734357	734357	734357	734357	734357
Truck collection cost per annum		913630	913630	806005	806005	853855	853855
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		1899098	1899098	1791473	1791473	1839323	1839323
Truck capital cost per household per annum		20.56	20.56	20.56	20.56	20.56	20.56
Truck collection cost per household per annum		25.58	25.58	22.57	22.57	23.91	23.91
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		53.18	53.18	50.16	50.16	51.50	51.50
Proportion of time truck spent collecting		73%	73%	78%	78%	72%	72%
Proportion of time truck spent in transit to depot or landfill		20%	20%	16%	16%	20%	20%
Proportion of time truck spent unloading		8%	8%	6%	6%	8%	8%
System 2 - Recycling							
Number of Trips Required		83	83	72	72	58	58
Hours Taken to Collect		347	347	332	332	311	311
Hours Taken per Trip		4.18	4.18	4.61	4.61	5.36	5.36
Number of trucks required		3	3	3	3	3	3
Truck capital cost per annum		183589	183589	165230	165230	165230	165230
Truck collection cost per annum		212015	212015	192960	192960	175962	175962
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		646716	646716	609301	609301	592303	592303
Truck capital cost per household per annum		5.14	5.14	4.63	4.63	4.63	4.63
Truck collection cost per household per annum		5.94	5.94	5.40	5.40	4.93	4.93
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		18.11	18.11	17.06	17.06	16.58	16.58
Proportion of time truck spent collecting		67%	67%	70%	70%	74%	74%
Proportion of time truck spent in transit to depot or landfill		25%	25%	22%	22%	19%	19%
Proportion of time truck spent unloading		9%	9%	8%	8%	7%	7%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52	52	52
System 2		12	12	12	12	12	12
System 3		0	0	0	0	0	0
Truck Visits Per property Per Year		64	64	64	64	64	64
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128	1857128	1857128
System 2		428568	428568	428568	428568	428568	428568
Total		2285696	2285696	2285696	2285696	2285696	2285696
Truck hours per collection (WRCM Output)							
Garbage		374	374	347	347	377	377
System 2		347	347	332	332	311	311
Total Truck Hours per year							
Garbage		19448	19448	18041	18041	19616	19616
System 2		4166	4166	3987	3987	3732	3732
Total		23614	23614	22027	22027	23348	23348
Truck hours per 1000 property visits		10.33	10.33	9.64	9.64	10.21	10.21
Fuel Consumption (L/hr)		12	12	12	12	12	12
Total Fuel consumption per 1000 visits		124.0	124.0	115.6	115.6	122.6	122.6
Garbage							
Collection (min/m3)		9.52	9.52	12.55	12.55	9.07	9.07
Unloading Garbage (min/m3)		1.01	1.01	1.00	1.00	1.00	1.00
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		9.40	9.40	10.87	10.87	13.29	13.29
Unloading Recyclables (min/m3)		1.21	1.21	1.21	1.21	1.20	1.20
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		4167002	4167002	3513051	3513051	1411618	1411618
Total Households		1424929	1424929	1234192	1234192	597447	597447

