Environment Waikato Technical Report 2005/35

Assessment of Waste Disposal vs. Resource Recovery

Prepared by:
J.E. Cavanagh
Landcare Research
PO Box 69, Lincoln 8152
New Zealand

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

ISSN: 1172-4005

August 2002

Document #: 1040720

Assessment of waste disposal vs resource recovery

J.E. Cavanagh

Landcare Research
PO Box 69, Lincoln 8152
New Zealand

Landcare Research Contract Report: LC0506/022

PREPARED FOR:
Environment Waikato

DATE: September 2005

Reviewed by:	*Approved for release by:*
James Lennox Scientist Landcare Research	Richard Gordon Science Manager Sustainable Business and Government

Contents

Summary 4
Glossary..8
1. Introduction 9
2. Background 9
3. Objective..10
4. Methods 10
4.1 Interviews..10
4.2 Scenario development 11
4.3 Assessment..11
4.4 Interpretation of the sustainability profile...13
5. Results 15
5.1 Background information 15
5.2 Processing of recyclable materials...22
5.3 Scenario development 23
5.4 Assessment..29
6. Discussion 36
7. Conclusion..38
8. Recommendations 40
9. Acknowledgements 41
10. References 41
11. Appendices 43
Appendix 1 Data input for SAM 43
Appendix 2 Estimation of environmental and resource use 46

Summary

Project and Client

Environment Waikato contracted Landcare Research to undertake an assessment of waste disposal versus resource recovery and to compare the financial, social and environmental effects of waste diversion programmes (community-based resource recovery operations, and commercial-scale resource recovery operations) with disposal of waste to landfill.

Methods

Interviews were held with representatives from organisations considered to represent the spectrum of waste disposal and diversion activities typically undertaken in New Zealand. These were: Xtreme Waste (Raglan) and Wastebusters Trust Canterbury (Ashburton); the Recovered Materials Foundation (Christchurch); Fullcircle Carter Holt Harvey (Auckland); and Hamilton City Council and Perry Environmental (Hamilton).

Two groups of scenarios, based on generic types of waste disposal or diversion operations, were developed:

- Two **disposal** scenarios: activities associated with the disposal of residual waste to landfill, including the operation of a refuse transfer station, 1) in the absence (base case) and 2) presence of waste diversion activities.
- Three **diversion** scenarios: activities associated with 1) small-scale community-based operations; 2) commercial-scale community based operations; and 3) commercial operations.

These scenarios exclude the delivery of waste or recovered materials (primarily via council or commercial collection services) to the location of disposal or diversion operation. However, this can comprise a significant proportion of the total financial cost and impacts associated with waste management activities. As such, an additional group of scenarios was created to indicate the relative magnitude of impacts of collection activities:

Two **collection** scenarios: activities associated with the collection of 1) residual waste and 2) residual waste and recoverable materials.

These scenarios provide a focus on individual components that typically comprise waste management activities in New Zealand. In any given location, it is likely that all three components will be operational, i.e, waste and recoverable materials will be collected from residents and businesses and delivered to waste disposal (landfill) and waste diversion (recycling) operations. Differences between locations will primarily arise from the scale (tonnage of materials handled) of activities.

The financial, social and environmental effects arising from the different scenarios were compared using the Sustainability Assessment Model (SAM), originally developed in the UK (Bebbington 2001). SAM monetises the non-financial impacts of a scenario, and produces a sustainability profile which represents the average annual flow of four capitals—economic, resource, environmental and social—over the assumed 35-year lifetime of the project. The economic capital is direct financial costs associated with the scenarios, while the other capitals include the direct and indirect impacts. The sustainability profiles, which indicated

the total costs and benefits of each scenario, and the ratios of individual capitals to economic activity or tonnage of material handled, were used to compare the scenarios.

Results

The relative magnitude of economic activity, resources used, environmental damage or spending to mitigate damage, and social benefit arising from the individual scenarios is shown in Table S1.

Table S1. Estimated costs and benefits, and tonnage of material handled for all scenarios*

Scenario (tonnes material handled)	Economic	Resource	Environmental	Social
Disposal scenario 1 (50 000)	4 500 000	-1 200 000	-600 000	1 000 000
Disposal scenario 2 (40 000)	3 500 000	-750 000	-400 000	700 000
Diversion scenario 1 (1700)	560 000	-55 000	-2 000	770 000
Diversion scenario 2 (12 300)	1 700 000	-150 000	-25 000	700 000
Diversion scenario 3 (10 000)	1 400 000	-120 000	-25 000	400 000
Collection scenario 1 (50 000)	2 000 000	-192 000	-63 000	776 000
Collection scenario 2 (50 000)	1 920 000	-188 000	-108 000	922 000

*costs are expressed as negative values, and benefits are positive values

- Economic activity (mainly operational costs) and social benefit (mainly benefits of employment) dominate the profiles of all scenarios.
- Resource and environmental costs were greatest for landfilling operations (including refuse transfer operations), and were typically small (relative to economic activity) for other scenarios.
- Resource costs were primarily associated with fuel used and infrastructure required.
- Environmental costs arose mainly from the impact of air emissions and, for landfilling operations, expenditure to mitigate environmental effects.
- Extension of the life of a landfill as a result of waste diversion activities (Diversion scenario 2) reduced the average annual costs (resources and environment) and benefits (economic activity, social) of waste disposal due to a reduction in the amount of waste being received.
- Collection activities can comprise significant additional costs and benefits to disposal or diversion activities
- Community-based waste diversion operations undertake a greater range of activities (e.g., waste education and awareness programmes, waste exchange) than commercial waste diversion operations.

Discussion

Expressed in another way, community-based waste diversion operations and collection activities deliver the greatest social benefit per dollar spent on activities, while landfilling operations use the greatest amount of resources (Table S2).

Table S2. Resource and environmental costs and social benefits arising from each dollar spent for all scenarios

Scenario	Economic	Resource	Environmental	Social
Disposal scenario 1	1	-0.27	-0.09	0.25
Disposal scenario 2	1	-0.28	-0.09	0.28
Diversion scenario 1	1	-0.12	-0.004	1.7
Diversion scenario 2	1	-0.06	-0.004	0.36
Diversion scenario 3	1	-0.05	-0.005	0.26
Collection scenario 1	1	-0.09	-0.03	0.38
Collection scenario 2	1	-0.1	-0.06	0.48

Conversely, considering only economic activity expressed per tonne of materials handled; the most cost-effective operations are, in decreasing order, landfilling, commercial recycling, commercial-scale community recycling and small-scale community recycling. Estimated costs ranged from $88 per tonne for landfilling operations to $270 per tonne for small-scale, community based operations. However, this excludes consideration of the environmental and resource costs, and does not adequately capture the additional activities undertaken by community-based operations. These additional activities are likely to deliver greater longer-term benefits associated with waste minimisation and increased waste diversion; moreover, community-based operations are often committed to assisting the local community by employing long-term unemployed or intellectually challenged people.

All scenarios had unexpectedly low environmental and resource costs, and the environmental benefit of waste diversion operations was apparently negligible. This reflects the exclusion of certain activities (disposal to landfill, remanufacture and reuse of recovered materials) from the scenarios and a likely under-valuation of environmental and resource impacts. The separate handling and beneficial use of greenwaste and waste from construction and demolition waste is also not included.

Conclusions

This assessment provides a focus on what benefits or costs arise from different waste management activities (disposal, diversion and collection) that are common across New Zealand. Within the constraints of the current assessment, the social benefit generated by waste diversion activities, and in particular community-based operations are the key difference between waste disposal and diversion scenarios; small-scale community based operations deliver the greatest social benefit per dollar spent on activities. Resource and environmental costs were greatest for landfilling operations (including refuse transfer operations), and were typically small (relative to economic activity) for other scenarios. Collection activities can comprise significant additional costs and benefits to disposal or diversion activities.

The apparently negligible resource and environmental benefit of diversion activities probably arises from the exclusion of certain activities (disposal to landfill, remanufacture and reuse of recovered materials) from those scenarios. Additionally, environmental and resource impacts, as currently understood, are likely to be under-valued; moreover, the relationship between individual operations and these impacts is poorly understood. Despite these uncertainties, the apparently negligible environmental and resource benefits also raises additional questions for consideration: How sustainable are existing practises in New Zealand for remanufacturing and reuse of recovered materials, what exactly are the environmental benefits of recycling, and where are these benefits realised?

The scenarios created could be considered to be generally applicable across New Zealand, with the primary considerations in transferring the results of the assessment to different regions being the scale of operations and, for community-based waste diversion operations, the range of activities being undertaken. In any given location, it is likely that all three components will be operational, i.e, waste and recoverable materials will be collected from residents and businesses and delivered to waste disposal (landfill) and waste diversion (recycling) operations. To assess the benefits and costs of waste management in a given region requires summing the benefits and costs for the specific activities being undertaken. This would provide an indication of the relative impact of changes to individual components of waste management in a given location.

Finally, while economic activity is presented as a positive benefit in the current assessment, it could be debated as to whether having a high level of economic activity in an ‘unsustainable’ activity (e.g. waste disposal) is actually a desired outcome. Further, prevention of waste generation will probably yield additional different benefits that may be more significant than those associated with waste diversion; this aspect has not been adequately explored in this assessment.

Recommendations

- The impacts of remanufacture and reuse of materials recovered in New Zealand should be assessed. A comparison between recovered materials remanufactured in New Zealand and remanufactured off-shore would disclose the magnitude of different impacts and where these impacts are realised.
- Assessment of the diversion of green waste and construction and demolition waste would provide an indication of the relative impacts of these activities.
- Similarly, the impacts of waste minimisation should be more explicitly addressed in further assessments.
- Further work is required to attain better valuations of currently understood environmental and resource impacts, and to enhance our knowledge of the relationship between individual operations and these impacts.

Glossary

Common terms used in this report are:

Recoverable materials—all materials that are currently diverted from landfill for beneficial use, specifically: paper/cardboard, glass, selected plastics, metal, greenwaste, construction and demolition waste, reusable items.

Recyclable materials— 'traditional' materials collected for recycling: paper/cardboard, glass, selected plastics, metal.

Remanufacture—the incorporation of recycled materials into newly manufactured products.

Residual waste—waste disposed to landfill.

Reusable materials – items delivered to recycling centres that can be reused with minimal further processing; includes furniture, electrical goods, clothes etc.

Waste diversion—diversion of recoverable materials from landfill.

Waste management—all activities associated with waste collection, disposal and diversion.

1. Introduction

Environment Waikato contracted Landcare Research to compare waste disposal with resource recovery, focusing on the wider benefits of waste diversion compared to disposal of waste to landfill. This report compares the financial, social and environmental effects of waste diversion programmes (community-based resource recovery operations, and commercial-scale resource recovery operations) with disposal of waste to landfill.

2. Background

The Sustainability Assessment Model (SAM) has been used to assess the overall impacts of waste diversion activities. The SAM was developed by British Petroleum (BP) and Genesis Ltd (UK) with the University of Aberdeen in Scotland (Bebbington 2001). SAM utilises a Full-Cost Accounting approach and considers the flow of four capitals within a project: economic capital, resource capital, environmental capital and social capital. For the current work, a 'project' is a waste management scenario.

Economic capital is that traditionally captured in the accounts of an organization or the costs associated with a given activity, and is affected by financial costs and revenues.
Resource capital includes:

- Raw materials (e.g., materials used to construct a landfill or recycling operation)
- Energy (e.g., fuel, electricity)
- Water (e.g., for composting).
- Land unavailable for use (e.g., resulting from the use of land for a landfill or a recycling operation)

Environmental capital includes:

- Damage cost estimates from emissions to the atmosphere (e.g., vehicle fuel emissions) or water (e.g., leachate from landfill or composting operations).
- Depreciation of properties from noise, odour, visual nuisance (e.g. from a landfill).

Social capital includes:

- Benefits of employment (estimated using job multipliers developed from economic input output analysis)
- Costs such as road accidents and injury from waste management activities (e.g., from vehicles transporting waste and recyclables, and waste-processing accidents).

Non-financial impacts are quantified in physical terms and then monetised using various methods. Economic and social impacts are typically positive values while resources used and environmental impacts are typically negative values. Positive impacts are referred to as benefits, while negative impacts are referred to as costs. When presented visually, these categories provide a sustainability profile of the organisation's activities; the profile can then be used by steering committees (or other interested parties) to compare the relative sustainability of different options.

However, sustainability profiles do not provide a definitive picture of the sustainability of a project. Rather, they present an attempt to capture the wider benefits and disadvantages or costs associated with alternative scenarios and they provide a starting point to consider how or what aspects could change to achieve a more ‘sustainable’ profile. An exact definition of sustainability has not been agreed, and a more ‘sustainable’ profile, including the components that make up that profile, depends on what is considered important—in this case, by Environment Waikato and its partners in relation to waste disposal and diversion activities. For example, are the benefits of people having jobs, even in an ‘unsustainable’ activity (e.g., waste disposal), better than people not having jobs? Further, the monetisation of, say, environmental impacts is vigorously debated at a fundamental conceptual level and also at a technical level. Additionally, few valuation studies can be applied to the assessment of waste diversion and disposal activities. However, monetisation provides a first step when considering items usually ignored when assessing a project. These constraints should be considered when viewing the sustainability profiles provided below.

