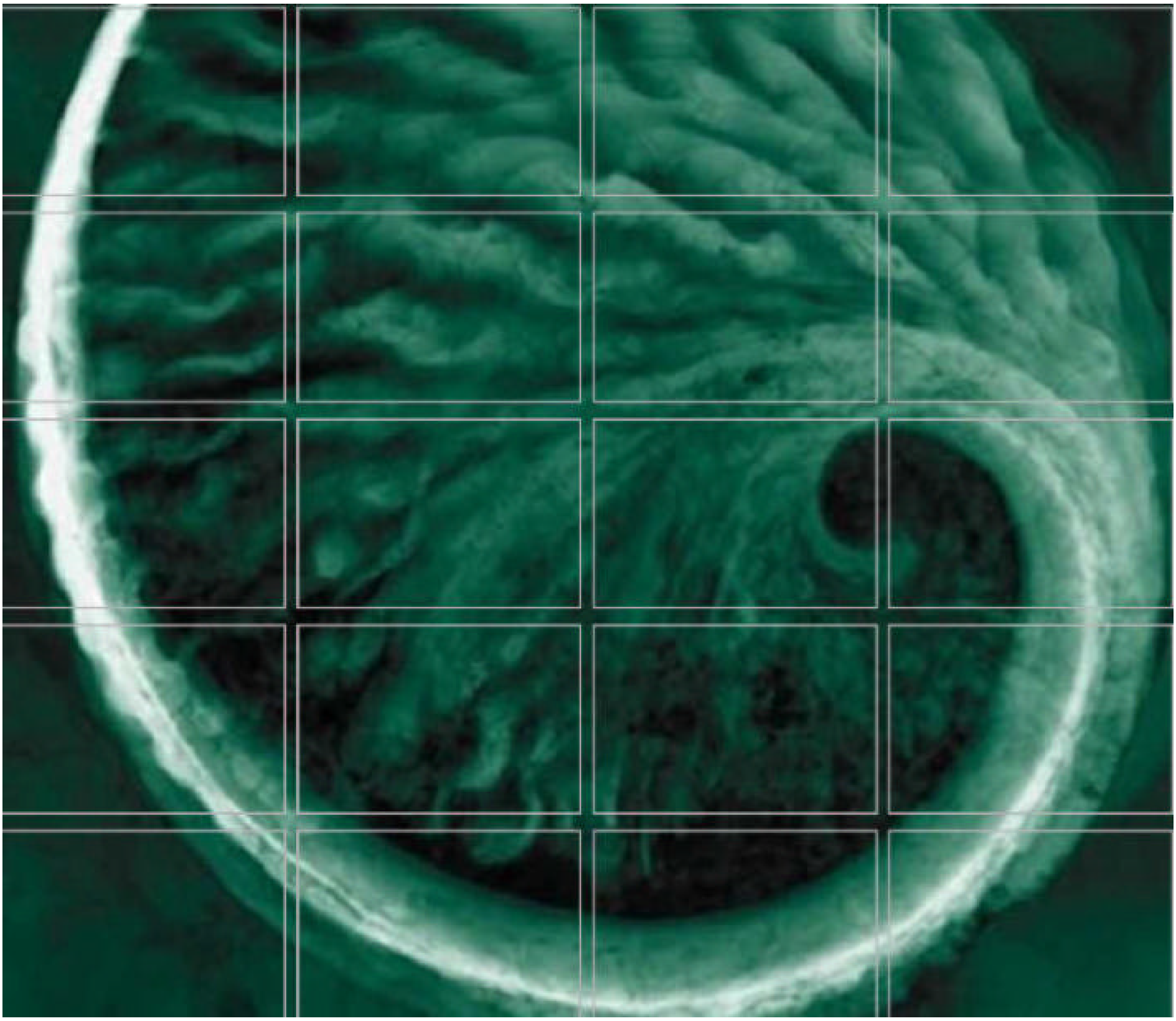


Brent Ealing Harrow

Hillingdon Hounslow Richmond

West London Waste Authority

DRAFT JOINT MUNICIPAL WASTE MANAGEMENT STRATEGY
September 2005

Volume 2: Technical Reports

ERM

FINAL REPORT

West London Waste Authorities and
Constituent Boroughs

Municipal Waste Management Strategy

Volume 2: Technical Reports

September 2005

Reference 0024509

Prepared by: Sarah Sanders Hewett, Natalie Riches,
Karen Fisher and Claire Stevens

For and on behalf of
Environmental Resources Management

Approved by: Simon Aumônier

Signed:

Position: Partner

Date: 16th September 2005

CONTENTS

Technical Report 1

Assessment of Options for Waste Reduction and Reuse

CONTENTS

1 ASSESSMENT OF OPTIONS FOR WASTE REDUCTION AND REUSE

1.1 INTRODUCTION

It is important to take the waste hierarchy into account whilst developing and evaluating options for WLWA's Joint Municipal Waste Management Strategy (JMWMS) and so three levels of options were set out accordingly:

- options for waste reduction and reuse;
- options for recycling and composting; and
- options for residual waste management.

This report describes the waste reduction and reuse options that have been assessed.

Waste minimisation is an integral part of WLWA's Strategy for municipal solid waste (MSW) management. Constituent Boroughs have individually stipulated a number of initiatives as part of their waste minimisation strategies. In particular, the promotion of home composting has been widely undertaken as a means of reducing household waste generation. This baseline level of waste minimisation currently occurring across the Authority has been taken into account in the forecasting of waste growth, as detailed in *Technical Report 1* (1).

The Strategy development process has built on this by investigating further options for waste reduction and re-use. There are a number of actions that can be taken to reduce or reuse household waste, such as the promotion of waste aware shopping, the mailing preference scheme, local waste exchanges, etc. Those that are considered to be the most promising of these, in terms of potential for minimising waste arisings have been assessed. These are:

- home composting;
- trade waste diversion;
- promotion of reusable nappies; and
- general reuse.

There is a lack of evidence-based data available to assess these options quantitatively. Initiatives have therefore been appraised qualitatively, focusing on opportunities, risks and ballpark costs. Their potential effect on waste arisings and composition has been modelled and will be taken into account during the assessment of options for recycling and composting and for residual waste management.

(1) A year-on-year growth rate of 0.8% has been assumed. This is significantly below the 2% that is commonly cited for MSW growth.

2 HOME COMPOSTING

Home composting prevents garden and vegetable waste from entering the waste stream. Hence it is an important contributor to the diversion of biodegradable municipal waste (BMW) for Local Authorities to meet their Landfill Allowance Trading Scheme (LATS) targets.

The WLWA's constituent Boroughs have, in particular, adopted the promotion of home composting initiatives as a means of reducing household waste generation. Across the WLWA to date, more than 60 000 home composters have been distributed to residents at a subsidised price. More than 11 000 tonnes of waste are estimated to have been diverted from the household waste stream as a result (approximately 1.6% of current household waste arisings equating to approximately 180kg per household).

Whilst these schemes are active across the WLWA, there is an opportunity to achieve higher levels of home composting through adopting best practice.

Table 2.1 Home Composting

Criterion	
Opportunities/ Benefits	• Reduced volumes of BMW to be sent to landfill and hence reduced collection and landfill/treatment costs • Contribution towards diversion of BMW to meet LATS targets • Reduced pollution by avoiding transporting waste to CA sites and composting facilities • Reduced pollution by avoiding home bonfires • Reduced use of peat-based composts • Cost saving for both Authority (reduced collection and disposal costs) and residents (reduced need to buy fertilisers, etc) • Public engagement/awareness raising – with knock-on benefits in relation to other aspects of waste prevention/recycling • Social inclusion – community composting projects can provide a focus for community development • Potential for WRAP support - WRAP works with partners to promote the sale of subsidised bins in their area and increase awareness of what can be composted. Dedicated helpline and advisors • Other support available - the Community Composting Network currently has over 200 member projects across the UK
Risks	Low demand due to lack of community support would impact on the quantity of waste generated. This could occur through: • Poor image – some groups (eg young urban dwellers) do not perceive it to be relevant, or attractive(1) • Incomplete understanding of what can be composted, or how compost can be used • Householders having insufficient space for bins, or use for compost product • Householders being put off by composter cost – at £30 for a standard 300-litre bin they are not affordable to those on a low income and not attractive to those with only a marginal interest in home composting(1)

(1) Prescient Ltd (2000), NWAI, *Rethink Rubbish - Towards a New Campaign*; MORI (2002) Strategy Unit Report

Criterion	
Approximate Costs	Little outlay, typical costs include: • Promotion and administration costs – these could be in the region of £20-30 000, but could get support from WRAP • Cost of bin subsidy – implementation is likely to require the provision of new home composter bins, this will result in additional costs if subsidised bins are provided • Cost of scheme support operations – coordination, transport, monitoring, overheads, etc; these could be in the region of £30 000 - 40 000/year • Also note that avoided collection and disposal costs have been variously reported to be in the region of £60-80/tonne(2). There is potential for a net financial benefit, for example, if even an additional 1000 tonnes are diverted the avoided costs will outweigh the scheme promotional and operational costs
Amount of Minimisation Potentially Achievable	• Over 60% of household waste (by weight) can in theory be composted(3). In practice, over 30% of household waste can be composted easily at home, or in the community – equating to approximately 360kg per household(4). Data from individual authorities suggests that home composting quantities typically range from 100-200kg(5). The Government wants to get at least 50% of households home composting in the near future(6). WLWA has over 500 000 households. If 50% of these composted 150kg/year this would equate to a total of 37 500 tonnes of waste • During modelling it was assumed that the total diversion of 37 500 tonnes could be realised by 2020, with a linear increase in diversion from 2006/07 to this maximum

(1) National Resource and Waste Forum (2004) *Household Waste prevention Toolkit. Part B: Specific Waste Prevention Activities.*
(2) National Resource and Waste Forum (2004) *Household Waste prevention Toolkit. Part B: Specific Waste Prevention Activities.*
(3) Strategy Unit Report - *Waste not Want not*
(4) National Resource and Waste Forum (2004) *Household Waste prevention Toolkit. Part B: Specific Waste Prevention Activities.*
(5) National Resource and Waste Forum (2004) *Household Waste prevention Toolkit. Part B: Specific Waste Prevention Activities.*
(6) National Resource and Waste Forum (2004) *Household Waste prevention Toolkit. Part B: Specific Waste Prevention Activities.*

3 TRADE WASTE DIVERSION

The diversion of trade waste from civic amenity (CA) sites is crucial in preventing trade abuse. These facilities are primarily for householders, so businesses should not be able to take advantage of this free service.

Approximately 54 000 tonnes of trade waste were weighed at CA sites across the WLWA in 2003/04. The London Borough of Brent does not accept trade wastes at CA sites, but trade waste is accepted at all of WLWA's other constituent Borough-operated CA sites. A number of measures to restrict trade wastes at CA sites within these Boroughs are in place. These include:

- height barriers;
- site entrance security checks; and
- charges for trade on site (£60/tonne; discounted to £50/tonne for recyclable waste).

There are limitations associated with each of these and so a number of other measures to reduce trade waste arisings and prevent cross-bordering of household waste could be taken. Commercial vehicle bans, together with either resident or exemption permitting, have been shown in a recent Network Recycling study to be the most effective method of trade waste control(1).

The use of best practice in the general provision and management of CA sites should also be regarded as a distinct method of deterring unwanted trade waste.

Table 3.1 ***Trade Waste Diversion***

Criterion	
Opportunities/ Benefits	• A number of case studies have shown van and trailer bans in conjunction with permit schemes to be a reliable method of trade waste control – eg Shropshire, Dudley, North Lincolnshire(2) • Each of the case study areas experienced significant reductions in CA trade waste tonnage throughput in the first year following implementation (Shropshire – 21.8%, Dudley – 13.4%, N Lincs – 15.7%), with slight increases in subsequent years(1) • Each of the case study areas realised significant cost savings following the implementation of restrictions - Dudley £94 000, N Lincs £350 000 and Shropshire £300 000 savings in the first year of operation • Trade abuse at CA sites is thought to have a negative impact on recycling rates (although this has not been proven statistically)(2) • Potentially positive impact on staff morale if measures are effective(3) • A commercial vehicle ban introduced without a permit system is likely to result in a significant number of complaints, however the introduction of a combined permit system allows WDAs to provide access to legitimate site users(4)

(1) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites*. Network Recycling, WPSD. Chapter 4
(2) Network Recycling - *Influential factors affecting diversion rates at CA sites* – chapter 3.10

Criterion	
Risks	• Potential for confusion - North Lincolnshire had to spend a significant amount of time dealing with enquiries for the first few months of their scheme[5] • Permit systems are not without their opponents – Norfolk's permit system, introduced in 2001, lasted for only three months and it was used as an issue in a successful political campaign[6] • Open to abuse - traders may still be able to park up outside and carry their waste onsite (although none of the TWICAS case studies reported this as a problem) • Potential to encourage fly-tipping. Dudley and North Lincolnshire both noticed a slight increase in fly-tipping following the implementation of schemes, but in neither case could this be linked directly to the scheme itself[7]
Approximate Costs	Depending on the extent of the scheme, specific costs can include[8]: • promotional leaflets (eg min. £480 for 3000 leaflets) • banners (eg min. £180 per 2m-banner) • staff costs for administering scheme • incentives (although these are linked to the savings that can be made through uptake of the scheme and avoided disposal) • Case studies show set-up and operating costs of a combined commercial vehicle ban and permit system to be low. North Lincolnshire's set-up costs were approximately £5000 and ongoing costs are negligible. Dudley's costs were in the form of some minimal administration and home visits, estimated at approximately £1000[9] • The ongoing cost of managing the permit system is in both schemes is small, and restricted predominantly to administrative support[10] • Shropshire has invested more heavily in publicity, to ensure the smooth running of the system following its implementation[11]. Data on the cost of this are unavailable, however These costs should be balanced against the potential cost savings as a result of reduced input tonnages. Using a nominal figure of £29/tonne for residual waste disposal[12] a 15% decrease in tonnage would relate to a saving of £235 000. This will be ultimately less than the revenue gained from the current charge of £60/tonne for trade waste, however.

(1) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(2) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.10
(3) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.10
(4) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.10
(5) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(6) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(7) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(8) personal communication, Choose2Reuse
(9) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(10) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4
(11) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.10
(12) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4

Criterion	
Amount of Minimisation Potentially Achievable	• On the basis of the reductions experienced by Network Recycling case study areas, (Shropshire – 21.8%, Dudley – 13.4%, N Lincs – 15.7%[1]) it would seem reasonable to project 15% as a high but potentially achievable diversion of trade waste from CA sites. This equates to a total of 8100 tonnes of trade waste reductions across WLWA in the year of implementation (proposed 2006/07) • The Network Recycling case studies each reported tonnage reductions in the year after implementation, but no further reductions (many reported slight increases from this point). Thus during modelling it was assumed that the initial reduction of 8100 tonnes would be realised in 2006/07 and this diversion remains the same in subsequent years

(1) Cameron-Beaumont & Bridgewater (2002). *Trade waste input to CA sites.* Network Recycling, WPSD. Chapter 4

4 REUSABLE NAPPIES

Using reusable nappies instead of disposable ones greatly reduces the number of soiled nappies from entering the waste stream. Hence, reusable nappies contribute to the diversion of biodegradable municipal waste (BMW) for authorities to meet their LATS targets.

An Analysis of National Household Waste Composition estimated nappies to comprise approximately 2% of the household waste stream, equating to almost 14 000 tonnes across WLWA(1).

A number of constituent Boroughs (eg Hounslow) are already active in the promotion of reusable nappies.