GRL
Triple Bottom Line Assessment
4075-08
WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Perth		Adelaide		Canberra	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	35,082	35,082	22,957	22,957	18,452	18,452
Recyclables Collected	t/yr	4,731	4,731	3,982	3,982	7,143	7,143
Waste Collected	t/yr	39,813	39,813	26,939	26,939	25,595	25,595
Garbage Collection Cost		$ 2,014,446	$ 2,014,446	$ 1,777,276	$ 1,777,276	$ 1,735,992	$ 1,735,992
Garbage Disposal Cost		$ 1,333,100	$ 3,437,995	$ 1,352,612	$ 2,249,831	$ 922,612	$ 1,660,701
Recyclables Collection Cost		$ 623,386	$ 623,386	$ 602,031	$ 602,031	$ 699,147	$ 699,147
Recyclables Processing/Revenue		-$ 23,655	-$ 23,655	-$ 59,726	-$ 59,726	-$ 107,142	-$ 107,142
Total System Cost		$ 3,947,277	$ 6,052,172	$ 3,672,193	$ 4,569,413	$ 3,250,608	$ 3,988,697
Cost if only weekly garbage service offered		$ 3,565,111	$ 5,953,865	$ 3,396,987	$ 4,449,819	$ 3,147,199	$ 4,171,000
Net cost of recycling		$ 382,166	$ 98,308	$ 275,206	$ 119,594	$ 103,409	-$ 182,303
Garbage Collection Cost	$/t	57	57	77	77	94	94
Garbage Disposal Cost	$/t	38	98	59	98	50	90
Recyclables Collection Cost	$/t	132	132	151	151	98	98
Recyclables Processing/Revenue	$/t	-5	-5	-15	-15	-15	-15
Garbage Collected	kg/hhld/yr	982	982	643	643	517	517
Recyclables Collected	kg/hhld/yr	132	132	111	111	200	200
Waste Collected	kg/hhld/yr	1115	1115	754	754	717	717
Garbage Collection Cost	$/hhld/yr	$ 56	$ 56	$ 50	$ 50	$ 49	$ 49
Garbage Disposal Cost	$/hhld/yr	$ 37	$ 96	$ 38	$ 63	$ 26	$ 47
Recyclables Collection Cost	$/hhld/yr	$ 17	$ 17	$ 17	$ 17	$ 20	$ 20
Recyclables Processing/Revenue	$/hhld/yr	-$ 0.7	-$ 0.7	-$ 1.7	-$ 1.7	-$ 3.0	-$ 3.0
Total System Cost	$/hhld/yr	$ 111	$ 169	$ 103	$ 128	$ 91	$ 112
Cost if only weekly garbage service offered	$/hhld/yr	$ 100	$ 167	$ 95	$ 125	$ 88	$ 117
Net cost of recycling	$/hhld/yr	$ 11	$ 3	$ 8	$ 3	$ 3	-$ 5
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	2023.95	2023.95	1324.48	1324.48	1064.56	1064.56
per week	t/wk	674.65	674.65	441.49	441.49	354.85	354.85
per annum	t/yr	35081.73	35081.73	22957.61	22957.61	18452.38	18452.38
per household per week	kg/hhld/wk	18.89	18.89	12.36	12.36	9.94	9.94
per household per year	kg/hhld/yr	982	982	643	643	517	517
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	1396.89	1396.89	1226.90	1226.90	2221.44	2221.44
per week	t/wk	90.98	90.98	76.57	76.57	137.36	137.36
per annum	t/yr	4730.97	4730.97	3981.70	3981.70	7142.80	7142.80
per household per week	kg/hhld/wk	2.55	2.55	2.14	2.14	3.85	3.85
per household per year	kg/hhld/yr	132.47	132.47	111.49	111.49	200.00	200.00
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	64376.00	104854.92	60190.31	77444.65	51127.13	65321.27
per annum	$/yr	3347552.00	5452455.93	3129896.33	4027121.57	2658610.66	3396705.93
per tonne	$/t	95.42	155.42	136.33	175.42	144.08	184.08
per household per week	$/hhld/wk	1.80	2.94	1.69	2.17	1.43	1.83
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	11533.20	11533.20	10428.88	10428.88	11384.57	11384.57
per annum	$/yr	599726.38	599726.38	542301.80	542301.80	591997.62	591997.62
per tonne	$/t	126.77	126.77	136.20	136.20	82.88	82.88
per household per week	$/hhld/wk	0.32	0.32	0.29	0.29	0.32	0.32
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	75909.20	116388.12	70619.19	87873.53	62511.70	76705.84
per annum	$/yr	3947278.38	6052182.31	3672198.12	4569423.36	3250608.27	3988703.55
per household per week	$/hhld/wk	2.13	3.26	1.98	2.46	1.75	2.15
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	67477.54	113415.27	64645.14	84892.02	59821.28	79509.88
per annum	$/yr	3508831.84	5897593.93	3361547.52	4414384.89	3110706.33	4134513.60
per household per week	$/hhld/wk	1.89	3.18	1.81	2.38	1.68	2.23
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	8431.66	2972.85	5974.05	2981.51	2690.42	-2804.04
per annum	$/yr	438446.54	154588.38	310650.60	155038.47	139901.95	-145810.05
per household per week	$/hhld/wk	0.24	0.08	0.17	0.08	0.08	-0.08

