Waste Levy Extension

Estimates of extending and raising levy

NZIER report to Ministry for the Environment

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Key points

In this report we examine the costs and benefits of various options for extending New Zealand's Waste Disposal Levy, both by spreading its coverage over currently unlevied Class 2 and/or Class 3 landfills, and also by various proposals for raising the levy from its current $10/tonne of landfill disposal applied to Class 1 landfills that accept household waste.

Key to this analysis is how changes in relative prices of different options for discarded waste are likely to prompt diversion of wastes to different destinations, compared to continuation of the current situation. Information on the New Zealand waste disposal industry is limited, and the analysis depends on assumptions that draw on experience in New Zealand and overseas.

Worldwide waste levies have been used since the 1970s

Waste levies and taxes have been widely used in OECD countries, particularly in Europe where a combination of high population density and limited space for landfill development has led to the use of levies to reduce the demands made on landfill space. They are also applied by most Australian state governments, at a variety of levels and with different rates applying to urban and rural waste generation.

Most countries' levies are set at levels designed to encourage diversion of waste from landfilling to meet reduction targets and are far higher than the environmental costs that have been estimated for landfill operation. The UK introduced a landfill tax in the 1990s specifically to charge for the environmental detriments caused by landfilling, but has since increased the tax above the estimated environmental cost. .

The international experience is that waste generation is not very responsive to changes in price of waste disposal

Empirical estimates of the impact of changing the price of waste disposal show there is some effect, but not a large effect on waste volumes. The percentage change in the volume of waste disposed of is much less than the percentage change in price of disposal – waste disposal demand is price inelastic. This explains why countries have opted for high levies to achieve diversion from the landfilling stream.

The international evidence also suggests that price changes are more effective if they are accompanied by other measures to reduce barriers to recycling and other alternatives.

Landfilling has a range of environmental effects

Landfilling has been associated with a range of adverse environmental effects, including discharges to air (greenhouse gas emissions and some local air pollutants), discharges into ground/water (leachates of heavy metals) and general nuisance effects such as noise, odours, lighting and attraction of vermin. Apart from greenhouse gases and discharges to water which may spread widely, these effects are highly localised. Siting landfills away from areas of habitation reduces their economic and environmental cost, offset partly by the consequent need to transport waste over longer distances from source to destination.

The international evidence suggests that the economic cost of these environmental effects is also relatively low, at least from modern landfills with management systems to contain the adverse environmental effects. There will be local exceptions to this.

New Zealand has a diverse mix of landfills

New Zealand's landfills range from the Class 1 sites authorised to accept active organic wastes such as the municipal waste collections, through Class 2 and Class 3 landfills that accept only small proportions of active waste to Class 4 cleanfills intended to accept only inert material. The exact number of sites that are open and receiving waste is difficult to determine, and they are distributed widely across the country.

Recently there have been around 40 Class 1 landfills paying the waste disposal levy, but estimates of the total number of landfills range between 250 and 400 sites. Over 80% of the Class 1 waste disposal is accounted for by 10 landfills and there is a long list of landfills receiving very low tonnages each year. We do not have data on disposal patterns in other classes of landfills but disposal volumes are likely to vary widely across sites.

The price of landfilling also varies widely

The effective price to customers of waste disposal combines the landfill charge plus the cost of collection and transport to point of disposal. These are highly variable with location and with the scale of waste consignments and the availability of discounts for different suppliers. Due to limited information we assume representative prices for different classes of landfills. This shows broad patterns that would be expected under alternative proposed changes to the waste disposal levy.

We model the effects of changes in the scope and level of waste disposal levy

The principal effect of changing the levy is to change the price to customers of waste disposal, as the levy at the landfill gate is passed up through intermediaries to waste collection and disposal services to customers. We model the changes to the levy in terms of their effects on waste deposited in different landfill categories or sent for material recovery and recycling. To do this we attach economic values to environmental consequences, material recovery, effects on costs and revenues for government and the landfill industry; and costs for waste service customers (residents households, commercial and industrial and construction and demolition businesses).,

Some costs or benefits are only partially quantified within the model, so the results should be viewed alongside other social, cultural and environmental considerations. The modelling covers the period 2020 to 2030 and focuses on the direct effects of levy changes on waste volumes and material recovery; indirect effects, such as the impacts of levy-funded initiatives to support material recovery, are excluded from the analysis to concentrate on the effects of levy changes alone.

Results are driven by price responsiveness of waste disposal

Modelling shows the importance of responsiveness to changes in disposal price, in driving the material diversion away from landfilling, reduction in environmental effects and the amount of levy collected. Responsiveness is modelled with a range of price elasticities from international literature, in the absence of New Zealand estimates.

The higher the elasticity, the greater the diversion of material out of levied landfills to alternatives such as material recovery and unlevied landfills. This reduces the revenue raised by the levy but increases net social benefit, with higher value of material recovery and averted greenhouse gas emissions and local environmental impacts.

Extending the levy to Class 2 and Class 3 landfills is necessary but not sufficient to improve waste outcomes

This would counter potential leakage of wastes from disposal at levied sites, increase government's levy revenue and divert some material from Class 2 and 3 landfills to material recovery. But it also imposes compliance cost on these landfills. For some landfills the fixed costs will be disproportionately high compared to the low waste volumes of some landfills.

Increasing the levy on only Class 1 landfills lifts their relative price, diverting some waste from them to alternatives

The price effect becomes more apparent the higher the Class 1 levy increase. There is risk of increased adverse environmental effects if active organic wastes are diverted, deliberately or inadvertently, to landfills with lower management standards than Class 1. This can be is offset to some extent by raising the levy on Class 2 as well as Class 1 landfills.

Waste levy options – class 1 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020	20	10	10	10	10	10
2021	30	10	10	10	20	10
2022	50	30	30	30	30	30
2023	50	50	60	60	50	50
2024	50	50	75	60	50	50
2025	50	50	90	60	50	50
2026	50	75	100	60	50	50
2027	50	75	110	60	50	50
2028	50	75	120	60	50	50
2029	50	75	130	60	50	50
2030	50	75	140	60	50	50

Source: NZIER

Waste levy options – class 2 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020						
2021	20	10	10	10	20	10
2022	20	20	20	20	20	10
2023	20	20	20	20	20	20
2024	20	30	20	20	20	20
2025	20	30	30	20	20	20
2026	20	30	30	20	20	20
2027	20	30	30	20	20	20
2028	20	30	30	20	20	20
2029	20	30	30	20	20	20
2030	20	30	30	20	20	20

Source: NZIER

Waste levy options – class 3 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020						
2021						
2022						
2023	10	10	10	10	10	10
2024	10	10	10	10	10	10
2025	10	10	20	10	10	10
2026	10	20	20	10	10	10
2027	10	20	20	10	10	10
2028	10	20	20	10	10	10
2029	10	20	20	10	10	10
2030	10	20	20	10	10	10

Source: NZIER

Results of the final set of levy change options are summarised in the table below.

Summary of results

Totals of levy-induced changes over 2020-2030

Price Elasticity	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Added levy revenue over 11 years *($ million)*						
-0.10	1,975	2,411	3,326	2,053	1,842	1,758
-0.23	1,867	2,226	2,875	1,916	1,742	1,662
-0.58	1,578	1,732	1,677	1,551	1,476	1,407
Added material recovery over 11 years *(Million tonnes)*						
-0.10	1.009	1.283	1.732	1.056	0.966	0.915
-0.23	2.349	2.944	3.975	2.423	2.217	2.099
-0.58	5.871	7.360	9.938	6.058	5.542	5.248
Net societal benefits over 11 years *(PV$ million)*						
-0.10	-28.7	-19.9	-2.6	-26.4	-29.9	-31.8
-0.23	16.8	35.5	75.1	20.6	12.5	8.2
-0.58	137.7	182.6	281.7	145.4	125.2	114.6

Source: NZIER

As material recovery rises, levy revenue falls

The table shows that the higher the elasticity, the higher the material recovered and the higher the net present value but the lower the revenue collected. The value of recovered material, plus the avoidance of environmental effects of landfill disposal contributes to net societal benefits increases with the price elasticity.

Option 3 escalates the levy on Class 1 landfill disposal in stages to $140/tonne by 2030 and is estimated to yield the highest additional levy revenue, the highest material recovery and highest net societal benefits. But Option 3 is exceptional in that, at high elasticity, the levy revenue declines after 2026 (when levies are at $100, $30 and $20 respectively for Class 1, 2 and 3 landfills), due to high diversion of material away from Class 1 landfills to lower levied or unlevied landfills and recovery.

Waste is also diverted from Class 2 and Class 3 landfills in response to their levy increases, but they also pick up waste diverted from Class 1. Material recovery and Class 4 landfills which are not subject to a levy gain most material volumes.

Option 4 is a truncated variant of Option 3 that halts the rise in levies after 2023 collects less revenue but does not experience the revenue declines after 2026, because the levy does not get high enough to induce additional diversion out of Class 1 landfills. Under the truncated option, Class 1 and Class 2 landfills experience the largest net material diversion away from disposal, and non-levied options like Class 4 landfills and material recovery have the largest net gain in material.

Large price rises combined with high elasticities, particularly in Option 3's "escalator" on Class 1 levies, increase the likelihood of businesses and waste disposal customers incurring additional costs to avoid the high disposal charges, which cannot be accurately reflected in the model based on available data. Elasticity estimates are derived from studies of effects of small price changes, so applying elasticities to these large levy increases is less reliable than applying them to smaller increases in levies and landfill prices.

Results little changed with variations in assumptions

The modelling includes transport cost as part of the price of landfilling, averaging $16.67 per tonne on Class 1 landfill waste and $8.33 per tonne on other classes of landfill. If that cost were removed the estimated societal benefit would increase to varying degrees across options depending on elasticity, because the levy forms a larger proportion of the transport-exclusive landfill price.

If the trajectory of waste generation over time is lower than that modelled, there would be reduced societal benefits from material recovery and savings in greenhouse gas emissions and in local environmental impacts around landfills. This would delay the point at which cumulative benefits outweigh cumulative costs and lower the net present value.

Compared to earlier iterations of modelling, final options delay the increase in extension or raising of waste disposal levies and yield lower revenue gain and net present value. But their benefit cost ratios frequently exceed those of earlier modelled options, as cost impacts are also lower and or delayed in the discounted analysis.

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1. Introduction

The Ministry for the Environment commissioned NZIER to provide a rigorous cost benefit analysis of extending the current waste disposal levy to more landfills, and model various changes to levy rates and coverage, which builds on international experience in the design, use and effectiveness of such levies. This is to inform a Regulatory Impact Assessment of the development of regulations around the waste disposal levy.

The Waste Disposal Levy was created under the Waste Minimisation Act 2008 and introduced in July 2009, at a rate (unchanged since) of $10/tonne of final disposal at Class 1 landfills. The levy has raised around $207 million by 2017, allocated approximately 50% to local authorities, 44% to the Waste Minimisation Fund for subsidising waste minimisation projects, and 6% to administration costs.

The number of landfills in each class is subject to limited and sometimes conflicting data and the classification of landfills is somewhat fluid. In this report the terms mean:

- Class 1 landfills are designed to handle municipal solid waste (MSW) and can receive all types of waste, including those with an active, putrescible content greater than 5% by volume; they account for about 21% of recorded gross waste sent for disposal (before material recovery and recycling) or 30% of net waste landfilled.
- Class 2 landfills include industrial monofills and construction and demolition fills and can handle waste with less than 5%putrescible content; they account for about 17% of gross waste
- Class 3 landfills are managed and controlled fills handling mixed waste with less than 2% putrescible content, including contaminated soil and inert materials; they receive less than 1% of total waste disposal;
- Class 4 landfills are designed to handle waste with less than 2% putrescible organic content such as inert "cleanfill" and excavated material; they receive 25% of gross waste.

Around 9% of recorded gross waste is disposed of in private farm dumps and 28% of material delivered to landfills is recovered in some form for recycling or reuse.

The first purpose of the levy is to raise revenue for promoting and achieving waste minimisation. A second purpose of the levy is to increase the cost of waste disposal, in recognition that disposal imposes costs on the environment, society and the economy.

At $10 (plus GST) per tonne the current waste levy rate was set to:

- generate revenue to fund waste minimisation activities within the current capacity and capability to spend such revenue efficiently
- identify any unintended consequences resulting from the levy
- minimise the risk of inducing perverse behaviour (such as illegal dumping).

As 70% of waste disposed is estimated to be at facilities that fall outside the scope of the levy, it will have had limited effect on the cost of disposal or the incentive for waste generators to minimise waste.

In this report we first review recent literature on experience with waste levies, then describe the existing environment for landfills in New Zealand, to set a baseline for analysis. We then describe modelling and assumptions before discussing results and implications of the options analysed in this report.

Our analysis takes account of the negative externalities of waste disposal, and the possible cost impacts for businesses and consumers in discarding their waste materials, and quantifies them to the extent it is feasible to do so. It considers the implications for waste material diversion such as resource recovery, recycling, and waste treatment, and also unintended consequences such as incentives created for fly-tipping or converting waste to energy.

2. Literature update

A waste disposal levy is a government surcharge added to landfill charges to raise the price of disposal in landfills. The price of disposal faced by a waste generator also includes the cost of collection and transport of waste to the point of disposal, which lowers the proportionate impact of a waste levy on the price of disposal. Collection cost is common to many options for waste discarding, but variations in transport distances complicate the calculation of the impact of transport costs on the effect of levies on price and demand for waste disposal.

Waste disposal levies have been applied since the 1970s, initially in small, densely populated countries with a shortage of land available for constructing new landfill facilities (e.g. Denmark, the Netherlands) and with an interest in diverting material from the landfill disposal stream to material recovery or alternative disposal such as through incineration and Energy from Waste plants. Since then they have been taken up widely by western European countries, although set by national or sometimes regional governments at rates and in ways that vary across jurisdictions.

They have also been taken up by most of the states and territories in Australia, except for the Northern Territory and Queensland (which had a levy, revoked it, and is considering reintroducing one). Canadian provincial governments apply waste levies. The USA has no national level levy, although some states, counties and city councils may levy fees on waste disposal facilities, e.g. a state fee of $1.40 per tonne imposed in 2002 to fund activities of the California Integrated Waste Management Board.

2.1. New Zealand literature

In New Zealand, the Ministry for the Environment publishes reviews of the effectiveness of the waste disposal levy at intervals of 3 years (MfE 2017). These summarise the volumes of waste covered by the levy, the revenues raised, and their allocation to councils and the income and outlays of the Waste Minimisation fund to businesses and non-profit organisations seeking funding for waste reduction or material recovery schemes. These reviews do not cover waste outside that recorded at Class 1 landfills subject to the levy, and data on *total* waste generation and disposal is limited. Table 1 shows recent performance of the waste disposal levy; levy revenue appears to be less than $10 per net tonne disposed, because of accruals between years.

Table 1 Recent performance of waste disposal levy

June Year ends	2014	2015	2016	3 Year Total
Gross tonnage	3,325,859	3,393,491	3,761,945	**10,481,295**
Diverted tonnage	406,417	418,971	382,398	**1,207,786**
Net tonnage	2,919,442	2,974,520	3,379,547	**9,273,509**
Levy revenue $	27,786,974	30,512,577	33,493,078	**91,792,629**

Source: MfE Review of Effectiveness of the Waste Disposal Levy 2017, Table 2 and Table 6

Two recent reports have examined a broader picture of waste generation and disposal in New Zealand. Covec (2012) examined economic factors relating to waste minimisation in New Zealand, including the market failure rationale for applying a levy that raises the price of disposal above the direct costs of landfill provision to reflect external impacts on the environment, public health and amenity. Covec also looked at the effect of landfill charges on waste minimisation, noting that structural changes in the New Zealand landfill sector towards larger landfills with better containment and treatment systems had caused some consolidation in the industry and resulted in closure of many smaller, older landfills that could no longer attract the volumes necessary to cover their costs of operation.

Covec found the levy at its current $10/tonne rate would have created limited incentive for waste minimisation: assuming a price elasticity from international literature of -0.47, and a weighted average landfill disposal charge of $155/tonne, the $10 levy would have increased disposal price by 6.9% and resulted in approximately 3% overall diversion of waste from Class 1 landfills.

The other report, by Eunomia (2017), was commissioned by a consortium of local authorities and waste industry interests with an explicit aim of making a case to increase the current rate of waste disposal levy. It argued existing Class 1 landfill charges per tonne in New Zealand varied significantly ($20-$190/tonne) but on average were around $75/tonne for active waste and $10/tonne for inert waste. Regarding the current levy of $10/tonne to be low compared with much higher levels in European countries (which Eunomia summarise in a table, but without the levy-exclusive landfill charges that would show the levy's proportional impact on the price of disposal), much of the report explores options for raising the levy to a modelled "optimal" level of $140/tonne for active waste, $15/tonne for inert waste, and $40/tonne for waste sent for incineration.

However, incineration in New Zealand is only used for small scale medical materials disposal. Except in the largest cities where local air quality and other environmental concerns deter siting such plants, in most parts of the country waste is too dispersed to provide the volumes to make large-scale incineration economic.[1] Eunomia's claim that extending the levy's coverage to most landfills and raising its rate 14-fold would create "no incentives for waste to be mis-managed or illegally disposed of"- understates the opportunities for fly-tipping in New Zealand. While the report contains much that is useful in presenting data on the total scale of waste generation beyond the Class 1 landfills to which the levy applies, its analysis obscures the net effect of the changes it proposes and exaggerates their likely benefits.

Tonkin and Taylor (2014) prepared a database of non-municipal landfills, including details on regional breakdown and waste composition over time which provides a picture of the tonnage disposed by class of landfill, and the totals by region. The numerically largest class of landfills, and the one accepting most tonnage, is the Class 4 Cleanfill. Tonkin and Taylor estimate the volume of waste disposals in all classes of landfill since 2004, but the reliability of these figures has been questioned.

[1] Two of the Eunomia report's authors (Dominic Hogg and Duncan Wilson) come to similar conclusions in WasteMINZ's October 2018 edition of Revolve (page 11), stating "We have never seen an analysis where the costs of switching from landfill to incineration (when the energy is not subsidised either explicitly or implicitly) are justified by the benefits" and concluding that when the issues are examined more carefully, it is hard to see waste for energy having a strong role to play

MWH-Stantec (2017) updated the Tonkin and Taylor database on the number of non-levied consented landfills (open and closed). They surveyed a selection of landfills of various classes to identify consented tonnages, consent periods and other operational details. These are mostly private landfills, often associated with wood processing or building and construction activities and there are few published details of disposal volumes or disposal charges. The report does not update the estimate of aggregate tonnage of waste being disposed of, because of insufficient information.

Table 2 shows a total of 381 non-levied landfills (MWH 2017) which coincides with the figure cited in the Ministry's 2017 review of the landfill levy. This provides a baseline for considering future disposals and the potential for extending the levy to classes 2 and/or 3 landfills.