3. Objective

To compare the financial, social and environmental effects of waste diversion programmes (community-based resource recovery operations and commercial-scale resource recovery operations) with disposal of waste to landfill.

4. Methods

Different options for waste disposal and resource recovery were assessed in three steps: Interviews, Scenario development and Assessment.

4.1 Interviews

Representatives from different organisations involved in waste management and resource recovery were interviewed to determine the range of activities undertaken by different types of operations; namely, landfill operations, community-based waste diversion operations (small-scale and commercial-scale) and commercial recycling operations. These were considered to represent the spectrum of waste disposal and diversion activities typically undertaken in New Zealand. Organisations interviewed were: Xtreme Waste (Raglan) and Wastebusters Trust Canterbury (Ashburton) (small-scale community-based operations); the Recovered Materials Foundation (Christchurch; a commercial-scale community-based operation); Fullcircle Carter Holt Harvey (Auckland; a commercial recycling operation); and Hamilton City Council and Perry Environmental (Hamilton; landfill operations). Information from the case study participants was used to determine a common set of activities representing different types of operations, and provided an indication of the financial costs of those activities.

4.2 Scenario development

To compare waste diversion operations with landfill operations, scenarios based on generic types of operations were developed. This was considered to be more widely applicable than a comparison of the activities of individual organisations. These scenarios do not indicate the actual costs, etc., associated with the activities of an individual organisation; rather, they provide a reasonable approximation of the financial costs and activities associated with a particular type of waste disposal or diversion as represented by the case study participants. Further, there was a requirement to protect the confidentiality of some of the information provided.

Two groups of scenarios, based on generic types of waste disposal or diversion operations, were developed:

- Two **disposal** scenarios: activities associated with the disposal of residual waste to landfill, including the operation of a refuse transfer station, 1) in the absence (base case) and 2) presence of waste diversion activities.
- Three **diversion** scenarios: activities associated with 1) small-scale community-based operations; 2) commercial-scale community-based operations; and 3) commercial operations.

These scenarios exclude the delivery of waste or recovered materials (primarily via council or commercial collection services) to the location of disposal or diversion operation. However, collection of waste or recovered materials can comprise a significant component of the total financial cost and impacts associated with management of waste or recovered materials, and so are considered in separate scenarios:

- Two **collection** scenarios: activities associated with the collection of 1) residual waste and 2) residual waste and recoverable materials.

These scenarios provide a focus on individual components that typically comprise waste management activities in New Zealand. In any given location, it is likely that all three components will be operational, i.e, waste and recoverable materials will be collected from residents and businesses and delivered to waste disposal (landfill) and waste diversion (recycling) operations. Differences between locations will primarily arise from the scale (tonnage of materials handled) and the types of activities occurring (e.g., community-based or commercial waste diversion operations). This information can be used to assess the benefits and costs of management of the entire waste stream by summing those benefits and costs for the individual activities relevant to a given location and scale of operation.

There were constraints on what could feasibly be considered within these scenarios. Specifically, the separate handling of green waste and construction and demolition waste was not considered, and importantly, it was not possible to include the benefits and costs of the remanufacture of recyclable materials, which often includes export from New Zealand. This latter aspect may have significant benefits and costs (e.g., offsetting manufacture of products from virgin materials, fuel use and emissions associated with the export of goods from New Zealand).

4.3 Assessment

Different scenarios were assessed using the sustainability assessment model (SAM) and considering the impacts of the flows of four ‘capitals’ associated with individual projects,

(projects being the different scenarios). The four capitals considered are:

- Economic capital
- Resource capital
- Environmental capital
- Social capital

The flow of each capital is the sum of several elements, which may be adapted to suit the specific project. A brief description of the elements used in the current study is provided in Table 1 and detailed technical information on their quantification and valuation is provided in the Appendix. Briefly, the economic bar represents the economic activity or direct financial costs associated with the activities described for a given scenario. All other capitals include the direct (e.g., wages paid) and indirect (e.g., environmental damage arising from air emissions) impacts associated with the described operations. Positive impacts are referred to as benefits, while negative impacts are referred to as costs. Data from the case study participants were used to estimate the economic capital associated with the scenarios. These data were also used to estimate some of the resource, environmental or social impacts. The *WISARD Lifecycle Software for Waste Management in New Zealand* was the primary source of data for estimation of emissions and electricity and fuel usage for the activities described in the various scenarios. These data were used to estimate some resource use and environmental impacts.

Table 1 Description of the elements used for input in the sustainability assessment

Category	**Element**	**Description**
Economic	Capital expenditure	Expenditure on capital (amortised over lifetime of the project, taken as 35 years)[1]
	Operating expenditure	Direct and indirect costs (e.g., administration) of operations
	Taxes	GST and company tax. PAYE and ACC paid by the employer are considered an individual's contribution to society and are included under operational costs
	Dividends/Reinvestment	Dividends paid to shareholders (commercial company only); retained earnings, which may be reinvested in activities undertaken by an organisation or within a project.
	Environmental and social spending	Spending on activities to manage or mitigate environmental impacts (consenting activities, cost of leachate and landfill gas collection systems) or spending on education activities (external to organisation or project)
Resource	Infra-structure	Infra-structure utilised in activities. Includes buildings or other capital structures (e.g., landfill)
	Energy	Resource depletion cost of electricity and fuel use
	Intellectual capital	Human capital unavailable for use in more sustainable activities. This is based on opportunity cost less benefit accrued to company, and benefit accrued to individual

Category	Element	Description
	Land	Uptake of land for waste management activities, based on land value amortised over the lifetime of the project (or lease rates)
Environment	Air emissions	Air emissions from transport of materials, plant operations (including electricity usage) and landfill gas emissions, less emissions offset by electricity production from landfill gas.
	Footprint	Based on the lost value of ecosystems (ecosystem service) present on the land
	Nuisance	Loss of amenity due to odours, noise and windblown litter associated with waste and recovered material activities.
Social	Jobs	Direct and indirect jobs associated with the activities. Based on employment multipliers for the Hamilton area.
	Health and safety	Health and safety spending by company, and negative costs of accidents associated with activities
	Public spend	Net social benefit of taxes paid, based on factors from UK SAM
	Other benefits	Additional benefits of activities, e.g., job creation[2] and waste minimisation as a result of education programmes

[1]For practical purposes, and if provided, depreciation of assets was used as a surrogate for capital expenditure.
[2]Job creation in this category refers to jobs created in industries not typically associated with waste management operations, specifically the creative industry, and therefore are not likely to be captured by the employment multipliers.

4.4 Interpretation of the sustainability profile

Data were analysed using SAM to develop a ‘sustainability profile’ as shown in Figure 1. Each bar represents the average annual flow of one of the capitals over the lifetime of the project. Thus, for the current example (landfilling and refuse transfer station operations), a total of $4.5M is estimated to be spent annually, yielding a total of $1M in social benefit while $1.2M of resources is required for operations and $0.6M is spent on mitigating environmental damage or the effect of environmental damage.

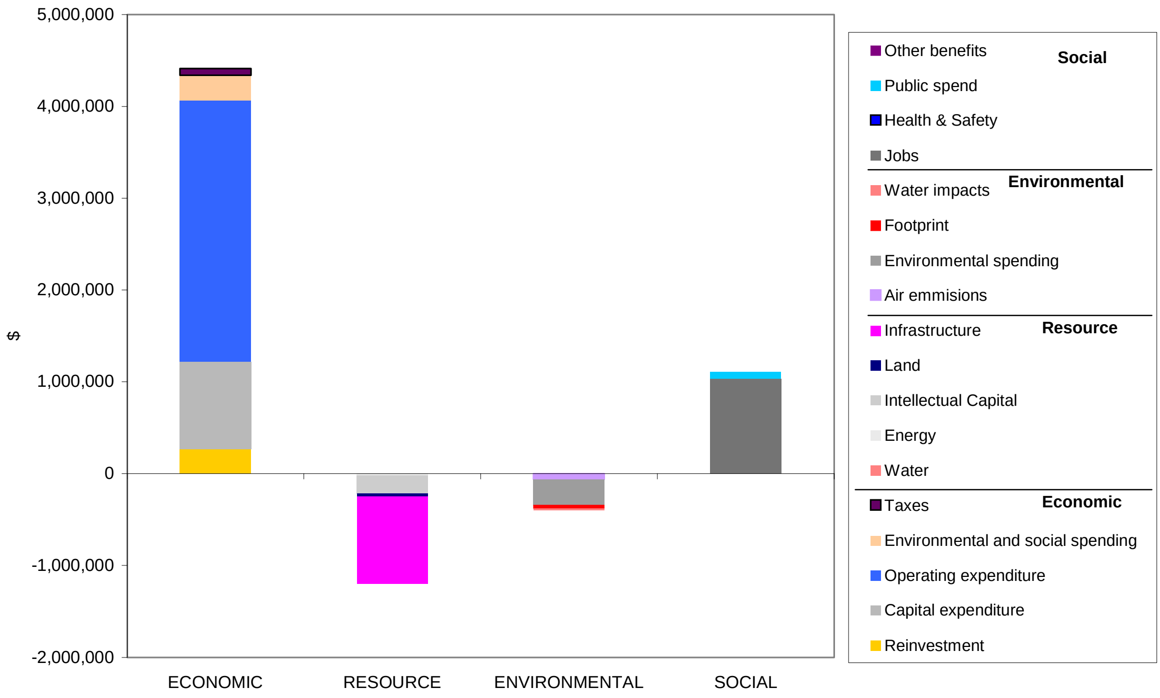

Fig.1 Sustainability profile for landfilling and refuse transfer station operations.

Because the scenarios encompass different activities and handle different tonnages of materials, the ratios of the different capitals to economic activity and to the total amount of materials handled are provided (Table 2) to help compare the scenarios. The ratio to economic activity indicates the direct and indirect benefit or cost arising from the given activity. For example, each dollar spent on establishing and operating landfill operations and refuse transfer stations yields $0.25 in direct and indirect social benefits. In contrast, $0.27 of resources are used and $0.09 is spent mitigating environmental damage or its effects. The ratio to the total amount of materials handled indicates the direct and impacts of the given activity, expressed on a per tonne basis. In this case, the financial cost of disposing waste to landfill is $88 per tonne and is the actual estimated cost to a council or other organisation for disposing of waste to a landfill in the manner described. For this activity, a social benefit of $22 per tonne and resource and environmental costs of $24 and $8 per tonne, respectively, are generated.

Table 2 Ratios of the different capitals to economic activity, and tonnage handled for refuse transfer station and landfilling operations

Ratio	Economic	Resource	Environmental	Social
Economic activity ($/$)	1	-0.27	-0.09	0.25
Per tonne ($/t)	88	-24	-8	22

5. Results

5.1 Background information

Landfill is the predominant method of waste disposal in New Zealand, and is considered to be the basis for comparing options. The following section summarises waste disposal to landfill activities in Hamilton, and the activities of the other case study participants.

Landfill

In Hamilton, residual waste is currently disposed to the Horotiu landfill, which is owned by Hamilton City Council and operated under contract. Residual waste may be received from the refuse transfer station or directly at the landfill (commercial customers only). The landfill is to close in December 2006 due to resource consent requirements, although a new cell (approximately 3 ha) has recently been constructed to enable more waste to be taken until this date. The new cell is estimated to allow the disposal of an additional 128,000 tonnes. Approximately 115,000 tonnes was received in the 11 months to May 2005. After closure of the Horotiu landfill, residual waste is likely to be transported greater distances for disposal. The landfill occupies 23 ha, and newer sections (including the recently constructed cell) have a gas extraction and electricity generation system which is used to produce electricity. The electricity produced is used by the Hamilton City Council to operate their drinking water treatment station, with surplus generation sold back to the main grid. Leachate captured from the landfill is pumped into the sewage system for subsequent treatment.

Xtreme Waste

Xtreme Waste is a community business based in Raglan, a seaside community of approximately 3500 people located on the West Coast of the Waikato region. Xtreme Waste has worked in partnership with the Waikato District Council since 2000 to manage the entire residual waste stream for the local community. It currently has 28 part time employees or contract workers, equating to 14 full time positions, and operates a resource recovery centre located in Te Hutewai Rd, Raglan. The centre diverted approximately 1300 tonnes of waste from landfill in the year ended June 2004, equating to a diversion of approximately 70% (by volume; 50% by weight) of waste previously sent to landfill.

Operations managed by Xtreme Waste include:

- kerbside household and business recyclables collection service
- kerbside residual waste collection service
- two rural recycling depots
- a resource recovery centre which includes a retail shop (Kaahu’s Nest) for reusable items, as well as being the location for drop-offs and sorting of recyclable material and processing of garden waste
- organisation of community events including a recycled raft race, and recycled trolley derby

Recyclable materials collected via kerbside collections are:

- paper
- cardboard
- glass bottles
- plastic bottles, bags, and film (Grades #1 (PET), 2 (HDPE) and 4 (LDPE))

- aluminium and steel cans

The resource recovery centre accepts the materials collected during kerbside collections in addition to:
- green waste
- scrap metal
- timber
- reusable items (including furniture, household goods, egg cartons, tools, paintings)
- computers and other electronic waste
- hazardous chemicals
- residual waste

Kerbside recyclables are collected by Xtreme Waste (from May 2005) who sort materials before delivering them to the resource recovery centre. Plastic and paper is baled on-site and placed in 30 m^3 skips for transportation to Auckland for further processing. Other recyclable materials collected (glass, aluminium and other metals (including scrap steel)) are also placed in 30 m^3 skips, which when full are transported to Auckland for processing. This includes export (some plastics and paper) or the manufacture within New Zealand of products containing recycled materials (glass, cardboard, some paper and plastics, steel).