GRL
Triple Bottom Line Assessment
4075-08
WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Perth		Adelaide		Canberra	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Garbage							
Number of Trips Required	trips	113	113	74	74	60	60
Hours Taken to Collect		391	391	350	350	337	337
Hours Taken per Trip		3.46	3.46	4.73	4.73	5.62	5.62
Number of trucks required		11	11	10	10	9	9
Truck capital cost per annum		807793	807793	734357	734357	660921	660921
Truck collection cost per annum		955542	955542	791807	791807	823959	823959
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		2014446	2014446	1777276	1777276	1735992	1735992
Truck capital cost per household per annum		22.62	22.62	20.56	20.56	18.51	18.51
Truck collection cost per household per annum		26.76	26.76	22.17	22.17	23.07	23.07
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		56.40	56.40	49.76	49.76	48.61	48.61
Proportion of time truck spent collecting		69%	69%	77%	77%	81%	81%
Proportion of time truck spent in transit to depot or landfill		22%	22%	16%	16%	14%	14%
Proportion of time truck spent unloading		9%	9%	6%	6%	5%	5%
System 2 - Recycling							
Number of Trips Required		78	78	69	69	124	124
Hours Taken to Collect		339	339	328	328	403	403
Hours Taken per Trip		4.35	4.35	4.76	4.76	3.25	3.25
Number of trucks required		3	3	3	3	3	3
Truck capital cost per annum		165230	165230	165230	165230	201948	201948
Truck collection cost per annum		207045	207045	185690	185690	246087	246087
Bin cost (amortized) per annum		218357	218357	218357	218357	218357	218357
Total cost per annum		623386	623386	602031	602031	699147	699147
Truck capital cost per household per annum		4.63	4.63	4.63	4.63	5.65	5.65
Truck collection cost per household per annum		5.80	5.80	5.20	5.20	6.89	6.89
Bin cost per household per annum		7.03	7.03	7.03	7.03	7.03	7.03
Total cost per household per annum		17.45	17.45	16.86	16.86	19.58	19.58
Proportion of time truck spent collecting		68%	68%	71%	71%	57%	57%
Proportion of time truck spent in transit to depot or landfill		24%	24%	22%	22%	32%	32%
Proportion of time truck spent unloading		8%	8%	8%	8%	11%	11%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52	52	52
System 2		12	12	12	12	12	12
System 3		0	0	0	0	0	0
Truck Visits Per property Per Year		64	64	64	64	64	64
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128	1857128	1857128
System 2		428568	428568	428568	428568	428568	428568
Total		2285696	2285696	2285696	2285696	2285696	2285696
Truck hours per collection (WRCM Output)							
Garbage		391	391	350	350	337	337
System 2		339	339	328	328	403	403
Total Truck Hours per year							
Garbage		20340	20340	18191	18191	17539	17539
System 2		4068	4068	3938	3938	4835	4835
Total		24409	24409	22129	22129	22375	22375
Truck hours per 1000 property visits		10.68	10.68	9.68	9.68	9.79	9.79
Fuel Consumption (L/hr)		12	12	12	12	12	12
Total Fuel consumption per 1000 visits		128.1	128.1	116.2	116.2	117.5	117.5
Garbage							
Collection (min/m3)		8.03	8.03	12.28	12.28	15.41	15.41
Unloading Garbage (min/m3)		1.00	1.00	1.01	1.01	1.01	1.01
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		9.90	9.90	11.35	11.35	6.22	6.22
Unloading Recyclables (min/m3)		1.21	1.21	1.21	1.21	1.21	1.21
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		1411618	1411618	1113765	1113765	321134	321134
Total Households		508494	508494	427742	427742	113959	113959