Table 2 Numbers and distribution of non-levied, consented landfills

	Class 1	Class 2	Class 3	Class 4	Unknown	Total	*Share*
Northland	0	2	1	5	2	**10**	*2.6%*
Auckland	0	0	21	73	0	**94**	*24.7%*
Waikato	0	1	4	0	18	**23**	*6.0%*
Bay of Plenty	1	13	5	0	11	**30**	*7.9%*
Taranaki	3	1	27	1	1	**33**	*8.7%*
Gisborne	2	2	0	0	0	**4**	*1.0%*
Hawke's Bay	0	3	1	0	9	**13**	*3.4%*
Manawatu-Wanganui	0	12	5	0	3	**20**	*5.2%*
Wellington	0	4	2	1	8	**15**	*3.9%*
Tasman	0	0	3	0	4	**7**	*1.8%*
Nelson	0	0	6	0	8	**14**	*3.7%*
Marlborough	0	0	17	0	0	**17**	*4.5%*
West Coast	0	1	6	1	11	**19**	*5.0%*
Canterbury	0	1	20	0	26	**47**	*12.3%*
Otago	2	0	6	0	2	**10**	*2.6%*
Southland	1	6	15	0	3	**25**	*6.6%*
Total landfills	**9**	**46**	**139**	**81**	**106**	**381**	*100.0%*

Source: NZIER, drawing on MWH (2017)

Table 2 shows Class 3 landfills to be the most numerous, in contrast to Tonkin and Taylor who identified only 5 as open and receiving low additional tonnages each year. The second most numerous class is Class 4 cleanfills, which have grown in number and tonnages deposited in recent years (part of which may be due to increases in inert material from earthquake damage and repairs). The distribution of these landfills is partly driven by population concentrations but also reflects the waste-generation characteristics of industries in each region, and the accessibility of regions to disposal facilities in other regions. The largest number of landfills is in Auckland followed by Canterbury, but Taranaki has the third highest number. Wellington is ranked 10th by the number of these landfills, having fewer such landfills than regions like Marlborough, West Coast and Southland.

2.2. International literature

Most of the international literature comes from Europe, including studies of the UK's landfill tax, EU member states, and reviews by the Nordic Council of Ministers of environmental charges across the region. There is also a variety of waste disposal levies applied in Australia, primarily by State and Territory governments.

2.2.1. Australian studies

Recent experience in Australia contrasts with the direction given by the Australian Productivity Commission review of waste management conducted in 2006, which concluded that the only efficient use of a waste levy was for internalising external effects of landfill operation, and that these are unlikely to be large for a modern designed and operated landfill. Its corollary was that it is inefficient to use a waste levy to raise revenue because of its relatively narrow revenue base and high costs of collection compared to wider-based taxes; also that it is inefficient to use a levy to raise disposal costs to divert material away from landfill disposal in pursuit of disposal reduction targets, because the resulting "price" of landfilling bears no relation to the marginal cost of adverse effects of landfilling.

The Commission (2006) examined a wide range of other arguments commonly heard in support of landfill levies, such as reducing environmental impacts of "upstream" production of virgin materials by substituting more recycled material for virgin material; conserving the availability of landfill space; or realising the value of recovered materials. But it concluded that managing the local social and environmental externalities of waste disposal is the main way in which a waste levy could be effective.

The Commission argued a waste levy is a tenuous and ineffective way of handling the externalities around producing virgin materials, and land available in Australia is plentiful and not costly to develop for landfilling. The value of recovered materials is a function of the market value of the materials recovered and the cost of recovering and recycling them: the latter faces rising costs the greater the dispersion, lower the concentration and greater the contamination of materials discarded, which is why recycling of many materials widely spread across a landscape is often not economic.

The Productivity Commission's report appears to have had little influence on waste policy in Australia, where landfill levies have been set by State governments rather than at Federal level, and exhibit the characteristics of high rates used to pursue material diversion targets, which the Commission concluded would be inefficient.

Landfill levies have been applied in most Australian States and the Australian Capital Territory (ACT) (Ritchie 2017). Ritchie summarises the characteristics of their application as:

- They are applied and set at the state level, primarily to achieve material diversion from the waste stream, rather than revenue raising

- Revenues collected are split between general state treasury and waste-related hypothecated funds
- They usually apply a higher rate for metropolitan areas and reduced rates for rural areas, lowering the cost to rural areas to counter disincentive for responsible disposal
- At the end of 2017 metropolitan levies were about A$138/t in NSW, A$85/t in South Australia and just over A$60/t in Western Australia and Victoria
- Queensland introduced a levy of A$38/t in 2011 applied to Commercial and Industrial and Construction and Demolition waste, but withdrew this within a few months
  - the levy's removal led to increased construction and demolition waste disposal and more pressure on disposal facilities in the short term
  - reimposition of a levy is under consideration
- Landfill prices range from A$350/t in Sydney to around A$90 in Hobart, with Canberra, Adelaide and Melbourne all on about A$150/t.
  - Brisbane's levy-free landfill price is currently about A$10/t, and it attracts around 600,000 tonnes/year of inter-state waste
- Levies at these levels increase material diversion rates over the unlevied baseline, but generally fall short of each state's targeted diversion rate.

In another report, Ritchie (2014) also examines the likely effects of introducing a A$10/tonne disposal levy in Tasmania, using a cost benefit analysis framework with some financial and impact analysis. The A$10/tonne levy has very little effect on either behaviour change or revenue raising.

Forghani et al (2017) examine the consequences of Queensland's brief introduction of a waste levy in 2011 and its withdrawal within a few months. The levy was set at A$10/tonne for household municipal solid waste, and A$35/tonne for commercial and industrial waste, including construction and demolition wastes. When the waste levy was revoked in 2012 the amount of construction and demolition material sent for disposal increased by nearly 25%, partly due to waste stockpiled during the levy period being sent for disposal, and partly because of waste being trucked into Queensland for disposal from New South Wales where levies and disposal costs were much higher. While much of this effect could be put down to short term adjustment or opportunism the Queensland experience does show how under the right conditions relatively small levies can have marked effects in changing behaviours.

Deloittes & Access Economics (DAE 2015) describe a useful breakdown of the costs of landfill disposal comprising:

- Private costs of landfill operation, including full-life-cycle costs of site establishment, operating and post-closure site management
- Direct externalities associated with landfill disposal, such as greenhouse gas emissions, other emissions to air, leachates and disamenity of the landfill site, and also transport externalities in moving material to and from it
- Indirect avoidable externalities associated with the extraction and production of virgin materials (which should decline as recycled materials increase in the manufacture of products).

Landfill gate fees should cover the private costs of landfill establishment and operation, including the opportunity cost of land used in facilities. Direct externalities are less likely to be fully covered, unless included in conditions for consents for operating the site, and it is the residual of such externalities which is the main justification for imposing landfill disposal levies. While indirect externalities in the long term may decline in response to changes in material use and disposal, the connection with waste levies is tenuous and a single country's changes to its waste levy is unlikely to have discernible effect on the externalities of material supply in other jurisdictions. But DAE suggest levies can also reflect society's desire to reduce waste and encourage resource recovery, noting that it is difficult to measure in a society with heterogeneous views, and there are only limited studies that have attempted to place a dollar value on this, often with contentious results.

Australian National Waste Reports

The Department of Energy and Environment of the Government of Australia has prepared published reports on waste strategies by state for the years 2010, 2013, 2016 and 2018 and a database on waste streams by state covering the years: 2007, 2009-2011 and 2014-17. A summary of this data along with a history of change in state waste levies is included in Appendix B.

The variation in waste levy settings across the Australian states over the past 15 years is a natural experiment on the connections between levies, waste generation and recycling. While there are question marks over the consistency[2] of reporting methods over time, the data has been used to measure the effectiveness of waste management policies in the states and shape policies. The high-level observations on the data and the report relevant to the modelling of the effect of waste levy on the generation and processing of waste are:

- Levy rates fall into two groups:
  - at or near zero (Queensland, Northern Territory and Tasmania)[3]
  - levies from A$60 to A$150 per tonne depending on the type of waste and where the waste is collected from for New South Wales, South Australia, Victoria, Australian Capital Territory and Western Australia
- states that charge waste levies have increased them over time in regular steps
- evidence for a causal relationship between waste levies and recycling is inconclusive. While states with higher waste levies tend to have higher recycling rates – they also have separate policies to encourage recycling. Queensland has a recycling rate of approximately 40 percent without charging a waste levy
- waste per capita and the proportion of organic waste in the 'metropolitan solid waste' and 'commercial and industrial' streams seems to be both stable over time and across states.

2 The information for recycling for some states by stream is not reported and is inferred from national rates.

3 Queensland State Government plans to introduce a lay of AUD 70 per tonne on 1 July 2019. Tasmania currently has a voluntary levy of AUD 7.5 per tonne.

2.2.2. European literature

Most (but not all) European countries have waste charges set substantially higher than $10 per tonne disposed. They have usually been set at a low level and then risen according to an "escalator" over a period of years. In most cases revenue goes to the general public purse, although in some a portion of revenue is directed at funds to support waste management or remediation activity. It is clear that in most of these cases of very high waste levies, the levy is not set to offset external costs but is intended to support the diversion of waste from disposal streams, or directing it towards incineration for energy generation.

Covec (2012) provide a literature review of the application of a levy in the UK and in selected European countries, usefully comparing landfill levies per tonne with levy-exclusive cost of disposal in landfill. The UK landfill tax, introduced in 1996 at rates supposedly based on the cost of landfilling externalities (£7/tonne), has since risen progressively to £64/tonne, breaking the link to measured damage costs and becoming more of a behaviour changing levy.

Acil Allen (2014) provide case studies of waste and landfill charges in the Netherlands, Italy and the UK. They note that the UK landfill gate fees have remained steady around £21/tonne throughout the landfill levy period, and that the levy escalation over that period has been of sufficient scale and duration for the building of plant for new material recovery options to be viable and be put into effect.

Eunomia (2017) provide updated details on waste levies in different jurisdictions, but not the levy-exclusive landfill charges that would indicate the levy's effect in changing disposal price.

Among Nordic countries Denmark first introduced a landfill disposal tax in 1987, and also a tax on waste incineration at the same time. The landfill tax was initially set at DKK40/tonne (about NZ$10/tonne) but it was successively raised to DKK375/t in 2009, with incineration at DKK330 (about $90/tonne) (Lindhjem et al 2009). In 2010 the landfill tax was reformed and reduced by around 40%, and the tax on incineration was removed (Braggadottir et al 2014). The Danish waste taxes were attributed with reducing net deliveries of municipal solid wastes to landfills by 26%, and to private landfills by 39% between 1990 and 1996 (Speck 2006).

A similar pattern emerges in other Nordic countries. Sweden introduced its landfill tax in 2000 at the rate of SEK250/tonne (about NZ$40), rising to SEK455/tonne (about NZ$75) by 2013 (Braggadottir et al 2014). But in 2005 it banned landfill disposal of sorted burnable material and organic waste to promote material recycling and energy recovery, and it removed its tax on incineration in 2010, as the composition of the waste stream changed and greenhouse gas emissions came down.

Norway introduced a tax on waste disposal and waste incineration emissions in 1999, initially to price environmental costs of disposal and encourage diversion to recycling. Martinsen and Vassnes (OECD 2004) describe how the waste tax was set to differentiate the rate between low- and high-quality landfills, and a separate rate was set to encourage energy recovery from incineration, but within a few years the differential tax on incineration was removed and replaced with a subsidy on waste-generated energy, which was available to both incineration and methane recovery from landfills. Norway removed the tax on incineration in 2010, following a ban on landfilling biodegrading materials the previous year; and reduced its landfill tax by around 50%, from NOK447 (about NZ$80) to NOK225/tonne (Braggadottir et al 2014).

Finland introduced its waste tax in 1996 at a rate of €30/tonne (about NZ$51). In 2011 it extended the tax from public to private landfills, raising the rate to €40/tonne, and it was raised again to €50/tonne (about NZ$85) in 2013 (Braggadottir et al 2014).

The Nordic countries' waste policies exhibit similarities because of the dialogue between officials in the Nordic Council, and because of intention to avoid setting up incentives for transfer of wastes across borders which are largely uncontrolled. Taken together they indicate that diversion of waste from the landfill stream can be achieved with tax rates that are in the middle of the range of those observed in Europe, and well below the rates applied in some municipal states in Australia.

Both Covec (2012) and the Nordic sources make the point that the connection between the levy and the ultimate generators of waste for disposal can be tenuous and distorted: a levy charged by the tonne will not be noticed by residential customers who pay a flat rate per property, and may not be transmitted effectively if they are charged by a volumetric measure other than weight (e.g. by bag or volume disposed).

2.3. What are the externalities that might be covered by a levy?

Landfill disposal has been commonly associated with a number of adverse effects on the surrounding environment, in particular discharges to air of both greenhouse gases and other substances affecting local air quality, odours, operation noise, night light, attraction of vermin, discharge of leachates and other pollutants into the soil and sub-soil water sources; occupation of land and sites of strategic significance; and general disamenity from the presence of the landfill and the traffic it generates.

External environmental and social costs of landfilling are not generally reflected in waste disposal charges or accounted for in waste management decision making, except to the extent that consent conditions require steps to be taken to avoid, mitigate or remedy adverse environmental effects in design or operation of landfills. Even then, the costs incurred and value of benefits gained are rarely made explicit in consenting deliberations. Because of this mis-pricing of disposal, waste generators lack the incentive to exercise due restraint and can produce a socially excessive amount of waste.

Numerous studies have attempted to estimate the cost of externalities produced by under-pricing waste disposal. These range from estimates of the avoidable costs of landfills (i.e. the damage caused by externalities or the cost of remedies to negate them) or estimates of societal willingness to pay to reduce them, using revealed preference methods such as hedonic pricing (econometric analysis of house values to determine how they differ with varying exposure to landfill effects, controlling for other factors) or stated preference techniques which ask a sample survey of respondents their preferences for different levels of exposure to landfill effects.

However, reliable estimates of the economic value of these effects are hard to find. Apart from greenhouse gas emissions, most of the adverse effects are localised (although some, like leachate, may spread through water) and their economic value depends on the occupation and uses of the land around them, and on the availability or otherwise of substitutes for the environments affected by landfill operation. Landfills are often purposefully located away from habitation and sensitive areas to minimise neighbourhood nuisance effects, which reduces the economic value of any adverse effects on the environment.

Kinnaman (2003) surveyed the economic literature on solid waste matters since 2000, identifying lifecycle estimates of the external marginal cost of waste disposal and the external marginal benefit of recycling. This survey found the external marginal cost of landfill disposal is in general rather small, but recycling of at least some materials has comparatively large marginal benefit under certain conditions.

Davies and Doble (OECD 2004) calculate the external costs of landfill in the UK to be in the range of £1 – £9 per tonne of waste, depending on the type of landfill, the existence of energy recovery, and rural or urban surroundings. Greenhouse gas emissions (mainly methane) vary with waste composition between £0.57 and £6.27/tonne of waste; leachate is £0.45/tonne of waste on existing landfills (but internalised in new landfills) and amenity cost is £2/tonne waste. The total monetised value per tonne was £5 on average, with £7/tonne on active waste and £2/tonne on inert waste. Further increments of £3/tonne were planned for the UK's landfill tax until it reaches £35/tonne; but this end point was neither an externality cost nor a rate necessary to achieve diversion targets, suggesting it may need to be revised.

Bartelings et al (2005) compare rates of levy required to internalise externalities of landfills and energy from waste incineration in the Netherlands. Although information gaps prevent a definitive conclusion on the 'lowest social cost' option for waste management, the social costs of a landfill tax are relatively low compared to incineration and other instruments, such as a ban on landfilling or an obligation to accept waste. Optimal pricing for externalities would probably mean a reduction of the Dutch landfill tax rate and an increase in the waste tax rate for incineration. Both rates should be around € 10 per tonne of waste, but this would reduce the incentive for waste diversion given by the current higher levy.

Nahman (2011) illustrates use of the benefit transfer method (for emissions) and the hedonic price method to estimate the marginal external costs of landfills in Cape Town. This found the cost to be to be R111 (US$16/tonne of waste), although this could be lower in scenarios in which energy is recovered from the deposited waste, or with relocation of urban landfills to less populated areas.

Martinez-Sanchez et al (2017) use societal life-cycle cost analysis to estimate both economic "budgetary" costs and environmental and externality cost impacts. Their externality costs include greenhouse gas emissions (CO_2, CH_4 N_2O), and air quality emissions (PM_{10}, $PM_{2.5}$, NOx, SO_2, VOC, CO, NH_3, Pb, Cd, dioxins) but not broader amenity issues commonly associated with landfills, such as noise, odours, dust, vermin attraction, and leachate contamination of water sources. They conclude from their modelling that a least cost or optimal waste reduction policy varies according to whether policies target single attributes (e.g. greenhouse gases) or multiple attributes (e.g. greenhouse gases and leachates). All such modelling is inherently affected by the coverage and robustness of emissions and discharge data.

The Australian Productivity Commission (2006) and Covec (2012) come to similar conclusions about the modest level of externalities on landfills in their respective reviews of local and international literature on quantifying and valuing such effects. Most adverse effects of landfills are localised, so modern landfills that have sealed compartments and are located away from population centres can have lower negative externalities than older landfills located closer to urban areas with less comprehensive containment features. Covec concluded on the limited evidence available in New Zealand and overseas, that externalities from modern landfills with leachate controls located far from population centres are unlikely to exceed the current levy rate of $10 per tonne.

Table 3 shows a range of estimates cited in a report into the full cost of landfill disposal in Australia (BDA Group 2009). It shows the relative difference between municipal solid wastes and commercial and industrial wastes, and the lower costs of the more inert construction and demolition wastes. It also shows difference between landfills with and without methane capture for electricity generation to be less than A$20/tonne.

Table 3 Estimates of externality values

$/tonne disposed of; Converted to NZ$ at contemporary exchange rates and updated by NZ CPI

Comparison of externality values by waste treatment (A$ 2006)				
	Municipal Solid Waste	**Commercial & Industrial**	**Construction & Demolition**	
Best practice landfill	$4-$18	$5-$24	$1-$7	
Best Practice plus methane capture & electricity generation	$0-$4	$0-$5	$0-$4	
Cost avoided by methane capture	**$4-$14**	**$5-$19**	**$1-$6**	
Source: BDA Group 2009 (citing Productivity Commission 2006)				
Comparison of externality values by Metropolitan, urban and rural location				
Landfill Emissions & Leachate discharges	**Metro**		**Rural**	
Original estimate A$2006	$ 6.00		$10.00	
Original estimate NZ$2006	$ 6.86		$11.44	
Updated to NZ$2018	$ 8.64		$14.40	
Source: BDA Group 2009 (citing BDA & Econsearch 2006)				
Comparison of externality values by type of effect range of lower and upper values				
	Lower bound A$2008/t	**Upper bound A$2008/t**	**Lower bound NZ$2018/t**	**Upper bound NZ$2018/t**
CO_2 emission/t waste	$15	$25	$20.53	$34.22
Leachate discharge/t waste	$1	$36	$1.37	$49.28
Landfill disamenity/t waste	$1	$9	$1.37	$12.32
Source: Covec 2007 (cited in BDA 2009)				

Source: BDA (2009)

The middle section of the table shows the difference between metropolitan landfills employing modern technology to manage adverse effects, and rural landfills where lower volumes and revenue capacity preclude the cost-effective use of such technologies, resulting in higher rural externality values despite fewer neighbours exposed to them.

The bottom of the table shows results from one New Zealand study of the relative value of CO_2 emissions, leachate discharges and landfill disamenity. The ranges between lower and upper estimates are quite wide, particularly for leachate discharges where the effect is particularly dependent on several location-specific factors. These value estimates are for separate adverse effects and would need to be added to arrive at the total value of effect; but this does not mean that the highest value in the range for one effect coincides with the highest value for other effects.

ACIL Allen (2014) examine the valuation of externalities as an influence on landfill levies, focusing on greenhouse gas emissions and disamenity effects. For greenhouse gas emissions they advise using current market prices of tradeable emission units as more transparent and reliable than attempting to value damage averted.[4]

With emission unit values of A$23/tonne CO_2 equivalent, they estimate a range of emission values per tonne of different types of waste, with and without methane capture (Table 4). They also offer two different estimates of the disamenity value per tonne of waste disposed, which lie between A$3.22 and A$5.63 when transferring values inferred from overseas studies; or between A$2.13 and A$3.20 when inferring value from variation in property rental yields between areas with and without landfills in proximity.