Table 4.1 Reusable Nappies

Criterion	
Opportunities/ Benefits	• Reduced volumes of BMW to be sent to landfill and hence reduced collection and landfill/treatment costs • Contribution towards diversion of BMW to meet LATS targets • There is an opportunity to reduce costs and minimise environmental impact if more parents can be encouraged to switch to home or service laundered reusable cloth nappies(2) • As well as reducing waste, use of laundries also has the benefit of encouraging more local economic activity(3) • Parents can save over £500 on the cost of keeping a baby in nappies by washing them at home(4) • Prices, for all the nappies and waterproof covers required for the whole of a baby's nappy wearing life, start at around £60. The same amount of money will only buy the first 10-12 weeks for disposable nappies. This saving takes into account the total cost of laundering nappies at home, which is about £50 a year, the savings are still considerable(5) • Potential for WRAP support – the WRAP programme includes efforts to make information available to parents when they are choosing which nappies to use; make information available for dissemination by healthcare professionals, nurseries, toddler groups and other points of contact for parents; work with high street retailers to improve the retail visibility of real nappies; raising the profile of existing real nappy businesses and schemes and supporting the development of others

(1) J Parfitt – National Waste Composition Study for *Waste not Want not.*
(2) *Rethinking Rubbish in London* The Mayor's Municipal Waste Management Strategy Mayor of London
(3) *Rethinking Rubbish in London* The Mayor's Municipal Waste Management Strategy Mayor of London
(4) *Rethinking Rubbish in London* The Mayor's Municipal Waste Management Strategy Mayor of London
(5) *Rethinking Rubbish in London* The Mayor's Municipal Waste Management Strategy Mayor of London

Criterion	
Risks	• The backing of key organisations and individuals (eg midwives, support organisations, hospitals), coupled with good promotion of the scheme is required to enable real nappy schemes to be successful. Non-performance will mean that anticipated levels of waste reduction will not be realised • An initial investment in the nappies is required, which can be an economic barrier to some. An incentive scheme has already been initiated by West Sussex County Council, which offers residents up to £30 cashback for using real nappies – this can outweigh the risk of the economic barrier(1)
Approximate Costs	Depending on the extent of the scheme, specific costs can include(2): • promotional leaflets (eg approx £60 for 500 leaflets) • display boards (eg approx £135 for single-sided board) • health professional packs (eg approx £27.5 per pack) • staff costs for administering scheme • incentives (although these are linked to the savings that can be made through uptake of the scheme and avoided disposal)
Amount of Minimisation Potentially Achievable	• Based on the West Sussex initiative(3) (estimated 47 million nappies enter the waste stream per year and the nappy scheme diverts around 3.6 million nappies) and the fact that approximately 14 000 tonnes of WLWA's household waste comprises disposable nappies, waste minimisation benefits are assumed to be in the region of 1100 tonnes/year • During modelling it was assumed that the total diversion of 1100 tonnes/year would be realised by 2020, with a linear increase in diversion from 2006/07 to this maximum

(1)*Rethinking Rubbish in London* The Mayor's Municipal Waste Management Strategy Mayor of London
(2) 2004 figures (personal communication, WEN)
(3) West Sussex County Council, Tel: 01234 777100

5 RE-USE

In principle, re-use involves taking used goods and passing them on (with or without sorting/refurbishment) to those who can make further use of them. Re-use is very important as it is high up the waste hierarchy, after waste prevention/minimisation and before recycling.

The WLWA's constituent Boroughs can influence the quantity of goods that are re-used in two main ways:

- Local Authorities can help to set-up, support and/or promote a number of activities in their area, such as the Furniture Re-use Network, computer re-use, donation campaigns, charity shops, local waste exchanges, etc.

- The establishment of re-use systems at CA sites presents a low cost opportunity to increase tonnages diverted from the waste stream, in line with the waste hierarchy. This does occur at sites across the WLWA, for example Brent has established a container at one CA site for the collection of furniture for re-use in partnership with a charitable organisation. However, this does not appear to be common practice across constituent Boroughs.

Table 5.1 Re-use

Criterion	
Opportunities/ Benefits	• Removal of a bulky waste stream that is difficult to separate from the household waste stream • One study found that 77% of upholstered furniture and 60% of domestic appliances disposed at CA sites could theoretically be refurbished and reused(1) • Associated potential to reduce disposal costs • A wide range of items can potentially be re-used • Creation of jobs and training opportunities • Provision of low-cost goods for low-income families, schools and charities • Help to meet requirements of the WEEE Directive through diversion of WEEE • The presence of re-use systems on a CA site provides a highly visible example to the public, which may have a positive effect by increasing public awareness • CA sites with re-use systems were found to have a positive impact on staff motivation(2) • CA sites with a re-use system have been found to generally have higher recycling rates (as a result of increased public awareness and staff motivation)(3)

(1) Anderson (1999) *Recycle, reuse, burn or bury?*

(2) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.3

(3) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.3

Criterion	
Risks	• The backing of key organisations and individuals, coupled with good promotion of the scheme is required to enable re-use networks and campaigns to be successful. Non-performance will mean that anticipated levels of waste reduction will not be realised • Poor public image/pre-conceived negative images can become a barrier to establishing a successful scheme at CA sites (in the minds of some people, re-use areas will forever be associated with piles of bric-a-brac and staff making an underhand buck)[(1)] • Common concerns regarding re-use schemes at CA sites include security, trading standards, concerns regarding selling and keeping money on-site and perceptions regarding staff distraction. Each of these are easily remedied, however[(2)] • Goods donated to charitable organisations may potentially not be re-used and end up back at CA sites. If this occurs it may be necessary to supply the organisation in question with subsidy to dispose these goods at CA sites
Approximate Costs	Minimal promotional material and administration costs
Amount of Minimisation Potentially Achievable	• A Network Recycling study of nine CA sites with re-use systems in place found that 0.5–2% of CA throughput was collected for re-use[(3)] This is thought to be achievable in the WLWA's CA sites • If this level of re-use can be achieved at CA sites, it is considered that it would be also achievable from the remainder of household waste, through the continued promotion and support of re-use networks and other schemes • During modelling it was assumed that a diversion of 1.25% of household (and trade CA) waste (average 0.5-2%) would be achieved by 2020, with a linear increase in diversion from 2006/07 to this maximum diversion of 11 469 tonnes/year.

(1) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.3

(2) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.3

(3) Cameron-Beaumont, Bridgewater & Seabrook (2004). *National Assessment of Civic Amenity Sites: maximising recycling rates at civic amenity sites.* Future West, Network Recycling. Chapter 3.3

Technical Report 2

Assessment of Options for Recycling and Composting

Assessment of Options for Recycling & Composting, 2005 - 2020

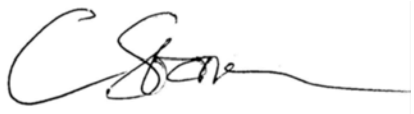
Produced for ERM

Date June 2005

Report for:

ERM

Prepared by:



Claire Stonier

Project Manager

Approved by

Joe Papineschi

Project Director

Contact Details

Eunomia Research & Consulting Ltd
120 Cotham Brow
Cotham
Bristol
BS6 6AR
United Kingdom

Tel: +44 (0)117 9426678
Fax: +44 (0)117 9426679

Web: www.eunomia.co.uk

Contents

1 Introduction

The achievement of statutory recycling and composting targets and Landfill Directive targets (through the LATS) for the Boroughs within the West London Waste Authority (WLWA) will require the development and establishment of new initiatives and changes to the operation of the existing waste and recycling collection services over the coming years. Furthermore, it will be important for the WLWA to anticipate the quantity and composition of the residual waste it will have to deal during and after the implementation of these collection system changes. The biggest changes will concern the largest sub-streams of municipal waste – household collected waste and civic amenity waste. However, in the long term, if local and national aspirations for recycling and composting are to be achieved, it will be necessary to consider the 'minor' sub-streams (e.g. street sweepings, commercial municipal waste etc.) as well. This report describes the work undertaken in evaluating options for change in the waste collection system in West London and aims to establish the extent to which recycling and composting will be likely to contribute towards the aspiration of LATS self-sufficiency.

1.1 Household Collected Waste

In order to ascertain the probable nature and scope of the changes that will be required, and the resulting recycling and residual waste compositions, a range of options were developed and subjected to a detailed modelling exercise. The scenario development and modelling exercise sought to identify feasible options for kerbside waste collection systems within each borough in order to provide an optimal service in terms of both recycling captures and cost. A favoured long term (2020) option was identified for each Borough's kerbside collection system. In order to reach this long term option, a second medium term option was then modelled to show how a gradual change in service level could be achieved and what results could be attained. The models estimate both performance in terms of % of material recycled and composted, and the costs of the system (total cost and cost per household). The outcome of the modelling represents what Eunomia Research and Consulting considers to be ambitious but realistically achievable levels of performance for each Borough from each system.

The modelling exercise also provided an estimate of the composition of residual waste resulting from the scenarios, which can be used to highlight areas where further improvements may be made in recycling and composting, and also presents valuable information that can feed into the decision making process for residual waste treatment and disposal options.

1.2 Civic Amenity Waste

Best practice in civic amenity site management systems and performance is well understood and is, for obvious reasons, much less complex than systems for collecting waste from individual households. A simple analysis was undertaken in order to quantify the tonnage and composition of recycled, composted and residual waste for civic amenity waste for each year of the strategy, building fairly rapidly towards best current practice levels of performance for urban CA sites (on the assumption that a business case would exist to do this in advance of, for example, collecting some additional materials at the kerbside). Cost has not been included in the analysis for the same reason – we believe that the business case is there for early action to achieve best practice and also consider that what constitutes best practice is quite well understood. In other words, the appraisal of options as such is unnecessary, although further work on detail would be advisable prior to implementation of any major changes in CA site management systems.

1.3 Other MSW Waste Streams

As discussed above, in the long term it will be necessary for the West London authorities to target the 'minor' waste streams for recycling, composting and other recovery if overall performance is not to become excessively 'diluted'. Whilst it has not been possible within the scope of this project to examine different options for the recovery of waste from the minor streams, we have made assumptions as to the extent of recycling and composting of different materials from commercial collected waste (CA commercial was considered in the overall analysis of CA waste), fly tip removals, municipal buildings waste, street sweepings and litter, special (bulky) collections, clinical waste collections and other municipal waste. The assumptions used, whilst somewhat crude, have at least allowed us to develop an overall picture of the quantity and composition of all municipal waste for each year of the strategy and to illustrate the extent of activity that will be required to deliver against the aspirations of the authorities and their citizens for recycling and composting.

2 Household Collected Waste

2.1 Introduction

Modelling has revealed the amount of household waste that can realistically be recycled from the household collected stream, by material, for each year of the strategy period. From this the composition of the residual waste can then be determined.

As household collected waste accounts for the majority of each borough's municipal waste, the bulk of the detailed modelling work was focused on these waste streams, and this work is the subject of the bulk of this report. A range of options were selected for modelling based on possible evolutionary pathways from current systems. The procedure that was followed is outlined below.

2.1.1 Aims of modelling

The two key aims of the modelling exercise were:

- To provide realistic projections of what recycling and composting captures could be achieved between 2005 and 2020 in the WLWA Boroughs. The projections would provide estimates of both capture rates and system costs.
- To identify the composition of residual waste for the options modelled, from which the WLWA can identify feasible treatment and disposal options.

2.1.2 Appropriateness to the Boroughs within the WLWA

The scenarios modelled were selected to give a range of options that were considered to be feasible for implementation in the context of each borough. In determining potential options it was decided that the scenarios modelled should build on existing systems as much as possible, as there would be significant implementation costs and difficulties associated with a complete change of system. However, it was also recognised that by 2020, significant changes to the current system would be necessary and so a range of different scenarios were modelled. The principal variations considered in the modelling focused on the addition of materials to the dry recyclables collections, methods for collection of organic wastes, changes to recycling and residual receptacle capacity and the effects of altering collection frequency. A number of options that were modelled were chosen specifically to demonstrate the impact of these variables.

2.2 Options Modelled

For each borough, the current collection system was modelled to obtain a baseline reference, to ensure the model was correctly calibrated, and to provide confidence that the model accounts for the key variables and produces meaningful results. Initial internal discussions, followed by consultation with officers if the six boroughs highlighted 12 potential scenarios that could be modelled across the boroughs; six of these were discounted following high-level analysis that revealed that they were either too similar to other scenarios that were likely to perform better or were simply likely to be unable to compete in terms of cost or performance, thereby rendering it not worthwhile subjecting them to full analysis.

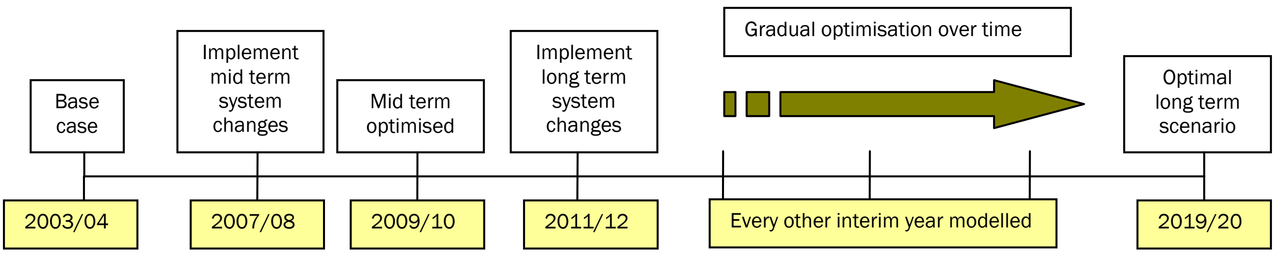
Of the 6 scenarios that remained, 5 were modelled for each borough for 2020. It was assumed that at 2020, the options would be 'fully optimised', having had several years for households (and contractors) to adapt to and engage with the change. The implementation date for the service changes entailed by the long term scenarios was initially assumed to be 2011/12, being between the first and second Landfill Directive targets (in 2010 and 2013). However, as will be discussed below, we also examined the option of bringing the 'long term' service changes forward to before the 2010 Landfill Directive targets, in order to maximise the contribution of borough based recycling and composting to the diversion of biodegradable municipal waste (BMW) in the early years of the Landfill Allowance Trading Scheme, where it seemed most difficult to imaging the West London area sustaining self-sufficiency in Landfill Allowances given the obvious challenges inherent in developing adequate treatment capacity for residual waste prior to 2010.

From the modelling undertaken for 2020, the optimal scenario was identified using an options criteria analysis (see section 2.4. below). The chosen scenario was then used to identify and model a number of intermediate options at 2010. In other words, it was assumed that the boroughs took two 'steps' to reach their long term collection systems, as opposed to one 'jump' – and that those steps occurred either side of the 2010 Landfill Directive target. However, as discussed above and below, we subsequently considered the affect of bringing forward the optimal long term scenario to pre-2010, thereby providing a one jump scenario as a comparator. A further options criteria analysis was performed to select the optimal intermediate or 'mid term' scenario.

For the years in between 2003/4 and 2019/20, the options chosen (either base case, mid term or long term options) were modelled every other year to show a progression in recycling rate and cost, based on population projections, changes in waste arisings and capture rates and changes to the landfill tax and gate fees.

This therefore presents an evolutionary approach towards the optimal solution i.e. making a progressive change to the system to reflect potential funding or political reality and minimise impact on householders (see Figure 1).

Figure 1: Modelling of scenarios



2.2.1 Selection of Options

Initial discussions, which included consultation with the relevant authorities revealed 12 potential long term options. However, 6 of these were eventually discounted, considered as being impractical or unlikely to yield good results. Of the 6 options that remained (scenarios 1, 2, 4, 6, 10 and 11) 5 scenarios were modelled for each Borough for 2020, with those chosen for modelling being selected on the basis of quality of 'fit' with current collection systems and infrastructure. From this modelling, the optimal scenario in terms of performance against the evaluation criteria was able to be selected. Using the optimal scenario as the standard to aim for, between 3 and 5 mid term scenarios were chosen and modelled for 2010. The overall aim being to design a system aimed at maximising the source separation of material for recycling and composting to a degree which goes far beyond that envisaged in the short term. The scenarios modelled were intended to be indicative of the types of system which *might* be introduced, rather than prescribing a single preferred system.

The scenarios for each authority are described in tables 2 - 7 below.