GRL
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WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Newcastle		Gold Coast		Weighted Average - All Centres	
		Landfill	GRL	Landfill	GRL	Landfill	GRL
Summary Information for Reporting							
Population		95,744	95,744	95,744	95,744	95,744	95,744
Total households		35,714	35,714	35,714	35,714	35,714	35,714
Collection System 1	Frequency Container, Truck Type	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction	Weekly 240 litre,G, single compaction
Collection System 2	Frequency Container, Truck Type	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact	Monthly 240 litre co-mingled, R, single compact
Garbage Collected	t/yr	32,734	32,734	33,719	33,719	27894	27894
Recyclables Collected	t/yr	5,420	5,420	1,385	1,385	4329	4329
Waste Collected	t/yr	38,154	38,154	35,104	35,104	32223	32223
Garbage Collection Cost		$ 1,990,886	$ 1,990,886	$ 1,936,832	$ 1,936,832	$ 1,865,220	$ 1,865,220
Garbage Disposal Cost		$ 1,636,703	$ 2,946,065	$ 1,854,529	$ 3,034,685	$ 1,705,167	$ 2,710,147
Recyclables Collection Cost		$ 660,902	$ 660,902	$ 555,707	$ 555,707	$ 621,695	$ 621,695
Recyclables Processing/Revenue		-$ 162,605	-$ 162,605	-$ 41,552	-$ 41,552	-$ 69,825	-$ 69,825
Total System Cost		$ 4,125,885	$ 5,435,247	$ 4,305,516	$ 5,485,671	$ 4,122,257	$ 5,127,237
Cost if only weekly garbage service offered		$ 3,948,725	$ 5,474,893	$ 3,874,595	$ 5,103,228	$ 3,903,098	$ 5,064,346
Net cost of recycling		$ 177,160	-$ 39,646	$ 430,921	$ 382,443	$ 219,159	$ 62,890
Garbage Collection Cost	$/t	61	61	57	57	67	67
Garbage Disposal Cost	$/t	50	90	55	90	61	97
Recyclables Collection Cost	$/t	122	122	401	401	144	144
Recyclables Processing/Revenue	$/t	-30	-30	-30	-30	-16	-16
Garbage Collected	kg/hhld/yr	917	917	944	944	781.0	781.0
Recyclables Collected	kg/hhld/yr	152	152	39	39	121.2	121.2
Waste Collected	kg/hhld/yr	1068	1068	983	983	902.3	902.3
Garbage Collection Cost	$/hhld/yr	$ 56	$ 56	$ 54	$ 54	52.2	52.2
Garbage Disposal Cost	$/hhld/yr	$ 46	$ 82	$ 52	$ 85	47.7	75.9
Recyclables Collection Cost	$/hhld/yr	$ 19	$ 19	$ 16	$ 16	17.4	17.4
Recyclables Processing/Revenue	$/hhld/yr	-$ 4.6	-$ 4.6	-$ 1.2	-$ 1.2	-2.0	-2.0
Total System Cost	$/hhld/yr	$ 116	$ 152	$ 121	$ 154	115.4	143.6
Cost if only weekly garbage service offered	$/hhld/yr	$ 111	$ 153	$ 108	$ 143	109.3	141.8
Net cost of recycling	$/hhld/yr	$ 5	-$ 1	$ 12	$ 11	6.1	1.8
TOTAL GARBAGE COLLECTED							
per collection	m3/coll'n	1888.51	1888.51	1945.32	1945.32	1609.3	1609.3
per week	t/wk	629.50	629.50	648.44	648.44	536.4	536.4
per annum	t/yr	32734.20	32734.20	33718.87	33718.87	27894.5	27894.5
per household per week	kg/hhld/wk	17.63	17.63	18.16	18.16	15.0	15.0
per household per year	kg/hhld/yr	917	917	944	944	781	781
TOTAL SORTED RECYCLABLES COLLECTED							
per collection	m3/coll'n	1785.03	1785.03	449.47	449.47	1330.6	1330.6
per week	t/wk	104.23	104.23	26.64	26.64	83.2	83.2
per annum	t/yr	5420.16	5420.16	1385.08	1385.08	4328.7	4328.7
per household per week	kg/hhld/wk	2.92	2.92	0.75	0.75	2.3	2.3
per household per year	kg/hhld/yr	151.77	151.77	38.78	38.78	121.2	121.2
FINANCIAL COST OF GARBAGE COLLECTION AND DISPOSAL							
per week	$/wk	69761.45	94941.61	72910.95	95606.34	68661.5	87988.1
per annum	$/yr	3627595.53	4936963.49	3791369.32	4971529.63	3570396.1	4575381.4
per tonne	$/t	110.82	150.82	112.44	147.44	128.7	165.7
per household per week	$/hhld/wk	1.95	2.66	2.04	2.68	1.92	2.46
FINANCIAL COST OF RECYCLING AFTER COLLECTION, SORTING AND SALE							
per week	$/wk	9582.53	9582.53	9887.56	9887.56	10612.8	10612.8
per annum	$/yr	498291.77	498291.77	514153.37	514153.37	551865.3	551865.3
per tonne	$/t	91.93	91.93	371.21	371.21	136.1	136.1
per household per week	$/hhld/wk	0.27	0.27	0.28	0.28	0.30	0.30
CURRENT TOTAL COST OF GARBAGE AND RECYCLING SERVICE							
per week	$/wk	79343.99	104524.14	82798.51	105493.90	79274.3	98600.9
per annum	$/yr	4125887.30	5435255.26	4305522.69	5485682.99	4122261.4	5127246.7
per household per week	$/hhld/wk	2.22	2.93	2.32	2.95	2.2	2.8
ESTIMATED TOTAL COST IF ONLY WEEKLY GARBAGE SERVICE OFFERED							
per week	$/wk	73484.80	102834.31	72213.98	95841.64	73488.4	95820.2
per annum	$/yr	3821209.81	5347384.30	3755127.07	4983765.29	3821398.6	4982652.6
per household per week	$/hhld/wk	2.06	2.88	2.02	2.68	2.1	2.7
REAL (MARGINAL) COST OF RECYCLING SERVICE							
per week	$/wk	5859.18	1689.83	10584.53	9652.26	5785.8	2780.7
per annum	$/yr	304677.49	87870.95	550395.62	501917.71	300862.8	144594.1
per household per week	$/hhld/wk	0.16	0.05	0.30	0.27	0.16	0.08