Table 4 Monetary value of greenhouse gas emissions from waste

Australian dollars, 2014 values

		Municipal Solid Waste	Commercial & Industrial	Construction & Demolition
Emissions	CO_2-e/t waste	1.2	1.1	0.2
Value without methane capture	A$/t waste	27.60	25.30	4.60
Value with methane capture	A$/t waste	6.90	6.33	1.15

Source: NZIER, drawing from (Acil Allen 2014)

The effect of waste levy on greenhouse gas emissions depends on the proportion of organic waste disposed of in landfills with methane capture – principally Class 1 landfills which burn the methane to reduce the global warming potential of emissions, and in some cases generate electricity from it for on-site use or sale on the grid-connected electricity market. Covec (2012) estimated around 44% of landfills had such

4 Because greenhouse gas emissions contribute to a global externality, the marginal cost of damage caused by a tonne of greenhouse gas emissions is the global damage cost attributable to one additional tonne of emissions. This is difficult to estimate accurately but likely to be rather larger than the value of emission permits in a trading scheme: the permit price reflects the scarcity of permits under the scheme, and is unlikely to align with the global cost of emissions, given the political manner in which emission reduction targets and emission trading schemes are derived.

methane capture. The greenhouse gas emissions inventory for 2017 indicated that managed landfills (principally Class 1 landfills accepting waste with more than 5% organic matter) accounted for 34% of solid waste tonnage admitted to landfill and for 31% of methane emissions from solid waste management, which implies 69% of emissions comes from the 66% of wastes deposited in landfills other than Class 1. There is a risk that raising the levy on Class 1 landfills could prompt diversion of wastes to other landfills which are less likely to manage methane and have higher emission rate per tonne, hence raising greenhouse gas emissions.

Estimates of economic value of externality effects vary widely because of site-specificity, and there are too few estimates to conduct a meta-analysis to get representative values for different categories of landfill. In our analysis we include externalities on the basis of a value per tonne deposited to indicate there is a non-zero value. This is an indicative rather than precise assessment of economic value of environmental effects.

2.4. How effective are waste disposal levies?

Previous reviews of the price elasticity of demand for waste disposal have concluded that waste generation is not particularly responsive to levy-induced price changes.[5] The OECD (2004) thought the average elasticity was -0.2, which means that a levy that raised disposal price by 10% would reduce volumes being disposed in landfills by only 2%. Covec (2012) reviewed several studies with price elasticities in the range of -0.075 and -0.6.

Acil Allen (2014) note that there are no accurate or up to date estimates of the own price elasticity of demand for waste disposal, and most of the studies that have been done have examined responsiveness to changes in fees or services provided (e.g. introduction of bagged collection services) rather than to a disposal levy as such. They also suggest that some previous studies have incorrectly interpreted data in ways that inflate the price elasticity estimate. For instance, demand changes may be attributed to price when they are partly due to policy conflation, as when a levy raises revenue that is used to subsidise recycling, which lifts demand for material diversion.

Despite these issues with published estimates, Acil Allen conclude that estimates tend to cluster around low elasticity, indicating landfill levy charges are not likely to be effective drivers of change – or at least not until critical thresholds are reached, at which point alternative uses of material become viable. An implication is that price elasticities may have limited use in predicting actual volume changes in response to price, as the material diversion is unlikely to increase in a smooth curve in response to price increases, but rather in steps as critical price points are reached that enable new alternative uses to become viable.

Acil Allen summarise results of 26 studies from various countries and then graph them in a density plot. This shows own-price elasticities for solid waste disposal peaking around a value of -0.11. Acil Allen also note the response is higher in the long run than

5 Price elasticity of demand is a measure of the responsiveness of quantity of service demanded to change in price. Formally it is estimated as the percentage change in quantity divided by the percentage change in price, and it can be inferred from observations of actual behaviour when prices change, preferably controlling for other factors that can influence the results. An elasticity of -1.0 is known as unitary elasticity as it creates a percentage change in quantity exactly proportional to the percentage change in price. A service with elasticity less than -1.0 is inelastic, i.e. relatively unresponsive to rising price. Own price elasticity of demand reflects the changes for demand for a service in response to changes in its own price. Cross-price elasticities of demand reflects changes in demand for a service in response to changes in prices of other services.

in the short run, as waste generators take time to adjust to new prices and have to bear the price increase in the short term. The long run results from its review of estimates are still consistent with a relatively low price response, so that high prices are required to achieve noticeable diversion of waste. Price elasticity for disposal is higher for biodegradable waste than for non-biodegradable wastes, as there are more alternatives available for diverting biodegradable material (e.g. composting, biodigesting and energy recovery).

ACIL Allen (2014) also plot the marginal effect on material diversion rates of a price change at different total gate prices. This shows that when gate prices are low, marginal changes in that price have little effect on diversion, but at higher gate prices the marginal effect on diversion becomes stronger over some range, but then tails off as the gate price continues upwards. Their plotted results suggest the maximum effect on diversion is at a total gate price of around A$50/tonne, and that beyond around A$160/tonne the effect of further increase becomes very small. Those results may be a function of their particular data, but the principle is generalisable and implies very high charges, such as those used in some European countries and proposed by Eunomia for New Zealand, may not be most effective at diverting waste from landfills.

Deloitte Access Economics (DAE 2015) examine three levy increases for Western Australia, from A$57/tonne of waste disposed to A$62, A$100 and A$133 per tonne. They use four alternative price elasticity of demand estimates: -0.13, -0.39, -0.65 and -1.1. These appear rather high compared to most other literature reviewed, but still suggest an inelastic average of -0.56.

Table 5 shows a summary of price elasticity estimates, with simple averages for each column and successive averages (low, low + medium, low + medium + high etc).

Table 5 Summary of elasticity ranges

Source	Low	Medium	High	Extreme
OECD (2004)		-0.2		
Bartelings (2005)	-0.1		-0.5	
Covec (2012)	-0.075		-0.6	
Acil Allen (2014)		-0.11		
Deloitte Access Economics (2015)	-0.13	-0.39	-0.65	-1.10
Average per column	**-0.10**	**-0.23**	**-0.58**	**-1.10**
Successive averages	-0.10	-0.17	-0.31	-0.39

Source: NZIER

The waste levies in Europe are relatively high and have often been attributed with substantial reductions in material being disposed in landfill. However, there is a risk of policy conflation in these cases, as levy changes have often coincided with other policy changes, such as restrictions on what can be disposed of in landfills.

Fullerton and Raub (OECD 2004) suggest that where illegal dumping of waste is a possibility, a combination of instruments is required to achieve a socially optimal disposal of wastes: they suggest a deposit refund scheme system that contains an advanced disposal fee that is redeemable if the material is returned to source, or used to fund a subsidy on proper waste disposal if it is not. In such a situation material sent for recycling ends up paying no net tax.

2.5. Implications for modelling waste levy changes

The New Zealand literature from the waste levy reviews and reports by Covec (2012), Tonkin and Taylor (2014), MWH (2017) and Eunomia (2017) provide information for forming a baseline of waste distribution across different landfill classes, from which future waste flows can be projected off forecasts of population or GDP to estimate the volumes of material being discarded and distributed across different ends.

The international literature reviewed outlines a framework for considering the full costs of landfill disposal including externalities and provides a range of estimates of externality costs and price elasticities that could be used to populate a model of price impacts on waste disposal and material recovery and distribution across different landfills. It also indicates that most levies in operation worldwide have not been set at a rate to put a price on externalities: those that started out doing so (such as the UK's Landfill Tax) have converted to applying levies at rates primarily intended for revenue raising or encouraging diversion of material from final disposal to some other use which becomes more competitive with the rise in levy-inclusive cost of disposal. Further, it suggests that levies may need to be substantial to be effective in changing levels of waste disposal, but that the marginal effect of levies on waste diversion becomes successively smaller beyond some price-point for specific recoverable material.

New Zealand's waste disposal levy is in the same position, as its rate is not aligned to demonstrable costs of externalities of waste disposal, and its legislative purpose emphasises raising revenue that can be used to support recycling and other alternatives to disposal. Other potential effects like reducing externalities of disposal or achieving diversion of materials from waste streams into recycling are less suited to a general levy on waste than they are to specific charge mechanisms such as obligations under the Emissions Trading Scheme or mechanisms that reflect local circumstances. There is potential for levy changes to change the share of waste material being diverted to recycling or to lower cost disposal options (including illicit dumping), reducing the revenue base of the levy and increasing adverse environmental effects. The issue of price elasticity and diversion of material is relevant for modelling reduction in waste volumes and revenues from any change in the levy and disposal price.

3. Landfilling – existing setting

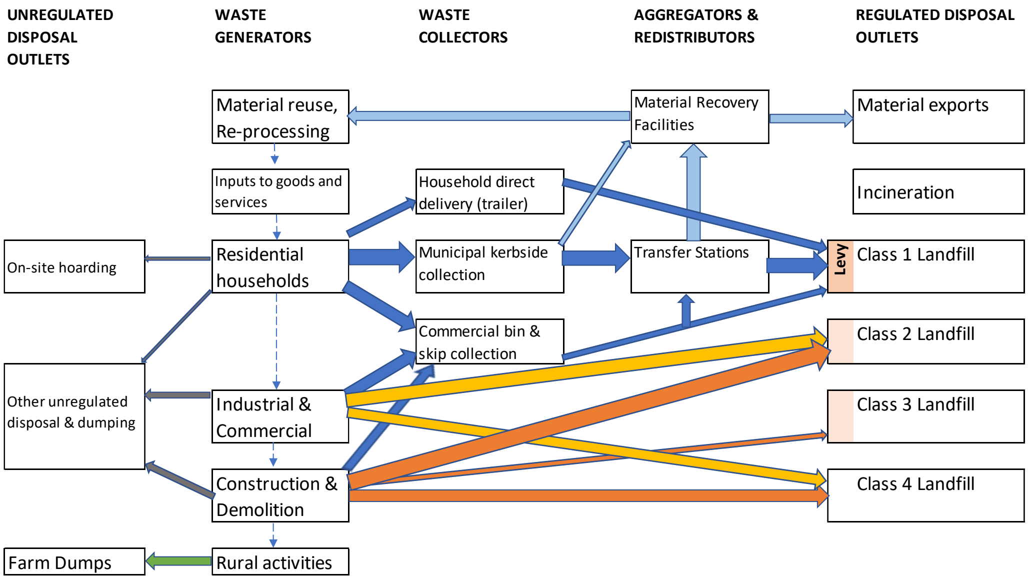
To tackle the problem of high levels of waste disposal in New Zealand (relative to other countries) and potential harms associated with it, the Waste Minimisation Act 2008 introduced a waste disposal levy with the aim of both raising revenue to support recycling and other waste reduction efforts, and also to provide a price signal to reduce waste going to landfill. The levy was set at a rate of $10/tonne of waste disposed of and applied to only a selection of landfills accounting for about 30% of total waste, so the purpose of this economic analysis is to examine the effects of extending the levy to a wider spread of landfills and raising it from its current rate. The aim is to inform the Ministry about the relative costs and benefits of:

- Extending the levy over a wider span of landfills to Class 2 and Class 3
- Raising the levy rate on the existing levied Class 1 landfills and Class 2
- The phasing of levy increases, immediate or spread over time.

3.1. Main choices in waste disposal

Waste management is a service for which there is a demand from waste generators (consumers and businesses), and a supply from businesses operating final waste disposal options (regulated and unregulated) and waste intermediaries (collectors and aggregators). The consumers of waste services can be divided principally between residential households (whose waste goes principally to the Municipal Solid Waste stream), Industrial and commercial users (whose waste is more sorted, and can have less organic content, and hence use a wider range of landfills), Construction and Demolition (whose waste is least organic, most inert, and dominates Class 4 cleanfills).

Figure 1 Main waste disposal pathways



Source: NZIER

There are various pathways through which waste is sent to disposal (Figure 1). Households in urban areas can use council-provided waste collection services or private bin-hire for "kerbside" collection, or deliver trailer-loads of residential waste directly to landfills or transfer stations. Commercial services in urban areas face similar choices, although tend to be more reliant on private bin collection and less on council-provided services. Large industrial and construction and demolition businesses rely on private contractors for waste collection and disposal.

Figure 1 includes incineration as an option but there is no large scale incineration in New Zealand. New Zealand's Greenhouse Gas Inventory for 2016 identified incineration (for quarantine purposes) used 0.05% of waste disposed of that year, and accounted for 0.07% of greenhouse gas emissions attributed to waste management. On average solid waste contains about a third of the energy content of other solid fuels so a sustained incineration operation requires a regular and high throughput of fuel. Large-scale incineration would be challenging in New Zealand because of relatively high cost, dispersal of waste sources, and local environmental concerns in consenting.

Consideration of full external costs (including externalities) makes incineration for energy appear less favourable than landfilling. Table 6 shows a cost comparison from a Dutch study. The private costs of constructing and operating a landfill are less than half those of incineration per tonne of waste, and the incinerator also has much larger environmental cost due to emissions and chemical discharges. The incinerator does recover more value from energy and materials extracted, but overall the net societal cost of landfilling is only slightly more than half that of incineration.

Table 6 Full costs of landfilling and incineration

	Landfill €/tonne	Incinerator €/tonne	Landfill NZ$/tonne	Incinerator NZ$/tonne
Private costs	**36.00**	**79.00**	57.60	126.39
Environmental costs				
Air discharge/tonne waste	5.86	17.26	9.38	27.61
Chemical discharge/tonne waste	2.63	28.69	4.21	45.90
Land use/tonne waste	17.88	0	28.61	0
Discharges/tonne waste	**26.37**	**45.95**	**42.19**	**73.51**
Environmental savings				
Energy	-4.76	-22.62	-7.62	-36.19
Materials	0	-5.60	0	-8.96
Net environmental cost	**21.61**	**17.73**	**34.57**	**28.37**
Net societal cost	***57.61***	***96.73***	**92.17**	**154.76**

Source: Acil Allen (2014)

In New Zealand, where compared to the Netherlands the availability of landfill sites is less restricted, and the value of energy from incineration is likely to be less, because it would displace a higher proportion renewable rather than thermal generation, landfilling is likely to be even more attractive than incineration.

3.2. The number of operating landfills

There is uncertainty over the number of operating landfills in New Zealand, so we estimate a composite of earlier studies, distributing unknown landfill classes to known classes in proportion to each class' share of total landfills of known class; we further assume adjustments for closures of Class 3 and 4 sites, as total volumes disposed of in these sites would be too small to sustain all identified sites as viable operations.

Table 7 Landfill numbers and annual disposal tonnages

Disposal tonnages for 2015 (Eunomia 2017)

	Organic share	Private sites (T&T)	Private sites (T&T) Tonnes	Sites # (Eunomia)	Tonnages (Eunomia)	Sites in Model	Mean Tonnes per site
Recovered material					4,288,743		
Class 1 landfill	>5%	34	700,000	39	3,220,889	45	71,575
Class 2 landfill	<5%	44	1,350,000		2,575,772	76	33,803
Class 3 landfill	<2%	5	50,000	382	64,395	5	12,879
Class 4 landfill	<2%	163	3,000,000		3,799,263	112	33,855
Landfill class unknown		19					
Total landfill disposal		**265**	**5,100,000**	**421**	**9,660,319**	**238**	**40,590**
Farm dumps				53,000	1,362,666		26
Total sites and disposals to land		**265**	**5,100,000**	**53,421**	**11,022,985**		

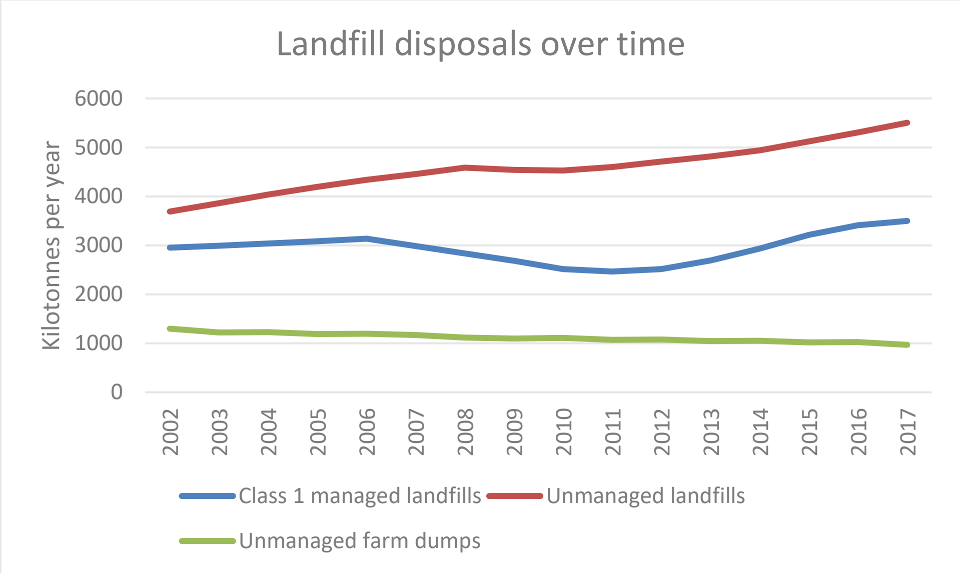
Source: NZIER, drawing on Tonkin and Taylor (2014) and Eunomia (2017)

3.3. Growth in waste volumes

The recent history of waste volumes is reflected in the profile from the New Zealand Greenhouse Gas Inventory, as described in Figure 2. Waste being deposited in Class 1 managed landfills declined after 2007 and the Global Financial Crisis, but began rising again from 2012. Waste deposited in unmanaged landfills continued to rise over that period except for a flattening from 2008 to 2010. Waste going into unmanaged farm dumps has declined slightly throughout the period in Figure 2.

Figure 2 Waste Disposal Trends over Time

Managed landfills are Class 1 landfills; Unmanaged landfills are all other significant landfill sites that do not accept household waste but are still subject to RMA controls; Unmanaged dumps are uncontrolled



Source: New Zealand Greenhouse Gas Emissions Inventory data

New Zealand's total waste tonnage from the Greenhouse Gas Inventory has had a higher annual average growth than population over the years since the 2013 Census, so there has also been growth in waste disposal per capita. Table 8 shows the estimated volume of waste per capita in 2015 by landfill class.

Table 8 Volume of waste disposed per capita

Based on waste volume and population figures as at 2015

Disposal outlet	Tonnes per year	Tonnes per capita	Cumulative tonnes per year	Cumulative Tonnes per capita
Class 1	3,220,889	0.698	3,220,889	0.698
Class 2	2,575,772	0.558	5,796,661	1.256
Class 3	64,395	0.014	5,861,056	1.270
Class 4	3,799,263	0.823	9,660,319	2.093
Farm dumps	1,362,666	0.295	11,022,985	2.389
Recovered material	4,288,743	0.929	15,311,728	3.318

Source: NZIER, drawing on Eunomia (2017) volumes and Statistics New Zealand population

Various estimates place the per capita waste disposal at around 0.7 tonnes per person, but this is only waste from Class 1 landfills. Of that waste, only about 40% would come from residential household sources, and industrial and commercial and construction and demolition sources combined contribute over half the volume going into Class 1 landfills. Industrial and commercial is the largest source of recovered material by volume, and construction and demolition is the largest source of disposals in Class 2, 3 and 4 landfills. New Zealand's total waste disposal per capita is 2.4 tonnes. Most of current waste volume is not from households but from industries and construction sectors (Table 9).