Table 1: Waste Collection Scenarios for Brent

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables	Box	Fortnightly
		Garden	240 litre wheeled bin	Fortnightly
		Residual	240 litre wheeled bin	Weekly
A	2010	Dry recyclables (paper, text, glass, cans)	Box	Weekly
		Garden	240 litre wheeled bin	Fortnightly, seasonal
		Kitchen	35 litre bucket & 10 litre kitchen caddy & bags	Weekly
		Residual	240 litre wheeled bin	Weekly
B	2010	Dry Recyclables (textiles, glass, cans)	Box	Fortnightly
		Paper	120 litre wheeled bin	Monthly
		Garden	Pre pay, reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Weekly
C	2010	Dry recyclables (paper, glass, textiles, cans)	Box	Fortnightly
		Garden	240 litre wheeled bin	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Weekly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
1	2020	Dry recyclables	140 litre wheeled bin	Fortnightly
		Kitchen	35 litre bucket & caddy & bags	Weekly
		Garden, user pays	Re-useable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen & garden	120 litre wheeled bin & kitchen caddy & bags	Weekly
		Residual	240 litre wheeled bin	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
4	2020	Dry recyclables	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden, user pays	Reusable sack	Fortnightly, seasonal
		Residuals	Sack	Fortnightly
10	2020	Dry recyclables	Box & reusable 35 litre sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

Table 2: Waste Collection Scenarios for Ealing

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables	Box	Weekly
		Garden	Sacks, user pays	Fortnightly; but by appointment in winter
		Residual	Sacks	Weekly
A	2010	Dry recyclables (paper, textiles, glass, cans)	Box	Weekly
		Garden & Card	120 litre Eco Sack	Fortnightly for 6 months
		Kitchen	35 litre bucket with 10 litre kitchen caddy and bags	Weekly
		Residual	240 litre wheeled bin	Weekly
B	2010	Dry recyclables (textiles, glass cans)	Box	Weekly
		Garden	120 litre Mater-Bi sack, user pays	Fortnightly for 9 months
		Paper	120 litre wheeled bin	Monthly
		Residual	Sack	Weekly
C	2010	Dry recyclables (paper, textiles, glass, cans)	44 litre box	Weekly
		Garden	240 litre wheeled bin	Fortnightly for 9 months
		Residual	Sack	Weekly
4	2020	Dry recyclables (including plastic)	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket, with kitchen caddy & bags	Weekly
		Garden, user pays	Re-usable sack	Fortnightly (seasonal only)
		Residual	Sack	Fortnightly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen, garden & card	120 litre wheeled bin	Weekly
		Residual	240 litre wheeled bin	Fortnightly
6	2020	Dry Recyclables	Sacks	Weekly
		Kitchen	Bucket and caddy & bags	Weekly
		Garden	Re-useable garden sacks	Weekly, seasonal
		Residual	Sack	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
10	2020	Dry recyclables	Box & reusable 35 litre sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

Table 3: Waste Collection Scenarios for Harrow

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables (including textiles)	Box	Fortnightly
		Garden, kitchen & card	240 litre wheeled bin (20% coverage)	Fortnightly
		Residual	240 litre wheeled bin	Weekly
A	2010	Dry Recyclables (paper, textiles, glass, cans)	44 litre box	Weekly
		Garden & card	240 litre wheeled bin	Fortnightly for 6 months
		Kitchen	35 litre bucket with kitchen caddy and bags	Weekly
		Residual	240 litre wheeled bin	Weekly
A1	2010	Dry recyclables (paper, textiles, glass, cans)	44 litre box	Weekly
		Kitchen, garden and card	240 litre wheeled bin	Fortnightly
		Residual	240 litre wheeled bin	Weekly
A2	2010	Dry recyclables (paper, textiles, glass, cans)	44 litre box	Weekly
		Garden & card	240 litre wheeled bin	Fortnightly for 6 months
		Residual	240 litre wheeled bin	Weekly
B	2010	Dry recyclables (textiles, glass, cans)	44 litre box	Fortnightly
		Garden	User pays, sack	Fortnightly for 9 months
		Paper	120 litre wheeled bin	Monthly
		Residual	240 litre wheeled bin	Weekly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
C	2010	Dry recyclables (paper, textiles, glass, cans)	44 litre box	Fortnightly
		Garden	240 litre wheeled bin	
		Residual	240 litre wheeled bin	Weekly
1	2020	Dry recyclables	140 litre wheeled bin	Fortnightly
		Kitchen	35 litre box & caddy & bags	Weekly
		Garden, user pays	Re-useable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen & garden & card	120 litre wheeled bin & kitchen caddy & bags	Weekly
		Residual	240 litre wheeled bin	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
4	2020	Dry recyclables	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden, user pays	Reusable sack	Fortnightly, seasonal
		Residuals	Sack	Fortnightly
10	2020	Dry recyclables	Box & reusable 35 litre sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

Table 4: Waste Collection Scenarios for Hillingdon

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables (no glass) including plastic	Sack	Fortnightly
		Garden	Reusable sack	Fortnightly
		Residual	Sack	Weekly
A	2010	Dry Recyclables (paper, card, textiles, glass, cans)	44 litre box	Weekly
		Garden	Reusable sack	Fortnightly (not December)
		Kitchen	35 litre bucket with kitchen caddy and bags	Weekly
		Residual	Sack	Weekly
B	2010	Dry recyclables (plastic, glass, cans).	Sack	Fortnightly
		Garden, user pays	Mater-Bi sack	Fortnightly for 9 months
		Paper & card	120 litre wheeled bin	Monthly
		Residual	Sack	Weekly
C	2010	Dry recyclables (paper, card, plastic, glass, cans)	Sack	Fortnightly
		Garden	240 wheeled bin	Fortnightly for 9 months
		Residual	Sack	Weekly
6	2020	Dry recyclables	Sack	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden	Reusable sack	Weekly, seasonal
		Residual	Sack	Fortnightly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen, garden & card	120 litre wheeled bin & kitchen caddy & bags	Weekly
		Residual	240 litre wheeled bin	Fortnightly
4	2020	Dry recyclables	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden, user pays	Reusable sack	Fortnightly
		Residual	Sack	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
10	2020	Dry Recyclables	Box & 35 litre reusable sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy and bag	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

Table 5: Waste Collection Scenarios for Hounslow

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables	Box	Weekly
		Garden, user pays	Sack	Weekly
		Residual	Sack	Weekly
A	2010	Dry recyclables (paper, card, textiles, glass, cans)	Box	Weekly
		Garden, user pays	Mater-Bi sack	Fortnightly
		Kitchen	35 litre bucket with kitchen caddy & bags	Weekly
		Residual	Sack	Weekly
B	2010	Dry recyclables (textiles, glass, cans)	Box	Weekly
		Garden, user pays	Mater-Bi sack	Fortnightly for 9 months
		Paper & card	120 litre wheeled bin	Monthly
		Residual	Sack	Weekly
C	2010	Dry recyclables (paper, card, textiles, glass, cans)	Box	Weekly
		Garden	240 wheeled bin	Fortnightly for 9 months
		Residual	Sack	Weekly
4	2020	Dry recyclables	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket, with kitchen caddy & bags	Weekly
		Garden, user pays (seasonal)	Re-usable sack	Fortnightly
		Residual	Sack	Fortnightly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen, garden & card	120 litre wheeled bin	Weekly
		Residual	240 litre wheeled bin	Fortnightly
6	2020	Dry Recyclables	Sacks	Weekly
		Kitchen	Bucket and caddy & bags	Weekly
		Garden	Re-useable garden sacks	Weekly
		Residual	Sack	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
10	2020	Dry recyclables	Box & reusable 35 litre sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

Table 6: Waste Collection Scenarios for Richmond

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
Baseline	2005	Dry recyclables	Box	Fortnightly
		Garden, user pay	Bin or sack	Fortnightly
		Residual	Sack	Weekly
A	2010	Dry recyclables (paper, glass, textiles, cans)	Box	Weekly
		Garden, user pay	Sack	Fortnightly for 6 months
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Residual	Sack	Weekly
B	2010	Dry recy'bles (tex, glass, cans)	Box	Fortnightly
		Garden, user pay	Sack	Fortnightly for 6 months
		Paper	120 litre wheeled bin	Monthly
		Residual	Sack	Weekly
C	2010	Dry recyclables (paper, textiles, glass, cans)	Box	Fortnightly
		Garden	240 litre wheeled bin	Fortnightly for 9 months
		Residual	Sack	Weekly
4	2020	Dry recyclables	Box	Weekly
		Paper	240 litre wheeled bin	Monthly
		Kitchen	35 litre bucket, with kitchen caddy & bags	Weekly
		Garden, user pays (seasonal)	Re-usable sack	Fortnightly
		Residual	Sack	Fortnightly
2	2020	Dry recyclables	240 litre wheeled bin	Fortnightly
		Kitchen, garden & card	120 litre wheeled bin	Weekly
		Residual	240 litre wheeled bin	Fortnightly

Scenario	Year	Wastes Collected	Receptacle	Collection Frequency
6	2020	Dry Recyclables	Sacks	Weekly
		Kitchen	Bucket and caddy & bags	Weekly
		Garden	Re-useable garden sacks	Weekly
		Residual	Sack	Fortnightly
11	2020	Dry recyclables	Sack	Weekly
		Kitchen & garden & card	180 litre wheeled bio-bin	Fortnightly
		Residual	180 litre wheeled bin	Fortnightly
10	2020	Dry recyclables	Box & reusable 35 litre sack for paper	Weekly
		Kitchen	35 litre bucket & kitchen caddy & bags	Weekly
		Garden & card, user pays	Reusable sack	Fortnightly, seasonal
		Residual	240 litre wheeled bin	Fortnightly

For the baseline scenarios the collection of dry recyclables assumes the collection of glass bottles, cans and paper, unless otherwise stated. Following detailed discussions, six long term options were used, spread across the boroughs. Each long term option assumes a fortnightly residual collection, which high-level analysis prior to full modelling revealed as being a pre-requisite to high performance at optimal cost and should be realistic in the longer term given the diversion of other wastes for recycling. The rationale for each of the long term scenarios chosen is discussed below:

- Each borough has an '**all wheeled bin**' scenario (scenario 2). The 120 litre garden and kitchen waste bin is designed to restrict garden waste arisings, while allowing capacity for all kitchen waste arisings, encouraged by the weekly frequency. The larger residual bin would also provide capacity to allow for fortnightly residual collection, even for most families. Having 3 bins is easy for residents to adapt to and understand and generally delivers good rates of capture, although it should be recognised that some properties may have issues with the space required for bin storage[1]. Changes in health and safety

[1] Kerbside collection has been modelled for all dwelling in each borough considered to be accessible to this type of service provision; in other words, modern high-rise and low-rise housing is assumed to be covered by high-density bring site provision, although accurate data for low-rise was incomplete.

regulation may eventually result in the use of sacks being phased out, due to the risk of injury e.g. needle puncture injuries and lifting of excessive weights. This option takes this possibility into consideration.

- Each borough has a **'5 waste stream, monthly paper collection'** scenario (scenario 4), with all paper grades (including card) being collected monthly and other dry recyclables collected weekly in a box. Separating out the paper provides capacity within the dry recyclables box, thus allowing for the addition of plastic and textiles. Kitchen and garden wastes are collected separately with weekly kitchen collection to avoid odour and vermin problems and garden on a user pays basis to minimise the increased waste arisings that is generally seen when local authority garden waste collections are free and utilise a bin. The sack based residual collection provides unlimited residual waste collection each fortnight.
- Each borough has a second **'5 waste stream - weekly dry recycling, separate kitchen/garden collection'** option (scenario 10). This option is designed to test the impact on captures and costs of collecting paper at the same time as the other dry recyclables. However, to allow sufficient capacity in the dry recyclables box for plastic and textiles, the paper is collected in a separate sack, set out with the box. This option is also designed to test the impact on performance of restricting fortnightly residual collection to a 240 litre bin.
- Each borough has a **'bio-bin organic collection'** system for card, kitchen and garden waste, which is collected free of charge (scenario 11). This option tests the cost and performance level with the use of bio-bins against the use of separate bins, caddys and bags for kitchen waste. The bio-bin is a realistic alternative to the bin, caddy and bag option, limiting odour problems and allowing kitchen waste to be collected on a fortnightly basis.
- For Ealing, Richmond upon Thames, Hounslow and Hillingdon, a primarily **'sack based system'** has been modelled (scenario 6). This builds upon their existing sack based services, and will limit potential opposition to scheme changes and should reduce costs. However, the use of sacks for the collection of kitchen waste is impractical, given the potential for vermin and odour problems, and so the option used for these boroughs is a 35 litre bin with a separate kitchen caddy with bags.
- Harrow and Brent currently have a non-sack based residual refuse collection system and so the all sack based option was not considered appropriate for these authorities. Instead, a **'140 litre dry recycling, with pre-pay garden sack'** system has been modelled (scenario 1). The pre-pay garden waste collection system is collected in re-usable bags. This option is designed to build on the existing infrastructure. Allowing for user pays garden waste will limit garden arisings and provide some revenue for the Councils.

For the medium term scenarios, 3 general approaches 'A', 'B' and 'C' were modelled. The rationale for these is as follows:

- Option A **'weekly dry recycling and kitchen organics collection'** introduces a weekly dry recycling collection, where there wasn't one before or the existing service was fortnightly, and introduces an additional kitchen waste collection service. It is generally recognised that kitchen waste collections will be required in order to maximise the collection of biodegradable material and thereby maximise contribution to LATS targets for the waste disposal authority prior to residual waste treatment capacity coming online and in order to demonstrate consistency with the waste management hierarchy. This model introduces such a collection and increases the frequency of dry recycling collection, in order to improve capture rates.

- Option B **'monthly paper collection'** provides extra capacity for the collection of dry recyclables by providing a wheeled bin for newspapers, magazines and junk mail. In order to minimise collection costs, the paper is collected monthly. This option seeks to maximise the capture of the most valuable biodegradable material in the domestic waste stream and also recognises that the box-based kerbside collection systems offered to most householders in West London can constrain performance by not allowing adequate capacity (i.e. box volume) for all of the materials that some users will want to set out.
- Option C tests the impact of providing '**free garden waste collection**', upon composting performance, waste generation and collection costs. It aims to examine the extent to which this approach, used very successfully by many of the 'high recycling rate' authorities in the shire counties, would deliver recycling performance in West London. However, it also seeks to examine the potential downside that has been experienced in many of these shires districts relating to the apparent increase in generation of garden waste and impact on overall waste arisings.

In addition to these, following consultation with each authority, and upon request, 2 additional options were modelled for Harrow only. This also serves as a comparison between the more minor incremental changes in service provision over the near term; the resultant observed effects (assuming the service change is applicable) can be assumed to be similar for the other districts:

- Option A1 provides for the collection of kitchen and garden wastes together.
- Option A2 does not provide for the collection of kitchen waste.

2.3 Modelling of Scenarios

2.3.1 Description of Model

Eunomia Research and Consulting's proprietary waste collection cost model was used to evaluate the selected scenarios. The model is a sophisticated spreadsheet based tool that allows a wide range of variables to be accounted for, and which enables the optimisation of scenarios to accurately reflect local circumstances. Changes over time for a waste collection system are accounted for by producing a new iteration of each scenario for each key year.

The recycling performance of each collection system scenario is built up by specifying a range of performance parameters for each component of the system. Performance parameters include weight and volume of material collected by current systems, residual composition, the materials targeted by each collection service, the number of households of each type (e.g. detached, semi-detached, terrace etc) that the service is available to, the participation rate of those households and the recognition rate achieved from participating households for the materials targeted.

Costs are accumulated by the model from cost data extracted from a database within the model. The model calculates the numbers of vehicles, containers, and crew required and multiplies these by their unit costs. Disposal costs and net cost/income from material sales are also calculated and included in the costings. Finally the model adds overheads for management and administration, depot costs, and insurances and financing. Although capital requirements are shown in the model, annual costs are based on the amortised cost of capital using depreciation periods and interest rates entered by the user.

2.3.2 Detailed Modelling

The following procedure was used to model the scenarios outlined above:

1. *Inputting of baseline data. The following data was obtained and inputted into the model:*

    - **Population.** Population data was based on 2003 population estimates supplied by ERM.
    - **Household numbers.** Household data was based on 2003 household estimates supplied by ERM.
    - **Numbers of houses by type of housing stock.** Numbers of houses by housing stock were based on information supplied by ERM.
    - **Residual tonnage data.** This was based on the latest available data for each borough. Residual tonnage data used in the model included material collected as part of the household waste collection. It did not include CA site waste, trade waste, street sweepings or special or clinical waste collections.
    - **Recycling tonnage data.** This was based on projections from the latest available data for each borough. It did not include CA site recyclables and composting or materials collected from bring sites.
    - **Composition data.** For Brent, Ealing, Harrow and Richmond, this was based on data specific to that Council. For Hillingdon, a UK wide data set was used[2]; and for Hounslow the composition was taken as the average of 4 of the other Boroughs within the WLWA (Richmond, Brent, Ealing and Harrow). The composition data can have a significant effect on the overall performance of all the recycling systems modelled, as the composition of the 'current residual' effectively represents what is still available to capture.

---

[2] *Analysis of household waste composition and factors driving waste increases*, Dr Julian Parfitt, WRAP, December 2002

- **Travel time by housing type.** Travel speeds between houses were estimated based on known collection times and environmental factors. The average speed with which collection vehicles are able to travel between houses is primarily a function of the housing density and traffic and road conditions. Although these are subject to large variations over time it was considered that they are broadly correlated to housing type: Where housing is denser it will take less time to get to each house but average speed will be lower due to the higher level of starting and stopping. Similarly housing density is generally correlated with more narrow streets, more difficult access due to cars parked next to the kerbside and higher levels of traffic congestion particularly at peak times.