Greenwaste is shredded and composted on-site and sold to the local community. Timber delivered to the centre is processed and stored on-site and is available for sale by the local community. Hazardous waste is stored on-site and removed regularly by the council. Residual waste is collected in large skips and transported to the Horotiu Landfill for disposal as required by the Regional Council. "Pre-loved" items are sold in the on-site retail shop, "Kaahu's Nest'. Additionally, Xtreme Waste organises community events such as the Recycled raft race and the Recycled trolley derby, and provides education services to raise the profile of waste issues in the community.

The Xtreme Waste website (http://www.xtremewaste.org.nz/) gives information about their activities and is used to communicate waste issues and upcoming events. This information includes the observed benefits of their activities (e.g., 'An account of the benefits for the last three years: Social/Cultural, Environmental and Economic' (Xtreme Waste 2004). The following list of observed benefits was adapted from Xtreme Waste (2004), and that provided by R. Thorpe (Xtreme Waste).

Cultural (Note: Maori culture and other cultural aspects form a key element in the philosophy of the activities of Xtreme Waste; consequently, these are identified separately from other social aspects)
- Tikanga maori, Permaculture principles and the Natural Step Programme
- Te Reo Māori
- Kaitiakitanga
- Care of the Earth
- Tiaki Papatuanuku.

Social
- Current employment of 28 people, including part-time and contract workers, equating to 14 full-time positions. Employment of 57 part time people, including previously long-term unemployed people, over 4 years. This has resulted in 18 people no longer claiming a work benefit. An additional 23 people received work experience.

- Local people finding local employment and not having to travel long distances
- Training of workers: driver's licences, first aid, numeracy and literacy
- Sponsorship of the community radio station and Tourism Raglan
- Partnerships, sponsorship, and supply of resources to various local organisations including Raglan Area School, Trade Aid, Lions Club and local District Council office
- Resources for many local schools and groups including kindergartens, community groups, retail shops and environment centre
- Raising the profile of waste issues and local solutions
- A place for individuals placed on community service to assist the local community

Economic

- Business establishment: new white-ware hire business (Pryde Electronics), and two new retail shops ('Jet Collective'; 'Thingys'), which utilise recycled materials
- Money in local economy: about $320,000 is spent locally on wages, contracts and goods annually
- Reduced landfill disposal costs

Environmental

- Reduction of waste and transportation of waste to landfill
- Diversion of hazardous waste from landfill
- Offsetting manufacture of products through reuse of items previously landfilled
- Protecting the local environment by keeping electronic waste and other materials out of farm pits.

Wastebusters Trust Canterbury

The WasteBusters Trust Canterbury is based in Ashburton District, a district of approximately 27,000 people. It was established in 1994 and now delivers six contracts to three councils in the central South Island for waste minimisation services and education activities. These include management and operation of a Resource Recovery Park (including an education centre and worm farm) in Ashburton and recycling depots at Methven, Willowby, Mayfield and Mt Somers; processing of household kerbside collections in Methven, Mt Somers, Mayfield, Hinds and Ashburton and a business kerbside collection service in Ashburton; and the operation of waste exchange services in Ashburton and Selwyn Districts. In addition, the Trust provides Zero Waste Education training programmes to councils and communities from surrounding districts, and organises workshops and community events centred around waste issues.

The Wastebusters Trust currently employs 28 people (14 full-time and 14 part-time), and has assisted some previously long-term unemployed people to re-enter the workforce. Approximately 2500 tonnes of waste was diverted from landfill in the 11 months to May 2005, resulting in diversion of approximately 60 % (by weight) of waste previously sent to landfill.

Material collected in kerbside collections includes:

- cardboard (flattened)
- glass bottles and jars (green, brown, clear)
- plastic bottles (No 1 (PET) & 2 (HDPE))
- aluminium and steel cans
- paper (including office paper, newspaper, glossy paper)
- plastic bags (supermarket bags, bread bags, clear plastic bags)

The resource recovery park accepts the materials collected during kerbside collections in addition to:

- green waste
- scrap metal
- plastics (film, 2 & 4)
- reusable items (including furniture, household goods, egg cartons, tools, paintings)
- hazardous chemicals, including waste oil
- televisions, computers and other electronic waste (3.5 tonnes were diverted from landfill in June)
- batteries
- building materials
- textiles

The collection of household kerbside recyclables from over 8000 households in the townships of Methven, Mt Somers, Hinds, Ashburton and Mayfields is carried out weekly, while the business area of Ashburton has twice-weekly pickups. Kerbside recycling is collected via a modified bus at the rate of 200 bins per hour. Clean materials are sorted on the bus and unloaded separately at the Ashburton Resource Recovery Park. The recent purchase of a commercial paper shredder has increased the amount of paper recycled by enabling businesses to recycle commercially sensitive documents (an earlier survey had indicated that approximately 64 m^3 of commercially sensitive papers was being dumped each month).

At the resource recovery park cardboard, plastics and paper are sorted on a conveyor belt. Cardboard and plastics are baled into export density bales and usually transported to Christchurch for further distribution. Similarly, aluminium and steel cans are baled for efficient transport to Christchurch for further distribution. Wastebusters Trust has a high level of community support and, because it operates in partnership with local transportation companies, is often able to negotiate transport rates lower than typical commercial rates.

Green waste is shredded and composted on-site. The Trust has also recently begun managing construction and demolition waste delivered to the transfer station. A resale yard for construction and demolition waste, including timber, window frame, bathroom bench tops, has recently been developed and other alternatives for reuse of construction and demolition waste are being investigated. Residual waste was previously transported to Burwood landfill, but is now transported to Kate Valley landfill.

Second-hand items are sold in a retail shop at the resource recovery centre, with total sales reaching $48,400 in the 11 months to May 2005. In addition, monthly takings increased from $2,400 in May 2004 to $8,000 in May 2005. The Waste Exchange, operated by Wastebusters Trust in the Ashburton and Selwyn Districts, links businesses wishing to dispose of a particular resource with businesses or community groups wanting that resource. This service is free to participants and is funded by Environment Canterbury. Wastebusters Trust is a key provider of training in the management of waste minimisation and education programmes. Additionally, the Trust organises community events such as the Annual Winter Waste Fest, and has a mobile recycling depot that is available for events. The benefits noted by Wastebusters Trust from its activities include:

Social/Cultural

- employment of 28 (14 full-time and 14 part-time people)—approximately 50% were previously long-term unemployed people.

- volunteers as part of the team, including retired tradesmen
- raising the profile of waste issues and finding local solutions
- the Ashburton Resource Recovery Park becoming a social centre regularly visited by a wide range of people. Local groups often also hold regular meetings at the education centre.
- provision of resources to community groups at no cost, through the Waste Exchange programme

Economic

- money in local economy: around $550,000 was spent locally on wages, transport and goods in the year ended June 2005.
- reduced costs for landfill disposal
- increased profits to local businesses by reducing their inputs or disposal costs through the provision or disposal of materials at no cost through the Waste Exchange

Environmental

- reduction of waste and transportation of waste to landfill
- diversion of hazardous waste from landfill
- offsetting manufacture of products (and associated impacts) through reuse of items
- protecting the local environment by keeping electronic waste and other materials out of farm pits.

Recovered Materials Foundation

The Recovered Materials Foundation (RMF) is a charitable trust established in 1997 by the Christchurch City Council, and business organisations such as the Canterbury Chamber of Commerce, Canterbury Manufacturers Association and Canterbury Development Corporation. It was initially focussed on developing reuse and recycling opportunities for Christchurch, but now also undertakes activities in the surrounding Waimakariri and Selwyn Districts. The RMF has four core areas of work:

1. collecting, processing and marketing recovered materials, including:
    - processing all materials received by the RMF
    - operating a retail outlet for reusable items (Supershed).
    - operating recycling centres located at Christchurch's three refuse transfer stations. From 1 July 2005, the RMF has assumed full management of these three refuse transfer stations.
2. Education and information services including:
    - operating a waste exchange service for Christchurch City and Waimakariri district
    - school education programmes
    - talks to community groups on recycling and tours of facilities
    - managing the kerbside recycling promotion committee
3. Business development: the RMF operates a Sustainable Initiative Fund on behalf of the Christchurch City Council. The fund is financed through an additional $2 levy on charges for waste disposal to landfill to help develop viable businesses related to the use or recovery of materials.
4. Internal business development: the RMF also develops its own products and markets within New Zealand for recovered materials. This is mainly focused on maximising value-added opportunities for recovered materials.

The RMF employs approximately 90 full-time staff and 30 part-time or casual staff. Most staff are employed at the Supershed and recycling centres, with 27 full-time staff as well as part-time and casual staff. Twenty-two full-time staff are employed at the materials processing plant with the remainder employed at the head office and paper sorting plant. As part of its commitment to social performance for triple bottom line reporting (RMF 2002), the Foundation also employs 3–5 intellectually challenged people through various agencies at the sorting plants and SuperShed. Part-time and casual staff are employed for busier periods such as weekends (recycling centres) or public holidays.

From 1 July 2005, approximately 30 people have been employed at the three Refuse Transfer Stations, with the aim of changing the focus of the stations from refuse disposal to resource recovery.

The RMF processes materials collected from kerbside collection services in Christchurch and the Waimakariri and Selwyn districts, and from other commercial sources. Just under 40 000 tonnes of recovered materials were processed by the RMF in the year ended June 2005. Of this, 27 850 tonnes of recyclable materials were received from the three kerbside collections, and 2500 tonnes from commercial sources.

Material collected in kerbside collections includes:
- paper (all types—newspaper, glossy, box board)
- corrugated cardboard
- glass bottles and jars (green, brown, clear)
- plastics (#1 (PET) & 2 (HDPE))
- aluminium and steel cans
- plastic supermarket shopping bags
- tetrapak milk cartons

In addition to the materials collected during kerbside collections, the RMF process materials from its recycling centres at the three refuse transfer stations in Christchurch and from elsewhere. Approximately 10 000 tonnes of reusable and recyclable materials were recovered through recycling centre operations, comprising 4300 tonnes of scrap metal, 2300 tonnes of other recyclable materials, and 2400 tonnes of reusable materials. Most material received at the recycling centres is scrap metal that is sent directly to a metal processing operation in Christchurch. Reusable items are also delivered to the recycling centres and are sold at the Supershed. In addition, approximately 200 tonnes of hazardous materials are handled through the recycling centres and are diverted from landfill for appropriate disposal.

Kerbside recyclable materials are partially sorted during collection with glass and paper separated from other materials. Currently, the RMF is investigating the viability of separating only paper during kerbside collection. After collection, all materials except paper and supermarket bags are sorted and processed at the materials processing centre site in Parkhouse Road, Sockburn. Commingled plastic and metal recyclables are sorted on a conveyer belt and baled for export.

Glass is sorted into separate colours, with some glass crushed on-site to meet local market demand and some whole bottles washed and sold for reuse. The bottle-washing facility washed approximately 780 tonnes of wine bottles in the year ended June 2004. However, this operation has recently been decommissioned while market strategies are being investigated. The bulk of the collected glass is sent to Auckland for processing, although alternative markets for glass continue to be investigated. Currently, the RMF is developing a pilot-scale manufacturing operation for glass tiles made from recycled glass.

Paper and cardboard is processed at a separate site in Buchannans Road, Hornby. This facility is operated as a joint venture between the RMF and Fullcircle Carter Holt Harvey, who share the lease of the building and baling services. The RMF sorts the paper into different grades (newspaper, mixed), while a separate contractor undertakes baling for both the RMF and Fullcircle Carter Holt Harvey (Fullcircle Carter Holt Harvey is the primary contractor for the baling services). Approximately 12 000 tonnes of paper and cardboard are processed by the RMF annually. Baled paper is exported for further processing. Supermarket bags are also baled at this site, ready for delivery to a remanufacturing operation.

Reusable items are sold at the 'SuperShed' in Pages Rd, Bromley. The site is owned by the council and leased to the RMF at market rates.

The Waste Exchange is operated by the RMF in the Christchurch region, and links businesses wishing to dispose of a particular resource with businesses or groups wanting that resource. Currently, over 70 local community groups, 50 schools and over 2000 individual organisations or companies are listed with the RMF waste exchange service. This service results in the exchange of resources at no cost to participants, other than any transportation costs. The service is provided through contracts with Christchurch City and Waimakariri District Councils.

During the year ending 30 June 2005, the Waste Exchange Service processed approximately 1100 requests for materials available or wanted, and achieved 680 successful exchanges. Approximately 3000 m^3 of material was estimated to have been diverted through the Waste Exchange in the last financial year. This does not translate directly into the volume diverted from landfill as some resources include large empty plastic containers which would have been compacted during disposal to landfill.