GRL
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WRCM Results Summary - Monthly Paper only Kerbside Collection

Item	Unit	Newcastle		Gold Coast		Weighted Average - All Centres	
		Landfill	**GRL**	**Landfill**	**GRL**	**Landfill**	**GRL**
Summary Information for Reporting							
Garbage							
Number of Trips Required	trips	105	105	109	109		
Hours Taken to Collect		382	382	388	388		
Hours Taken per Trip		3.63	3.63	3.56	3.56		
Number of trucks required		11	11	11	11		
Truck capital cost per annum		807793	807793	807793	807793		
Truck collection cost per annum		931982	931982	877928	877928		
Bin cost (amortized) per annum		218357	218357	218357	218357		
Total cost per annum		1990886	1990886	1936832	1936832		
Truck capital cost per household per annum		22.62	22.62	22.62	22.62		
Truck collection cost per household per annum		26.10	26.10	24.58	24.58		
Bin cost per household per annum		7.03	7.03	7.03	7.03		
Total cost per household per annum		55.75	55.75	54.23	54.23		
Proportion of time truck spent collecting		71%	71%	70%	70%	74%	74%
Proportion of time truck spent in transit to depot or landfill		21%	21%	21%	21%	19%	19%
Proportion of time truck spent unloading		8%	8%	8%	8%	7%	7%
System 2 - Recycling							
Number of Trips Required		100	100	31	31		
Hours Taken to Collect		370	370	279	279		
Hours Taken per Trip		3.70	3.70	8.99	8.99		
Number of trucks required		3	3	2	2		
Truck capital cost per annum		183589	183589	146871	146871		
Truck collection cost per annum		226202	226202	157725	157725		
Bin cost (amortized) per annum		218357	218357	218357	218357		
Total cost per annum		660902	660902	555707	555707		
Truck capital cost per household per annum		5.14	5.14	4.11	4.11		
Truck collection cost per household per annum		6.33	6.33	4.42	4.42		
Bin cost per household per annum		7.03	7.03	7.03	7.03		
Total cost per household per annum		18.51	18.51	15.56	15.56		
Proportion of time truck spent collecting		62%	62%	85%	85%	69%	69%
Proportion of time truck spent in transit to depot or landfill		28%	28%	11%	11%	23%	23%
Proportion of time truck spent unloading		10%	10%	4%	4%	8%	8%
TRUCK INFORMATION							
Truck Visits Per Property Per Year							
Garbage		52	52	52	52		
System 2		12	12	12	12		
System 3		0	0	0	0		
Truck Visits Per property Per Year		64	64	64	64		
Total Property Visits Per Year							
Garbage		1857128	1857128	1857128	1857128		
System 2		428568	428568	428568	428568		
Total		2285696	2285696	2285696	2285696		
Truck hours per collection (WRCM Output)							
Garbage		382	382	388	388	367	367
System 2		370	370	279	279	336	336
Total Truck Hours per year							
Garbage		19839	19839	20169	20169		
System 2		4445	4445	3345	3345		
Total		24284	24284	23514	23514		
Truck hours per 1000 property visits		10.62	10.62	10.29	10.29		
Fuel Consumption (L/hr)		12	12	12	12		
Total Fuel consumption per 1000 visits		127.5	127.5	123.5	123.5		
Garbage							
Collection (min/m3)		8.57	8.57	8.38	8.38	10.13	10.13
Unloading Garbage (min/m3)		1.00	1.00	1.01	1.01	1.00	1.00
Garbage Transit (km)		6	6	6	6	6	6
Bulk Garbage Transit (km)		16	16	16	16	16	16
Recyclables							
Collection (min/m3)		7.77	7.77	31.45	31.45	10.48	10.48
Unloading Recyclables (min/m3)		1.21	1.21	1.49	1.49	1.20	1.20
Recyclables Transit (km)		10	10	10	10	10	10
Total Population		496990	496990	439374	439374	12874552	12874552
Total Households		179893	179893	168617	168617	4655273	4655273