The above data was based on current data and then extrapolated to provide data for calculating the 2010 and 2020 scenarios.

2. *Collation and inputting of background data relevant to the selected systems:*

   - **Vehicle specifications and performance data.** Actual cost and performance data for a range of vehicle types that are either currently being used in the collection systems, or that are deemed probable options for future collection systems were obtained and inputted into the model. Performance parameters included working payloads by weight and volume, required or average crew sizes, fuel efficiency, capital cost, and type and number of materials able to be separately collected.

   - **Container specifications and costs.** Actual cost and performance data for a range of container types that are either currently being used in the collection systems or that are deemed probable options for future collection systems were obtained and inputted into the model. Performance parameters included container volume, life expectancy, and unit cost.

   - **Personnel costs.** Personnel costs were based on known industry costs used in collection contracts adjusted to reflect West London labour market conditions. Costs for a range of positions were obtained and inputted into the model including management, supervisors, administrative support, HGV drivers, Non-HGV drivers, collection crew and yard crew.

   - **Depot and overhead costs.** Overhead costs including insurance, performance bonds, administrative support, rent, legal and accounting costs were estimated and inputted into the model. Depot costs were calculated based on estimated rental/lease costs, building maintenance, site works, machinery operation and site personnel costs. Costs for these elements were considered to be shared across the collection systems in the integrated contract and were apportioned relative to the tonnages handled by each system.

- **Profit margin.** A profit margin of 10% of operating expenses was allowed for and apportioned relative to the gross cost of each system based on an integrated contract (i.e. recycling and refuse collection) assumption.

- **Commodity and disposal prices.** Prices for collected commodities and disposal charges were entered into the system based on conservative current market prices and local gate fees as appropriate. The commodity prices used in the modelling are included in Annex 4. Where kitchen and garden waste were modelled as being collected together, the higher kitchen waste gate fee was applied to all the collected organic material. Costs associated with the landfill tax escalator were included in each progressive year modelled.

3. *Selection of specifications for each scenario*

- **Materials to be collected by each system.** Up to four integrated collection systems are able to be modelled together. Up to 3 collection systems for recyclable or compostable material can be modelled plus one system for collection of residual material. Materials specified as being collected by one of the recycling or composting collections are subtracted from the residual component based on their specified capture rate.

- **Capture rates.** Capture rates for each material and housing type were specified by estimating the coverage of each system and nominating a participation rate for each system and a recognition rate for each material type in each system. In the baseline scenario this was calculated so as to be equal to reported historic tonnages collected for the relevant materials. In the 2010 & 2020 scenarios these known rates were adjusted to account for system design factors that would improve the participation or recognition rates. Factors such as increasing the frequency of a collection or container size will, for example, were assumed to yield an increase in capture rate.

- **Rejection rates.** Rejection rates for materials collected from kerbside and processed through a Materials Recovery Facility were estimated based on reported current rejection rates. As it was assumed reject material would not be collected in kerbside sort systems, no rejection rate factor was applied to dry recyclables collected in this way.

- **Frequency of collection.** The frequency for each collection system was specified by the number of collections that would be performed each year. This was either weekly, fortnightly, monthly or seasonal.

- **Container type and size.** The type of container to be used for each system was selected from the model's database. The model calculates the available volume of material per household each collection day to allow optimisation of container volumes.

- **Vehicle type and number.** The type and number of vehicles to be used for each collection system was selected from the model's database. As a default, the model automatically calculates the optimum number of vehicles required based on the time available, the number of households to be collected from, and the quantity of material to be collected. This number can be adjusted manually to allow for other factors such as down-time and redundancy.

4. *Calculation and adjustments*
   As the data was inputted into the model, the potential performance of each system was calculated and a range of output data generated, which were used to evaluate each scenario. Following initial input of the above data the models were subjected to an extensive audit and review to ensure all specifications had been correctly entered and that they were an accurate reflection of what could be expected in terms of the performance of each system. Minor adjustments to performance parameters were made to the scenarios before the final results were produced. The adjustments included minor alterations to capture rates for certain materials from each system, adjustments to the amount of additional material generated by wheeled bin systems collecting green waste, adjustments to expected disposal and commodity prices, and amendments to the number of trucks used for certain systems.

2.3.3 Performance Assumption Guidelines

The assumptions used to calculate the performance of each scenario are critical to determining the outcomes, particularly when it comes to estimating future capture rates of materials targeted for recycling and composting. There is a high level of potential for bias towards favoured systems even with the best of intentions on the part of the modellers. In order to minimise the risks of bias the following guidelines were established regarding the assumptions used.

- All 2010 system performance data was based where possible on actual system performance from systems currently operating in the WLWA boroughs or elsewhere in the UK.

- All 2020 system performance data was based on known actual system performance currently achieved by similar and well operated systems in Europe.

- Convenience to the householder is a key factor affecting capture rates. Wheeled bins were considered the most convenient receptacle, followed by sacks and then kerbside boxes. For the purposes of this exercise a differential of approximately 10% was assumed in the relative performance of the wheeled bin compared to the sack and the sack compared to the box. All other factors being equal therefore a wheeled bin was assumed to yield the highest capture rates for whatever material it was used for. Where a wheeled bin was specified for residual it was assumed that this would negatively impact the recycling rate for other elements of the system. However, kerbside box based systems benefited from a zero rejection rate of collected material.

- It was assumed that weekly collections were the most convenient to the householder and that all other factors being equal a weekly collection would yield a higher total quantity of material than a fortnightly or monthly collection.

- When adding additional materials to an existing kerbside recycling collection, checks were conducted to gauge the available space in the recycling container. Spare capacity was considered both for the average recycling household and also higher recycling households as described by a normal distribution curve of recycling performance per individual household. Where there was a shortage of space, containerisation was optimised by providing either a larger, additional or alternate container. This technique was also applied to residual collections. Also, restricting or making residual disposal less convenient was assumed to increase diversion through the other collection systems.

- It was assumed that all performance characteristics of vehicles and containers including operating costs, interest rates on capital etc, are as for current systems. Although it is likely that the performance of equipment and systems will improve by 2020 this is not accounted within the modelling.

- An amortisation period of 10 years was assumed for all wheeled bins and recycling boxes with a 5% per annum replacement rate for loss and breakage. A 5% cost of capital was used for all systems.

- All costs are expressed in 2003/4 pounds sterling and no allowance is made for inflation. Similarly it is assumed that all commodity prices remain essentially unchanged, although assumptions applied were generally on the conservative side.

- The 2010 & 2020 scenarios assume that sufficient processing technology infrastructure has become available to enable the processing of co-mingled recyclables and in-vessel composting of kitchen waste. The performance characteristics of these recovery facilities are assumed to be similar to the best performing existing facilities.

Note on system costs

System costs as presented for household collected waste include the estimated costs of collection *and disposal via landfill* for household waste and recycling collection services. Special, clinical, and commercial collection services are not included in the modelling data, nor are any of the street cleansing, bring site and CA site operations included. The costs represented by the modelled data will therefore not be equivalent to either the likely contract costs or the total cost of waste service provision. The projected cost data presented here should therefore be used for indicative comparison purposes only. The cost of disposal has been included because it is important to consider *cost avoided* as well as cost incurred and income generated.

2.3.4 Summary of Performance Assumptions by Scenario

The tables in Annex A detail the assumptions used to calculate each scenario for each Borough, based on the process described above.

2.4 Option Evaluation

From the models developed, it was important to objectively evaluate each one and come up with a preferred approach for both the mid and long term scenarios. In order to avoid individual bias on the part of the modellers, criteria were selected against which each option was evaluated. Each criterion was then weighted according to importance. The criteria chosen together with their weighting score is shown in Table 7 below:

Table 7: Evaluation Criteria & Weighting

Criteria	Scenarios Applied To	Weighting
Recycling & Composting rate	All	3
Cost per Household	All	2
Arisings Growth	All	1
Biowaste diversion	All	2
Fit with long term	Mid term only	2

The 'fit with the long term' criterion was subdivided into 3 categories: materials targeted, container type and the potential for confusion in changing from the mid term to long term scenarios. For the evaluation of the long term scenarios, the 'fit with longer term' criterion was omitted and not replaced, for obvious reasons.

All criteria were measured out of 1 (with one being the best outcome) and then multiplied by the weighting. The weighted figures were then summed to give an overall score, meaning that the higher the score the better the approach.

2.5 Household Collected Waste Results

2.5.1 Summarised results of the initial modelling exercise

The summarised results of the initial modelling exercise for each borough are displayed in the tables and charts below. For each Borough the recycling rate & biowaste diversion rate given is adjusted for any increase in arising resulting from system effects such as where free collections of green waste are assumed, which are assumed to lead to more waste being collected overall. The revenue column is the revenue gained from the sale of the recyclables collected. In some cases, this is a negative value, since it accounts for the negative commodity value (or cost) associated with the recovery of kitchen and garden waste (and card where kitchen, garden and card are collected together).

As a reminder, the scenarios are as follows:

- Scenario A = Mid term, weekly dry recyclables & kitchen organics collection
- Scenario B = Mid term, monthly paper collection
- Scenario C = Mid term, free garden waste collection
- Scenario 1 = 2020, 140 litre dry recycling with prepay garden sacks
- Scenario 2 = 2020, All wheeled bin option
- Scenario 4 = 2020, 5 waste stream with monthly paper collection
- Scenario 6 = 2020, Sack based system
- Scenario 10 = 2020, 5 waste stream, weekly dry recycling with separate kitchen and garden collections
- Scenario 11 = 2020, Bio-bin organic collection

Table 8: Brent

	Baseline	A	B	C	1	2	4	10	11
Total System Cost (£,000)	**10,710**	**13,854**	**12,814**	**12,415**	**11,719**	**12,542**	**12,732**	**13,224**	**12,786**
Total Cost Minus Disposal (£,000)	**5,648**	**7,575**	**6,267**	**6,023**	**6,135**	**7,256**	**7,640**	**7,057**	**7,322**
Total Revenue (£,000)	**137**	**212**	**414**	**125**	**- 2,124**	**- 2,851**	**- 498**	**- 96**	**- 2,781**
Net Total Cost (£,000)	**10,572**	**13,642**	**12,399**	**12,540**	**13,844**	**15,393**	**13,231**	**13,320**	**15,568**
Net Cost/ HH (£)	**103**	**129**	**117**	**123**	**126**	**140**	**120**	**121**	**141**
Net Cost/ Tonne (£)	**106**	**130**	**119**	**118**	**122**	**127**	**117**	**118**	**129**
Recycling rate (%)	**7.6%**	**16.6%**	**13.0%**	**10.8%**	**36.8%**	**40.2%**	**42.4%**	**30.2%**	**38.2%**
Biowaste diversion rate (%)	**8.4%**	**19.2%**	**15.2%**	**13.4%**	**39.1%**	**43.2%**	**48.3%**	**30.9%**	**39.2%**

Table 9: Ealing

	Baseline	A	B	C	2	4	6	10	11
Total System Cost (£,000)	**10,754**	**13,956**	**9,502**	**13,336**	**13,135**	**12,715**	**13,436**	**13,532**	**13,279**
Total Cost Minus Disposal (£,000)	**6,129**	**7,870**	**5,306**	**7,087**	**8,171**	**7,995**	**8,596**	**7,769**	**8,071**
Total Revenue (£,000)	**245**	**87**	**292**	**85**	**-2,544**	**-544**	**-2,440**	**-136**	**-2,421**
Net Total Cost (£,000)	**10,509**	**13,869**	**9,209**	**13,251**	**15,679**	**13,259**	**15,876**	**13,669**	**15,700**
Net Cost/ HH (£)	**87.58**	**111.77**	**114.68**	**106.79**	**121.92**	**103.1**	**123.45**	**106.28**	**122.08**
Net Cost/ Tonne (£)	**111.08**	**138.54**	**136.9**	**127.63**	**139.8**	**123.17**	**141.72**	**126.98**	**139.96**
Recycling rate (%)	**11.10%**	**15.60%**	**13.40%**	**13.30%**	**40.90%**	**43.80%**	**42.40%**	**31.40%**	**38.00%**
Biowaste diversion rate (%)	**11.50%**	**17.40%**	**12.60%**	**14.70%**	**42.80%**	**49.10%**	**43.30%**	**30.90%**	**37.70%**

Table 10: Harrow

	Baseline	A	A1	A2	B	C	1	2	4
Total System Cost (£,000)	**8,521**	**10,544**	**10,371**	**10,428**	**9,923**	**9,328**	**9,121**	**9,587**	**9,746**
Total Cost Minus Disposal (£,000)	**4,835**	**6,092**	**5,888**	**5,654**	**5,201**	**4,796**	**5,181**	**6,272**	**6,273**
Total Revenue (£,000)	**112**	**-190**	**-469**	**38**	**238**	**-334**	**-1,614**	**-2,969**	**-589**
Net Total Cost (£,000)	**8,409**	**10,734**	**10,840**	**10,390**	**9,685**	**9,663**	**10,735**	**12,556**	**10,335**
Net Cost/ HH (£)	**102.56**	**127.17**	**128.42**	**123.09**	**114.74**	**114.47**	**122.17**	**142.89**	**117.61**
Net Cost/ Tonne (£)	**109.83**	**128.08**	**129.34**	**123.98**	**125.68**	**110.19**	**128.51**	**130.1**	**123.72**
Recycling rate (%)	**10.90%**	**19.80%**	**19.20%**	**14.00%**	**14.90%**	**18.30%**	**39.50%**	**49.10%**	**46.70%**
Biowaste diversion rate (%)	**11.50%**	**20.20%**	**20.40%**	**13.50%**	**15.30%**	**21.30%**	**40.00%**	**52.00%**	**49.30%**

Table 11: Hillingdon

	Baseline	A	B	C	2	4	6	10	11
Total System Cost (£,000)	**9,237**	**11,645**	**11,420**	**10,770**	**11,026**	**11,673**	**11,352**	**11,447**	**11,351**
Total Cost Minus Disposal (£,000)	**5,554**	**6,898**	**6,355**	**6,048**	**7,305**	**7,713**	**7,686**	**6,755**	**7,416**
Total Revenue (£,000)	**-624**	**-48**	**-127**	**-963**	**-2,988**	-563	**-2,399**	**-217**	**-2,867**
Net Total Cost (£,000)	**9,861**	**11,692**	**11,547**	**11,733**	**14,014**	12,236	**13,751**	**11,663**	**14,218**
Net Cost/ HH (£)	**98.21**	**113.11**	**111.71**	**113.51**	**130.24**	113.71	**127.79**	**108.39**	**132.13**
Net Cost/ Tonne (£)	**118.77**	**134.77**	**137.11**	**126.78**	**137.82**	136.65	**135.39**	**130.26**	**139.75**
Recycling rate (%)	**15.30%**	**20.10%**	**14.80%**	**20.50%**	**46.60%**	**43.20%**	**47.40%**	**32.80%**	**43.60%**
Biowaste diversion rate (%)	**16.10%**	**23.00%**	**14.90%**	**23.90%**	**52.30%**	**48.70%**	**49.50%**	**33.70%**	**46.90%**

Table 12: Hounslow

	Baseline	A	B	C	2	4	6	10	11
Total System Cost (£,000)	**8,208**	**10,064**	**10,142**	**9,874**	**9,626**	**9,626**	**9,864**	**10,016**	**9,833**
Total Cost Minus Disposal (£,000)	**4,987**	**5,804**	**5,871**	**5,638**	**6,167**	**6,227**	**6,502**	**5,886**	**6,196**
Total Revenue (£,000)	**202**	**55**	**299**	**-21**	**-2,147**	**-472**	**-1,915**	**-178**	**-1,814**
Net Total Cost (£,000)	**8,007**	**10,010**	**9,843**	**9,895**	**11,773**	**10,098**	**11,780**	**10,194**	**11,647**
Net Cost/ HH (£)	**90.65**	**110.08**	**108.25**	**108.82**	**124.37**	**106.67**	**124.44**	**107.69**	**123.04**
Net Cost/ Tonne (£)	**117.01**	**139.37**	**137.06**	**128.71**	**140.09**	**129.7**	**140.42**	**130.93**	**138.55**
Recycling rate (%)	**14.40%**	**17.60%**	**17.40%**	**18.00%**	**43.00%**	**43.90%**	**44.50%**	**31.90%**	**40.00%**
Biowaste diversion rate (%)	**15.10%**	**20.50%**	**18.70%**	**20.60%**	**46.30%**	**49.20%**	**45.90%**	**32.50%**	**41.20%**