Table 9 Distribution of sources of waste to different end points

Based on waste volume for 2015

	Resident	Kerbside	Industry, Commercial, Institutional	Construction & Demolition	Rural	**Total**
Recover-able	367,739	253,846	2,264,909	1,373,947	28,302	**4,288,743**
Class 1 Landfill	206,390	1,110,432	913,221	880,568	110,278	**3,220,889**
Class 2 Landfill	0	0	257,577	2,318,195	0	**2,575,772**
Class 3 Landfill	0	0	0	64,395	0	**64,395**
Class 4 Landfill	0	0	189,963	3,609,300	0	**3,799,263**
Farm dumps	0	0	0	0	1,362,666	**1,362,666**
Other dumped						**0**
	574,129	**1,364,278**	**3,625,670**	**8,246,405**	**1,501,246**	**15,311,728**

Source: Eunomia (2017)[6]

3.4. Waste distribution across Class 1 landfills

Class 1 levied landfills provide the most reliable information on which to infer waste generation. Figure 3 shows the distribution of waste across Class 1 landfills of different size, based on the average annual tonnage of disposal over the years 2015 to 2017. The landfills have been sorted from largest to smallest tonnages then assembled into groups of 5 and an annual tonnage calculated for each group to illustrate the size distribution of annual disposal across Class 1 landfills.

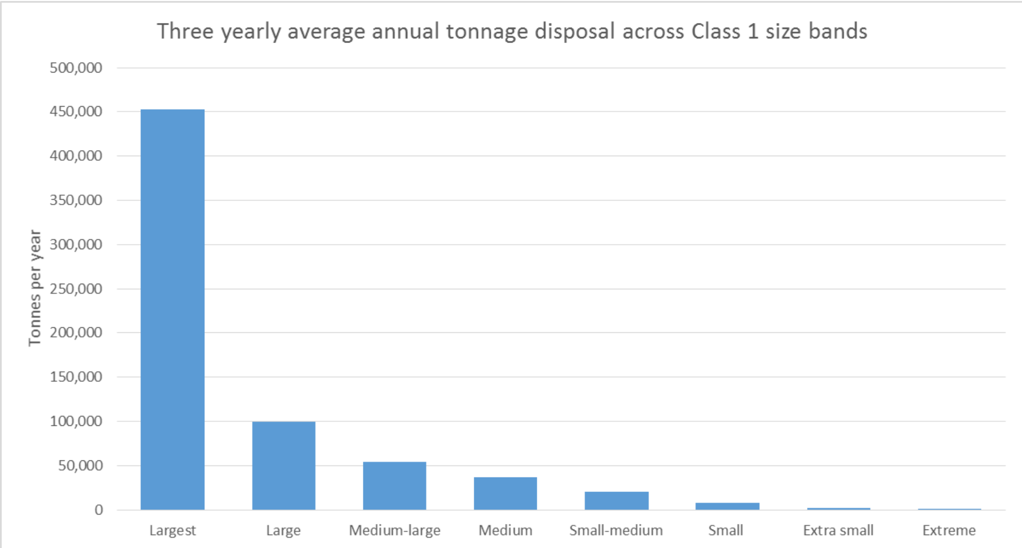
The graph shows a skewed distribution, with the 'Largest' (5 landfills) accounting for 67% of total waste and the top 10 landfills ('Largest' and 'Large') accounting for 82%. The next 5 ('Medium-large') add 7% and the next group ('Medium') account for a further 6%, but beyond that the 'Small-medium' group adds just 3% and the remaining groups account for successively smaller shares of total waste disposal. The 'Large' group spans a range of about 80,000 tonnes to 120,000 tonnes per year, and the 'Medium-large' group spans a range of 50,000 to 80,000 tonnes. Industry sources

6 'Resident' means household waste directly delivered to waste facilities; 'kerbside' means household waste collected by council or private bin-hire services; Eunomia's Landscape, Special and Excavation categories included in Construction & Demolition

suggest 80,000 tonnes annual disposal would be commercially attractive to invest in new capacity with all the management features of a Class 1 landfill, including sealed cells and methane capture and flare off with or without energy recovery. Annual disposal of below 50,000 tonnes would be challenging for recovering full cost of landfill provision, and marginal for methane capture at current cost of carbon credits of around $25 per tonne CO_2-e.

Figure 3 Waste disposed of in Class 1 landfills of different size

Average annual tonnage of disposal over the years 2015 to 2017.



Source: NZIER, drawing from MfE's Waste Disposal Levy review data[7]

The implication is that around half the Class 1 landfills are disposing of volumes too small to cover the long run marginal costs of landfill provision, and are unlikely to cover operating cost and a return on assets sufficient to provide new landfill space once current space is depleted. They are also unlikely to employ the full range of environmental management techniques found on the larger landfills. These appear to be “legacy landfills” built before current management standards were required and which are being filled up, but not necessarily with the highest standard of management of environmental effects. This may enable them to charge a lower fee for disposal than more modern landfills, raising the potential for an increase in levy on the modern landfills prompting diversion to these landfills where environmental effects per tonne disposed of may be greater.

The same risk applies to Class 2 and Class 3 landfills, which are currently not designed to manage environmental effects from putrescible organic wastes. They are legally precluded from accepting more than very small proportions of such waste in their total waste for disposal, but they may have limited capacity to identify and screen out such wastes.

[7] Compiled from monthly returns for 39 sites, which can be aggregated yearly and sum to Eunomia’s (2017) total for 2015

3.5. Waste disposal pricing

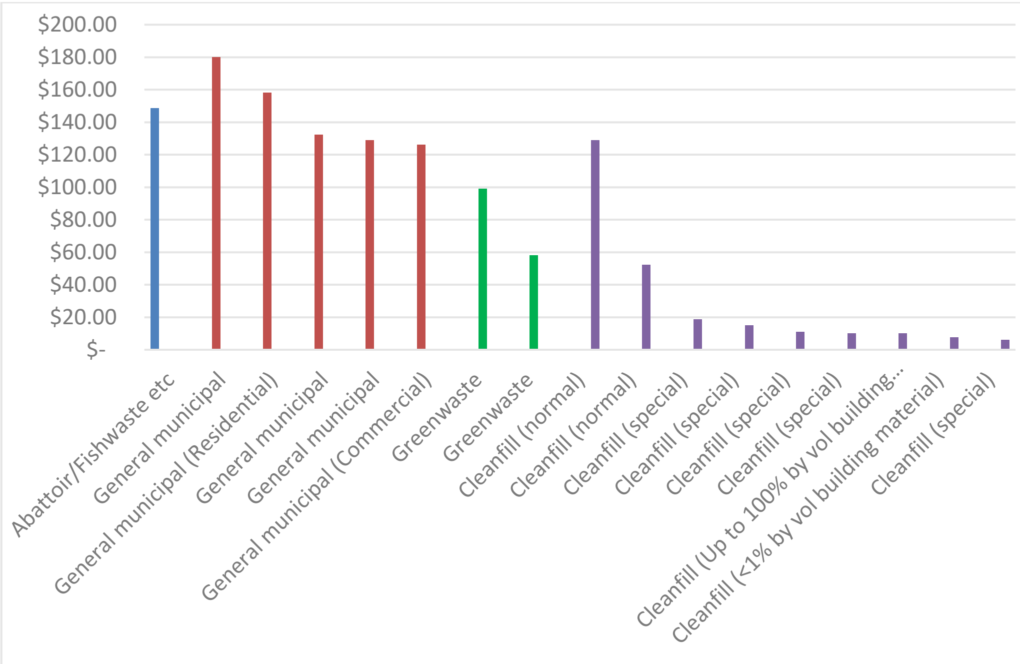
The price of waste disposal in landfills is a combination of landfill fee and the cost of transporting waste to landfill. The levy is charged at the landfill but is passed on by collection and sorting intermediaries into user charges paid by waste generators.

Landfill fees vary according to the type of waste and the type of customer. Fees posted on websites are a retail price for casual customers (such as residents arriving with a trailer-load of waste) and will be paid only on a fraction of total waste disposal (around 6% by tonnage according to Eunomia 2017). Regular and bulk customers, such as municipal kerbside collection operators, waste skip hireage companies and some industrial waste generators, obtain discounts on their waste disposal, pulling the weighted average disposal fee down from posted fee levels.

Figure 4 shows posted disposal fees from a selection of landfills in metropolitan and secondary urban areas across both Islands. General municipal waste has fees of between $120 and $180 per tonne; greenwaste which may be compostable is around $55 to $100 per tonne. Cleanfill material has fees of $10/tonne under special deals and in dedicated cleanfills which are often found in rehabilitated quarry workings, but may be charged as high as much more active general waste in mixed waste landfills that have only limited capacity for inert material in their disposal cells.

Figure 4 Posted disposal fees from a selection of landfills

Landfills in metropolitan and secondary urban areas



Source: NZIER survey of websites

The current $10 levy accounts for about 8% of a $120/tonne GST inclusive landfill fee. That percentage would rise if the levy were raised or extended to Class 2 and 3 landfills which offer disposal at lower fees.

A representative price for disposing of waste to landfill is difficult to determine, because of discounted prices which are commercially confidential. Covec (2012) suggested a weighted average of $155/tonne in Class 1 landfills, but it is unclear how representative that price was. Industry sources suggest disposal charges in the range of $100-$150 per tonne, which may reflect the price for a new landfill to cover its long run marginal cost of disposal on medium to large annual tonnages. But they note older landfills with fewer facilities accept waste for disposal at much lower charges.

Table 10 shows previous estimates of landfill charges (Eunomia 2017). The low $20/tonne fee for large landfills is closer to a fee for cleanfill (which accounts for 27% of Class 1 disposal, according to Eunomia) than for general waste. The $55/tonne fee reflects the fee for bulk municipal disposal, but the average for all waste will not be the mean of these two values as shown in the table, but should include and be pulled up by fees for less discounted disposals (such as direct deliveries to landfill by residents and industrial and commercial concerns). Given the skewed distribution of volumes disposed of in large and small landfills, the and mix of posted gate fees paid by casual customers and bulk discounted fees paid by regular large customers, this table's mean is unlikely to be the weighted average of waste sent to landfills for disposal, and we do not rely on these figures in our modelling.

Table 10 Previous estimates of landfill charges

$/tonne

	Low	High	Mean (unweighted)
Landfill disposal (large)	$20.00	$55.00	$37.50
Landfill disposal (medium)	$70.00	$90.00	$80.00
Landfill disposal (small)	$110.00	$190.00	$150.00
Class 2, Class 3	$25.00	$40.00	$32.50
Class 4	$0.00	$15.00	$7.50

Source: Eunomia 2017

4. Modelling costs and benefits of extending the levy

To assess the waste levy options we apply a framework of societal cost benefit analysis, as outlined in Table 11.

Table 11 Cost benefit framework of changes in levy scope and rate

Quantified in analysis; Discussed with some quantification; Discussed without quantification

Item	Effect	Quantification feasibility
Benefits Discussed & quantified	Benefit to recycling from value of increased material diverted from disposal and recovered for use	Multiple materials, variable prices and geographical constraints on recycling mean quantification is indicative
Discussed & quantified	Benefit to landfill operators from avoided costs of landfill use, reduced operating costs and landfill depletion	These effects are internalised into landfill fees based on long run marginal costs; redistributed among landfills modelled
Discussed & quantified	Benefit to communities from avoided environmental costs due to reduced landfilling, e.g. greenhouse gas emissions, other local emissions, leachate leakage and amenity damage (e.g. noise, smell, pests, visual impact)	Greenhouse gas emissions covered by the Emission Trading Scheme but varies between landfills with or without methane capture. Local environmental discharges only indicatively modelled on current information.
Quantified	Benefit to government from added revenue to support waste management activities	Technically a transfer payment by those ultimately paying the levy but quantified
Discussed but not quantified	Indirect wider benefit to communities due to changes in material use, e.g. avoidance of new material production effects and reduction in net trade of materials into New Zealand	Reduced imports and external effects associated with them are possible, but NZ very small on the world trade in materials. Not modelled on current information.
Costs Quantified	Landfills' capital costs, including weighbridges and information systems for reporting levies due on newly levied Class 2 and 3 landfills	Assumed average costs for the number of landfills of Class 2 and Class 3 brought into the levy scheme
Quantified	Landfills' operating costs, due to reporting of tonnages received (mainly Class 2 and 3)	Assumed average costs for the increased throughput of different landfills
Quantified	Councils' and governments' regulatory and administrative costs in overseeing, monitoring and enforcing levy application	Assumed average costs for introduction and oversight (fixed cost and annual recurring cost)
Quantified	Impacts on waste disposal consumers who ultimately pay the levy increases	Transfer payments to government: distributed across classes modelled
Discussed & quantified for waste but not transport	External environmental costs arising from waste diversion from Class 1 landfills, additional transport, illicit dumping	Extent of this cannot be fully quantified on current information, but indicative values are used in the analysis driven off waste volumes in different landfills.

Source: NZIER

We identify, quantify and value to the extent practicable the effects of extending or raising the levy on waste generators, consumers of waste disposal services (households, commercial industries and institutions, construction and demolition), waste management suppliers (landfill operators and intermediary agencies) and third parties (government and council regulators, impacts on the natural environment).

A waste levy, like a tax, is a transfer payment from the public to the government, and such transfers are often excluded from costs benefit analysis as they do not add to the net value calculation. In this case we include it as levy revenue is an item of interest in comparing the options. We also include costs to consumers of their waste disposal, which includes the levy and the resource costs of using landfills. The consumer costs offset the revenue gained from the levy in the analysis, and also the revenue from landfill fees, so only the landfill operators' margin counts towards net benefit.

4.1. Modelling approach

We use the following modelling approach:

1. Establish the counterfactual in the absence of waste levy extension
    - 1.1 Project a baseline of total annual volumes of discard material from the present into the future, in line with growth in population
        - 1.1.1 Consideration was given to separating regional population growth and impacts on wastes, but lack of data on regional waste generation and location of disposal precluded it from modelling
        - 1.1.2 We assume slightly reduced rate of waste generation per head of population in the period from 5 to 10 years ahead to allow for some reduction in waste generation at source in response to levy
    - 1.2 Estimate the volume going to Class 1 landfills at the current share of total
    - 1.3 Estimate the levy revenue at $10 per tonne

2. For extension to Class 2 and 3 landfills
    - 2.1 Calculate the percentage change in price from imposition of the levy
    - 2.2 Estimate the percentage of material diversion using price elasticities
    - 2.3 Distribute diverted material to other disposal options and material recovery in proportion to these options' shares of the sum of current waste disposal excluding that of the class from which waste is being diverted[8]

3. Estimate monetary values of this redistribution of waste volumes and their associated costs and benefits
    - 3.1 Government receives benefit of new levy receipts over and above the counterfactual

[8] While this fixity of diversion may be challenged, and it could be reasonable to assume some increase in diversion as levy funds are invested in alternatives, without knowing what those alternatives might be, we exclude that possibility to avoid conflating effects of different measures, and to focus on responses to waste levy changes alone.

3.2 Benefits to material recovery and recycling industries from increased volumes of recovered material
3.3 Environmental benefits from reductions in greenhouse gas emissions, driven off changes in waste volumes disposed of at different classes of landfill and different emission rates per waste composition, valued at the price of traded emission permits in emission trading at a value assumed to rise gradually over time
3.4 Reductions in other externalities (noise, odours, local air quality, discharges to water and soil) valued at dollar rates per tonne disposed of, using value transfer process from overseas sources
3.5 Waste disposal customers (residents, commercial & industrial, construction & demolition industries and rural) bear the cost of the new levy, assuming its full pass through into waste service prices
3.6 Class 2 & 3 landfill operators incur costs of compliance with extended levy, including:
    3.6.1 One-off cost of installing weighbridge (or alternative weight verification process) at each landfill newly subject to levy
    3.6.2 Handling costs per tonne of recorded waste sent to these landfills
    3.6.3 Annual costs for administering the waste levy and for maintaining weighbridges
    3.6.4 Loss of the margin per tonne disposed of for each tonne diverted from these landfills because of the levy

4. Landfills gain margin on each added tonne diverted to them due to the levy

5. Recovered waste receivers/recyclers gain value from the diverted material

6. Government agencies incur regulatory costs in monitoring the establishment of levy collection and on-going monitoring of the levy's operation.

In this model Community externality effects on the environment are reduced or deferred to the future for waste diverted to material recovery; reduced to the extent that active waste is diverted from lower managed to higher managed landfills; but increased to the extent that active waste is diverted from higher managed to lower managed landfills or informal dumps (although this may not be legally allowed).

The same process is followed in examining each of the levy raising options. Where these options involve extension of the levy to Class 2 and 3, the one-off costs of installing weighbridges at those newly-levied landfills are included in all options examined, and the counter-factual in all cases is the projection of the current levy on Class 1 landfills only.

4.2. Analysis structure and assumptions

The cost benefit analysis uses an 11 year discounted cash flow model, to examine the effect of immediate change in coverage or level of the levy, and the phased introduction and increase over a period of years. The values are projected in constant dollar terms and discounted at Treasury's default social discount rate of 6% per annum. Most options are examined across the period 2021-2030, but Otion 1 provides for earlier levy changes starting in 2020.

Waste levels and distribution across landfill classes and other disposal options are drawn from Eunomia's 2017 report. After reviewing literature, and in particular Australian waste disposal statistics which show waste volumes are more closely related to population growth than GDP growth, we update total waste levels in line with population growth, and forecast them using Statistics New Zealand's medium population projections.

The model calculates the counter-factual in which total discards are driven by forecast population growth and shared amongst discard options in the same proportion as their current shares. It then calculates the with-levy alternative in which volumes to each discard option change according to the elasticity-driven diversion and distribution across other discard options.

In the counter-factual we calculate the levy revenue from the tonnages disposed of in Class 1 landfills at the current $10/tonne levy rate. We do not explicitly calculate other costs and benefits of operations in the counter-factual, but calculate the change in costs and benefits in the with-levy alternative driven by the change in volumes handled (from the counter-factual) in the different discard options. Other activities to encourage disposal alternatives to landfilling (such as levy-funded recycling initiatives) have not been accounted for in the model to avoid conflating the effects of different policies, blurring the impact of the levy changes.

4.2.1. Waste diversion between landfills and other ends

The principal effect of changing the levy is to change the price to customers of waste disposal, assuming the levy at the landfill gate is passed up through intermediaries to waste collection and disposal services to customers. This may cause some adjustment to the use of different disposal options. We estimate this adjustment by calculating the price-induced change in volume disposed of to each landfill class affected by levy-induced price change, assuming price elasticities empirically estimated in the international literature.

The literature review suggests most price elasticity estimates for waste disposal are low (below 1). We assume the price elasticity for raising the waste levy will most likely be low because of these empirical results, and because examination of waste data in Australia shows insignificant change in waste disposal in response to substantial levy increases. Given that, we make separate estimates for three assumed elasticities to illustrate the possible range of responses to raising the waste disposal levy: lowest (-0.1), medium (-0.23) and highest (-0.58) elasticities (see Table 5 above).

Diverted wastes from each landfill class are assigned to other disposal options (including material recovery) in proportion to each option's current share of total waste disposal excluding the landfill class from which waste is being diverted.