Benefits observed by the Recovered Materials foundation from their activities include:

Social/Cultural

- Employment of 120 people (approximately 90 full-time and 30 part-time or casual), including 3–5 intellectually challenged people
- Raising the profile of waste issues
- Provision of resources, at no cost, to around 120 local community groups

Economic

- Money in local economy: approximately $2.5M in wages directly from RMF operations
- Reduced costs for landfill disposal
- Increased profits to local businesses by reducing their inputs or disposal costs through the provision or disposal of materials at no cost through the Waste Exchange

Environmental

- Reduction of waste and transportation of waste to landfill
- Offsetting manufacture of products (and associated impacts) through reuse of items
- Diversion of hazardous and electronic waste from landfill

Fullcircle Carter Holt Harvey

Fullcircle Carter Holt Harvey is a subsidary of Carter Holt Harvey and collects over 200 000 tonnes per annum of waste paper and cardboard in New Zealand. Much of this is recycled at Carter Holt Harvey's own mills at Kinleith, Penrose and Whakatane. Fullcircle Carter Holt Harvey has extended the range of recycled materials it processes from paper and cardboard to other recyclables, including glass, tin, plastic and aluminium. These materials, along with paper surplus to mill requirements, are traded in New Zealand and also exported to South East Asia.

Fullcircle Carter Holt Harvey contracts out the operation of its processing plants, and works with contractors to collect and process recyclable materials from council kerbside household collections.

Material collected in kerbside collections includes:
- paper (newspaper, glossy paper)
- cardboard
- glass bottles and jars (green, brown, clear)
- plastics (#1 & 2)
- aluminium and steel cans

Paper and cardboard collected from industry are also collected. Paper and cardboard from both kerbside collection and industry is transported to one of Carter Holt Harvey’s paper mills for recycling, with the surplus being exported. Glass and steel are primarily processed into new products in Auckland, although a recent drop in the price received for glass may result in alternative markets being investigated. Other materials such as plastic and aluminium may be exported for further processing.

5.2 Processing of recyclable materials

It was not possible to include the relative benefits and costs of remanufacturing or reusing recovered materials; however, this is important if the consequences of waste diversion operations are to be assessed fully. Therefore, a brief description of the handling of recovered materials in New Zealand is provided here.

Some materials are manufactured into new products in New Zealand, with the remainder being exported for further processing. The fate of individual products depends partly on location. For example, recycled steel collected in the Auckland region (including Hamilton) tends to be processed in New Zealand, while metal collected in the South Island is primarily exported to south-east Asia (B. Gledhill, Steel Can Association of New Zealand, pers. comm.). Recycled steel is used for making wire and bars. Recovered aluminium is primarily exported (RONZ 2004a).

Most LDPE recovered is processed and remanufactured in New Zealand into products such as black film and sheeting, and irrigation pipes (RONZ 2004b). Plastic film (LDPE) is not usually collected in household collections. Approximately two thirds of the HDPE material (milk bottles) recovered is reprocessed in New Zealand into products such as drainage pipes, recycling bins and buckets, with the remaining third exported, primarily to Asian and Australian markets (RONZ 2004c). Most polyethylene terephthalate (PET) is exported (RONZ 2004d). PET bottles are usually sorted into colours before export, as different prices are received for clear and coloured PET—clear PET is the most valuable. Plastic products are often granulated before export (RONZ 2004d) to facilitate transport.

Glass is manufactured into new bottles and jars by Owens Illinois (previously ACI) in Auckland (RONZ 2004e), although a recent drop in the price paid for glass has prompted recycling organisations to seek alternative processing options.

5.3 Scenario development

Seven scenarios for waste disposal, diversion and collection were developed and assessed using SAM. These scenarios are intended to provide a reasonable approximation of the costs and activities associated with a particular type of waste disposal or diversion operation, as represented by the case study participants. The scenarios do not explicitly represent the actual amounts of waste handled, people employed, costs, etc., of the individual participants; moreover, in some cases the full range of activities of an organisation is not captured by a scenario. The individual scenarios are summarised in Table 3, with more detailed information in the following text.

Table 3 Summary of activities included in and omitted from each scenario, and weight of materials handled and number of staff in each scenario.

Scenario	Activities included	Tonnage	People employed	Activities not included
Disposal scenarios				
Landfill with no waste diversion	Handling of residual waste through a refuse transfer station; disposal of residual waste to landfill.	30 000 tonnes received at the refuse transfer station; 20 000 tonnes received at the landfill; 50 000 tonnes disposed to landfill.	20	Collection of materials; handling of recoverable materials; waste education and awareness programmes.
Landfill with waste diversion	Handling of residual waste through a refuse transfer station; disposal of residual waste to landfill.	20 000 tonnes received at the refuse transfer station; 20 000 tonnes received at the landfill; 40 000 tonnes disposed to landfill.	18	Collection of materials; handling and disposal of residual waste; handling of greenwaste or construction and demolition waste.
Diversion scenarios				
Small-scale community based recycling operations	Handling of recyclable[2] and reusable materials for further processing including transport to location of further processing (100 km); sale of reusable materials; operation of a waste exchange; education and awareness programmes.	1700 tonnes of recyclable and reusable materials.	17	Collection of materials; handling and disposal of residual waste; handling of greenwaste or construction and demolition waste.
Commercial-scale community based recycling operations	Handling of recyclable and reusable materials for further processing (includes transport to location of further processing-100 km); sale of reusable materials; operation of a waste exchange; education and awareness programmes.	12 300 tonnes of recyclable and reusable materials.	17	Collection of materials; handling and disposal of residual waste; handling of greenwaste or construction and demolition waste.
Commercial recycling operation	Handling of recyclable materials for further processing, including	10 000 tonnes of recyclable materials.	5	Collection of materials Handling and disposal of

Scenario	Activities included	Tonnage	People employed	Activities not included
	transport to location of further processing (100 km).			residual waste; handling of greenwaste, or construction and demolition waste. Waste education and awareness programmes.
Collection scenarios				
Collection of residual waste	Collection of residual waste and delivery to refuse transfer station via kerbside collection, commercial operations and direct delivery by individuals or businesses.	50 000 tonnes of residual waste.	12	Handling or disposal of residual waste or recoverable materials.
Collection of residual waste and recyclables	Collection of residual waste and delivery to refuse transfer station via kerbside collection, commercial operations and direct delivery by individuals or businesses. Kerbside collection of recyclable materials and delivery to processing operation; delivery of reusable materials.	38 000 tonnes of residual waste. 12 000 tonnes of recyclable or reusable materials.	15	Handling or disposal of residual waste or recoverable materials.

Waste disposal scenarios

Disposal scenario 1—Disposal to landfill with no waste diversion

This scenario is considered to be the base case against which other options for waste disposal or diversion are compared. It assumes the disposal of waste to landfill with no waste diversion activities, and is based on refuse transfer station and landfill operations undertaken in Hamilton, and information contained in the *Landfill Full Cost Accounting Guide* (MfE 2004). This scenario considers the operations of a refuse transfer station and a landfill, with an assumed total of 50 000 tonnes per year being landfilled. Of this, 30 000 tonnes per year are handled through the refuse transfer station and transported 50 km to the landfill; 20 000 tonnes are received directly at the landfill. Systems for collecting leachate and landfill gas have been installed, and electricity is generated from the gas.

The landfill is assumed to cover 17.5 ha in a rural area, while the refuse transfer station is located on a 0.5 ha site in an urban area. 10 people are employed for landfill operations, and another 10 are employed at the refuse transfer station and in transporting waste to landfill.

Disposal scenario 2—Disposal to landfill with waste diversion

This scenario considers the disposal of waste to landfill with waste diversion activities. The magnitude of the impact of waste diversion activities on the benefits and disbenefits of landfill operations will depend in part on the relative amount of waste diverted. For example the benefits of the diversion of 2000 tonnes of waste from a landfill that receives 130 000 tonnes per year will be marginal compared to the overall benefits and disbenefits of the landfill operation. In terms of the SAM model, these impacts will primarily translate into a longer lifetime over which some costs are distributed. This scenario is based on a modification of disposal scenario 1, and considers the extension of the life of a landfill as a result of diversion of recovered materials from landfill disposal. The activities described in disposal scenario 1 were used, with the exception that 40 000 tonnes of waste is disposed annually, resulting in an extension of the life of the landfill by five years, and 18 people were employed. Costs or impacts that were likely related to the amount of waste handled, e.g., operational costs, were scaled for the tonnage handled.

Waste diversion scenarios

Diversion scenario 1—Small scale community-based operations

This scenario is based largely on the activities of Xtreme Waste and Wastebusters Trust Canterbury, although it considers only the handling of recovered materials. The activities considered in this scenario are:

- sorting and processing (for transport) of recyclable materials
- operation of a retail shop for reusable items
- waste exchange service
- education/awareness activities: these include formal education programs (e.g., for schools, classes) and organisation of community events centred around waste minimisation/reuse, and liaison with businesses
- market development: research into opportunities to add value to materials currently collected, alternative uses of materials not currently recovered, or strategies for minimising waste

This scenario assumes that 1700 tonnes of material are diverted from landfill per year. Of this, 200 tonnes are reusable materials sold in a retail shop, 200 tonnes are exchanged through the waste exchange service and the remainder is recovered materials comprising 700 tonnes of paper and cardboard, 400 tonnes of glass, 40 tonnes of plastic and 160 tonnes of metal. Recovered materials are transported 100 km to point of sale. A total of 17 people (full-time equivalents) are employed. The 0.5 ha Resource Recovery Centre (RRC) adjoins the refuse transfer station, with buildings that encompass the retail shop, sorting operations and office area. On-site equipment includes a small conveyer belt, baler and forklift.

The social benefits considered in this scenario are based on those noted by Xtreme Waste and Wastebusters Trust and are: employment of long-term unemployed (assumed rate is 3 per year), and new jobs in the creative industry (assumed rate of 1 per year). All jobs created are located in the local community. The benefits of education and community activities are captured as additional waste diverted from landfill through either increased recycling or avoided waste generation, and are 100 tonnes per year, valued at $100 per tonne. Although there is no basis for the rate of diversion, it is included to recognise the benefits of education and awareness programs. Similarly, a nominal value of $20,000 is assigned to recognise an enhanced ‘sense of community’—noted by both Xtreme Waste and Wastebusters Trust as a positive outcome of their operations.

Diversion scenario 2—Commercial-scale community-based operations

This scenario is based on the range of activities undertaken by the Recovered Materials Foundation Canterbury. It is provided as a separate scenario because the RMF, although operating on a commercial scale, undertakes a range of activities more characteristic of smaller community-based operations. The activities considered in this scenario are:

- sorting and processing (for transport) of recyclable materials
- operation of a retail shop for reusable items
- waste exchange service
- education/awareness activities, including formal education programs (e.g., for schools) and liaison with businesses
- market development: research into opportunities to add value to recovered materials currently collected

This scenario has a resource recovery centre located on a site separate from sorting and processing facilities. A total of 12 300 tonnes is diverted from landfill; 1000 tonnes is diverted through waste exchange operations, and 1300 tonnes is handled through the RRC, and the remaining 10 000 tonnes is delivered directly to the sorting facility. Of the 11 300 tonnes handled through the RRC and sorting facility, 7300 tonnes are paper and cardboard, 2000 tonnes are glass, 700 tonnes are scrap metal, 400 tonnes are plastic, 300 tonnes are cans (steel and aluminium) and 600 tonnes are reusable items for sale in the retail shop. Scrap metal is delivered directly to a metal recycler. The remaining recovered materials are delivered to a sorting plant, which sorts and bales materials ready for subsequent transport to ports (for materials that are exported) or locations for remanufacturing within New Zealand.

The RRC and retail shop employ 7 people and the sorting plant employs another 7. Three people are employed in waste education, market development and administration activities, including 2 intellectually challenged people. The RRC is co-located with a refuse transfer station, while the retail shop (0.2 ha) and sorting plant (0.5) ha are at separate sites. Equipment present on-site is a large conveyer belt and baling plant, and a forklift. Baled materials are transported 100 km to locations for export or remanufacturing.

Social benefits include education programmes and the employment of intellectually challenged people. The benefits of education programmes are realised as additional waste diverted from landfill through either increased recycling or avoided waste generation, and accrue at a rate of 100 tonnes per year, valued at $100 per tonne. There is no basis for the rate of diversion, however it is included to recognise the benefits of education and awareness programs.

Diversion scenario 3—Commercial operation

This scenario considers only the handling of recovered materials, and reflects the activities of a commercial recycling operation that handles recovered materials delivered to a sorting plant. It considers the diversion of 10 000 tonnes annually from landfill of which 7300 tonnes are paper and cardboard, 2000 tonnes are glass, 400 tonnes are plastic, and 300 tonnes are cans (steel and aluminium). The recovered materials are delivered to a sorting plant, which sorts and bales materials ready for subsequent transport to ports (for materials that are exported) or locations for re-manufacturing within New Zealand.

The sorting plant employs 5 people is located on 0.5 ha site. On-site equipment includes a large conveyer belt, a baling plant and a forklift. Baled materials are transported 100 km to a place of export or remanufacturing.