Table 13: Richmond

	Baseline	A	B	C	2	4	6	10	11
Total System Cost (£,000)	**6,995**	**9,216**	**8,834**	**8,408**	**8,891**	**8,887**	**9,125**	**9,287**	**9,146**
Total Cost Minus Disposal (£,000)	**3,903**	**5,277**	**4,654**	**4,317**	**5,582**	**5,687**	**5,975**	**5,462**	**5,657**
Total Revenue (£,000)	**195**	**77**	**226**	**42**	**-1,880**	**-575**	**-1,811**	**-296**	**-1,777**
Net Total Cost (£,000)	**6,800**	**9,139**	**8,608**	**8,366**	**10,772**	**9,463**	**10,937**	**9,583**	**10,924**
Net Cost/ HH (£)	**87.17**	**113.81**	**107.2**	**104.19**	**128.86**	**113.2**	**130.83**	**114.64**	**130.68**
Net Cost/ Tonne (£)	**106.09**	**135.86**	**127.97**	**118.6**	**140.04**	**129.76**	**142.34**	**131.42**	**141.97**
Recycling rate (%)	**12.30%**	**18.70%**	**13.70%**	**15.50%**	**41.80%**	**43.70%**	**44.60%**	**32.70%**	**38.70%**
Biowaste diversion rate (%)	**13.30%**	**22.60%**	**14.10%**	**18.30%**	**46.00%**	**51.10%**	**47.50%**	**35.10%**	**40.00%**

These key results are presented graphically in Figure 2 to Figure 7 below:

Figure 2: Brent

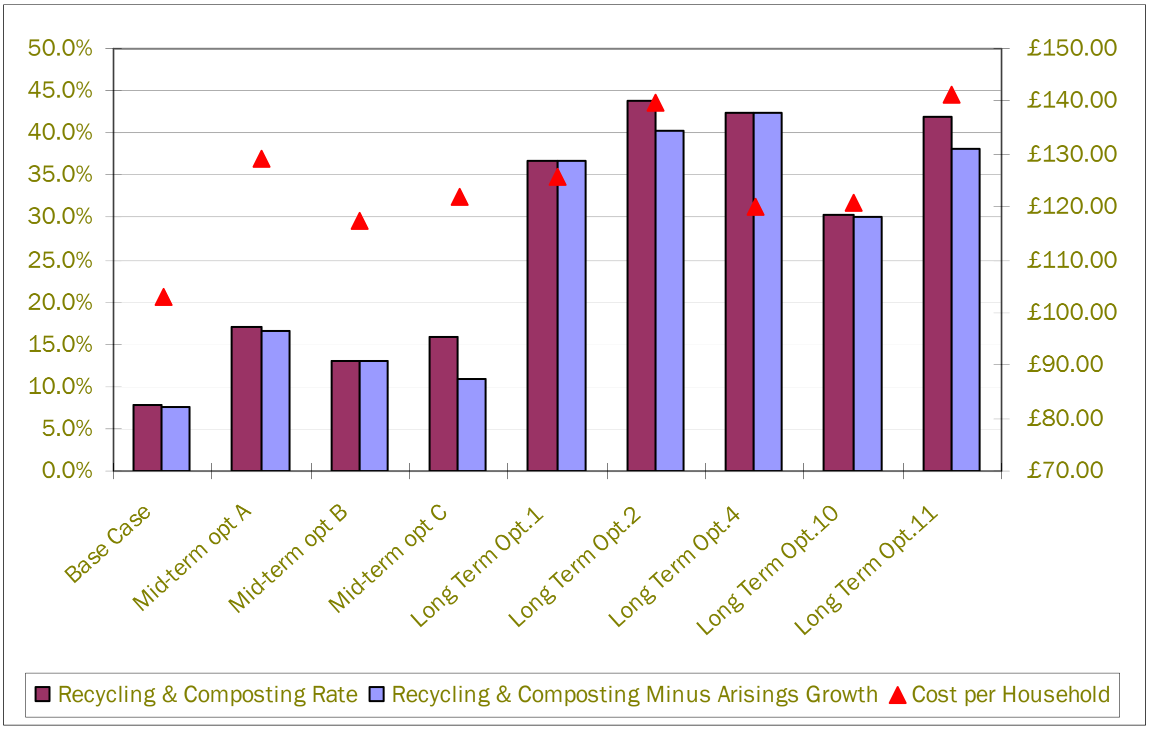


Figure 3: Ealing

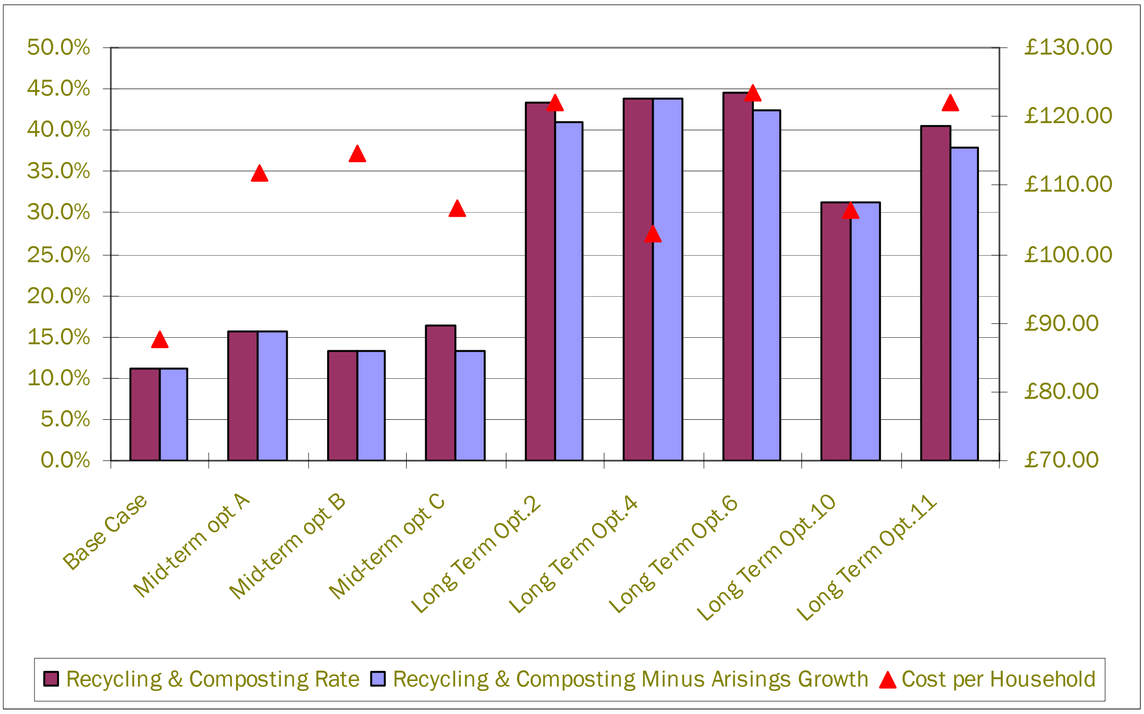


Figure 4: Harrow

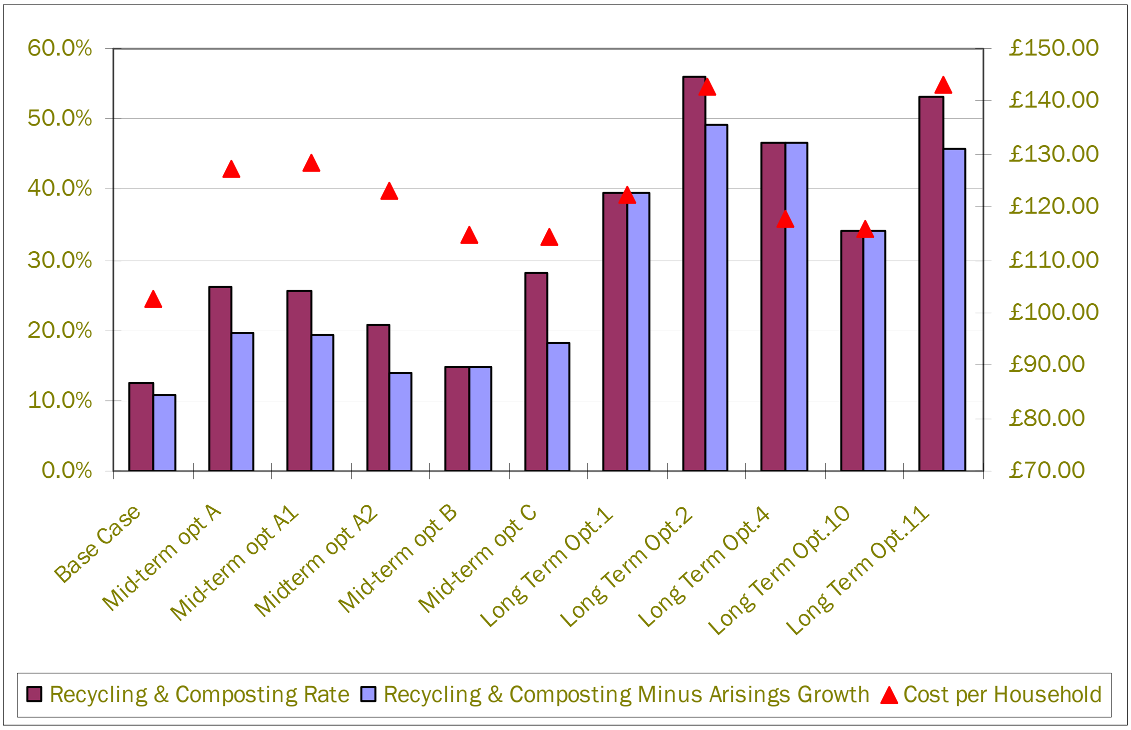


Figure 5: Hillingdon

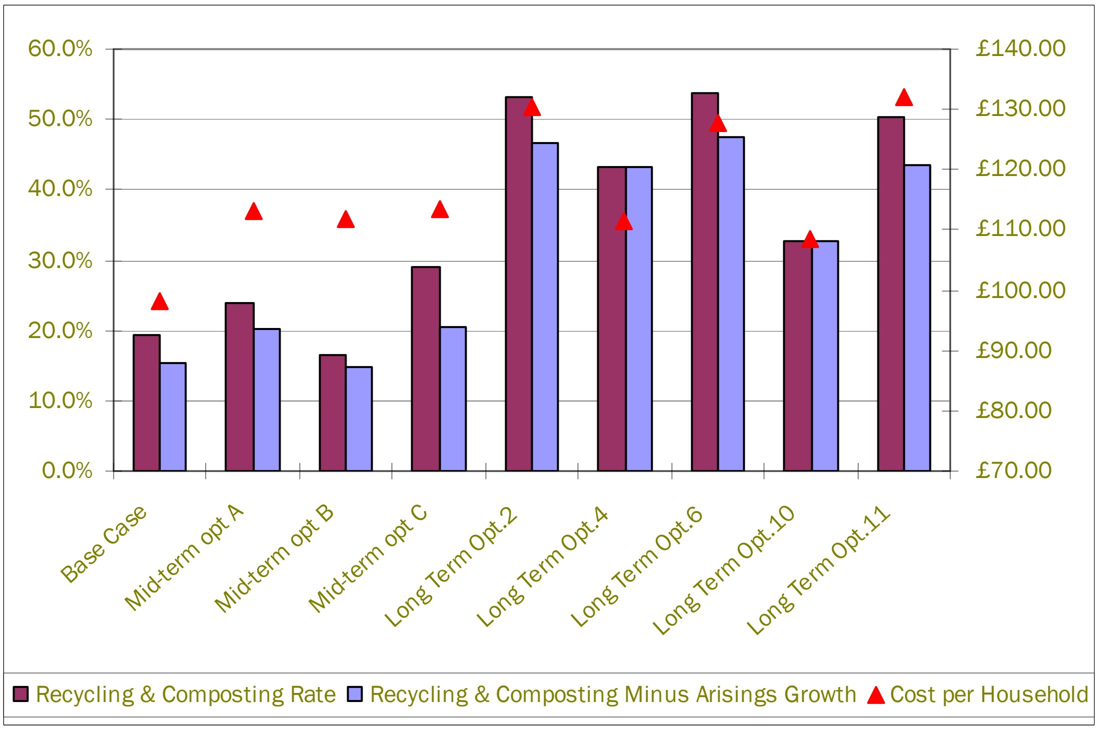
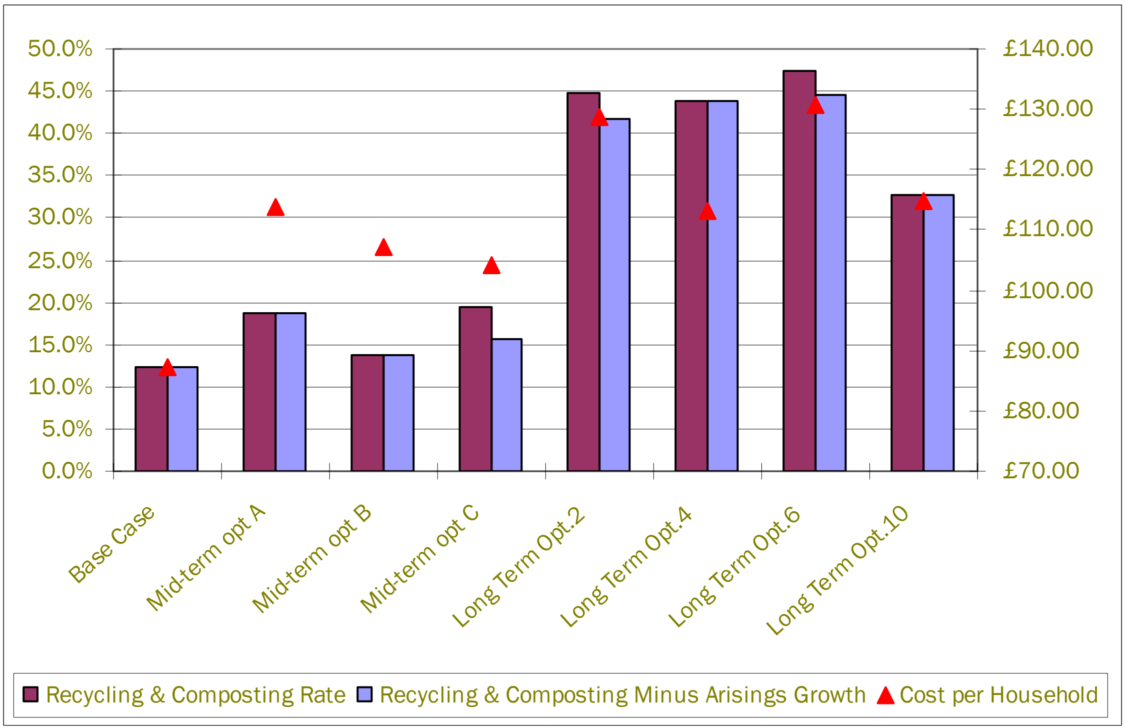


Figure 6: Hounslow

Figure 7: Richmond



2.6 Discussion

The following section aims to bring together some of the key findings of the modelling performed, focussing particularly on issues of cost, recycling performance and timing.

When comparing these collection systems, it is important to look at the processing requirements of the materials collected. Where the dry recyclables are collected in a wheeled bin or sack (e.g. long term options 1, 2, 6 and 11), the collected materials must then be transported to a Materials Recycling Facility (MRF), where they are separated using mechanised and manual sorting techniques before being sent to the appropriate reprocessing facility. Where dry recyclables are deposited in a kerbside box (usually assumed to be of 44 litre capacity), the collection crews are able to separate the materials at the kerbside, before being transported directly to the reprocessing facility (usually via a transfer station for bulking). There are numerous advantages and disadvantages to each option. For example the commingled/MRF options introduce extra costs, although these are offset by speedier and therefore cheaper collections. Co-mingled collection is also assumed to be more convenient for the householder and generally commands a higher capture rate. However, the kerbside sort systems have a lower rejection rate of contrary or contaminated material, since the materials do not get collected together and compacted, resulting in a propensity for them to contaminate one another. Also, with kerbside sort systems any contrary materials set out can be returned to the householder and ultimately collected by the residual waste collection; this potentially improves education and shows an inefficiency of cost which would be incurred through MRF gate fees for the delivered non-recyclables.

The collection of kitchen and garden waste is also important to consider. Under the Animal By-Products Regulations, kitchen waste must be treated in an in-vessel facility, to prevent the spread of disease such as foot and mouth, although garden waste can be composted much more cheaply using open-air techniques. However, where kitchen and garden (and card, as in long term scenario 10) are collected together, all must be treated in-vessel, due to the commingling with kitchen waste. This greatly increases costs of treatment.