Appendix B

Landfill LCA Inventory Data

DERIVATION OF LANDFILL LCA DATA

Australian Life Cycle Inventory data for landfills has considerable data gaps including in the area of trace organic contaminants. The missing data has meant that environmental economic valuation of landfills in Australia has previously been understated. To ensure that a more comprehensive environmental economic assessment is conducted, this study has sought to identify trace organic contaminants associated with Australian landfills and value their pollutant loads.

The calculation of LCA data requires that concentration-based data be converted to load-based data per tonne of waste landfilled. The data is presented in Table B-1 (pollutant loads to water) and Table B-2 (pollutant loads to air). In deriving load-based data, the volume of gas and leachate has been calculated for Australian Capital Cities assuming best practice landfill (refer Section 5.1 for description). A 30 year time frame is assumed.

Pollutant Loads to Water

Table B-1: Landfill LCI Data - Pollutant Loads to Water

Pollutant Grouping	Pollutant	Life Cycle Load (g/t MSW/30yr)
Aromatic Hydrocarbons	Benzene	152.800
	Toluene	1153.646
	Xylene	327.925
	Ethylbenzene	119.970
	Trimethylbenzene	23.075
	Naphthalene	24.379
	Diethylphthalate	60.970
	Di-n butylphthlate	0.938
	Butyl-benzyl-phthalate	0.272
Chlorinated Hydrocarbons	Chlorobenzene	10.309
	1,2 - Dichlorobenzene	2.992
	1,4- Dichlorobenzene	1.491
	1,1 - Dichloroethane	4.259
	1,2 - Dichloroethane	0.000
	1,1,1- Trichloroethane	357.369
	Trans- 1,2 - Dichloroethylene	8.104
	Cis - 1,2 - Dichloroethylene	43.955
	Trichloroethylene	70.284
	Tetrachloroethylene	23.441
	Methyl chloride	5.909
	Chloroform	6.472
	Carbon tetrachloride	0.469
Phenols	Phenols	112.466
	Creosols	196.886
	Tri-n butylphosphate	33.655

Pollutant Loads to Air

Landfill gas pollutant loads over the 30 year life assume 56% fugitive emissions, 100% flaring and 33% cogeneration by mass.

Table B-2 Landfill LCI Data - Pollutant Loads to Air

Pollutant	Life Cycle Load (g/t /30yr)
1,2-Dichloroethane	1.3714
1,4 Dichlorobenzene	0.6857
1,1 Dichloroethane	2.0571
1,2 Dichloroethane	0.6857
1,1,1 Trichloroethane	196.1143
Trans 1,2 Dichloroethylene	4.8000
Cis 1,2 Dichloroethylene	24.0000
2,4-D	0.3429
Acetone	226.2857
Butyl Benzyl Phthalate	0.6857
Benzene	83.6571
Chloroform	3.4286
Carbon Tetrachloride	0.6857
Chlorobenzene	5.4857
Creosol	108.3429
Diethylphthalate	34.2857
Di N Butyl Phthalate	1.3714
Ethylbenzene	65.8286
Ethyl Phenols	30.8571
Methyl Chloride	3.4286
Methyl Ethyl Ketone	344.9143
Naphthalene	13.7143
Phenol	61.7143
Toluene	632.9143
Trichloroethylene	38.4000
Tetrachloroethylene	13.0286

Pollutant	Life Cycle Load (g/t /30yr)
Tri-N Butylphosphate	18.5143
Triethylphosphate	1.3714
Tetrahydrofuran	22.6286
Trimethylbenzene	13.0286
Xylene	180.3429
Dioxin/Furans	1.93E-07

Appendix C

Expanded Environmental Valuation

ENVIRONMENTAL VALUATION

The expanded environmental valuation has been conducted to ensure that a more complete list of trace organic contaminants is included in the final assessment. The valuations used are presented in Table C-1 (water) and Table C-2 (air).