Collection scenarios

Two collection scenarios were developed to indicate the relative magnitude of economic activity and impacts associated with waste and recovered materials. Greater uncertainty is attached to the estimated economic activity for the collection scenarios compared to the disposal scenarios, as the former were approximated from costs of household collection, which is only one route by which waste and recyclables are collected. Similarly, estimates of the number of trucks and distance travelled were based on data collected from operators in Christchurch and assuming an average waste density of 0.45 t/m^3 and an average volume of 20 m^3 carried by collection trucks.

Collection scenario 1—Residual waste collection

This scenario represents collection of waste materials with no recycling, i.e. all waste is destined for landfill. This scenario considers the collection of 50 000 tonnes; 18 500 tonnes from residential sources and 31 500 tonnes from industrial/commercial sources. Tonnages from residential sources come via three routes; council kerbside collection (10 000 tonnes), commercial household collection (4000 tonnes) and direct delivery to a refuse transfer station (5500 tonnes). Waste from industry is delivered primarily by commercial waste collection services (10 000 tonnes), with 1500 tonnes delivered directly to the Refuse Transfer Station and 20 000 tonnes delivered directly to landfill. Two collection trucks are assumed to travel 30 km per day (5 days per week) to collect and dispose of household waste to the RTS for council collections; two collection trucks travel 150 km per day for commercial household collection that is delivered to the RTS. Businesses and residents make 2000 trips, at an average of 15 km per trip, to deposit waste at the RTS. Two collection trucks (front-load trucks) deliver commercial waste to the RTS and are assumed to travel 150 km per day, and an additional 4 collection trucks (gantry trucks) travel 150 km per day to dispose of waste directly to landfill. The collection service employs 12 people.

Collection scenario 2—Residual waste and recyclables collection

This represents the collection of waste materials where recycling operates. 50 000 tonnes of waste and recovered materials is collected from residential and industrial or commercial sources. 38 000 tonnes of this goes to landfill and 12 000 tonnes are recovered (based on the diversion scenarios above). Household kerbside collection is considered the primary source of recylable materials (7000 tonnes), with 3000 tonnes of paper and cardboard delivered to a sorting plant from commercial sources and 2000 tonnes (including scrap metal) delivered by residents to a resource recovery centre co-located at a refuse transfer station. Three trucks travel 70 km per day to collect and deliver household recyclables (7000 tonnes) to a sorting plant. Two trucks travel 120 km/day to collect paper and cardboard from businesses, while residents and businesses make 1000 trips, each of 15 km, per year to deposit recyclables at the RTS. An associated reduction in residual waste collection operations is assumed. Ten people are employed for the collection of residual waste, and 5 people in the collection of recyclables.

5.4 Assessment

Waste disposal scenarios

The sustainability profiles for disposal of waste to landfill, including operation of a refuse transfer station, with and without waste diversion are shown in Figures 2 and 3 respectively. Disposal of 50 000 tonnes annually to landfill (Disposal scenario 1) costs $4.5M annually, yielding $1M in social benefit while $1.2M of resources is required and $0.6M is spent on mitigating environmental damage or its consequences (Figure 2). Disposal of a reduced amount of waste (40 000 tonnes annually) to landfill (Disposal scenario 2) would cost $3.5M annually and yield $0.7M in social benefit while $0.75M of resources is required and $0.4M is spent on mitigating environmental damage or its effects (Figure 3). The profile for Disposal scenario 2 is essentially a flattened version of that for Disposal scenario 1 and arises from reduced activity because the landfill receives less waste and can accept waste for a longer period.

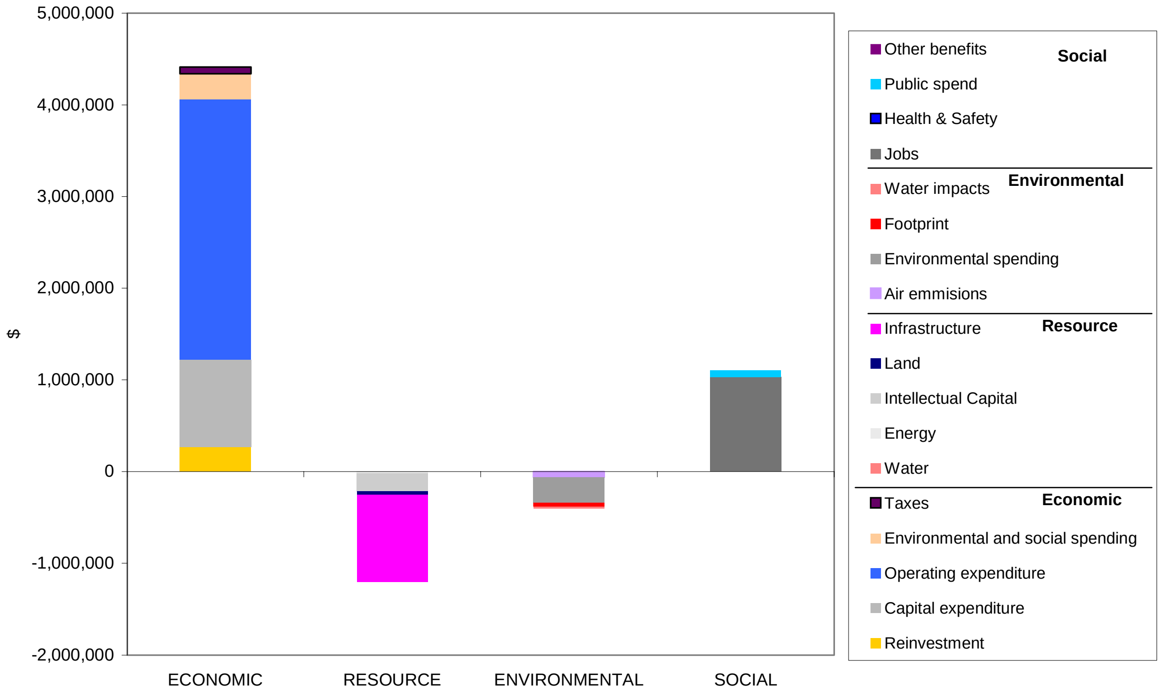

Fig. 2 Sustainability profile for Disposal scenario 1—disposal to landfill with no waste diversion.

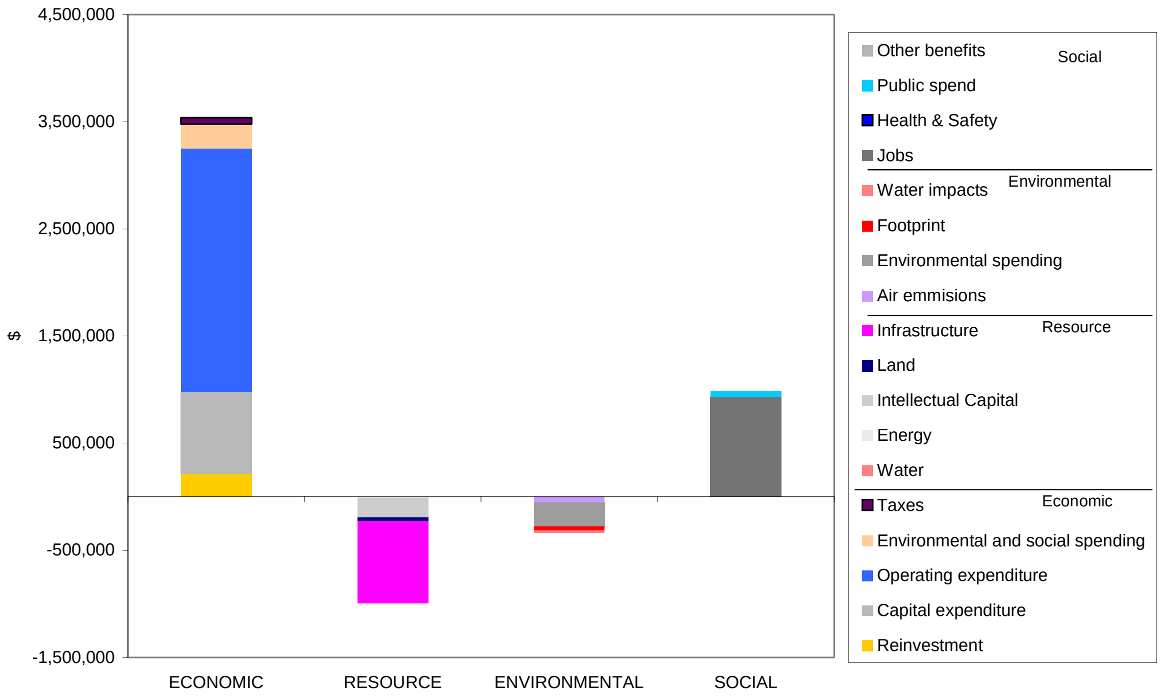

Fig. 3 Sustainability profile for Disposal scenario 2—disposal to landfill with waste diversion.

Economic activity associated with the landfill and refuse transfer station operations dominates both profiles. Capital and operating costs are the primary expenditures with some environmental expenditure related to landfill gas and leachate collection systems also occurring. Resource costs are primarily associated with infrastructure for landfill operations and the unavailability of the land for other, more sustainable, purposes. Environmental costs from air emissions and loss of ecosystem services are surprisingly small, and environmental spending to mitigate environmental effects dominates the environmental costs. The negative effects of air emissions from the landfill are partly offset by electricity production from landfill gas and the consequent reduction in emissions for electricity produced from other sources. Social benefits are largely derived from direct and indirect jobs arising from landfill operations.

Social benefits and resource and environmental costs arising from each dollar spent are similar for both disposal scenarios—as indicated by the ratio of these capitals to economic activity (Table 4). In contrast, for each tonne disposed to landfill, the resource, social benefits and resource and environmental disbenefits reduce more in Disposal scenario 2 than in Disposal scenario 1 (Table 4). Similarly, the estimated actual cost per tonne for disposal to landfill reduces in Disposal scenario 2. However, these differences are probably within the uncertainties associated with the assumptions used to generate the profiles.

Table 4 Ratios of the different capitals to economic activity and tonnage handled, for Disposal scenarios 1 and 2.

Ratio	Economic	Resource	Environmental	Social
Disposal scenario 1—disposal to landfill with no waste diversion				
To economic activity ($/$)	1	-0.27	-0.09	0.25
Per tonne ($/t)	88	-24	-8	22
Disposal scenario 2—disposal to landfill with waste diversion				
To economic activity ($/$)	1	-0.28	-0.09	0.28
Per tonne ($/t)	71	-20	-6.6	20

Waste diversion scenarios

Sustainability profiles for waste diversion operations are shown in Figures 4-6. Small-scale waste diversion operations (Diversion scenario 1, Figure 4) spend $560,000 annually to divert 1700 tonnes of waste and support other activities (primarily education and awareness programmes), yielding $770,000 in social benefit. In addition, $55,000 of resources are required and an estimated $2,000 of environmental damage arises from air emissions (primarily from transportation). For commercial-scale, community based waste diversion operations (Diversion scenario 2, Figure 5), $1.7M is spent annually on diverting 12,300 tonnes of waste and on other activities, yielding $0.7M in social benefit. Resources cost $150,000 and $25,000 of environmental damage arises, primarily from air emissions from transportation. Commercial recycling operations (Diversion scenario 3, Figure 6) spend $1.4M annually on diverting 10 000 tonnes of waste, yielding $0.4M in social benefit. This requires $120,000 of resources and $25,000 of environmental damage arises, primarily from air emissions from transportation.