4.2.2. The costs of landfill services

For each landfill class, we assume the operators receive a fee for each tonne of waste. The fees will be set to provide revenue and a contribution to recovering all the costs of operating and maintaining the landfill and waste handling facilities, including liabilities for emissions under the Emissions Trading Scheme. Landfill operators also incur costs in handling these volumes, which we model by deducting 85% of the fees received, derived from the shares of intermediate inputs, fixed capital consumption and labour costs in waste management from Statistics New Zealand's inter-industry tables. So, relative to the counter-factual, landfill operators receive a positive benefit from the margin gained if their volumes go up (as in the case of Class 4), or a negative benefit if their volumes go down (as in all other landfill classes facing levy increases).

The customers of waste disposal services pay the levy and the operator fees on wastes disposed of at the different classes of landfill. We use the initial shares of the waste stream attributable to different customer groupings from Eunomia's 2017 report to identify which customer groups pay the levy (see Table 9 above). Households contribute 41% of Class 1 landfill wastes. Industry, commerce and institutions contribute 28% to Class 1, 10% to Class 2 and 5% to Class 4; and construction and demolition contribute 27% to Class 1, 90% to Class 2, 100% to Class 3 and 95% to Class 4 landfill disposals.

We model additional costs of fitting weighbridges to record the tonnages on which the levy is due, for landfill operators brought into the levy scheme. While large modern landfills often require two weighbridges to measure inward and outward loads, to allow for a material transfer and diversion function that is unlikely to be necessary for most Class 2 and 3 landfills brought under the levy system. The cost of weighbridge installation can be considered as a maximum cost, as landfill operators could also (with approval) use an alternative system for estimating and verifying weights. There is a modest cost for handling each additional tonne, and also annual costs incurred in calibrating and maintaining weighbridges and administration of levy collection.

There are also costs for the Ministry in establishing the levy scheme and in monitoring its on-going operation. The assumptions used are summarised in Table 12.

Table 12 Principal assumptions associated with levy changes

Fees by landfill class and cost by type

Item	$	Unit
Gate fees (excluding GST, levy; transport)		
Class 1 landfills, high volume or North Island	49.00	$/tonne disposed of
Class 1 landfills, lower volume or South Island	101.00	$/tonne disposed of
Class 2 landfill	40.00	$/tonne disposed of
Class 3 landfill	30.00	$/tonne disposed of
Class 4 landfill	15.00	$/tonne disposed of
Additional cost components		
Installing In & Out Weighbridges	130,000	$/new levied site
Installing Single Weighbridge	80,000	$/new levied site
Operating new systems & weighbridge	2	$/added tonne
Calibration & maintenance	5,500	$/year/new levied site
Administration cost of levy	10,000	$/year/new levied site
Recurring monitoring	160,000	$/year
MfE Establishment monitoring	250,000	$/ landfill class
Number of landfills in Class 1, 2, 3	45, 76, 5	As in Table 8 above

Source: NZIER

4.2.3. The price of waste disposal

The price of waste disposal in landfills is a combination of landfill fee and the cost of transporting waste to landfill. There can also be costs incurred for collection and sorting by various intermediaries (Table 13). Waste can be transported large distances between collection point to landfill. Some large landfills receive waste from 200km or more, but the average distance that waste is transported to disposal point is much shorter. Both Class 1 and Class 2 landfills are widely distributed, so both classes of landfill are options in most regions.

Changes to the levy primarily affect the landfill fees, as landfill operators are liable to pay the government for tonnages disposed of in their landfills, so they raise their disposal fees to collect the levy. Intermediaries who pay for delivery to the landfill will raise their fees to cover the levy, so that the levy is ultimately passed on to the customers of disposal services.

Assuming the levy is passed on in full in intermediaries' prices, these are intra-community transfers which do not need to be modelled in a cost benefit analysis, removing a complication that would be challenging to model on available data. Waste generators and customers of waste management services ultimately pay the levy through the charges that are passed on from landfill operators through the intermediary services.

Table 13 Who pays the waste levy?

	Receipts	Payments
Customers of Disposal Services		
Residential		Levy-inclusive Municipal Solid Waste fees
Industry & Commercial		Levy-inclusive gate fees
Construction & Demolition		Levy-inclusive gate fees
Waste Management Intermediaries		
Council waste services	Rates & fees for MSW services	Payments for services
Waste collectors & brokers	Fees for services	Costs per added waste
Waste transporters	Fees for services	Added costs of diversion
Waste Disposal Supply and Oversight		
Landfill Operators	Levy-inclusive gate fees	Levy due to government
Landfill Operators		Administrative costs
Newly-levied operators		New capital & Operations and Maintenance costs
Government	Levy due to government	Oversight costs

Source: NZIER

Landfill fees vary widely. Posted gate fees for general wastes at Class 1 landfills generally exceed $120/tonne disposed of, and may be substantially higher (see Figure 4 above). Disposal of cleanfill material at special rates can be found for $20 per tonne or lower, but cleanfill deposited at some Class 1 landfills attracts much higher price to discourage delivery of cleanfill to such facilities.

We revised the landfill gate fees in our initial modelling, drawing on results of a 2019 Eunomia survey of 21 landfills covering approximately 90% of total Class 1 landfilled waste in New Zealand. This survey found a national weighted average disposal fee of $69 per tonne. But it also revealed a marked difference between landfills in the Upper North Island around Auckland, Hamilton and Tauranga, with an estimated weighted average gate fee of $49 per tonne; from the lower North Island, with an estimated weighted average gate fee of $84 per tonne; and from the South Island, with an estimated weighted average gate fee is $125 per tonne.

Our model divides Class 1 landfills into two groups, based on landfill fee and geographical location. We use $49/tonne for our Class 1a landfills (upper North Island) covering 62% of national Class 1 landfill disposal; and $101/tonne for Class 1b landfills (rest of New Zealand)[9] covering 38% of national Class 1 landfill disposal. These fees exclude the current levy and GST, but include any Emissions Trading Scheme charges.

For other classes of landfill we lower the gate fees from our initial modelling in line with the high fee estimates provided in Table 1-18 in Eunomia (2017), which are

9 Combining the information from the lower North Island and South Island, the weighted average gate fee would be $101/tonne.

reasonably similar to the survey results from 2019. We reduce Class 3 landfills to $30/tonne in this round of modelling to provide a reduction from the previous modelled results in May and to distinguish these landfills from Class 2. Table 14 shows the prices input into the latest and initial modelling, compared to Eunomia 2017.

Table 14 Representative landfill gate fees

$/tonne disposed of, excluding levy and GST but including ETS charges

Landfill class	Gate fee $/tonne	May 2019 model	Eunomia 2017
Class 1a	49	100	55
Class 1b	101	110	90
Class 2	40	75	40
Class 3	30	40	40
Class 4	15	20	15

Source: NZIER, drawing on Eunomia 2019 information and Eunomia 2017 Table 1-18.

4.2.4. Transport costs

Our model includes a component for transport costs to landfills, as part of the full economic price of disposal. Including transport cost has the effect of reducing the proportionate impact of a given waste levy increase on the price of disposal. This affects estimation of material diversion in response to price elasticities.

The price faced by customers for waste disposal also includes, in addition to the fee, the cost of gathering waste and transporting it from source to landfill. Although some landfills receive waste transported from very long distances, most waste will be transported much shorter distances. We have no data on the distance transported by waste from all sources to all disposal points, so make a simplifying assumption that, on average, waste is transported 30km one way at a cost of $0.375 per tonne-km from a transfer station to the landfill. That assumption would add $16.65 to the gate fee of a Class 1 landfill, and $8.33 to a Class 2, 3 or 4 landfill, on the assumption that because they are more numerous than Class 1 landfills they will face half the transport cost.

While it is likely that alternatives such as material recovery will also be subject to transportation costs, this is already implicitly covered by our treatment of recovered material value in the CBA as an economic surplus. Collection from source to transfer station or material recovery centre is common to all waste; from there transport cost to landfill is part of the cost of disposal and is explicitly included in our model as an addition to gate fee. For material that is recovered for recycling or export there is also transport cost from recovery centre to point of export or use; this is already implicitly allowed for by converting material recovery revenues into economic surplus in the CBA, so accounting for transport cost is also required for the disposal to landfills.

4.2.5. Environmental effects

As indicated in section 2.5 above, it is difficult to model environmental externalities of landfills without geographically referenced data, because many of the adverse effects are localised and vary with surrounding land use activities. But the national Greenhouse Gas Emissions Inventory enables average emissions of CO_2-e per tonne to be identified for different classes of landfill.

For Class 1 “managed” landfills the average emissions per tonne of waste is 0.47 tCO_2-e. For Class 2 and Class 3 landfills, which the Emissions Inventory describes as “unmanaged” but are still subject to RMA controls, the average emissions per tonne is 0.21 tCO_2-e. For farm dumps it is 1.2 tCO_2-e. We apply these figures to changes in waste tonnages going to different types of landfill, and also credit tonnages diverted to recovered materials with emissions savings at the weighted average of the other classes of 0.41tCO_2-e.

In this model re-run we assume the price of carbon credits rises from \$25/tCO_2-e to \$42/tCO_2-e in 2030, in line with EU forecasts. This rise represents a compound annual average percent change of 4.8%, by which the price is adjusted each year.

Our model does not calculate emissions from Class 4 landfills, as Class 4 disposals are predominantly of inert material with emissions, if not zero, much lower than those from Class 2 or 3 landfills. Class 4 landfills do gain volume in modelling scenarios, and if organic material is mixed up and undetected in those depositions, greenhouse gas emissions can be expected to increase from them. But it would take a high proportion of contamination for cleanfill material to approach the emission levels of other landfills. There is no evidential basis for estimating emissions for cleanfills.

These are very approximate estimates: despite having methane capture and other measures, Class 1 landfills have higher assumed emissions than Class 2 landfills, because of the higher proportion of active material in their wastes. Diversions of waste from Class 2 to Class 1 are likely to lower the active proportion and hence the emissions, but we have no basis for adjusting for that effect. Emissions from unofficial dumps or fly tipping may be overstated by using farm dump emission ratios, but the extent of unofficial dumping or fly tipping in New Zealand is unknown as there is no published data, except for periodic reports from some local councils of annual spending on cleaning up such dumps.

We also include a value for other externalities at the assumed rate of \$10/tonne for Class 1a landfills with modern management practices, but \$15/tonne for Class 1b landfills which include older and smaller landfills with less environmental management. Class 2 and 3 landfills have lower active components in waste and should have fewer externalities, but we assume \$10/tonne of waste because of the risk of levy changes leading to more active waste being diverted to them. We assume \$5/tonne for Class 4 cleanfills because of their lower active component, and \$20/tonne for unofficial dumps. These values are solely to provide non-zero value for changes in volume deposited in lieu of more accurate information.

4.2.6. Material recovery and recycling

Waste diversion in response to levy-induced landfill price rises may lead to increases in material recovery and recycling. To value the recovered material would ideally require geographically sourced data on the origins and potential uses for individual materials, which is not currently available.

The amount of recycling in New Zealand fluctuates with the uses of, demand for and prices of recovered materials, and also varies across materials. There is firm demand for ferrous and non-ferrous metals that makes them widely recycled, but for other materials a combination of low value, high bulk and high transport cost to the few and scattered facilities with the scale economies to recycle material have made New Zealand recycling efforts dependent on exporting materials to other countries that can better handle them, principally in East Asia.

However, a shifting political climate internationally, with recent restrictions on importing other nations' waste material announced in China and some other countries, is creating stockpiles of material for recycling and an increased domestic focus on onshore processing of materials. Improvement in market conditions could come from applications of revenue collected from the waste disposal levy, but we do not model that because of the complexity of modelling multiple materials without reliable data.

To acknowledge that the value of recovered materials is non-zero, we measure the increased tonnages implied by the model, the savings in environmental costs resulting from such diversion (valued at $11 per tonne of material) and apportion diverted material to different types of material (metals, plastic, paper, glass etc) according to volume shares and prices identified for each material in Eunomia (2017).

Recovered materials come in many grades and prices vary over time. For this modelling we need an all-classes average for each broad material type. We use the assumed dollars per tonne of material recovered estimated by Eunomia in 2018. In Table 15we compare Eunomia's prices with recent prices and low and high range bounds over the past 25 years from the Sounds Resource Management Group for four of these materials. Eunomia's prices are within the range but somewhat below the mean over the period, so we assume they may be used as roughly representative long term prices for their respective materials. We do not attempt to predict future price fluctuations, so these prices are held constant over the 10 year analysis period.

Table 15 Recovered material prices

By type of material

Material	Assumed $/tonne	Mean $/tonne	Recent $/tonne	Low $/tonne	High $/tonne
Rubble	20				
Ferrous metals	100	$164.02	$41.58	$41.58	$450.49
Paper	120	$127.06	$64.69	$16.17	$300.33
Glass	75				
Timber	100				
Non-ferrous metals	1,000	$1,386.12	$1,108.89	$831.67	$2,217.79
Plastics	300	$589.10	$450.49	$346.53	$970.28
Rubber	8				
Textiles	500				
Rubble	20				

Source: Eunomia 2018; Sounds Resource Management Group info@zerowaste.com

These values are effectively the free on board prices of materials for export to overseas customers. To get to that state there will be handling and processing costs. There is insufficient information to calculate these costs for each product line from all parts of the country, so we use the operating surplus share of gross output in the waste management industry, in Statistics New Zealand's inter-industry input output tables, as the economic surplus for producers on this material in the cost benefit analysis.[10]

[10] The benefit modelled is derived from tonnage recovered times average price times proportion of operating surplus.

5. Results of the levy extension

We use our model to examine options with variations in the cover of the waste disposal levy and in the rate of levy applied to different landfill classes. The modelling was done in three stages:

- Modelling of an initial set of options in May 2019
- Interim modelling of a revised set of options, with revised input assumptions around gate fees in August 2019
- Final modelling of a further refined set of options in October/November 2019

5.1. Initial modelling

Initial modelling in May 2019 examined options for extending the levy over Class 2 and Class 3 landfills, increasing the levy of Class 1 landfills only, and recurring increases in levy on Class 1 and Class 2 landfills. That modelling used assumed landfill prices that look too high in light of more recent results of a gate fee survey by Eunomia (2019).

While the gate fees may have been high and to have dampened the price effect of increasing the levy, some findings of that modelling have general relevance.

- Extending the levy to Class 2 and Class 3 landfills (to counter the potential leakage of wastes away from Class 1 if only it incurred the levy), is necessary but not sufficient to improve waste outcomes
  - This would increase government's levy revenue and divert some material from these landfills to material recovery, but
  - It also imposes compliance cost on Class 2 and 3 landfills, some of them fixed costs disproportionate to the low volume of waste handled by these landfills, reducing the likely viability of some of them
- Increasing the levy on only Class 1 landfills that raises the price of Class 1 disposal relative to alternatives diverts some waste away from Class 1 sites
  - This effect becomes more apparent the higher the Class 1 levy increase
  - If active organic wastes are diverted, deliberately or inadvertently, to landfills with lower management standards than Class 1, there is a risk of increased adverse environmental effects
  - That effect is offset to some extent by raising the levy on Class 2 as well as Class 1 landfills
- A phased increase of levies over 10 years, to $80 per tonne for Class 1 sites and $30 per tonne for Class 2 sites, achieves lower overall diversion and levy revenue collected than other options in which high levy increases are introduced without any transitional phasing.

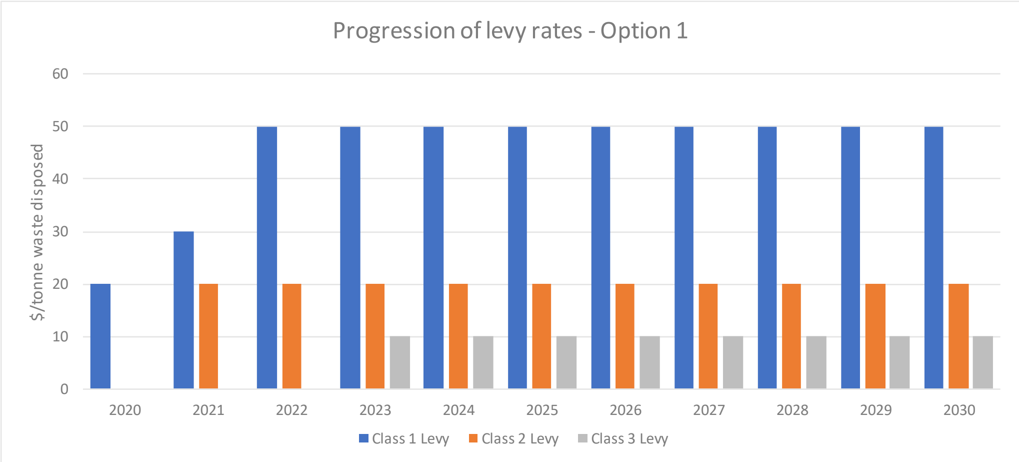
5.2. Final modelling

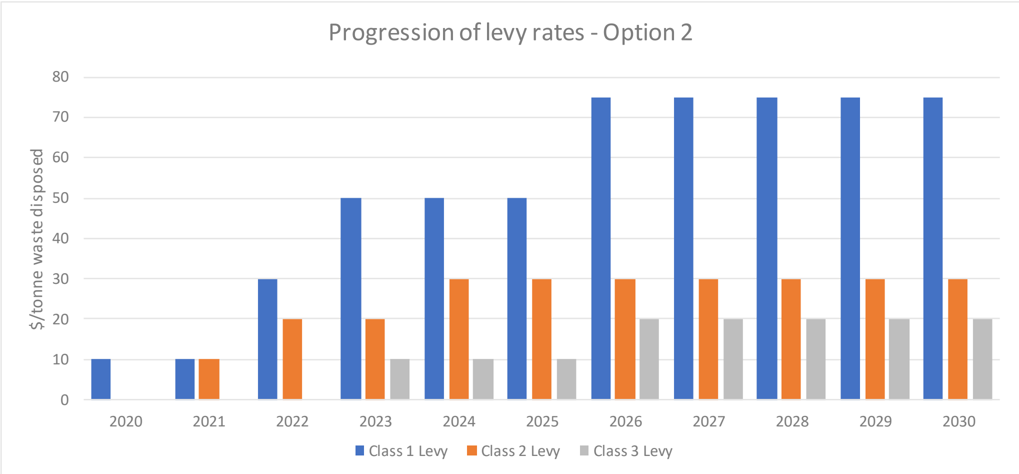
The final round of modelling assessed further options for extending the coverage, and raising the rates of the Waste Disposal Levy. Figure 5 sets out the six options examined in the final modelling. These options have slight variation in timing or rates of levy rises from earlier modelling of options.

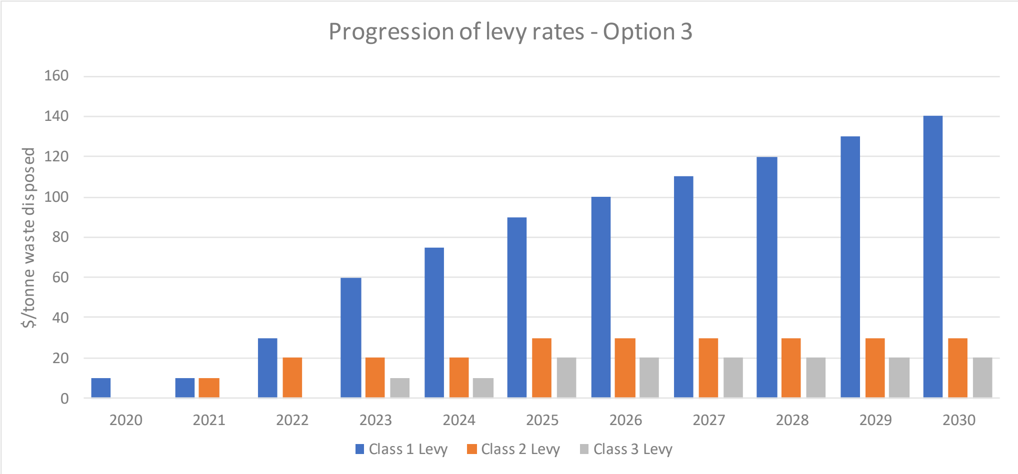
At the start of the analysis period only Class 1 landfills incur a levy of $10/tonne of waste but Option 1 increases it successively to $50 by 2022. Levies are extended to other landfill classes and raised at varying rates across the six options, with the most rapid rises being in the Option 3 "Escalator" on Class 1 levies (but slower in the early years than in the earlier escalator modelling). Option 1 is exceptional in that its Class 1 levy is raised from $10 to $20 in 2020, one year ahead of any other option.