Contamination is also an issue where glass is collected with other dry recyclables, especially paper. Such contamination can both reduce the price paid when good market conditions prevail and can reduce demand for the collected paper when the market is poor, risking in the worst case a lack of any available market. Therefore, it is preferable, from a recycling perspective, to collect paper and to a lesser extent card and textiles separately from glass. However, this decision should always be weighed against convenience for householders when set against the other source separation elements of the system, since the more complex a system is for the householder, the lower the participation and material recognition.

As highlighted earlier, experience shows that where garden waste is collected separately and free of charge, particularly in a large container, these arisings increase. Therefore authorities end up collecting waste that would not have been present should the free collection not be available. This leads to higher costs which can be avoided by adopting a user pays collection. User pays systems avoid the arisings increase, yet allows the effective separate collection of garden waste. A number of user pays systems can be adopted including the use of Mater-Bi[3] sacks which are a single use, or a tag system on re-usable garden sacks. The latter option is a lower cost option. The obvious downside of these approaches is that they do not deliver such high absolute recycling rates and whilst the Government continues to use weight based total household waste recycling rate as a key performance indicator the attraction of large volume free garden waste collection systems will remain strong.

2.6.1 Mid Term Scenarios

With the exception of Scenario B in Hillingdon, all mid term options out-performed the base cases in terms of recycling and composting rates.

However, it is clear that significant improvements to the recycling and composting rate are only achieved when the long term scenarios have been implemented. Furthermore, the mid term options are financially very expensive, especially given that in some cases only limited improvements in recycling rate have been achieved. This high cost is due in part to the weekly residual waste collections which have been retained for all of the mid term scenarios.

The weekly refuse collection is expensive in itself, but also limits the captures of recyclables as relatively unlimited and convenient capacity exists in the residual refuse system and residents have a tendency to use it. This limited capture has little impact on collection costs, as the recyclables still have to be collected. This effect is most marked for the collection of kitchen wastes, which for public health and acceptability reasons should be collected weekly. The weekly residual collection is a strong disincentive for the separation of kitchen wastes yet, even with low capture, the kitchen fraction must still be collected weekly.

Given that the mid term scenarios differ depending on the base case systems in place it is difficult to draw out generalised trends. However, with the exception of Brent, scenario B was the poorest performer in terms of recycling and biowaste captured. This can be explained by the lack of kitchen waste collection which, even though residual waste collections remain weekly, represents a significant gap in service given the high proportion of household waste that this makes up (range 21.6% in Brent – 26% in Richmond).

The free garden waste collection in scenario C means that the waste arisings growth is highest for all Boroughs. Scenario C performed better in Hillingdon and Hounslow due to the weekly collection of dry recyclables including card.

Scenario A is one of the higher performers in terms of recycling; however, it is also one of the more expensive systems given the kitchen collection issues discussed above. In addition, for Hillingdon and Harrow scenario A includes free garden waste collection, and so waste arisings increase for these boroughs in scenario A

2.6.2 Long Term Scenarios

It is important to emphasise that the development of these long term options have taken into account that by 2020, the social, political and legislative climate will have

---

[3] Biodegradable sacks made from cornstarch, which are now certified by the Composting Association

evolved. For example, it is likely that forms of direct and/or variable charging for waste collections will be legal and widespread, potentially making the move towards fortnightly residual collection a more politically attractive option, and acting to encourage further residual waste diversion. The models have taken into account these 'cultural' changes in a general way through the application of, by today's standards, high capture rates, and so do not necessarily represent what could be achieved should the preferred scenario be implemented tomorrow. However, while being aspirational, the scenarios and their results are considered achievable in the longer term.

All the long term options assume a fortnightly residual waste collection. One area of concern highlighted with this relates to nappies, and the accumulation of soiled nappies over a two week period, which could produce issues of capacity in the residual waste stream. The Environment Agency have provided advice stating that soiled nappies are not defined as clinical waste, and therefore should a council wish, they could be collected separately without any special requirements. The separate collection of nappies, or the provision of additional residual waste capacity for families with young children has not been modelled for any scenario.

2.6.2.1 Scenario 1 - 140 litre dry recycling with prepay garden sacks

Option 1 was modelled in Brent and Harrow only. Overall, it appears to have been an average performer, being neither best nor worst on cost, recycling rate or biowaste diversion. However, the recycling rate achieved was one of the lowest for the boroughs. This is largely due to the residual waste being collected in a 240 litre wheeled bin which provides a large volume, and in turn acts as a disincentive to separate recyclable materials.

Given that there was no free garden waste collection, there was no increase in waste arisings, and associated costs.

2.6.2.2 Scenario 2 – All wheeled bin

The all wheeled bin option is one of the most convenient for householders to use, and it will generally be expected to do well in terms of recycling rate. This has shown through in the results of the modelling performed.

Due to the free garden waste collection it performs generally well on biowaste diversion, being the best option in this respect for Harrow and Hillingdon. It also performs well on the recycling rate (always achieving above 40%), and provides the best recycling rate for Harrow. This good result for Harrow is because the Council has a very high garden and kitchen waste proportion within its waste composition (17.6% and 24.4% respectively). Therefore, offering free collections of both of these will naturally lead to relatively higher recycling rates.

Despite this good general performance on recycling rate and biowaste diversion, the option is one of the most expensive, this being due to the collection of garden and kitchen waste together, requiring the in-vessel treatment of the large volumes of garden waste collected. It also performs poorly on waste arisings, acting to increase the amount of waste the authorities must collect – due to the free garden collection facility.

2.6.2.3 Scenario 4 - 5 waste stream with monthly paper collection

Despite being relatively complex, scenario 4 is the best system all round for Brent and Ealing. It is also the best performer in respect of cost and biowaste diversion for Hounslow and Richmond, and is the best option for all boroughs on waste arisings growth (joint with scenarios 1 and 10). Furthermore, it is not the worst performing scenario for any Borough, against any criterion.

This good performance is due to the comprehensive nature of collection, which is balanced with collection frequency and pay per use garden collection to provide a high performing scenario. The separate collection of paper in a large container and on a monthly basis limits cost of collection and provides sufficient capacity for collection of a high volume/ density material, which in turn provides sufficient capacity for the collection of other dry recyclables in the kerbside box. The kerbside sort means that the materials are not sent to a MRF and so a commodity price is obtained rather than a sorting fee paid.

The pay per use garden collection restricts increases in waste arisings while at the same time allows for composting of the garden material that is captured. Using a sack for residual waste generally reduces the amount of waste collected when compared to a bin based system, and also allows for cheaper and quicker collection.

This option assumes the development of a mechanical sorting facility for sorting the wide range of paper grades collected in the wheeled bin. This type of technology is considered viable for West London due to the availability of a very large quantity of appropriate material. However, it is probably the case that three or more boroughs would have to commit their material to make such a development viable.

An obvious issue with scenario 4 is the use of a sack for fortnightly collection of refuse. This approach contributes towards the general cost-effectiveness of scenario 4 and has been successfully used by other English authorities, but may be considered unacceptable in West London, particularly by boroughs already using wheeled bins for refuse collection. For this reason, scenario 4 has also been modelled with a wheeled bin for residual refuse, an approach that is discussed further below.

2.6.2.4 Scenario 6 – Sack based system

Option 6 was modelled for 4 of the Boroughs. In all 4 it came out as the most expensive option. This is primarily due to the commingled dry recyclables collection which commands a lower commodity price and higher fees, and also because of the free garden waste collection, which increases waste arisings meaning higher costs of collection and treatment. The free collection of garden waste means that more vehicles are required for collection, which adds further costs – for example scenario 6 requires 4 trucks for garden collection, compared to 2 in scenario 4 which has a user pays garden collection.

Leaving cost aside, scenario 6 performed well on the recycling rates achieved, being the best option in 3 Boroughs and came a close second in Ealing. This is due in part to the comprehensive and simple nature of the collection facilities available. The second place achieved in Ealing could be due to the fact that garden waste is a fairly low proportion of the total waste (4.8%) and is therefore less affected by the free garden waste collection. This is probably due to the lower proportion of detached houses within Ealing when compared to Boroughs like Richmond, indicating fewer properties with large gardens.

2.6.2.5 Scenario 10 - 5 stream, weekly recycling, separate kitchen/garden collection

Scenario 10 was the worst performer across all of the boroughs in terms of the recycling rate achieved and on biowaste diversion rates. This poor performance is shown particularly in the poor capture of kitchen waste and card. The capture of card is very low because it is collected as part of the user pays garden sack, so there is very little incentive not to place it in the residual bin. Kitchen separation is low because of the large residual capacity, which in most circumstances would be sufficient to capture most kitchen waste.

Despite this, the user pays garden collection minimises waste arisings growth and so is a good performer in this respect. It is also one of the cheaper options, being cheapest in Harrow and Hillingdon. This is because the containers are reusable (except the kitchen bags) and the garden collection is user pays, so generates some revenue. The dry recyclables are collected at the same time and the commodity prices are kept high by the kerbside sort.

2.6.2.6 Scenario 11 - Bio-bin organic collection

Scenario 11 is a simple system for householders to use and so captures would be expected to be quite high. However, looking at the results, it is generally a poor performer, especially on cost. The recycling rates achieved vary from 38% in Ealing to almost 46% in Harrow, and was a medium level performer when compared to the other options modelled for each borough.

However, because of the free garden waste collection, and with that collection being in a 180 litre bin (which generally attracts more material), the increase in waste arisings was the highest for any scenario modelled across all of the boroughs. It is also the most expensive scenario for 3 boroughs, and for the other 3 is second only to option 6. This high cost is due to the expensive bio-bins themselves, the MRF treatment requirements and the weekly collection of dry recyclables, but mostly because the kitchen, garden waste and card are all collected together and therefore all have to be treated in-vessel.

2.6.3 Summary

The collection modelling exercise has demonstrated a number of key points:

- Councils must look to the long term. A short term perspective will act as a disincentive to invest time and resources into new collection systems, and will hinder the achievement of long term goals.
- Fortnightly residual collection is important in encouraging resident participation in recycling to the extent required to meet the recycling aspirations of the West London boroughs. Ideally, the capacity of residual containment should be restricted. Fortnightly residual collection is also fundamental to improving the economics of collection systems based on high levels of source separation as they save significant amounts of money over weekly collections which can then be used to enhance the separate collection of other materials.

- The frequent collection of kitchen waste in a convenient container is vital to achieving high biowaste diversion through source separation.
- To keep treatment costs down, kitchen waste should be collected separately from garden waste and card.
- Separate collection of kitchen waste is only likely to deliver high capture rates where residual waste collections are fortnightly.
- 'Free' garden waste collections, while able to deliver high recycling rates, add significant cost to the system, particularly where garden waste has to be treated in-vessel by virtue of being collected with kitchen waste. Such collections are unlikely to be efficient at diverting the organic waste that is already being collected in the residual waste (i.e. primarily kitchen waste) unless collections are made weekly.
- Careful consideration must be given to the capacity (volume) available for the collection of materials; this is especially the case for kerbside box collections, which may already be placing a restriction on the amount of recycling that it is convenient for some households to undertake – and will become a greater constraint if further materials are added (especially plastics).
- Higher levels of capture can lead to efficiencies – the scenario that achieves the highest captures is not always the most expensive option.
- All of the high-performing long term options require access to facilities (sorting facilities, in vessel composting plants etc.) that are currently in short supply in proximity to West London. The procurement approaches and lead times for developing such infrastructure would therefore need to be considered in any implementation plan for high recycling/composting schemes.

2.7 Notes on Interpretation of Cost & Performance Data

Recycling Rate. The recycling rate percentages quoted represent only a percentage of the material handled by the collection systems modelled. They are not equivalent to the BVPI recycling rate, which would also include material from civic amenity sites, street cleansing etc. These waste streams are considered below.

Processing Facilities. The scenarios assume that sufficient processing technology infrastructure is or will become available in WLWA to enable the in-vessel composting of kitchen waste. The performance characteristics of these recovery facilities are assumed to be similar to the best performing existing facilities. Costs of these facilities are included in the model simply through the application of a gate fee based on current quoted figures.

Bring Systems. Only kerbside collection systems are included in the model. There is an interrelationship between the amounts of material collected through kerbside and bring systems which has not been modelled. Generally speaking kerbside systems are considered to be more convenient for householders and therefore they will normally divert material away from existing bring systems. However where bring systems are introduced in addition to existing kerbside systems they will collect *some* extra material not captured by the kerbside system. This may be partly due to bring systems providing a facility to recycle larger loads of material than are able to be placed in the kerbside system – such as may result from parties or cleanups etc.

System Costs. System costs as presented here include the estimated costs of collection *and disposal* for household waste and recycling collection services, in order to account for the impact of avoided disposal costs. Special, clinical, and commercial collection services are not included in the modelling data, nor are any of the street cleansing, bring site and CA site operations included. The costs represented by the modelled data will therefore not be equivalent to either the likely contract costs for any waste management contacts or the total cost of waste service provision. The projected cost data presented here should therefore be used for indicative comparison purposes only.

2.8 Appraisal of Options

The options criteria analysis that was performed on the results from the modelling exercise have shown that for each authority, there is one clear preferred long term option – that is scenario 4. In the short term, again there is one preferred option, and that is scenario A.

To test how sensitive these results were to the criteria chosen, adjustments were made to the weightings applied. Changing the weightings made little difference to the overall outcome, and shows that the preferred options that result from the analysis are robust.

The results of the options appraisal for the medium term scenarios are shown in Figure 8. The long term options are shown in Figure 9. Detailed results of the options appraisal carried out are presented in Annex 3.