Table C-1 Environmental Valuation – Trace Water Contaminants

Pollutant Grouping	Pollutant	Pollutant Valuation (Eco $/ kg)
Aromatic Hydrocarbons	Benzene	46.25
	Toluene	13.21
	Xylene	15.31
	Ethylbenzene	36.07
	Trimethylbenzene	36.07
	Naphthalene	242.34
	Diethylphthalate	5.93
	Di-n butylphthlate	23.43
	Butyl-benzyl-phthalate	3.76
Chlorinated Hydrocarbons	Chlorobenzene	397.18
	1,2 - Dichlorobenzene	386.39
	1,4- Dichlorobenzene	46.28
	1,1 - Dichloroethane	1216.28
	1,2 - Dichloroethane	1216.28
	1,1,1- Trichloroethane	70.88
	Trans- 1,2 - Dichloroethylene	70.88
	Cis - 1,2 - Dichloroethylene	70.88
	Trichloroethylene	146.01
	Tetrachloroethylene	249.70
	Methyl chloride	80.29
	Chloroform	546.55
	Carbon tetrachloride	9584.75
Phenols	Phenols	2.15
	Creosols	2.15

Table C-2 Environmental Valuation – Trace Air Contaminants

Pollutant	Valuation ($/kg)	Proxy Valuations
1,2-Dichloroethane	41.56	
1,4 Dichlorobenzene	4.59	
1,1 Dichloroethane	31.24	
1,2 Dichloroethane	31.24	
1,1,1 Trichloroethane	75.45	
Trans 1,2 Dichloroethylene	25.37	
Cis 1,2 Dichloroethylene	31.24	1,2-Dichloroethane
2,4-D	437.35	2,4-Dichlorophenol
Acetone	3.81	Formaldehyde
Butyl Benzyl Phthalate	46.63	
Benzene	871.73	Benzene at 8,717 $/kg
Chloroform	58.09	
Carbon Tetrachloride	1,011.22	
Chlorobenzene	42.37	
Creosol	2.38	Phenol
Diethylphthalate	1.45	
Di N Butyl Phthalate	116.02	
Ethylbenzene	4.47	
Ethyl Phenols	4.47	Ethylbenzene
Methyl Chloride	9.06	Dichloromethane
Methyl Ethyl Ketone	9.06	Dichloromethane
Naphthalene	37.22	
Phenol	2.38	
Toluene	1.50	
Trichloroethylene	157.88	
Tetrachloroethylene	25.37	
Trimethylbenzene	4.47	
Xylene	0.20	
Dioxin/Furans	562,000.00	

Appendix D

Environmental Valuation – Method Summary

ENVIRONMENTAL VALUATION – METHOD SUMMARY

A summary of the approach used to derive environmental economic values is provided in Table D-1. For a more detailed methodological description, the original studies should be referenced. These are:

- Nolan-ITU (2004), *Getting more from our recycling systems – assessment of domestic waste and recycling systems*, for NSW Department of Environment and Conservation, ISBN: 1 920887 09 1, March 2004
- Nolan ITU (2001) *Independent Assessment of Kerbside Recycling in Australia*, National Packaging Covenant Council

Table D-1 Environmental Economic Valuation
Summary of Environmental Impact Categories

Impact Category	Short Description	Detailed Description
Water and Air Pollutant Valuation	Pollutant loads from the inventory are classified as Water Pollutant Loads or Air Pollutant Loads if they have the potential to effect: human health.	Environmental economic values from published government sources are used where possible. If values are not available, equivalence factors are used to scale the economic values for unknown pollutants relative to known pollutant values. Equivalence factors are derived from local regulations and published international LCIA references. Sensitivity analyses reveal that the final values used for this study provide valuation results which are lower than would be if the "lowest" of a range of pollutant value were adopted from the comprehensive international valuation project, ExternE (European Union DGXI, 1998). Base pollutant values (AUS$/kg) for air include: SO_2: $0.44, NO_x: $3.82, Fine Particulates (PM_{10}) : $18.50, CO: $0.025 Base pollutant values (AUS$/kg) for water include: Lead $226
Greenhouse Gases - Global Warming Potential	Global warming pollutants are common to all inventory data sets include the UR-3R Facility, landfill and energy inventories. A limited range of greenhouse gases has been considered.	Global Warming Potentials are determined using CO_2 equivalence (Australian Greenhouse Office, April 1999). The economic value used by the study is $ 20.60/ tonne CO_2 equivalents. Pollutants included from the environmental economic model (Nolan-ITU, January 2001) given in $/tonne: Carbon dioxide @ $20; Methane @ $410 and Nitrous oxide @ $610.