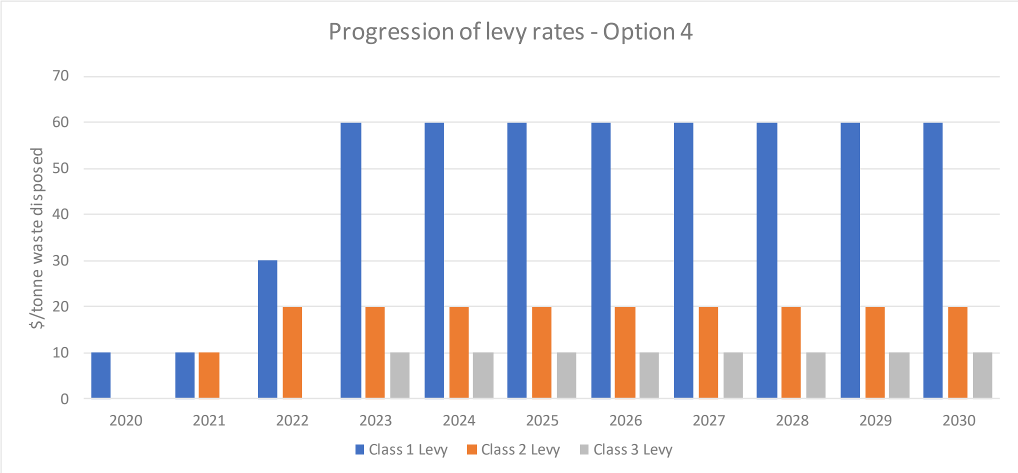
Figure 5 Options for extending and raising levy rates

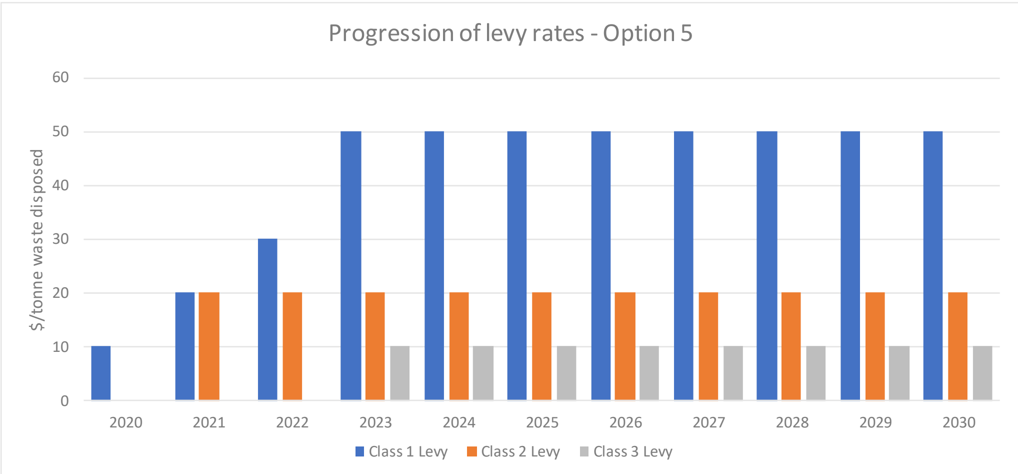
Note: Left hand axis scales vary

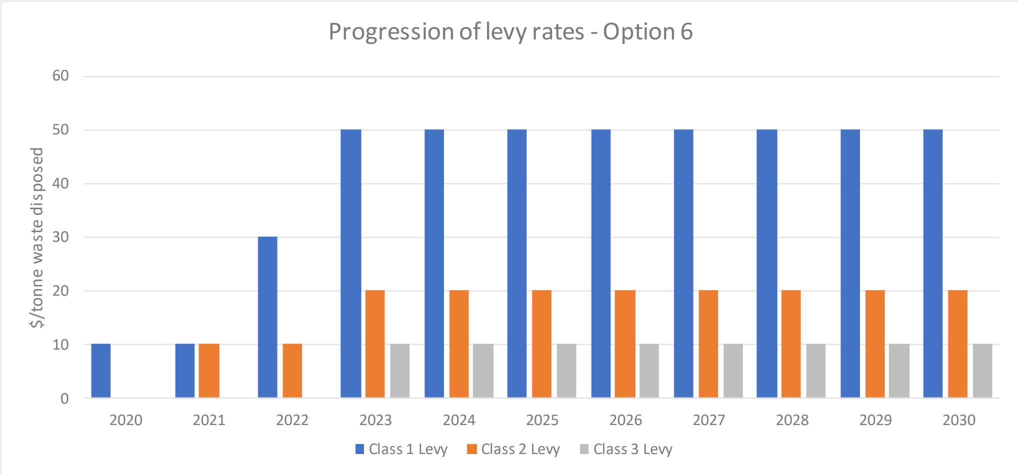





Progression of levy rates - Option 3
$/tonne waste disposed
0
20
40
60
80
100
120
140
160
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Class 1 Levy
Class 2 Levy
Class 3 Levy


Progression of levy rates - Option 4
$/tonne waste disposed
0
10
20
30
40
50
60
70
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Class 1 Levy
Class 2 Levy
Class 3 Levy


Progression of levy rates - Option 5
$/tonne waste disposed
0
10
20
30
40
50
60
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Class 1 Levy
Class 2 Levy
Class 3 Levy



Source: NZIER

Table 16 Waste levy options – class 1 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020	20	10	10	10	10	10
2021	30	10	10	10	20	10
2022	50	30	30	30	30	30
2023	50	50	60	60	50	50
2024	50	50	75	60	50	50
2025	50	50	90	60	50	50
2026	50	75	100	60	50	50
2027	50	75	110	60	50	50
2028	50	75	120	60	50	50
2029	50	75	130	60	50	50
2030	50	75	140	60	50	50

Source: NZIER

Table 17 Waste levy options – class 2 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020						
2021	20	10	10	10	20	10
2022	20	20	20	20	20	10
2023	20	20	20	20	20	20
2024	20	30	20	20	20	20
2025	20	30	30	20	20	20
2026	20	30	30	20	20	20
2027	20	30	30	20	20	20
2028	20	30	30	20	20	20
2029	20	30	30	20	20	20
2030	20	30	30	20	20	20

Source: NZIER

Table 18 Waste levy options – class 3 landfill

$ per tonne of waste 2020-2030

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
2020						
2021						
2022						
2023	10	10	10	10	10	10
2024	10	10	10	10	10	10
2025	10	10	20	10	10	10
2026	10	20	20	10	10	10
2027	10	20	20	10	10	10
2028	10	20	20	10	10	10
2029	10	20	20	10	10	10
2030	10	20	20	10	10	10

Source: NZIER

5.2.1. Option 1 – One-step medium levy extension

Figure 6 shows the results of Option 1 under each of the low, medium and high elasticities. As the medium and high elasticities are roughly 2 and 6 times the low elasticity, the aggregate net change is in the same proportions. The proportional split of diversions between material recovery and landfill types does not change over time.

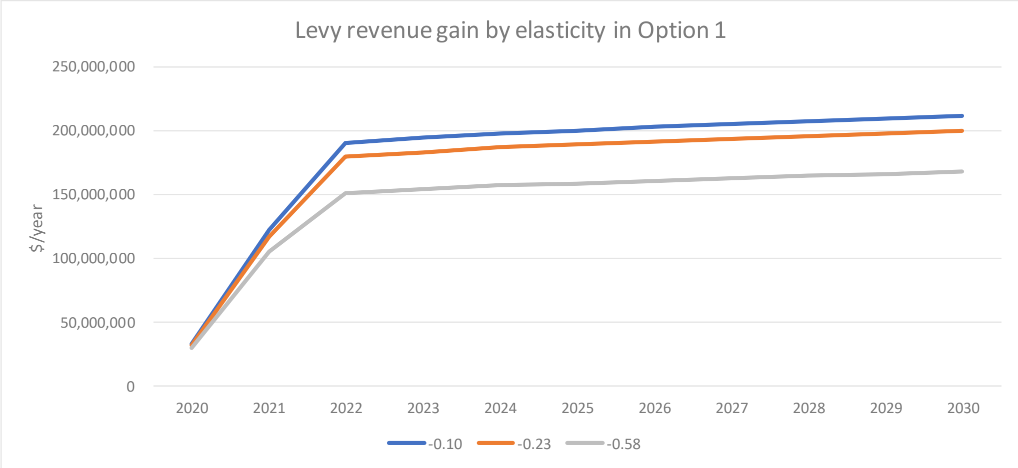
Figure 6 Net change in material disposal – Option 1

Tonnes per year over 11 year period (note: left hand axis scales vary)

Source: NZIER

Figure 7 shows the levy revenue gain under each elasticity. The higher the elasticity, the lower the revenue gain, as the greater the diversions the more material ends up in landfill classes (3 and 4) that are not subject to any levy, eroding the revenue yield.

Figure 7 Levy revenue gains with Option 1



Source: NZIER

Table 19 summarises the results of this option. Although higher elasticities lower the revenue gain, they improve net benefits by increasing environmental gains from shifting material from disposal options with higher externalities.

Table 19 Option 1 One-step medium extension

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.10	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	93,025	213,501	533,753
Emission avoided tCO_2-e/year	117,967	270,745	676,863
Levy revenue gain $m	1,975	1,867	1,578
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,440	1,361	1,153
Societal benefits	46	105	263
Industry benefits	-12	-27	-69
Government costs	-4	-4	-4
Societal costs PV	-1,440	-1,361	-1,153
Industry costs PV	-58	-57	-52
NPV	**-28.7**	**16.8**	**137.7**
BCR	**0.98**	**1.01**	**1.11**

Source: NZIER

5.2.2. Option 2 Two-step high extension

Figure 8 shows the results of Option 2, which in 2021 extends the levy to Class 2 landfills, in 2022 raises the levy on Class 1 and 2 landfills, in 2023 raises the levy again on Class 1 and introduces a levy on Class 3, and in 2026 raises levy on both Class 1 and Class 3. This has larger impact on material diversion than Option 1.

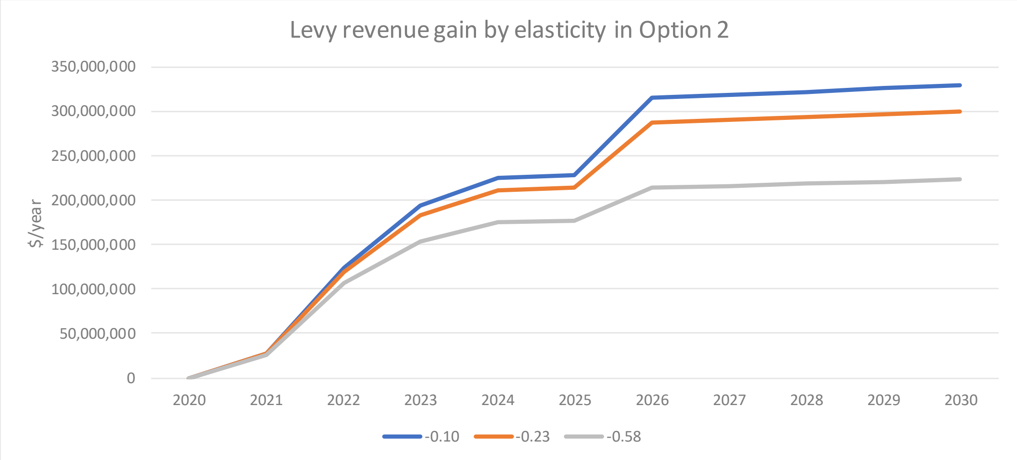
Figure 8 Net change in material disposal – Option 2

Tonnes per year over 10 year period (note: left hand axis scales vary)

Source: NZIER

Figure 9 shows the revenue gain under the different elasticity assumptions. As with Option 1, the higher the elasticity, the lower the levy revenue gained.

Figure 9 Levy revenue gains with Option 2



Source: NZIER

Table 20 summarises the modelling of this option. This option has a positive net present value under the medium (-0.23) and highest (-0.58) elasticity assumptions, and a small negative net present value under the lowest elasticity (-0.1).

Table 20 Option 2 Two-step high extension

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.10	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	116,618	267,649	669,122
Emission avoided tCO_2-e/year	151,293	347,229	868,073
Levy revenue gain $m	2,411	2,226	1,732
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,662	1,538	1,207
Societal benefits	55	126	315
Industry benefits	-14	-32	-80
Government costs	-3	-3	-3
Societal costs	-1,662	-1,538	-1,207
Industry costs	-58	-56	-50
NPV	**-19.9**	**35.5**	**182.6**
BCR	**0.99**	**1.02**	**1.14**

Source: NZIER

5.2.3. Option 3 "Escalator" extension

Figure 10 shows material impacts of Option 3, which extends the levy to Class 2 in 2021; raises levy on Class 1 and 2 in 2022; introduces a levy on Class 3 in 2023; raises the levy on Class 1 each year after 2023; and raises the levy on Class 2 and Class 3 in 2025.

As shown in Figure 10, this option drives visibly rising volumes of material away from Class 1 landfills where the impacts are greatest. Class 1a, 1b and 2 are net losers of waste volume, while Class 4 and recovered materials are the principal volume gainers.

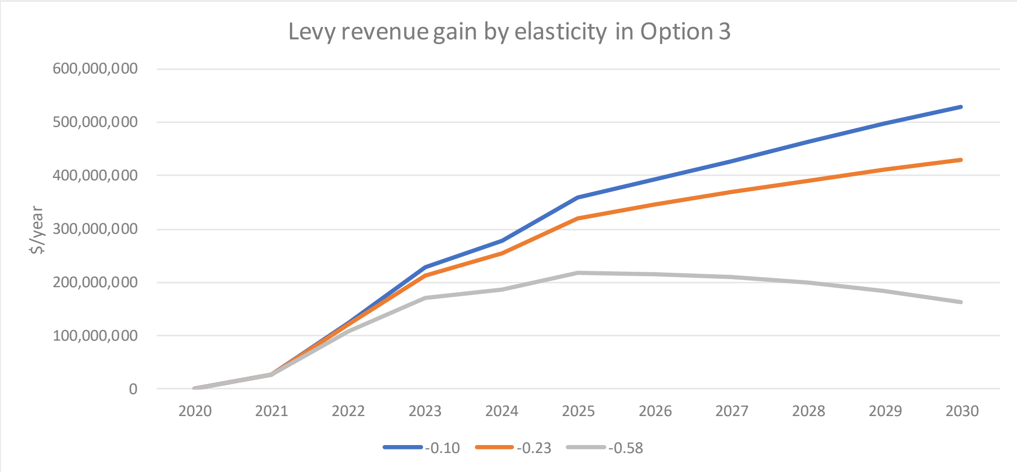
Figure 10 Net change in material disposal

Mean tonnes per year over 10 year period (note: left hand axis scales vary)

Source: NZIER

Figure 11 shows the two-stepped profile in revenue gain in 2023 and 2025 under Option 3. At the highest elasticity revenue gain falls because of increase in diversions of material to recovery and other unlevied options (like Class 4 and dumps).

Figure 11 Levy revenue gains with Option 3 Escalator



Source: NZIER

Table 21 shows Option 3 continues the pattern of revenue gain falling, but NPV improving the higher the elasticity assumption.

Table 21 Option 3 levy extension to all classes and increases

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.10	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	157,467	361,399	903,499
Emission avoided tCO_2-e/year	235,971	541,573	1,353,932
Levy revenue gain $m	3,326	2,875	1,677
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	2,257	1,965	1,188
Societal benefits	79	181	452
Industry benefits	-20	-46	-115
Government costs	-3	-3	-3
Societal costs	-2,257	-1,965	-1,188
Industry costs	-58	-57	-52
NPV	**-2.6**	**75.1**	**281.7**
BCR	**1.00**	**1.04**	**1.23**

Source: NZIER

5.2.4. Option 4 Truncated escalator

Figure 12 shows material impacts of Option 4, which truncates levy rises after 2023. It extends the $10 levy to Class 2 in 2021, raises the levy to $30 on Class 1 and $20 on Class 2 in 2022, and in 2023 introduces a $10 levy on Class 3 and raises the Class 1 levy to $60. All levy rates then remain unchanged for the rest of the decade until 2030.

As shown in Figure 12, this option drives the largest volume of material away from Class 1 landfills where the impacts are greatest. Class 1a, 1b and 2 are net losers of waste volume, while Class 4 and recovered materials are the principal volume gainers.

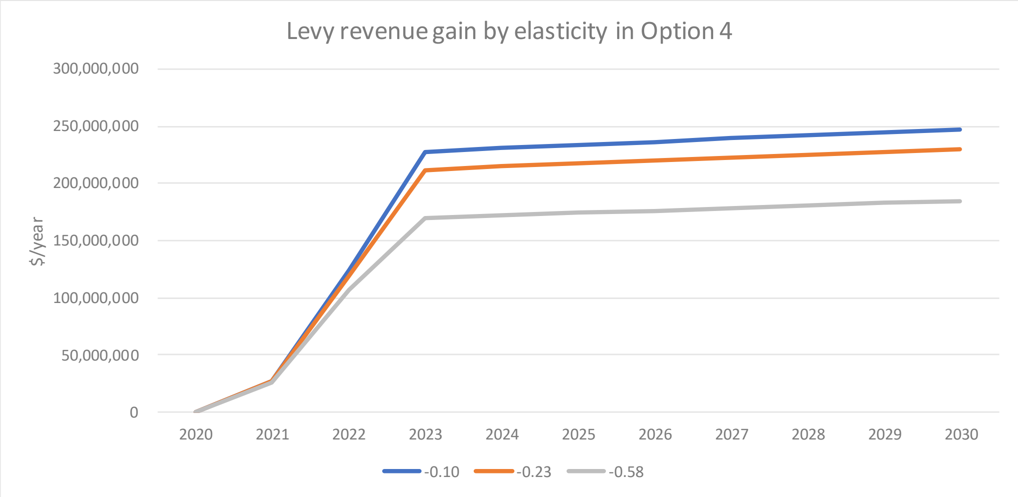
Figure 12 Net change in material disposal

Mean tonnes per year over 10 year period (note: left hand axis scales vary)

Source: NZIER

Figure 13 shows the stepped profile in revenue gain in 2021 and 2023 under Option 4. The higher the elasticity the lower the revenue gain, because of increase in diversions of material to recovery and other unlevied options (like Class 4 and dumps). The revenue profile does not decline over time with high elasticity, unlike Option 4.

Figure 13 Levy revenue gains with Option 4 truncated escalator



Source: NZIER

Table 22 shows Option 4 continues the pattern of revenue gain falling, but NPV improving, the higher the elasticity assumption.