Figure 8: Results of the options criteria analysis – mid term options

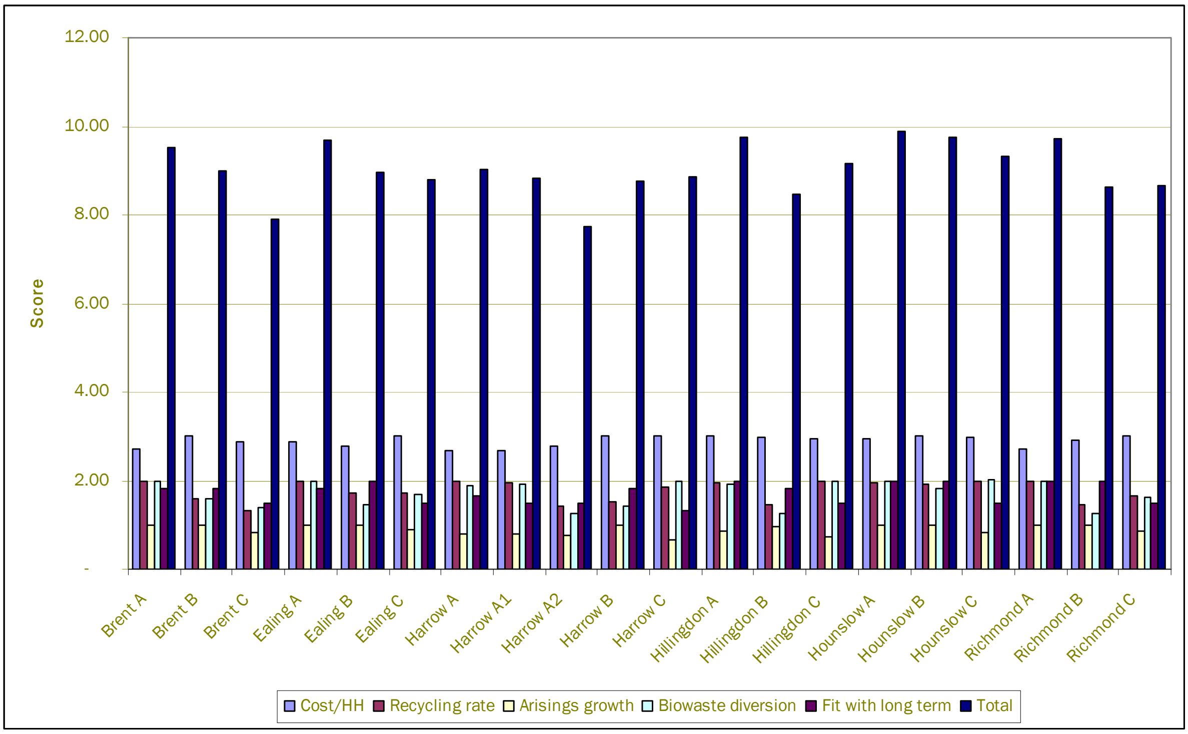
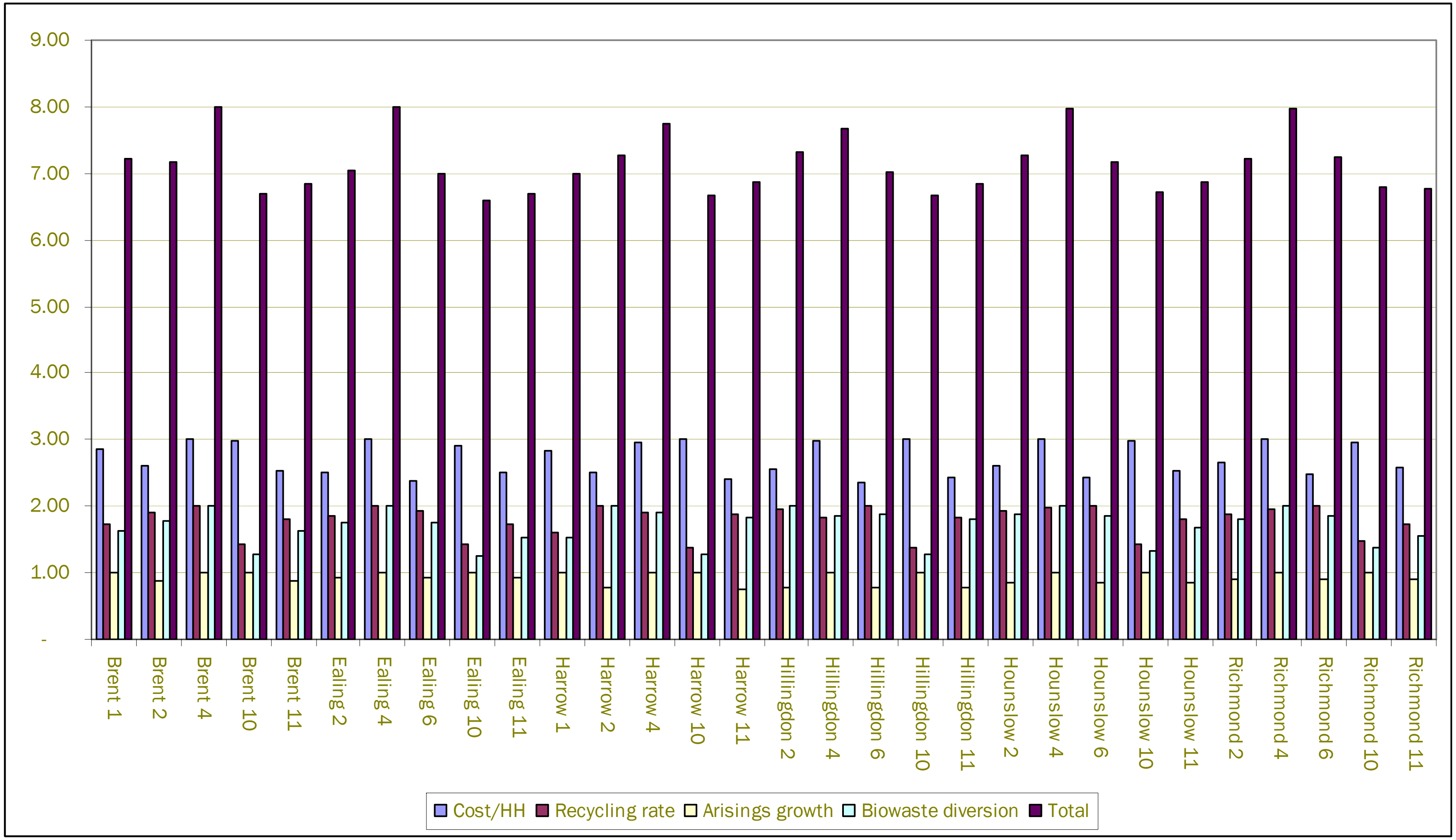


Figure 9: Results of the options criteria analysis – long term options



2.9 Sensitivity Analysis: Option 4 Sacks vs. Wheeled Bins

It is clear from the above analysis that scenario 4 is the optimal scenario across the WLWA. However, the use of a sack based system for fortnightly residual collection, as is the case in scenario 4, can be an unwelcome move among residents, and therefore challenging to pass through the democratic process. The main reasons for concern centre on health and hygiene issues including the potential to attract vermin. Issues of space to store sacks for two weeks at a time is also a key concern. Therefore Eunomia has carried out a sensitivity analysis to see how the results are affected when sacks are replaced by 180 litre wheeled bins. This has been done by remodelling scenario 4 with wheeled bins for each Borough for one year (2019/20). The model has taken account of the costs of changes to the receptacle and vehicles (which will require bin lifts) and changes to participation and recognition rates. This is because it is assumed that residents will use a bin based residual system more than a sack based system, and so capture rates of dry recyclables and kitchen waste will decrease slightly when bins are introduced.

The results of the sensitivity analysis are shown in

Table 14 below. As can be seen from the table, by using bins instead of sacks for residual waste collection, there is around a 3 percentage point drop in the recycling rate (accounting for increases in waste arisings) and between a 3 and 5 percentage point drop in biowaste recycling. This is due to the fact that wheeled bins are much more convenient than sacks for residents, and there will be a tendency to put more recyclables in the residual bin, especially kitchen waste, rather than use the 35 litre bucket for kitchen collection. This effect would be more marked if residual waste collections were weekly, or for a larger 240 litre wheeled bin, but even with a fortnightly collection, this effect is still considered likely to be significant.

In terms of cost, for every authority, with the exception of Hillingdon, the total system cost would increase with the introduction of bins. However, taking into account revenues received from the recyclables collected, there is a variation in impact on costs. For Brent and Hillingdon, the cost per household appears to decrease (by 0.4 and 2.8% respectively). For Harrow, the change makes very little difference to the cost (0.1% increase), and for Ealing, Hounslow and Richmond, the increase in cost is more significant (3.3%, 2.2% and 1.8% respectively). This is, however, mainly due to differing numbers of vehicles modelled in each case which have changed as material is sent down the different collection routes. The cost differences are in essence a reflection of collection efficiency where either the change has resulted in the vehicle capacities being better utilised on the rounds, or the vehicles being overstretched and hence additional vehicles being required. Therefore, these costs presented are not intended to provide an accurate reflection at the borough level of a switch from sacks to bins. Other things being equal, however, this change would be expected to result in higher costs due to the expense of the containers, the added expense of the bin-lift equipped vehicles, the increased times associated with collection, and the reduction in revenue from less collected recyclables.

Table 14: Scenario 4 – Bags vs. Bins For Scenario 4

District	Brent		Ealing		Harrow		Hillingdon		Hounslow		Richmond	
	Sack Based Scenario 4	Bin Based Scenario 4	Sack Based Scenario 4	Bin Based Scenario 4	Sack Based Scenario 4	Bin Based Scenario 4	Sack Based Scenario 4	Bin Based Scenario 4	Sack Based Scenario 4	Bin Based Scenario 4	Sack Based Scenario 4	Bin Based Scenario 4
Total System Cost (£,000)	12,733	12,804	12,715	13,290	9,746	9,864	11,673	11,421	9,626	9,951	8,887	9,139
Total Cost Minus Disposal (£,000)	7,640	7,403	7,995	8,233	6,273	6,151	7,713	7,271	6,227	6,345	5,687	5,798
Total Revenue (£,000)	-498	-374	-544	-416	-589	-485	-1	-476	-472	-378	-575	-498
Net Total Cost (£,000)	13,231	13,177	13,259	13,706	10,335	10,348	12,236	11,897	10,098	10,329	9,463	9,637
Net Cost/ Household (£)	120.16	119.67	103.1	106.58	117.61	117.77	113.71	110.56	106.67	109.12	113.2	115.29
Net Cost/Tonne (£)	116.78	116.31	123.17	127.33	123.72	123.88	136.65	132.87	129.7	132.67	129.76	132.15
Recycling Rate (%)	42.40%	38.90%	43.80%	39.80%	46.70%	43.00%	43.20%	40.50%	43.90%	40.50%	43.70%	41.30%
Biowaste Diversion Rate (%)	48.30%	44.40%	49.10%	44.20%	49.30%	45.30%	48.70%	45.40%	49.20%	45.40%	51.10%	47.70%
TOTAL Recycling & Composing (T)	48,008	44,055	47,136	42,819	39,019	35,941	38,782	36,338	34,272	31,626	31,901	30,091
TOTAL Residual Waste (T)	65,289	69,243	60,512	64,829	44,515	47,593	50,758	53,203	43,581	46,227	41,022	42,832

2.10 Recycling & Residual Waste: From 2004 to 2020

In deciding upon future disposal and treatment options for residual waste, it is important to be able to predict how the quantity and composition of both the recycling/ composting and residual waste streams change through time. This change will be a function of, among other things, population and household size, waste arisings growth rate, the type of recycling facilities in place and the coverage, recognition and participation levels of the schemes provided.

2.10.1 Total Quantities of Recycling/Composting & Residual Waste

From the modelling performed and using the preferred scenarios that have emerged, the years in between the mid (2009/10) and long term (2019/20) scenarios have been modelled. These results are presented in Figure 10 and Figure 11 below.

The bottle shape produced in Figure 10 clearly shows an increase in recycling and composting levels and a reduction in residual waste quantities over time. Between 2003/04 and 2009/10 there is a gradual increase in the amount of waste for recycling and composting that is collected at the kerbside. However, it is not until the introduction of scenario 4 that a significant change is made to quantities of both the recycling/composting and the residual waste fractions. As the graph shows, after a scheme is introduced, there is then a gradual increase in recycling capture rates over time as households get used to the system. The rate of increase over time once a system has been put in place is initially very quick, but then slows down, until optimal capture rates are achieved.

What isn't clear from Figure 10 is the impact that increases in waste arisings over this period have. Figure 11 shows this more clearly, and as can be seen, the overall amount of waste produced increases by around 50,000 tonnes between 2003/04 and 2019/20.

Figure 10: Recycling/Composting & Residual Waste Quantities Over Time

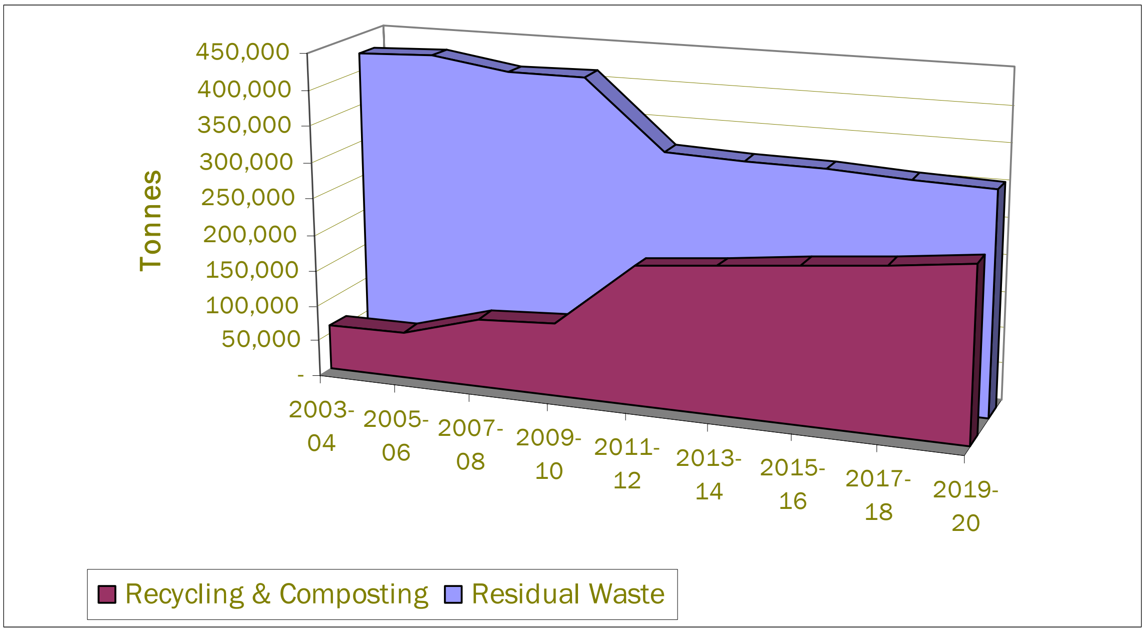
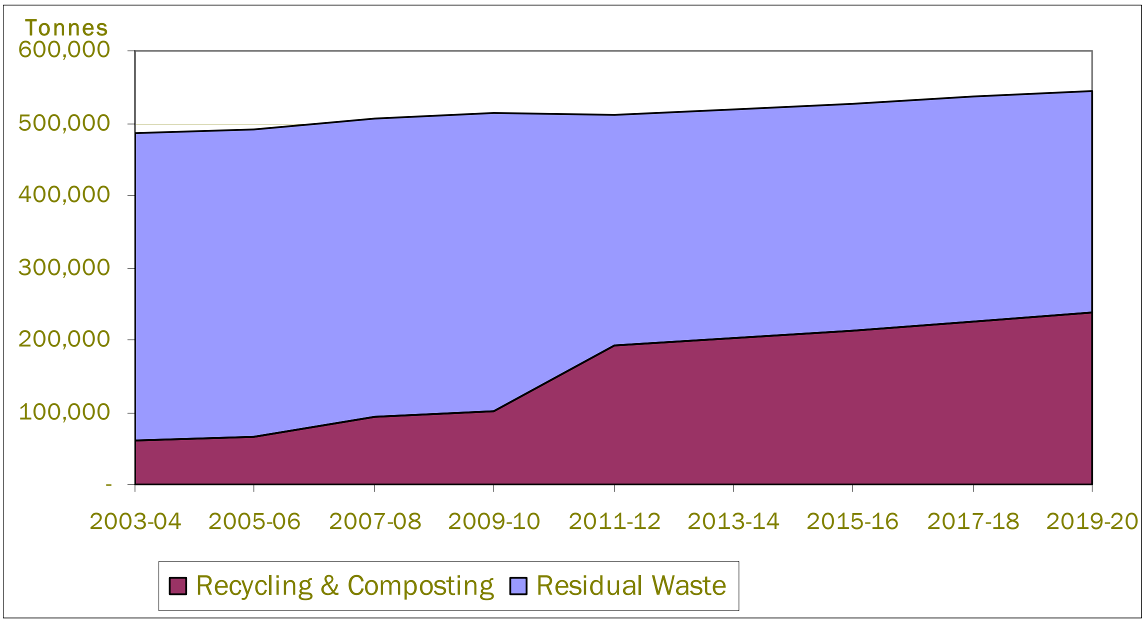


Figure 11: Recycling & Residual Waste Quantities Showing Impact of Increased Waste Arisings



2.10.2 Recycling/Composting and Residual Waste Composition

Tables 15 to 20 below show how the residual and recycling/composting compositions change over time for each borough. To aid presentation of the data, the tables present the compositions for the base case, the optimised mid case (i.e. 2009/10) and the optimised long term scenario (i.e. 2019/20) only. It is important to note that the recycling percentages presented do *not* account for any increases in waste arisings due to the collection of free garden waste.