Impact Category	Short Description	Detailed Description
		More recent additions to this (RMIT, 2001) are ($/tonne): Dichloromethane @ $300 Trichloromethane @ $500 Tetrachloromethane @ $ 26,000 1'1'1 Trichloroethane @ $2,000
Resource Conservation – mineral resources	A small range of resource inputs have been considered The resources modelled are the most significant resources by weight in the inventories used: This limitation may devalue the resource value assigned in the valuation of systems as some of the trace materials such as copper have a relatively high environmental value.	Resource values have been referenced from published Australian valuation studies or estimated based on the application of international ranking to Australian data. The environmental economic valuation of mineral resource use has included categories of resource sustainability and land use impacts. In the absence of data values, published valuation data on the avoided costs for black coal are ranked using international equivalence factors. The assessment of land use values has used two variables: net free primary productivity (fNPP) and land use impact on vascular plant diversity per tonne of mineral extraction ($\propto$). It is assumed that the future sustainability of resources is predominantly costed in to existing economic values for resources and an allocation of only 0.05% for resource sustainability and 95% for land use impacts in resource valuation. The final resource value cost of coal is $47.50 per tonne. This results in subsequent values (AUS $/t) of: Bauxite: $111.55, Coal: $47.51 Crude oil: $34.84 iron (ore): $80.56 limestone and phosphate $91.52 and natural gas $34.84 and sand $10.37.
Resource Conservation – Forestry Resource Values	Inventory data distinguishes between three pulp sources: native and regrowth forest and plantation forests.	The environmental value (AUS $/t) of timber from native forests is 35.9, for regrowth eucalypt timber 12.6 and plantation timber 6.5. No published data on environmental values of timber could be sourced hence a conservative environmental valuation of forest resources was developed. The original reference data value of forest resources comes from the production of paper estimate by the Industry Commission (Industry Commission, (Feb 1991) *Report No.6 Recycling in Australia,- Appendix H, Forestry*) "hypothetical non-wood charges" for forest resources. The calculated harvested timber value assuming sustainable yield of 10.25% timber per year is 35.9 AUS$/t.
Resource Conservation – Water	A water loss saving from compost application arises due to the water retention capacity of organic matter when applied to soil.	The water loss saving associated with compost is the ecological value of this amount of water. The ecological value refers to non-costed environmental benefits of water.

Impact Category	Short Description	Detailed Description
		The value used is 600 $/ML. This is consistent with other published valuations and consistent with the attempt to allocate a dollar value to these costs made in the foreword to the Hassall report (1998) by Francis Grey of Australian National University.
Resource Conservation – Compost	Compost benefits considered in this study include avoided product credits, compost application benefits associated with soils, crop yield benefits and greenhouse benefits.	The environmental value of compost is composed of a number of impacts and benefits associated with the application of compost. Credits associated with avoided products including fertilisers and pesticides are modelled using conventional LCA data and the most recent environmental economic values for pollutant loads. Three different types of fertiliser are modelled. Soil benefits associated with compost application include: • Soil structure decline @ 1.69 $/t • Acidification @ $ 2.54 $/t • Salinity @ 2.06 $/t Crop yield benefits are modelled for canola seed and only the environmental benefits associated with yield improvements are included. Greenhouse benefits through reduced nitrous oxide and carbon sequestration are modelled at IPCC values as summarised above.
Solid Waste	This assessment includes the non-chemical environmental and social impacts of landfills. These are predominantly established by the EPA NSW for land value loss and loss of amenity.	Landfill environmental values as determined by cost benefit analysis (NSW EPA, 1997) is estimated to be between $ 13.10 - $33.20 per tonne in metropolitan centres. After removing the cost components for chemical stressor impacts, the valuation used for landfill is based on amenity & intergenerational equity values of $9.35 per tonne for metropolitan centres.