Table 22 Option 4 truncated escalator

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.10	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	95,981	220,285	550,712
Emission avoided tCO_2-e/year	129,338	296,842	742,104
Levy revenue gain $m	2,053	1,916	1,551
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,445	1,350	1,096
Societal benefits	47	108	271
Industry benefits	-12	-28	-70
Government costs	-3	-3	-3
Societal costs	-1,445	-1,350	-1,096
Industry costs	-58	-57	-53
NPV	**-26.4**	**20.6**	**145.4**
BCR	**0.98**	**1.01**	**1.13**

Source: NZIER

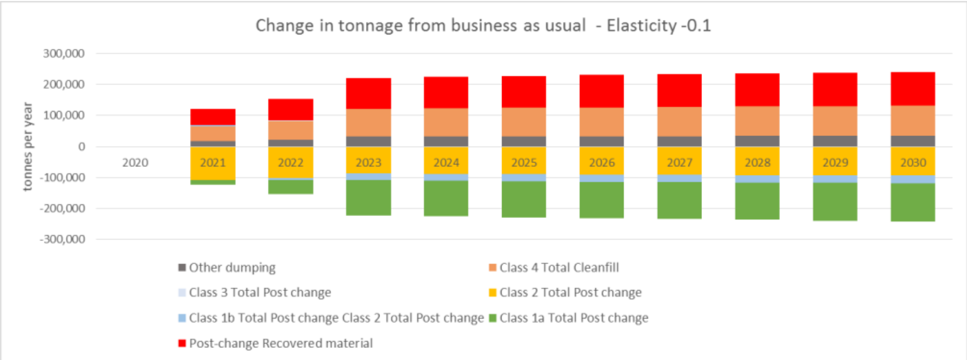
5.2.5. Option 5

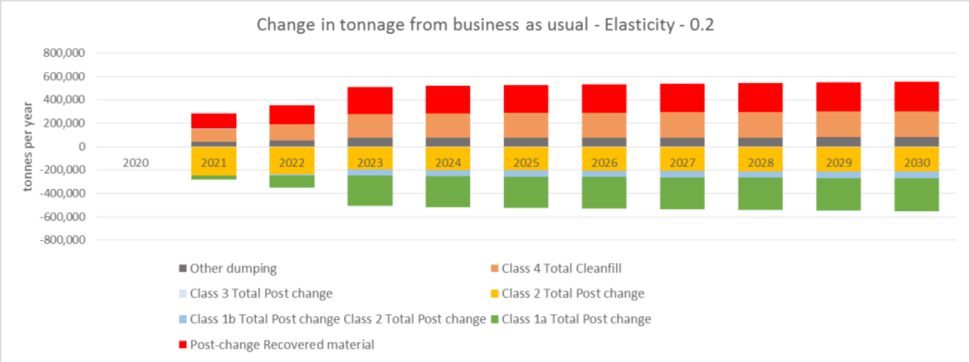
Option 5 increases the levy on Class 1 landfills in 2021, introduces a $20/tonne levy on Class 2 that same year, then raises Class 1 levy to $50/tonne by 2023, and introduces a $10/tonne levy on Class 3 in that year. This is similar to Option 1 above, but without the early increase in Class 1 levy in 2020.

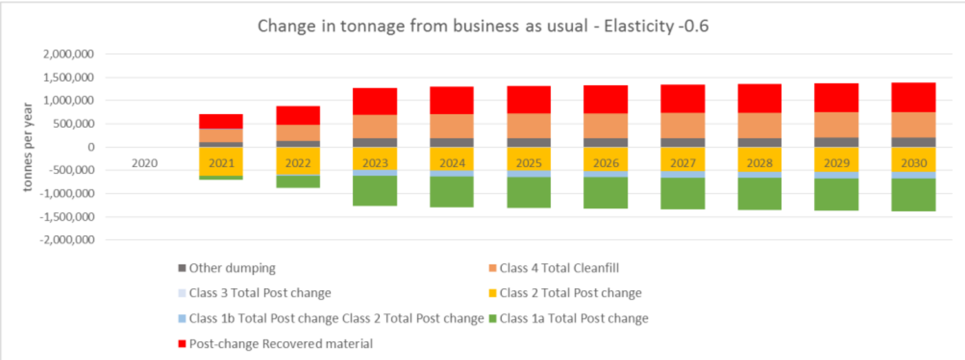
Figure 14 illustrates the effect this has on tonnes of material disposal.

Figure 14 Net change in material disposal – Option 5

Mean tonnes per year over 10 year period



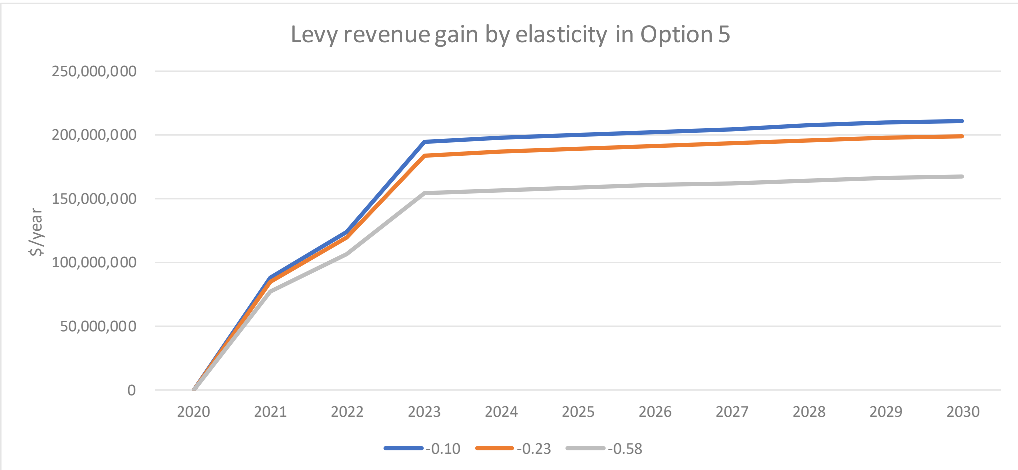




Source: NZIER

Figure 15 shows the growth of levy revenues under Option 5. As with previous options the higher the assumed elasticity the lower the revenue collected.

Figure 15 Levy revenue gains with Option 5



Source: NZIER

Table 23 summarises the results of Option 5. The levy revenue gain decreases the higher the assumed elasticity. Conversely the added tonnes of recovered material, the emissions avoided and the net present value all increase with higher elasticities. The levy achieves a positive net present value with medium and highest elasticities, but falls short with the lowest elasticity. Overall results are similar to those of Option 1.

Table 23 Option 5

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.1	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	87,814	201,540	503,849
Emission avoided tCO_2-e/year	110,303	253,153	632,883
Levy revenue gain $m	1,842	1,742	1,476
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,315	1,245	1,058
Societal benefits	42	97	242
Industry benefits	-11	-25	-62
Government costs	-3	-3	-3
Societal costs	-1,315	-1,245	-1,058
Industry costs	-58	-56	-52
NPV	**-29.9**	**12.5**	**125.2**
BCR	**0.98**	**1.01**	**1.11**

Source: NZIER

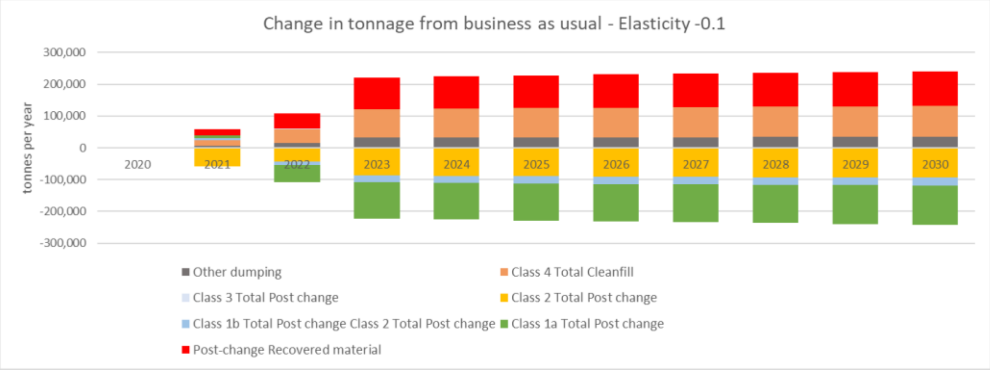
5.2.6. Option 6

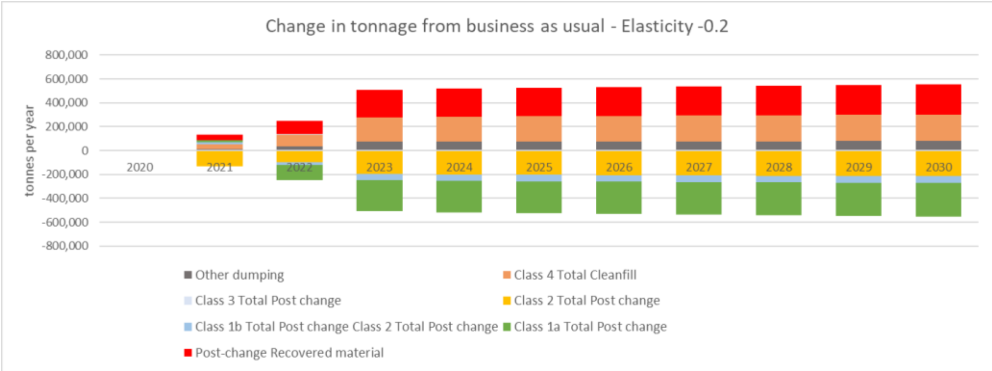
Option 6 is similar to Option 1 and Option 5. It introduces a $10/tonne levy on Class 2 in 2021, increases the levy on Class 1 landfills to $30 in 2022, and in 2023 raises that to $50/tonne, raises Class 2 levy to $20/tonne, and introduces a $10/tonne levy to Class 3.

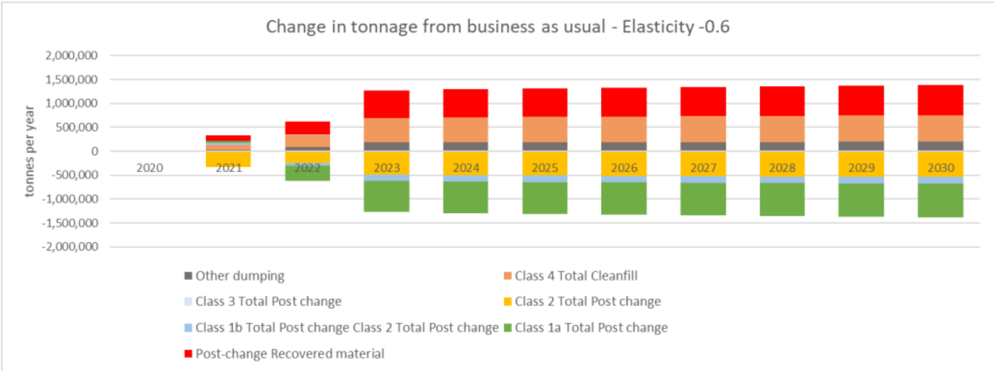
Figure 16 illustrates the effect this has on tonnes of material disposal.

Figure 16 Net change in material disposal – Option 6

Mean tonnes per year over 10 year period



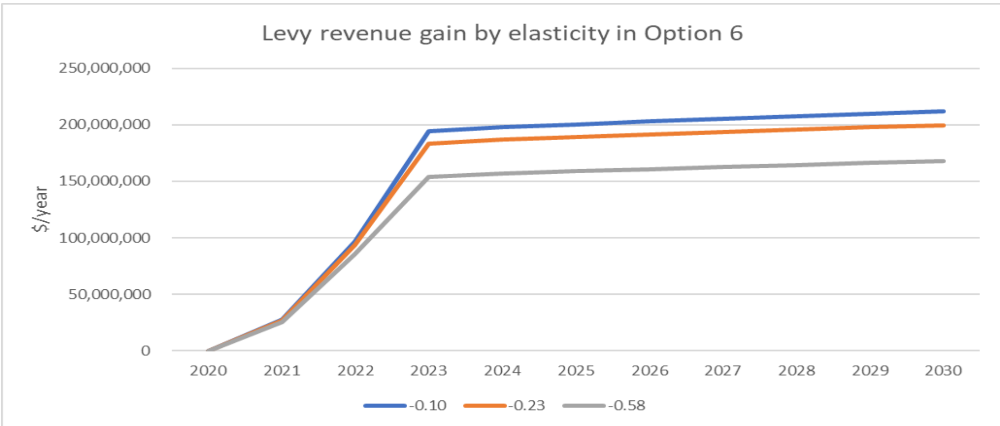




Source: NZIER

Figure 17 shows the growth of levy revenues under Option 6. As with previous options the higher the assumed elasticity the lower the revenue collected. Figure 13 shows a similar profile to Option 5, but with a less steep increase in the first 3 years.

Figure 17 Levy revenue gains with Option 6



Source: NZIER

Table 24 summarises the results of Option 6. The levy revenue gain decreases the higher the assumed elasticity. Overall results are similar to Option 1 and Option 5, but with slightly lower revenue gain and lower societal costs and benefits as well. Unlike those other options, Option 6 only just breaks even with the medium elasticity assumption, but falls just short with the lowest elasticity assumption.

Table 24 Option 6

Tonnes recovered and emissions annual averages; Present values calculated over 10 years at 6% rate

	Price Elasticity 0.1	Price Elasticity 0.23	Price elasticity 0.58
Added tonnes recovered/year	82,893	190,246	475,616
Emission avoided tCO_2-e/year	107,033	245,650	614,124
Levy revenue gain $m	1,754	1,658	1,403
	PV ($m)	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,234	1,167	990
Societal benefits	40	92	229
Industry benefits	-10	-24	-59
Government costs	-3	-3	-3
Societal costs	-1,234	-1,167	-990
Industry costs	-58	-57	-53
NPV	**-31.8**	**8.1**	**114.1**
BCR	**0.98**	**1.01**	**1.11**

Source: NZIER

5.3. Sensitivities to key assumptions

The assumption around price elasticity applied to measure the effect of raising landfill price has an important impact on all these results. The results under three different elasticities are reported in descriptions of each of the levy options above.

Table 25 illustrates the effects of changing some of the assumptions in the analysis, through the example of Option 3 with the medium elasticity assumption. The base estimate is that in Table 21 above. Two columns show the effect of applying a zero value to externality effects around landfills that would be avoided with material diverted away from landfilling, which reduces the net benefit; and of doubling the value attached to those effects, which almost doubles the net benefit. The two right hand columns show the effect of assuming no transport component in the cost of landfilling, which compared to the base estimate increases the material tonnage recovered, emissions avoided and net benefits, but reduces the net gain in levy revenue; or alternatively increasing the assumed transport distance included in landfilling cost, which has the opposite effect in lowering tonnes recovered, revenue and net benefit.

Table 25 Results under alternative assumptions

Option 3, medium elasticity assumption (-0.23)

	Base estimate	0 Site effects	2x Site effects	Transport 0 km	Transport 50km
Added tonnes recovered/year	361,399	361,399	361,399	458,833	317,336
Emission avoided tCO_2-e/year	541,573	541,573	541,573	697,736	472,423
Levy revenue gain $m	2,875	2,875	2,875	2,639	2,979
	PV ($m)	*PV ($m)*	*PV ($m)*	*PV ($m)*	*PV ($m)*
Levy revenue gain	1,965	1,965	1,965	1,812	2,032
Societal benefits	181	115	247	231	159
Industry benefits	-46	-46	-46	-44	-47
Government costs	-3	-3	-3	-3	-3
Societal costs	-1,965	-1,965	-1,965	-1,812	-2,032
Industry costs	-57	-57	-57	-56	-57
NPV	**75.1**	**9.1**	**141.1**	**126.7**	**52.0**
BCR	**1.04**	**1.00**	**1.07**	**1.07**	**1.02**

Source: NZIER

A key uncertainty in this modelling is the impact of including transport costs in the landfill fees. The transport costs are relatively modest: on average $16.65 per tonne to Class 1 landfills and $8.33 to other landfills. Depending on the class of landfill, this varies from around 15% to 36% of the levy-exclusive landfill fee.

Excluding transport cost from the disposal cost lowers the price of landfilling and increases the impact of the assumed price elasticity in driving material diversions away from landfills facing price increases. Including transport cost suppresses the impact of levy extensions to some extent. The overall tonnage being diverted reduces, material recovery goes down, and with it any value obtained from that recovered material. Lower diversions also lower the reductions in greenhouse gas emissions and the other externalities driven primarily off the tonnage sent to landfills with more organic content (Class 1 and, to lesser extent, Class 2 and Class 3). Including transport cost has a small proportional impact on the revenue gained from the levy, but a larger proportional impact on the overall NPV.

The difference made by including or excluding transport increases with the elasticity. In the model it also varies with the range and extent of landfills facing price increases: whenever some landfill classes are not subject to the levy, there is less overall diversion and less effect from including or excluding transport costs.

If the trajectory of waste generation over time is lower than that modelled in the counterfactual, the levy becomes less effective in terms of the measures reported here, other things held constant. Such a lowering of waste generation may occur for reasons unrelated to the levy, such as changing behaviours and more effective design for waste minimisation, or because of other policies such as product stewardship by suppliers.

The levy is less effective on lower waste volumes because the elasticities drive percentage diversions off a smaller baseline of waste generation. This lowers the societal benefits from material recovery volume and value, and also lowers the reductions in greenhouse gas emissions and local disamenity effects around landfills. That in turn means the cumulative value of societal benefits across the years takes longer to outweigh the costs of implementing the levy with its large fixed cost component. The net present value of levy change options is lowered, and the time at which levy benefits exceed costs is delayed. These changes apply to varying degree under all the levy options, and all elasticity settings, examined in this modelling.

6. Comparison of options

Table 26 outlines the results of the six final levy options on three key outcome variables: the additional levy revenue raised, additional material recovery, and the additional net societal benefit, compared to the continuation of current levy over the next 10 years. Results are shown for each of the three elasticity assumptions.

The table shows that the higher the elasticity, the lower the revenue collected but the higher the material recovered and the higher the net present value. The higher elasticities drive more material away from the landfills facing higher prices, including to landfills with lower prices and to material recovery. The value of recovered material, plus the avoidance of externalities from landfill disposal when material is diverted from waste streams with high externalities to uses with lower externalities, also result in net societal benefits increasing with high elasticities.