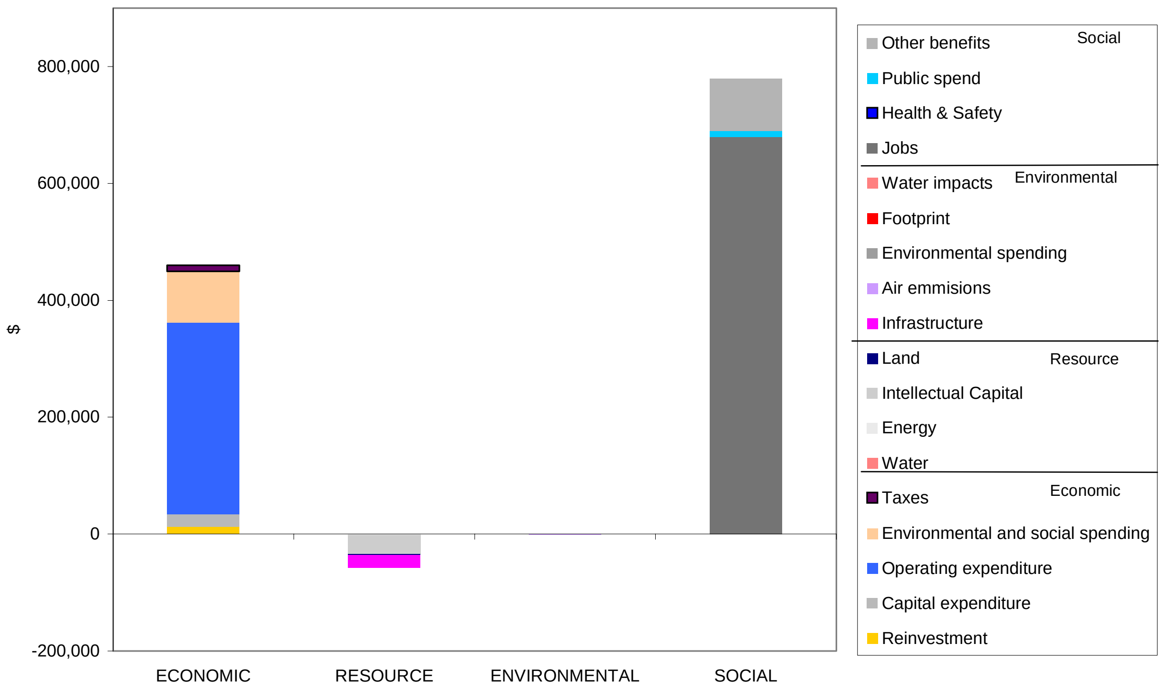

Fig. 4 Sustainability profile of Diversion scenario 1—small-scale community based operation

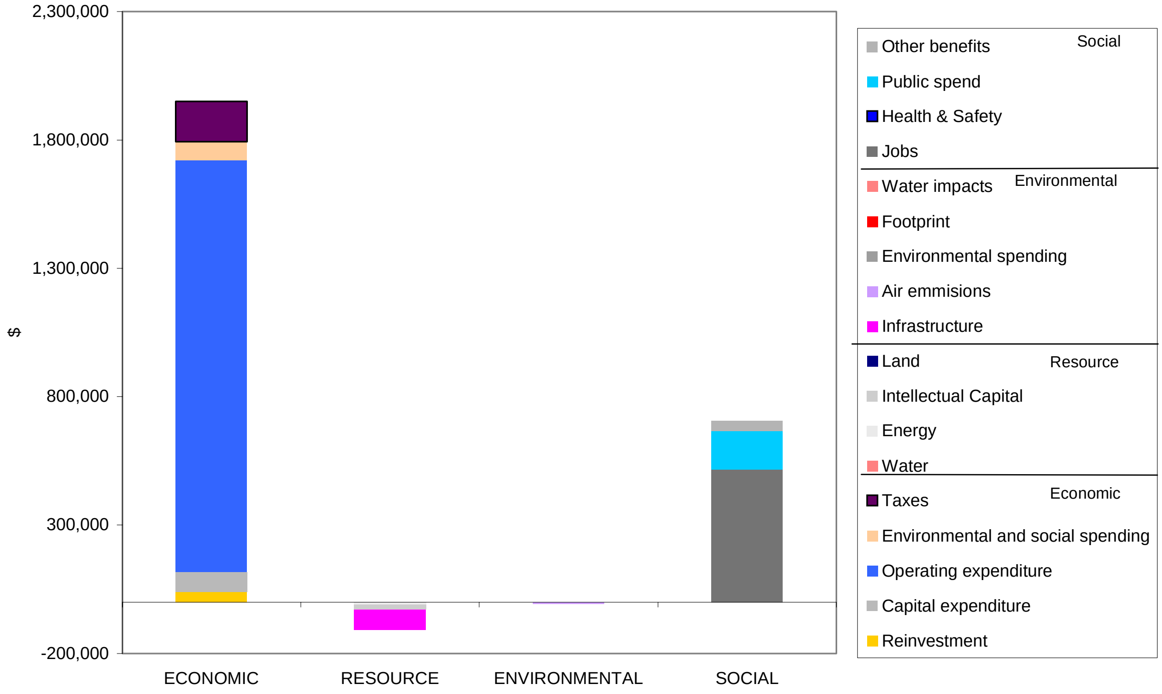

Fig. 5 Sustainability profile of Diversion scenario 2—commercial-scale community operation

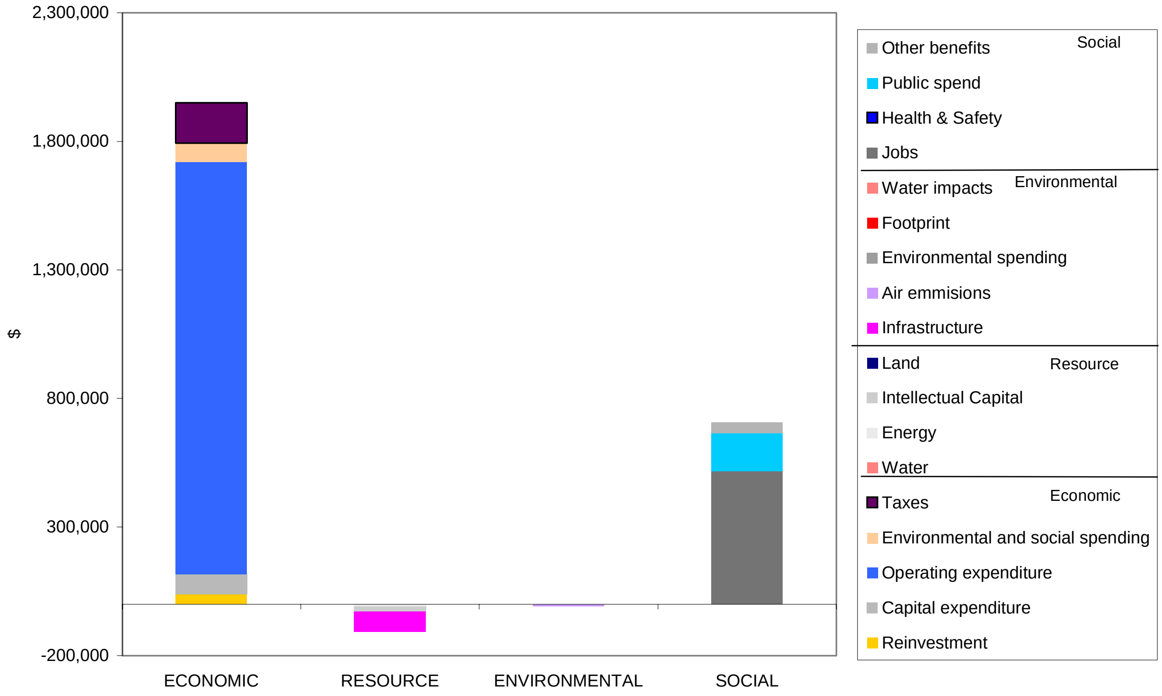

Fig. 6 Sustainability profile of Diversion scenario 3—commercial operation

Economic activity and the social benefit dominates all profiles. Expenditure by small-scale, community based operations is mainly associated with the operational costs of waste diversion, and with expenditure on activities such as education and awareness programmes (environmental and social spending). For the commercial-scale operations, economic activity expenditure is mainly associated with the operational costs of waste diversion. For all operations, resource use is mostly associated with infra-structure, and fuel usage in transportation, while environmental costs are mainly associated with emissions while transporting recyclable materials to the place of export or remanufacture. Social benefits arise mainly from the direct and indirect jobs created by the different operations. For community-based operations, additional social benefits arise from waste and education programmes, reintegration of long-term unemployed into the workforce and jobs created in the creative industry.

The ratio of social benefit to economic activity is greater in small-scale, community-based waste diversion operations than in any other waste diversion or disposal operation (Figure 4, Table 5). This is largely because more people are employed (for the tonnage of materials handled), and because additional benefits arise from the reintegration of long-term unemployed into the workforce, the creation of new jobs, and the waste education and awareness programmes. While it can be argued that social benefits are over-estimated by the inclusion of these latter items for which there are no robust valuations, they have been included to recognise some of the observed, but less tangible benefits of these operations. Further, while a median wage ($16/hr, see appendix 1) was used to calculate the value of direct and indirect jobs for most scenarios, a lower wage ($10/hr) was used to calculate the value of direct jobs in this scenario. This was done because using the median wage caused employment alone to cost more than all the activities described in the scenario, based on the information provided by two case study participants. This suggests that people employed in small-scale, community based waste diversion scenarios are typically paid less than the median wage (see also appendix 1).

The profiles for commercial-scale waste diversion operations (Figures 5 and 6) more closely resemble those of landfilling operations (Figures 2 and 3) than small-scale community operations. This is largely because the profile becomes dominated by the operational costs associated with handling larger quantities of recyclable materials.

Compared to landfill operations, the ratio of social benefit to economic activity for diversion operations is greater while the ratios of environmental and resource costs to economic activity are smaller (Table 5). However, the nominal cost per tonne for waste diverted for all diversion scenarios is greater than that for waste disposal to landfill (Tables 4 and 5), ranging from $140 per tonne for commercial recycling operations to $270 per tonne for the small-scale, community-based waste diversion operations. This indicates a greater financial cost for waste diversion operations, although there are smaller resource and environmental impacts. For community based operations, the additional financial costs are also partly due to the costs associated with the wider range of activities undertaken by these operations, including education programmes, waste exchange and organisation of community events.

The most surprising feature of all profiles is the apparent absence of any significant environmental benefit from waste diversion activities. This is largely because it was not possible to include the benefits and costs associated with the remanufacture of recyclable materials. Moreover, an additional environmental benefit of waste diversion activities is the reduction in environmental and resource impacts resulting from a reduced amount of waste going to landfill and an extension in the life of the landfill. Consequently, these benefits are reflected in the disposal to landfill scenarios (Disposal scenario 2) rather than the diversion scenarios.

Table 5 Ratios of the different capitals to economic activity, and tonnage handled for the small-scale community operation.

Ratio	Economic	Resource	Environmental	Social
Diversion scenario 1—small-scale community based operation				
To economic activity ($/$)	1	-0.12	-0.004	1.7
Per tonne ($/t)	270	-34	-1.0	458
Diversion scenario 2—commercial-scale community based operation				
To economic activity ($/$)	1	-0.06	-0.004	0.36
Per tonne ($/t)	158	-8.8	-0.6	57
Diversion scenario 3—commercial operation				
To economic activity ($/$)	1	-0.05	-0.005	0.26
Per tonne ($/t)	140	-7.6	-0.8	37

Collection scenarios

Residual waste is collected via several routes, including council household collection, commercial household collection, commercial industrial/business collection and direct delivery by residents and businesses. Figures 6 and 7 show the sustainability profiles for the two collection scenarios.

The two profiles are very similar, although they differ slightly in the environmental cost and social benefit generated (Table 6). The social benefit is greater for collection scenario 2 per dollar of money spent on collection activities and tonne of materials handled. This largely reflects the extra people employed to collect recyclables. Conversely, the estimated environmental damage arising from the collection scenario 2 is greater than for collection scenario 1 due to the emissions generated by the additional trucks needed to collect recyclables.

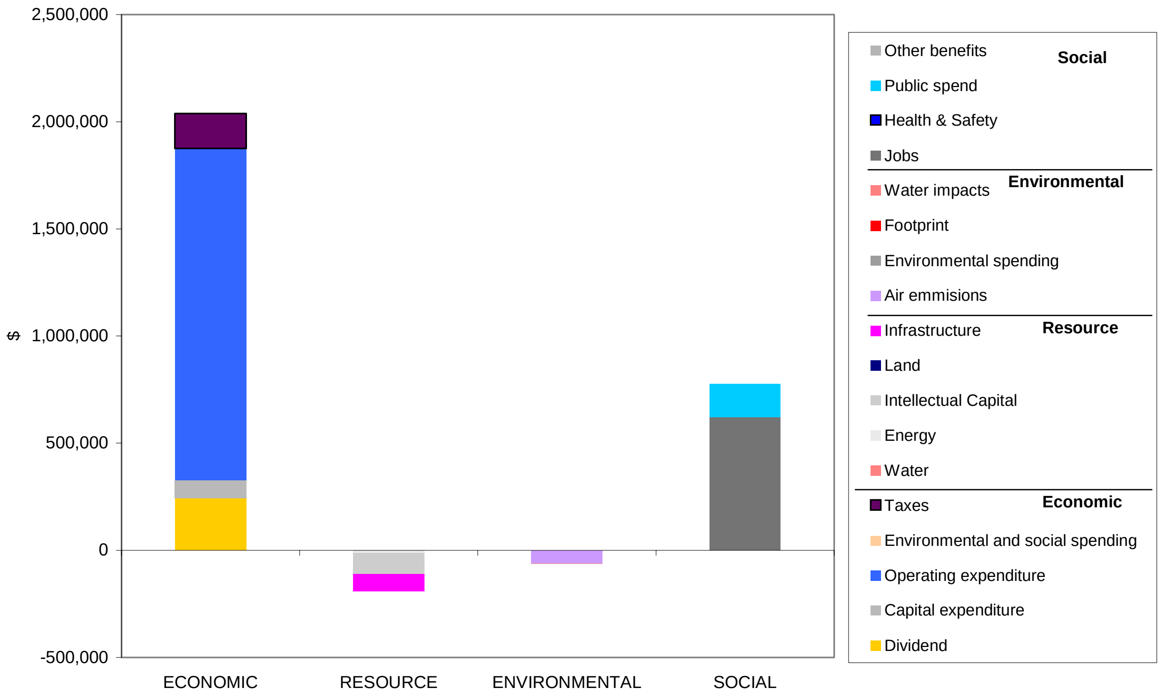

Fig. 6 Sustainability profile of Collection scenario 1—residual waste collection.

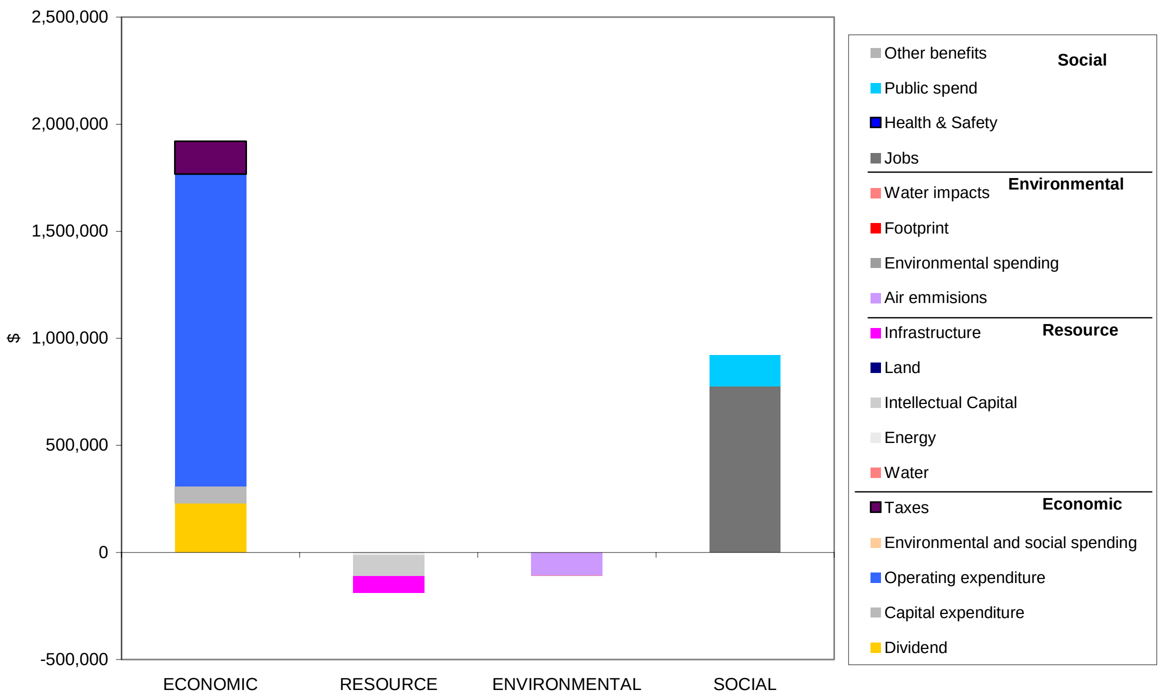

Fig. 7 Sustainability profile of Collection scenario 2—residual waste and recyclable collection.

Table 6. Ratios of the different capitals to economic activity, and tonnage handled for collection of residual waste

Ratio	Economic	Resource	Environmental	Social
Collection scenario 1— residual waste collection				
To economic activity ($/$)	1	-0.09	-0.03	0.38
Per tonne ($/t)	41	-3.8	-1.3	16
Collection scenario 2—residual waste and recyclable collection				
To economic activity ($/$)	1	-0.1	-0.06	0.48
Per tonne ($/t)	37	-3.7	-2.1	18

Collection of waste or recoverable materials is an essential part of any disposal or diversion activity. As such, the total benefits and costs of waste management activities for a given location is the sum of that for collection and the appropriate disposal and diversion scenarios. For example, using the scenarios developed here, the total benefits and costs of disposal of 50 000 tonnes of waste to landfill are the sum of that obtained for disposal scenario 1 plus collection scenario 1. If 12 000 tonnes of recyclables are diverted from landfill through recyclable collection and 38 000 tonnes of waste is disposed to landfill, the total benefits and costs of waste management are the sum of that obtained for disposal scenario 2, diversion scenario 2, and collection scenario 2.

6. Discussion

Economic activity and the social benefit of jobs typically dominate the profiles of all scenarios. Small-scale, community based waste diversion operations are probably the stand-out operation because social benefits from these operations are estimated to be greater than the economic activity arising from their activities. This probably reflects the greater range of activities undertaken by these organisations, and their typically close working relationships with the local community. Moreover, these operations in particular are driven by a philosophy wider than just recycling; thus, they often provide education programmes and organise community events, and will seek innovative ways to raise awareness about waste issues and encourage recycling and the utilisation of recovered materials. The enhanced social benefit may also reflect the scale of the operations; specifically, a smaller absolute benefit appears to be relatively larger when the absolute economic activity is also relatively small.

However, these enhanced social benefits in relation to economic activity of the small-scale community-based operations do not appear to be translated to community-based operations operating at a commercial scale. Here, the profile becomes dominated by the operational costs of handling larger quantities of recyclable materials, despite a similar range of activities. The profile of the commercial scale community based operation is most similar to that of the commercial recycling operations, although the community-based operation has larger ratio of social benefit to economic activity. This arises from the wider range of activities (and hence larger number of people employed) and the additional benefits of these activities.

Considering only economic activity expressed per tonne of materials handled; the most cost-effective operations are, in decreasing order, landfilling, commercial recycling, commercial-scale community recycling and small-scale community recycling. Estimated costs ranged from $88 per tonne for landfilling operations to $270 per tonne for small-scale, community based operations. However, this excludes consideration of the environmental and resource costs, and does not adequately capture the additional activities undertaken by community-based operations. These additional activities are likely to deliver greater longer-term benefits associated with waste minimisation and increased waste diversion; moreover, community-based operations are often committed to assisting the local community by employing long-term unemployed or intellectually challenged people.

Resource and environmental costs were greatest for landfilling operations (including refuse transfer operations), and were typically small (relative to economic activity) for other scenarios. While the costs for disposal scenarios may be reduced by diverting waste, and thus extending the life of the landfill, an interesting conundrum arises when considering the increased diversion of organic material (paper, food waste, green waste) from landfill. Specifically, reducing the amount of organic waste to landfill will reduce the potential production of electricity from landfill gas, which is an environmental benefit arising from landfill operations. In the current political climate, where carbon credits and alternative options for electricity generation are highly topical, this issue may foster resistance to an increased diversion of organic materials from landfill. Of interest is that the WISARD database indicates that landfill gas generation potential is greater for paper and timber than greenwaste (Table A10), suggesting that diversion of paper and timber from landfill may result in a greater decrease in landfill gas production.

The apparently negligible environmental and resource benefits of waste diversion operation are initially somewhat surprising given a key underlying motivation for people to recycle is the perceived environmental benefit arising from these activities. However, there are a number of reasons for this result. Firstly, the waste diversion scenarios included only waste diversion activities and not waste disposal activities—environmental benefits can be gained by extending the life of a landfill, in addition to reduced impacts from less hazardous materials being placed in the landfill. Secondly, the environmental benefits are also likely to reflect the amount of waste diverted relative to the total amount of waste going to landfill; specifically more waste would need to be diverted from landfills to result in greater environmental benefits. However, the realisation of greater environmental benefits may also depend on how that diverted waste is handled. Thirdly, the benefits and costs of remanufacturing or reusing recovered materials were excluded from this assessment, as was the handling of green waste and construction and demolition waste, which are increasingly diverted from landfill. Finally, the apparently negligible environmental benefit of waste diversion activities is also likely to arise from the under-valuing of currently understood impacts, and a limitation in our understanding of the relationship between individual projects and environmental impacts. These latter aspects remain challenges for future research.

The exclusion of the benefits and costs of remanufacturing or reusing recovered materials is a potentially significant gap in assessing the overall effects of waste diversion activities. A substantial amount of recyclable material collected in New Zealand is exported to South-east Asia for remanufacture, and there are potentially significant emissions associated with the transport of these materials. At the point of remanufacture, negative environmental impacts may be associated with the remanufacturing process, in addition to any economic and social benefits arising from the jobs created. Additionally, the remanufacture of recyclable materials reduces the use of virgin products in product manufacture, while the sale of reusable items reduces the demand for new products. While the apparently negligible environmental and resource benefits are likely a result of the exclusion of the impacts associated with the remanufacture and reuse of recovered materials, it also raises additional questions for further consideration: How sustainable are existing practises for remanufacturing recyclable materials, and what exactly are the environmental benefits? For example, a recent life-cycle analysis of disposable nappies and cloth nappies found a negligible difference in the environmental impact of the two types of nappies (Environment Agency 2005). This is contrary to the belief of many environmental groups who considered that cloth nappies were significantly less harmful to the environment.

Deciding what constituted an appropriate comparison of different waste disposal and diversion options was a key challenge in undertaking this project. This assessment focussed on comparison of the different individual components comprising waste management activities in New Zealand; namely, waste disposal, diversion and collection. Furthermore, scenarios, as opposed to the specific activities of the case study participants, were used to provide the comparison. This approach was considered to be more widely applicable than a comparison of the activities of individual organisations, as individual organisations are likely to include a different range, and scale, of activities. For example, Xtreme Waste collects residual waste for disposal to landfill in addition to handling recovered materials; in contrast Wastebusters Trust handles only recovered materials. Furthermore, there was a requirement to protect the confidentiality of some information provided–scenarios provided a reasonable approximation, as opposed to actual, financial costs and activities associated with a particular type of waste disposal or diversion as represented by the case study participants. The scenarios also allowed normalisation of the costs and activities appropriate for that required for handling a defined waste stream–this also assisted in comparison between different types of activities. In addition, focussing on the assessment of different components of waste management allows greater flexibility in the assessment of whole waste stream, which can be undertaken by appropriately summing, based on activities and scale (tonnage), the profiles for the different components (collection, disposal and diversion). Finally, the scenarios developed are considered to be generally applicable to other regions of New Zealand, if adjusted for a similar scale and type of activity.

7. Conclusion

Sustainability profiles were developed for the individual waste disposal, diversion and collection scenarios and present an attempt to capture the wider benefits and disbenefits associated with the different scenarios. While improvements could undoubtedly be made to the absolute values comprising the elements of the sustainability profiles for the different scenarios, the current profiles provide a starting point to consider how or what aspects could change to achieve more 'sustainable' activities, or indeed, what additional aspects should be considered. An exact definition of sustainability has not been agreed, and a more 'sustainable' profile, including the components that make up that profile, also depends on what is considered important—in this case, by Environment Waikato and its partners in relation to waste disposal and diversion activities.

The scenarios created provide a focus on individual components that typically comprise waste management activities in New Zealand. In any given location, it is likely that all three components will be operational, i.e, waste and recoverable materials will be collected from residents and businesses and delivered to waste disposal (landfill) and waste diversion (recycling) operations. Differences between locations will primarily arise from the scale (tonnage of materials handled) and the types of activities occurring (e.g., community-based or commercial waste diversion operations). This information can be used to assess the benefits and costs of management of the entire waste stream by summing those benefits and costs for the individual activities relevant to a given location and scale of operation.

Economic activity and the social benefit of jobs typically dominate the sustainability profiles for all waste disposal and diversion scenarios. The ratio of social benefit to economic activity is largest for small-scale, community based operations, which typically undertake a wide range of activities including education programmes and organisation of community events around waste issues. For commercial-scale waste diversion operations, economic activity (mainly operating costs) dominate the profiles, which are similar to those generated for landfill operations.

Resource and environmental costs were greatest for landfilling operations (including refuse transfer operations), and were typically small (relative to economic activity) for other scenarios.

However, there were limitations on the current assessment. Specifically, the separate handling of green waste and waste from construction and demolition was not considered; importantly, it was also not possible to include the benefits and costs of remanufacturing recyclable materials, which often includes export from New Zealand. This latter aspect may have significant positive and negative impacts (e.g., offsetting manufacture of products from virgin materials, fuel use and emissions associated with the export of goods from New Zealand). Under-valuing of environmental and resource costs may also occur and arises from our limited understanding of the relationship between activities and resource and environmental impacts; moreover, the valuation of non-financial impacts is debated at both conceptual and technical levels. Nonetheless, monetisation enables the relative magnitude of these impacts to be considered alongside financial costs.

Despite these uncertainties, the apparently negligible environmental and resource benefits of waste diversion scenarios in the current report also raises additional questions for consideration: How sustainable are existing practises in New Zealand for remanufacturing and reuse of recovered materials, what exactly are the environmental benefits of recycling, and where are these benefits realised?

Finally, while economic activity is presented as a positive benefit in the current assessment, it could be debated as to whether having a high level of economic activity in an ‘unsustainable’ activity (e.g. waste disposal) is actually a desired outcome. Further, prevention of waste generation will probably yield additional different benefits that may be more significant than those associated with waste diversion; this aspect has not been adequately explored in this assessment.

8. Recommendations

- The impacts of remanufacture and reuse of materials recovered in New Zealand should be assessed. A comparison between recovered materials remanufactured in New Zealand and remanufactured off-shore would disclose the magnitude of different impacts and where these impacts are realised.
- Assessment of the diversion of green waste and construction and demolition waste would provide an indication of the relative impacts of these activities.
- Similarly, the impacts of waste minimisation should be more explicitly addressed in further assessments.
- Further work is required to attain better valuations of currently understood environmental and resource impacts, and to enhance our knowledge of the relationship between individual operations and these impacts.