Table 26 Summary of results

Totals of levy-induced changes over 2020-2030

Price Elasticity	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Added levy revenue over 11 years *($ million)*						
-0.10	1,975	2,411	3,326	2,053	1,842	1,758
-0.23	1,867	2,226	2,875	1,916	1,742	1,662
-0.58	1,578	1,732	1,677	1,551	1,476	1,407
Added material recovery over 11 years *(Million tonnes)*						
-0.10	1.009	1.283	1.732	1.056	0.966	0.915
-0.23	2.349	2.944	3.975	2.423	2.217	2.099
-0.58	5.871	7.360	9.938	6.058	5.542	5.248
Net societal benefits over 11 years *(PV$ million)*						
-0.10	-28.7	-19.9	-2.6	-26.4	-29.9	-31.8
-0.23	16.8	35.5	75.1	20.6	12.5	8.2
-0.58	137.7	182.6	281.7	145.4	125.2	114.6

Source: NZIER

The principal effects of these modelled results can be summarised as:

- The principal driver of the model is the price effect caused by adding or raising the levy as a component of landfill disposal price: landfills experiencing price rise see diversion of some waste to material recovery or other disposal to an extent that varies with the price elasticity assumed
- Levy revenue is a large item, which appears as a benefit for government but also as a cost to waste generators/disposal customers – residential, industrial and commercial, building and construction (except those using Class 4 landfills) - who ultimately pay for pay it
- To the extent that waste is diverted away from landfills to material recovery, society at large benefits from the value from recovered materials and environmental costs avoided with the reduction in landfilled volumes (e.g. greenhouse gas emissions and other amenity costs); the model estimates:
  - A value of recovered material net of the costs of realising that value, represented by the operating surplus of the recovery and recycling industries on the volumes recovered
  - A reduction in liability for greenhouse gas emissions for landfill operators and ultimately their customers to the extent that emissions costs are passed on in landfill fees
  - A reduction in adverse effects around landfills from waste disposal, a public benefit to those in the neighbourhood of landfills
- There can also be benefit to landfill operators to the extent that volumes are redistributed across landfills, so that some gain margin on handling increased volumes while others lose volume – but note:
  - At the higher levy rates applied to Class 1 landfills, these landfills face diversion of wastes to material recovery and disposal in landfills with lower gate fees that earn lower margins on their disposal
  - The model estimates the net effect of diversions between landfills is a negative benefit (i.e. cost) for landfill operators, because the overall margin generated by their business declines relative to the counter-factual, caused by both reduced waste volumes going to landfill and also diversion of volume from higher margin Class 1 landfills to lower margin Class 2, 3 and 4 landfills
- The waste management industry also faces costs in complying with levy changes, including one-off fixed costs (fitting weighbridges in landfills not previously subject to a levy) and recurring fixed costs in recalibrating equipment and administering the levy; in addition to the fees and costs they incur that vary with changes in volume of waste handled
- Costs for government in administering and overseeing the levy expansion.

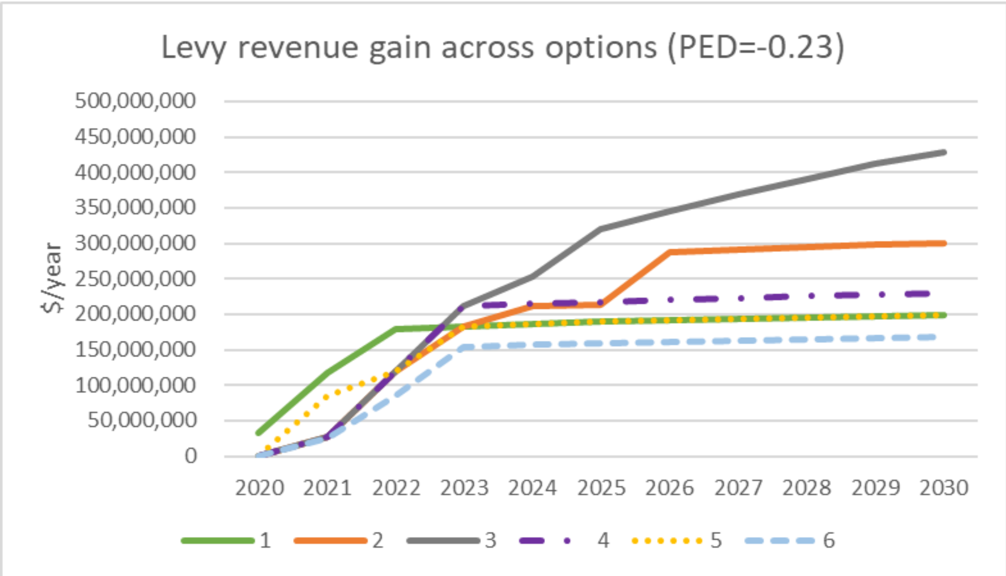
The fixed costs for industry initially tilt the CBA into net negative territory in the early years of the analysis, but the benefits from environmental improvements expand as the effects of the levy persist over time, increasing the tonnage of waste diversion and value of externality benefits. That pattern is enhanced and more net beneficial if elasticities are assumed to be higher than the lowest, as shown in Table 26 where none of the options is net beneficial at the lowest assumed elasticity, but all options are net beneficial at the highest elasticity.

The results suggest that on all measures in Table 26, the net gains increase when progressing sequentially through the options from Option 1 through to Option 3, but they regress with Option 4, and also 5 and 6 which are effectively slow-start versions of Option 1. In all cases a higher elasticity assumption yields improved results.

However, caution should be attached to the results of Option 3. The scale and rapidity of price increases in Option 3 are not marginal and could result in behaviour changes which do not align with those observed in the studies that estimated the price elasticities, which are inferred from observations of many small marginal changes in prices and their corresponding impact in changing quantities demanded. The elasticities become less valid when price increases become large and non-marginal.

Figure 18 compares the revenue profiles across the different options with a medium assumed elasticity of -0.23. This shows the flat profiles for Options 1, 5 and 6, the stepped profile for Option 2 and the rising profile of Option 3. These patterns are replicated at other elasticities, just at different levels.

Figure 18 Revenue profiles across options



Source: NZIER

The higher the price of landfill disposal, the higher the cost consumers and providers of landfill facilities are prepared to incur to avoid the high price, by preparing material for other use or disposal at lower cost (e.g. greater sorting, extracting or consolidating valuable elements from mixed waste materials). In practice these additional costs vary with waste type, circumstances and the potential emergence of new technologies and market conditions. Our model does not account for these new conditions.

6.1. Comparison with previous estimates

Table 27 summarises the results of a previous round of modelling of interim options for extending the waste disposal levy in August 2019. That modelled 4 options, including Option 1 which has not been modelled in the final results, and Options 2, 3, and 4 which were earlier variants of what are now called Options 1, 2 and 3 in the final results. Levy changes in all interim and final options modelled are outlined in Appendix A.

Table 27 shows the results from the interim model, with inputs consistent with the final results. The pattern is similar to other results, with added revenue declining but material recovery and net present value both increasing with higher elasticities. The results for options 2, 3, and 4 are slightly larger than the corresponding final results, because the interim variants of these options raised or extended waste levies earlier than in the final option variants modelled.

Table 27 Summary of results of August analysis (updated)

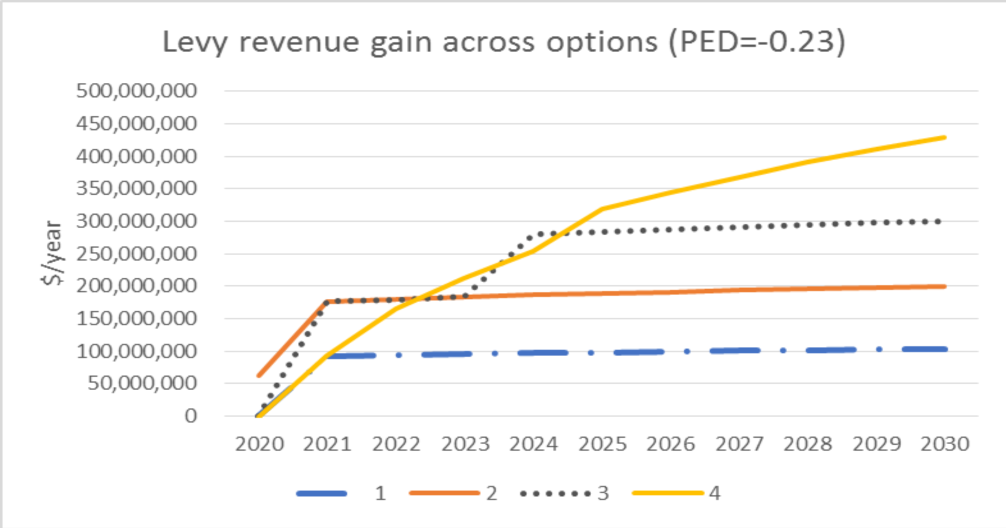
Totals of levy-induced changes over 2020-2030

Price Elasticity	Option 1	Option 2	Option 3	Option 4
	Added levy revenue over 11 years *($ million)*			
-0.10	1,019	2,074	2,801	3,446
-0.23	986	1,957	2,573	2,989
-0.58	898	1,647	1,964	1,773
	Added material recovery over 11 years *(Million tonnes)*			
-0.10	0.517	1.066	1.464	1.785
-0.23	1.186	2.447	3.361	4.096
-0.58	2.964	6.118	8.402	10.239
	Net societal benefits over 11 years *(PV$ million)*			
-0.10	-43.2	-27.1	-12.4	-0.8
-0.23	-20.0	20.6	52.7	79.9
-0.58	41.5	147.7	225.7	294.3

Source: NZIER

Figure 19 shows the revenue profiles across options at the medium elasticity assumption of -0.23. Combined with Table 26, this shows that the escalating levy on Class 1 in Option 3 is estimated to yield the highest levy revenue gain, the largest diversion of material to recovery, and the highest net present value of all options.

Figure 19 Revenue profiles across options



Source: NZIER

Table 28 compares results of final and interim modelling, showing interim results have higher revenue gain and net present value but the final variants generally have a better benefit cost ratio. The BCR is a measure of societal return on investment and indicates that even though they yield a lower revenue gain and net present value, the final options return greater value per dollar invested in implementing the levy extension.

Table 28 Comparison of current and previous modelling results

Summarised results for interim (x.1) and final (x.2) options assuming elasticity of -0.23

	Recovered k tonnes	Revenue gain $m	NPV $m	BCR
1.1	1.186	985.8	-20.0	0.97
2.1	2.447	1,957.1	20.6	1.01
1.2	2.349	1,866.8	16.8	1.01
3.1	3.361	2,572.6	52.7	1.03
2.2	2.944	2,225.8	35.5	1.02
4.1	4.096	2,989.0	79.9	1.04
3.2	3.975	2,875.1	75.1	1.04
5.2	2.217	1,742.1	12.5	1.01
6.2	2.099	1,661.8	8.2	1.01

Source: NZIER

Option 3 yields the highest values in the final option set, but its revenue gain and NPV are smaller than in the interim modelling, as it raises the levy on Class 1 and introduces a levy on Class 3 later than in the interim Option 3.

6.1.1. Potential for unintended consequences

Our model includes diversions to unofficial dumps, based on the shares of wastes currently estimated to be going to farm dumps. This is not to imply that the levy would cause farms to open their dumps for disposal of active general municipal solid wastes which they are not designed to manage, but rather to acknowledge that the larger levy increases that significantly raise the price of disposal will increase the potential for some waste disposal customers to seek lower cost options, such as surreptitious dumping on farms, roadside reserves or other unstaffed landfills accessible to the public. There is no hard data on the extent of such dumping or "fly-tipping" in New Zealand, which by its nature tends to be a hidden activity. Our modelling includes unofficial dumping as an indicative value to acknowledge there could be a portion of waste disposed of outside the regulated landfill sector.

We note that the options proposing higher levy rises on Class 1 landfills have the effect of driving waste away from Class 1 landfills to other disposal options less designed to manage the full range of wastes, from active wastes to the more inert cleanfill material. It creates a risk of cleanfill material being co-mingled with more active components and of increasing environmental effects such as emissions or leaching from such waste when deposited in a facility with less management than a Class 1 landfill. It could also have the effect of making Class 1 landfills a less viable prospect for investment, because of the higher prices and lower volumes expected.

6.2. What the modelling shows

Our model is a high-level representation of landfilling in New Zealand and implications of changes in the waste disposal levy. It is driven primarily by recent data on waste disposals, projected into the future in line with population forecasts, and reflecting a distribution of wastes across different landfill classes drawn from recent literature. Changes in the extent and rate of levy are then driven primarily by the diversion of materials to different end uses in response to changes in landfill price.

Subject to the limitations of the model and its reliance on inputs drawing from overseas estimates, particularly of the price elasticity of demand and monetary values of environmental effects associated with landfills, the modelling indicates most of the options examined would be net beneficial provided the price elasticity is around -0.2 to -0.6 or higher. It also suggests that increasing the levy on Class 1 landfills ahead of extending it to Class 2 and Class 3 landfills would lead to material diversion away from Class 1 into other landfill classes if the levy's proportional impact on Class 1 disposal price exceeds that on other classes.

That carries a risk of more active organic material being sent to landfills with less design and active management to control them, and increased environmental impacts across landfilling activity as a whole. That risk is greater with options where the increase in levy on Class 1 landfills is proportionately larger and more frequent than on other classes of landfill.

The modelling shows the importance of the elasticity assumption in obtaining costs in excess of benefits. The higher the elasticity, the higher the benefit cost ratio, but the lower the levy revenue collected. Existing literature suggests price elasticities for waste disposal tend to be low, but they could rise over the longer term with increased awareness of alternatives and improved viability of material recovery under changing market conditions.

That influence of elasticities also depends on the assumptions made about the price of landfill disposal. Changes in the prices assumed for different landfills would change the numerical estimates of the modelling, but the broad pattern of elasticities determining waste diversion out of landfilling would remain in the results of the model.

The model shows that large increases in the levy on Class 1 waste disposal would maximise revenue from the landfill levy. However, it also shows that result depends on large diversions away from Class 1 landfills which are designed to handle active organic wastes, and large diversions to Class 4 cleanfills and to recovered material. Such a result would have dynamic consequences that are not included in the model. These include:

- It is likely to hasten the closure of a number of Class 2 and 3 landfills, many of which have insufficient tonnage to justify improving handling and weighbridge equipment to comply with the levy
- It may also hasten the closure of some Class 1 landfills, many of which do not handle large annual volumes and would be challenged to invest in improving their capacity to deal with diversion and potential changes to volumes received
- It increases the risk of high organic content waste being diverted to landfills least well equipped to deal with it, with potential for increase in local externalities or increased greenhouse gas emissions from wastes
- It increases the risk of unofficial dumping and illegal fly-tipping in areas of public and private land, with increased risk of adverse environmental effects and increased need for local monitoring and clean-up activities.

The number of open landfills used in the model may well change in future, irrespective of changes in the landfill levy. Half of the current Class 1 landfills account for less than 3% of total waste disposed and receive annual volumes too small to cover the long run marginal cost of landfilling.

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Appendix A Levy changes

Table 29 Summary of levy options examined

Waste disposal levies applying to different landfill classes $/tonne (Currently $10 in Class 1 only)

Option	Class	2020	2021	2022	2023	…	2030
1 Final	Class 1	20	30	50	50		50
	Class 2	0	20	20	20		20
	Class 3	0	0	0	10		10
2 Final	Class 1	10	10	30	50		75
	Class 2	0	10	20	20		30
	Class 3	0	0	0	10		20
3 Final	Class 1	10	10	30	60		140
	Class 2	0	10	20	20		30
	Class 3	0	0	0	10		20
4 Final	Class 1	10	10	30	60		60
	Class 2	0	10	20	20		20
	Class 3	0	0	0	10		10
5 Final	Class 1	10	20	30	50		50
	Class 2	0	20	20	20		20
	Class 3	0	0	0	10		10
6 Final	Class 1	10	10	30	50		50
	Class 2	0	10	10	20		20
	Class 3	0	0	0	10		10
1 Interim	Class 1	10	30	30	30		30
	Class 2	0	10	10	10		10
2 Interim	Class 1	30	50	50	50		50
	Class 2	0	20	20	20		20
	Class 3	0	0	10	10		10
3 Interim	Class 1	10	50	50	50		75
	Class 2	0	20	20	20		30
	Class 3	0	0	0	10		20
4 Interim	Class 1	10	30	45	60		140
	Class 2	0	10	20	20		30
	Class 3	0	10	10	20		20

Source: NZIER, from information provided by the Ministry for the Environment

Appendix B Australian waste levies and streams

The following tables summarise the information from the National Waste Report database on the following:

- Waste levy – rate for metropolitan areas by waste stream
- Waste generated by stream; - metropolitan solid waste (MSW), commercial and industrial (C&I) and construction and demolition (C&D)
- Waste disposal method; ‘landfill’, ‘recycling’, ‘energy from waste’ and ‘other’.

The National Waste Report database includes two streams of reporting – by ‘category’ (broad classification) and by ‘type’ (narrow classification) and has not been fully quality assured. For the tables in this report we have:

- used the data reported by ‘category’ rather than ‘type’ as the reporting of ‘category’ data appears to be more complete
- where the total for waste generated exceeds the total for disposal options (landfill, recycling or conversion to energy) we have listed the difference as unknown.

Some of the state names are abbreviated as follows:

- Australian Capital Territory - ACT
- New South Wales – NSW
- Northern Territory - NT
- South Australia – SA
- Western Australia – WA

Table 30 Comparison of solid waste levies by state

AUD per tonne for metropolitan waste collected in a metropolitan area

State	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NSW	22.70	30.40	38.60	46.70	58.80	70.30	82.20	95.20	107.80	120.90	133.10	135.70
SA	10.20	11.20	24.10	24.70	23.40	26.00	35.00					76.00
Victoria	7.00	8.00	9.00	9.00	6.00	30.00	44.00	48.40	53.20	58.50	60.52	62.00
ACT					64.15							90.55
WA[1]	6.00					28.00			28.00	55.00		60.00
Queensland[2]						35.00						
Tasmania[3]											5.00	
NT												

Notes:

1. Levy for WA is for putrescible waste only
2. Queensland is proposing to introduce a levy of AUD 70 per tonne from 1 July 2019
3. Tasmania's levy is voluntary over a range from zero to the maximum shown in the table

Source: NZIER

Table 31 Share of total waste in landfill

Tonnes of waste sent to landfill for 'disposal' or 'energy recovery' – used as a proxy for estimating recycling because of incomplete reporting of recycling by some states

State	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NSW		39%		41%	36%	36%			38%	36%	38%	39%
SA		25%		22%	20%	17%			20%	17%	17%	16%
Victoria		59%		56%	51%	53%			50%	51%	44%	47%
ACT		30%		28%	26%	28%			26%	31%	32%	50%
WA[1]		68%		68%	69%	60%			48%	54%	48%	40%
Queensland[2]		53%		55%	56%	50%			54%	53%	53%	53%
Tasmania[3]		59%		56%	51%	53%			50%	51%	44%	47%
NT		94%		87%	87%	87%			88%	80%	86%	37%
Notes: 1.												

Source: NZIER

Table 32 Total waste – 'metropolitan solid waste', 'commercial and industrial' and 'construction and demolition'

Tonnes per capita based on state population

State	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NSW		2.35		2.66	2.46	2.44			2.41	2.35	2.35	2.35
SA		2.00		2.09	2.06	2.35			2.33	2.26	2.39	2.48
Victoria		2.38		2.18	2.39	2.41			2.15	2.22	2.21	2.22
ACT		2.10		2.05	2.00	2.46			2.19	1.82	2.20	2.33
WA		2.83		2.75	3.29	2.78			2.37	2.66	2.23	2.31
Queensland		2.38		2.31	2.12	2.07			2.20	2.24	2.16	2.36
Tasmania		1.70		1.58	1.67	1.82			1.76	1.81	2.07	1.86
NT		2.52		1.70	1.67	1.61			2.35	1.95	2.00	3.35

Source: NZIER

Table 33 Total organic waste – 'metropolitan solid waste', 'commercial and industrial' and 'construction and demolition'

Tonnes per capita based on state population

State	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NSW		0.60		0.68	0.63	0.65			0.72	0.70	0.61	0.61
SA		0.68		0.62	0.67	0.79			0.89	0.82	0.93	0.92
Victoria		0.62		0.58	0.60	0.61			0.52	0.55	0.46	0.46
ACT		0.96		0.82	0.75	1.05			1.00	0.83	0.87	0.96
WA		0.79		0.80	0.95	0.77			0.57	0.56	0.59	0.55
Queensland		0.81		0.76	0.68	0.69			0.63	0.64	0.61	0.58
Tasmania		0.56		0.46	0.48	0.52			0.48	0.51	0.48	0.56
NT		0.83		0.55	0.57	0.53			0.78	0.73	0.51	0.48

Source: NZIER