9. Acknowledgements

A huge thanks is owed to Richard Bax (Hamilton City Council), Rick Thorpe (Xtreme Waste), Sarah Gordon (Recovered Materials Foundation), Sheryl Stivens (Wastebusters Trust Canterbury), Louisa Palmer and Wayne Schache (Fullcircle Carter Holt Harvey) and Phill Houben (Perry Environmental) for their time, provision of information regarding the activities of their respective organisations, and comments on the activities of their respective organisations, and comments on drafts; and also to Environment Waikato for accommodating the delays in the writing of the report. James Lennox and Bob Frame (Landcare Research) and Michael Fraser (Victoria University) are thanked for constructive comments and input to the report, as are James Lennox and Robbie Andrew (Landcare Research) for review. Thanks also to Felicity Fahy, Annabelle Giorgetti, and Robert Brodnax (Environment Waikato), and Chris Purchas (Ministry for the Environment) for comments on the draft report. Finally, Peter MacGregor and Wendy Weller (Landcare Research) are thanked for editorial and formatting assistance.

This work was supported by funding from:
- Environment Waikato
- Fullcircle Carter Holt Harvey
- Zero Waste New Zealand
- Dunedin City Council
- Marlborough District Council
- Taranaki Regional Council
- South Taranaki District Council
- Gisborne District Council
- Waimakariri District Council
- Horowhenua District Council

10. References

Bebbington, J. 2001. Sustainability assessment modelling at BP. Advances in Environmental Accounting 56-66.

Booz, Allen and Hamilton 2005. Surface transport costs and charges study. Environmental Impacts Working Paper. Report for the Ministry of Transport.

CTU (Council of Trade Unions) 2004. Economic Bulletin 51. Available at: http://www.union.org.nz/policy/109391207516520.html. Accessed July 2005.

Environment Agency 2005. Life cycle assessment of disposable and reusable nappies in the UK., Bristol, UK, Environment Agency.

MfE (Ministry for the Environment) 2004. Landfill full cost accounting guide. Wellington, Ministry for the Environment.

MfE undated. WISARD Lifecycle software for waste management in New Zealand. Wellington, Ministry for the Environment. CD-ROM.

Patterson M, Cole A 1999. Assessing the Value of New Zealand's Biodiversity. Massey University, Palmerston North.

Price Waterhouse Cooper 2004. Building Sustainable Development—SAM Discussion Report. Unpublished report to Landcare Research.

RMF (Recovered Materials Foundation) 2002. Sustainability report 1999–2002. Christchurch, Recovered Materials Foundation.

RONZ (Recycling Operators of New Zealand) 2004a. Aluminium Fact Sheet. http://www.ronz.org.nz/information/index.html. Accessed July 2005.

RONZ 2004b. LDPE Fact Sheet. http://www.ronz.org.nz/information/index.html. Accessed July 2005.

RONZ 2004c. HDPE Fact Sheet. http://www.ronz.org.nz/information/index.html. Accessed July 2005.

RONZ 2004d. PET Fact Sheet. http://www.ronz.org.nz/information/index.html. Accessed July 2005.

RONZ 2004e. Glass Fact Sheet. http://www.ronz.org.nz/information/index.html. Accessed July 2005.

Waste Management NZ limited 2004a. Financial Information 2004. http://www.wastemanagement.co.nz. Accessed July 2005.

Waste Management NZ limited 2004b. Environmental and social report. http://www.wastemanagement.co.nz. Accessed July 2005.

Xtreme Waste 2004. An account of the benefits for the last three years Available at: http://www.xtremewaste.org.nz/finance.htm. Accessed March 2005.

11. Appendices

Appendix 1 Data input for SAM

Economic

Data on economic activity for the individual scenarios were based on data provided by case study participants, data provided in the 2004 Annual Report for Waste Management, and data provided in the Ministry for the Environment's *Landfill full cost accounting guide* (MfE 2004). Data from the financial information of the Annual Report of Waste Management (Waste Management 2004a) provided an estimate of the distribution of costs expressed as a percentage of the total revenue for a commercial recycling scenario (Table A1).

Table A1 Distribution of costs estimated from Waste Management (2004a)

Item	% of total revenue
Dividend/retained earning	12
Capital	4
Tax	8
Operating	Remainder of total revenue

Resource

The resource depletion costs used in this assessment are shown in Table A2.

Table A2 Resource depletion costs used in the current assessment

Resource	Cost	Basis
Crude oil	$131.4/tonne	Global average of economic rents of crude oil over 1992-2001, World Bank[1] (USD92/tonne), converted to NZD where NZD=0.7USD
Steel	$37.4/tonne	Global average of economic rents of steel 1992–2001, World Bank[1] (USD26.3/tonne), converted to NZD where NZD=0.7USD
Electricity	$0.201/kwh	Based on cost of electricity, in the absence of other data
Water	$1.74/tonne	Based on cost of water, in the absence of other data
Land uptake	$70000/ha	Cost of land amortised over the lifetime of the project
Infra-structure	variable	Based on capital expenditure

[1] http://lnweb18.worldbank.org/ESSD/envext.nsf/44ByDocName/GreenAccountingAdjustedNetSavings. Accessed March 2005

Environment

With the exception of electricity, quantitation of emissions from different waste disposal and diversion operations used data from *WISARD Lifecycle software for waste management in*

New Zealand (MfE undated); these are provided in the next section. For electricity an emission factor 0.0001671 tCO_2/kWh was used. This is an average value for current electricity generation in New Zealand and is used in EBEX21 (S.McKenzie, Landcare Reseaerch, pers. comm.), a programme to estimate greenhouse gas emissions from business and domestic activities (http://www.ebex21.co.nz/index.htm, Accessed July 2005)

Valuation of environmental damage caused by air emissions used damage cost estimates from a recent Ministry of Transport publication (Booz et al. 2005), and are shown in Table A3.

Table A3 Damage costs used in the current assessment

Pollutant	\$A/tonne[1]	\$NZ/tonne[2]
Particulates	93 180	103 500
CO	0.8	0.9
NO_x	1750	1950
THC	875	970
SO_2	4380	4870
CO_2[3]	-	25
CH_4[4]	-	525
N_2O[4]	-	9500

[1] Original study: Watkiss 2002. Fuel taxation Inquiry: The air pollution costs of transport in Australia.
[2] Based on conversion rate of \$NZ1 = \$A0.85
[3] Damage costs used in Booz et al (2005), on advice from the Ministry of Transport; the current carbon tax proposed by the government is \$15 per tonne of CO_2
[4]Calculated from cost for CO_2, multiplied by global warming potential of 21 for methane, and 380 for N_2O

In addition, a damage cost of 0.17c per vehicle kilometre travelled was used to estimate the impact of transportation on surface water quality (Booz et al. 2005). A value of \$2080 per ha was used to estimate the value of ecosystem services on land used for landfill operations (Price Waterhouse Cooper 2004). This was the economic value of New Zealand's biodiversity estimated by Patterson and Cole (1999), updated to 2004 dollars and expressed as an average for the total land area of New Zealand. Ecosystem services were assumed to be zero for urban land, which is likely to be covered by buildings.

Currently, the value associated with nuisance aspects of waste diversion and disposal operations is assumed to be zero for all scenarios because resource recovery operations are typically located in industrial zones in urban areas for which this loss in value is considered to be minimal, and because few people live close to landfills. Further, no data were found on which to estimate loss in value of land surrounding waste management facilities in New Zealand. This would be an area of further investigation.

Social

Jobs: The value of direct and indirect jobs was estimated using a median wage of \$16 per hour (CTU 2004), as insufficient information was provided by most case study participants to enable the use of a more representative value. However, a lower wage value (\$10/hr) was used in the small-scale, community based recycling operations because the median wage resulted in wage costs greater than the total economic activity indicated by the case study participants, for the specified number of employees.

Employment multipliers, calculated using input-output analysis, for Hamilton City region were provided by Butcher Associates. For the Waste disposal, sewerage and drainage services sector, the Type I multiplier was 1.45, and Type II multiplier was 1.65. The type II multiplier was used in the current assessments to estimate the value of indirect jobs.

Taxes: The social benefit of taxes was based on the proportion of taxes spent on different items, and a social benefit factor (Table A4). The social benefit factors are based on those developed for the UK SAM, and are unlikely to be directly applicable to New Zealand. This is an area for further research.

Table A4 Distribution of expenditure of taxes, and social benefit factors.

Item	Percentage [1]	Factor[1]
Education	18	2
Health	20	2
Law and order	5	0.5
Defence	3	0
Transport and communications	4	0
Social and welfare spending	34	0.5
Other (core government, finance and other)	16	

[1]Source: Budget 2005 Key Facts for the Taxpayer (NZ Treasury)
[2]From the UK SAM

Health and Safety: A lost time rate of 323 days per million hours worked (Waste Management 2004b) was used to estimate the amount of time lost due to injury. This is similar to the rate estimated from RMF (2002), which reports the number of days lost due to accidents for 2001/2002 year as 37.5 days. The number of FTE employed by RMF in 2001/2002 is 51. Assuming these employees work an 8 h day for 245 days per year (5 days a week, 49 weeks) this equates to a lost time rate of 375 days per million hours worked.

The value of the time lost was estimated to be $384 per day. This was based on 1.5 times the wage for the person injured plus a replacement to allow for additional costs of injury. This is also an area for further research.

Appendix 2 Estimation of environmental and resource use

Quantitation of air emissions and resources used data from WISARD Lifecycle software for waste management in New Zealand. The data are provided in the following tables.

Table A5 Resources used in landfill construction and operations

Item	Large dry composite lined landfill (WISARD)	Normalised to 50 000t/yr (this study)
Lifetime (yr)	30	30
Waste t/mth	10 420	4166.67
Tracked bulldozer fuel consumption (l/mth)[1]	10 420	4166.67
Diesel used in capping(l)[1]	330 000	131 958
Clay construction (t)	465 048	185 960
Sand construction (t)	620 221	248 009
Bentonite construction (t)	1600	639.795
HDPE construction (t)	761	304.303
PP construction (t)	500	199.936
Steel construction (t)	130	51.9834
Diesel construction (l)[1]	300 000	119 962

[1]Emissions associated with fuel use are provided in Table A8

Table A6 Resources used in refuse transfer construction and operations

Item	NZ—Transfer Station with Compaction	Adjusted for 30 000 tonnes pa
Lifetime	20	20
Concrete construction (t)	2380	
Asphalt construction (t)	520	
Steel construction (t)	75	
Fuel consumption of transport (l/100 km)[1]	38	38
Tonnage carried in truck	24	24
Treated tonnage t/mth	3083	2500
Volume of treated compacted waste (m^3/mth)	12333	10000
Loader – fuel consumption (l/mth)[2]	1600	1297
Electricity (kWh/mth)	4167	3379
Water use l/mth	37.5	30

[1]Emissions based on data provided in Table A9
[2]Emissions based on data provided in Table A8

Table A7 Resources used in Resource Recovery Park construction and operations

Type	NZ – Resource Processing Centre (Simple MRF) Semi-mechanised	NZ – Resource Processing Centre (MRF) Mechanised
Working time (d/mth)	21	22
Lifetime	10	10
Treated tonnage (t/mth)	1200	1000
Electricity (kWh/mth)[1]	2856	27720
Asphalt construction (t)	18.3	18.3
Concrete construction (t)	256	256
Steel construction (t)	61.6	61.6
Aluminium construction (t)	0.22	0.22
Rubber construction (t)	0.21	0.21
Fuel use (l/mth)[2]	2000	2000
Water usage (m^3/mth)	100	150

[1]includes operation of conveyer belt, baler, and general site operations
[2]includes operation of a loader and forklift, emissions based on data provided in Table A8

Table A8 Air emissions from fuel use

Emission type	Emissions (g/l)
CO_2	2640
CO	17.1
Non-methane hydrocarbons	6.26
CH_4	0.16
Particulates	3.58
SO_x	0.76
NO_x	38.1
N_2O	1.13
NH_3	0.01

Table A9 Resources used and air emissions associated with collection vehicles

Item	Vehicle type			
	Rigid 7.5-17 (Refuse collection vehicle)	Truck/trailer unit (60m^3)	Small recycling truck (compactor & trailer)	Large recycling truck
Actual load (m^3)	27	60	3.2	5
Steel in the vehicle (t)	11	18.5	3.04	8.5
Aluminium in the vehicle (kg)	390	1300	105	0.05
Fuel consumption urban (l/100 km)	26.7	45.28	16.03	16.03
Fuel consumption rural (/100 km)	20.91	38.89	14.25	14.25
Fuel consumption autoroute (/100 km)	27.8	34.66	19.68	19.68
CO_2 urban (g/100 km)	61 810	121 210	42 910	42 910
CO urban (g/100km)	251.2	479.3	188.3	188.3
Non-methane hydrocarbons urban (g/100km)	99.3	194.7	68.9	68.9
CH_4 urban (g/100 km)	3.8	7.5	2.7	2.7
Particulates urban (g/100km)	101.6	96.9	140.8	140.8
SOx urban (g/100km)	19.4	38	13.5	13.5
NOx urban (g/100km)	265.6	687.3	172	172
N_2O urban (g/100 km)	6.5	16.7	4.2	4.2
NH_3 urban (g/100 km)	0.8	2.1	0.5	0.5

Table A10 Biogas production of different waste materials

Waste Type	Biogas production (kg/kg)
Clothing	0.18
Paper	0.375
Cardboard	0.375
Wood	0.375
Green waste	0.167
Food	0.167