Table 15: Brent

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	4,653	15,471	23%	8,460	12,663	40%	15,952	6,945	70%
Cardboard	-	6,150	-	-	6,455	-	4,174	2,823	60%
Non recyclable paper	-	5,886	-	-	6,178	-	-	6,697	-
Recyclable plastic bottles	-	2,488	-	-	2,611	-	1,533	1,298	54%
Other dense plastic	-	3,179	-	-	3,337	-	1,390	2,227	38%
Plastic film	-	5,089	-	-	5,342	-	2,043	3,748	35%
Textiles	266	2,781	9%	452	2,747	14%	1,237	2,230	36%
Glass bottles	1,662	4,515	27%	2,887	3,596	45%	4,283	2,745	61%
Other glass	-	546	-	-	573	-	-	621	-
Steel cans	100	2,051	5%	472	1,786	21%	1,073	1,374	44%
Alu cans	33	823	4%	324	575	36%	594	381	61%
Other ferrous	-	-	-	-	-	-	-	-	-
Other non-ferrous	-	-	-	-	-	-	-	-	-
Kitchen	-	21,486	-	4,156	18,396	18%	13,289	11,157	54%
Garden	1,128	6,712	14%	1,241	7,354	14%	2,440	6,135	28%
Miscellaneous	-	14,860	-	-	15,597	-	-	16,907	-
TOTAL	7,843	92,038	8%	17,990	87,210	17%	48,008	65,289	42%

Table 16: Ealing

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	6,507	9,388	41%	5,961	10,857	35%	12,773	5,312	71%
Cardboard	-	6,717	-	-	7,108	-	4,572	3,071	60%
Non recyclable paper	-	5,393	-	-	5,706	-	-	6,136	-
Recyclable plastic bottles	-	2,176	-	-	2,303	-	1,360	1,116	55%
Other dense plastic	-	3,311	-	-	3,504	-	1,472	2,296	39%
Plastic film	-	3,595	-	-	3,804	-	1,468	2,623	36%
Textiles	74	5,508	1%	678	5,229	12%	2,325	4,026	37%
Glass bottles	3,030	5,485	36%	3,366	5,644	37%	6,003	3,685	62%
Other glass	-	378	-	-	400	-	-	431	-
Steel cans	333	1,559	18%	343	1,659	17%	963	1,190	45%
Alu cans	63	694	8%	239	562	30%	534	328	62%
Other ferrous	-	378	-	-	400	-	-	431	-
Other non-ferrous	3	376	1%	-	400	-	-	431	-
Kitchen	-	22,801	-	4,535	19,591	19%	14,331	11,613	55%
Garden	475	4,066	11%	467	4,338	10%	1,336	3,831	26%
Miscellaneous	30	12,269	0%	-	13,014	-	-	13,994	-
TOTAL	10,516	84,096	11%	15,589	84,520	16%	47,136	60,512	44%

Table 17: Harrow

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	4,763	8,630	36%	5,963	7,753	44%	10,994	3,875	74%
Cardboard	145	4,746	3%	315	4,694	6%	3,281	2,149	60%
Non recyclable paper	-	4,514	-	-	4,624	-	-	5,012	-
Recyclable plastic bottles	-	1,956	-	-	2,004	-	1,252	920	58%
Other dense plastic	-	2,107	-	-	2,158	-	965	1,374	41%
Plastic film	-	1,279	-	-	1,310	-	539	881	38%
Textiles	44	1,762	2%	270	1,580	15%	797	1,208	40%
Glass bottles	1,335	3,706	27%	2,410	2,753	47%	3,664	1,933	66%
Other glass	-	226	-	-	231	-	-	251	-
Steel cans	233	1,183	17%	307	1,143	21%	749	823	48%
Alu cans	77	388	17%	175	300	37%	338	178	66%
Other ferrous	-	-	-	-	-	-	-	-	-
Other non-ferrous	-	226	-	-	231	-	-	251	-
Kitchen	-	18,359	-	4,051	14,751	22%	11,986	8,396	59%
Garden	2,936	11,624	20%	8,479	11,831	42%	4,455	10,247	30%
Miscellaneous	-	6,320	-	-	6,473	-	-	7,017	-
TOTAL	9,532	67,026	13%	21,972	61,834	26%	39,019	44,515	47%

Table 18: Hillingdon

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	4,170	6,839	38%	5,068	6,437	44%	9,287	3,184	75%
Cardboard	1,152	2,729	30%	333	3,723	8%	2,658	1,738	61%
Non recyclable paper	-	3,089	-	-	3,228	-	-	3,499	-
Recyclable plastic bottles	521	1,142	31%	-	1,738	-	1,095	789	58%
Other dense plastic	-	2,138	-	-	2,235	-	1,009	1,414	42%
Plastic film	-	3,168	-	-	3,311	-	1,376	2,213	38%
Textiles	-	2,534	-	392	2,257	15%	1,158	1,713	40%
Glass bottles	2,530	3,727	40%	3,105	3,434	48%	4,684	2,403	66%
Other glass	-	396	-	-	414	-	-	449	-
Steel cans	584	1,444	29%	456	1,663	22%	1,107	1,191	48%
Alu cans	220	445	33%	261	434	38%	498	255	66%
Other ferrous	-	2,297	-	-	2,400	-	-	2,602	-
Other non-ferrous	-	-	-	-	-	-	-	-	-
Kitchen	-	17,582	-	4,016	14,358	22%	11,848	8,070	60%
Garden	6,891	9,204	43%	7,201	9,618	43%	4,062	9,665	30%
Miscellaneous	-	10,217	-	-	10,677	-	-	11,574	-
TOTAL	16,068	66,951	19%	20,831	65,926	24%	38,782	50,758	43%

Table 19: Hounslow

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	5,304	7,503	41%	5,281	8,161	39%	10,427	4,145	72%
Cardboard	842	3,111	21%	277	3,873	7%	2,697	1,801	60%
Non recyclable paper	-	3,767	-	-	3,954	-	-	4,286	-
Recyclable plastic bottles	-	1,782	-	-	1,870	-	1,130	898	56%
Other dense plastic	-	2,285	-	-	2,398	-	1,032	1,568	40%
Plastic film	-	2,818	-	-	2,957	-	1,170	2,036	37%
Textiles	67	2,163	3%	299	2,042	13%	952	1,585	38%
Glass bottles	2,288	2,471	48%	2,060	2,934	41%	3,410	2,004	63%
Other glass	109	293	27%	-	422	-	-	458	-
Steel cans	266	972	22%	246	1,053	19%	642	767	46%
Alu cans	83	401	17%	167	341	33%	347	204	63%
Other ferrous	-	209	-	-	219	-	-	238	-
Other non-ferrous	20	177	10%	-	207	-	-	224	-
Kitchen	-	16,470	-	3,390	13,897	20%	10,527	8,212	56%
Garden	862	5,347	14%	928	5,589	14%	1,938	5,127	27%
Miscellaneous	7	8,808	0%	-	9,252	-	-	10,029	-
TOTAL	9,849	58,576	14%	12,648	59,171	18%	34,272	43,581	44%

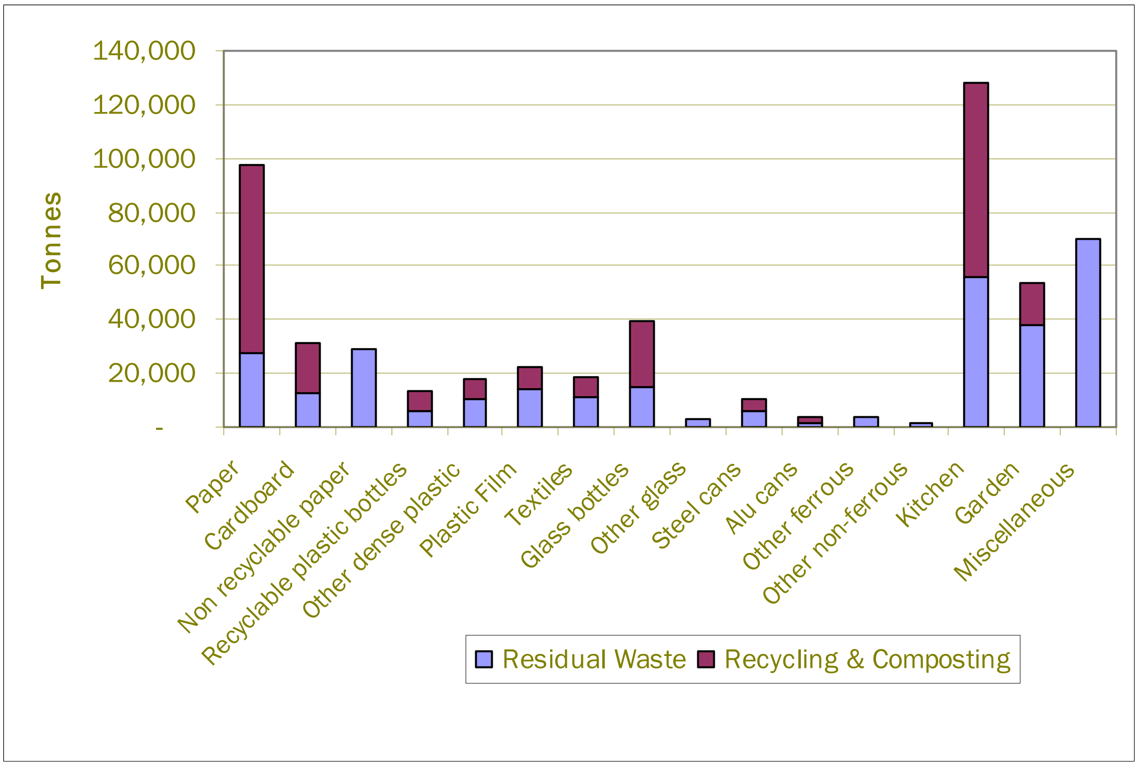
Table 20: Richmond

	Base Case - 2003/04			Scenario A - 2009/10			Scenario 4 - 2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	5,307	7,461	42%	6,118	7,282	46%	10,402	4,125	72%
Cardboard	-	2,109	-	10	2,203	0%	1,440	959	60%
Non recyclable paper	-	2,801	-	-	2,940	-	-	3,187	-
Recyclable plastic bottles	-	1,922	-	-	2,018	-	1,219	969	56%
Other dense plastic	-	2,462	-	-	2,584	-	1,112	1,689	40%
Plastic film	-	3,737	-	-	3,922	-	1,551	2,700	37%
Textiles	84	973	8%	163	947	15%	451	752	38%
Glass bottles	1,935	2,462	44%	2,186	2,428	47%	3,150	1,852	63%
Other glass	265	440	38%	200	540	27%	-	802	-
Steel cans	110	646	15%	174	620	22%	392	468	46%
Alu cans	50	302	14%	140	230	38%	253	149	63%
Other ferrous	-	526	-	-	552	-	-	598	-
Other non-ferrous	-	288	-	-	303	-	-	328	-
Kitchen	-	16,677	-	3,425	14,079	20%	10,694	8,280	56%
Garden	134	3,879	3%	141	4,071	3%	1,238	3,327	27%
Miscellaneous	-	9,524	-	-	9,996	-	-	10,836	-
TOTAL	7,885	56,207	12%	12,557	54,714	19%	31,901	41,022	44%

2.10.2.1 WLWA as a whole

The information presented in Tables 15 to 20 have been collated to give the tonnages for recycling and residual waste for the WLWA as a whole. These results are shown in Table 21. Figure 12 below shows the total residual and recycling/composting tonnages projected for 2020 (assuming the optimal scenario has been implemented in each Borough).

Figure 12: Projected residual & recycling/composting for the WLWA in 2020.



Even with the preferred options in place, by 2020 there is still a large quantity of potentially recyclable material left in the waste stream. Further development will be required if higher capture rates are to be attained, including the central extraction of material through residual waste treatment technologies. Looking at the residual waste tonnages alone, it can be seen that there is a broad spectrum of wastes that will need to be dealt with, and ignoring the miscellaneous category, the key challenge will be to work towards capturing a higher proportion of biodegradable waste, in particular kitchen and garden waste and paper based materials. This additional diversion may be achieved primarily through the development of new residual waste treatment technologies, which may also be well suited to capturing additional non-biodegradable materials (e.g. ferrous and non-ferrous metals, glass and aggregates) for recycling.

Even with this, the modelling shows that a 43% recycling and composting rate for household collected waste is achievable across the WLWA. Given that the model is generally conservative in nature, this shows that this high level of recycling should be achieved if the appropriate kerbside recycling systems are developed. Table 21 below provides a summary of performance for the 'winning' systems in 2009/10 and 2019/20 for the whole of the WLWA area, along side the baseline figures.

Table 21 Total Recycling & Composting and Residual Waste Tonnages for WLWA

	2003/04			2009/10			2019/20		
	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled	Recycling & Composting (tonnes)	Residual (tonnes)	% Recycled
Paper	30,704	55,292	36%	36,852	53,153	41%	69,835	27,585	72%
Cardboard	2,139	25,562	8%	935	28,055	3%	18,821	12,542	60%
Non recyclable paper	-	25,450	-	-	26,629	-	-	28,817	-
Recyclable plastic bottles	521	11,467	4%	-	12,544	-	7,588	5,990	56%
Other dense plastic	-	15,482	-	-	16,215	-	6,978	10,568	40%
Plastic film	-	19,686	-	-	20,646	-	8,147	14,201	37%
Textiles	536	15,721	3%	2,253	14,800	13%	6,922	11,513	38%
Glass bottles	12,779	22,366	36%	16,015	20,789	44%	25,194	14,624	63%
Other glass	375	2,278	14%	200	2,581	7%	-	3,011	-
Steel cans	1,627	7,855	17%	1,998	7,925	20%	4,926	5,814	46%
Alu cans	527	3,053	15%	1,306	2,443	35%	2,563	1,494	63%
Other ferrous	-	3,410	-	-	3,572	-	-	3,868	-
Other non-ferrous	23	1,066	2%	-	1,141	-	-	1,234	-
Kitchen	-	113,375	-	23,572	95,072	20%	72,675	55,728	57%
Garden	12,426	40,833	23%	18,457	42,800	30%	15,469	38,332	29%
Miscellaneous	37	61,998	0%	-	65,009	-	-	70,358	-
TOTAL	61,693	424,895	13%	101,587	413,374	20%	239,118	305,677	44%

3 Timing of Change

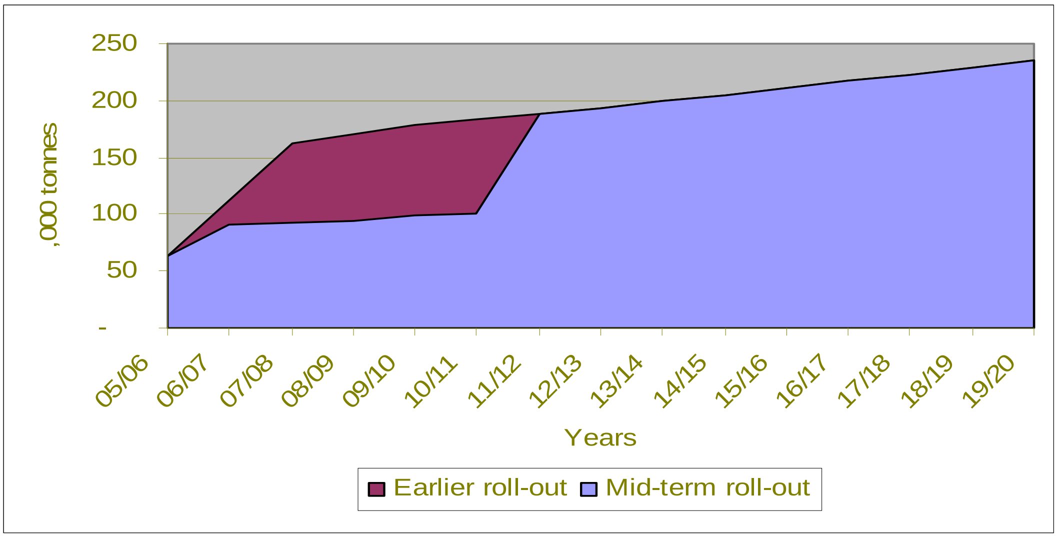
Although in the case of all options we have concluded that the cost of waste collection will increase significantly over the status quo, some scenarios are clearly more 'cost optimised' than others and these may suggest the kind of directions that should be pursued by the boroughs in developing their collection systems. However, the marginal variation in cost between the scenarios is trivial when compared to the potential impact of LATS. For example, the difference between the best and worst performing scenarios in cost terms in Ealing (the largest West London borough in terms of population) is only £19 per tonne, where as the fines associated with LATS (and probable price ceiling in the Landfill Allowance market) will be £150 per tonne.

A stated aim of the Municipal Waste Strategy development process has been to deliver an approach that will minimise exposure of the West London boroughs to the uncertainties of the LATS market by maximising self-sufficiency in landfill allowances. This objective will only be achieved through diversion of West London's own biodegradable municipal waste from landfill. Whilst there may be opportunities for doing so in the very early years of the scheme without major change in the way waste is managed in West London, this will not be possible by around 2008/09 at the latest. The two-step approach, with a mid-term 'single change' (i.e. scenarios A, B and C – kitchen waste, paper or garden waste collection) and long term scenarios serves to illustrate a progressive but not radical change in the short to medium term. However, this approach has two significant disadvantages:

1. The medium term options cause significant increases in cost without delivering major improvements in recycling rate or biowaste diversion, due to the non cost optimised nature of the systems. In other words, overall value for money is limited by the fact that new services are added without reducing capacity in others (i.e. refuse collection). In fact, the worst performing (in cost terms) mid-term options are more expensive than the best performing long term options.
2. From a LATS perspective, the roll-out of comprehensive, relatively optimised collection systems after 2011 may not make sense when both the waste collection (i.e. borough) and waste disposal (i.e. WLWA) functions are considered. The WLWA will not be in a position to put in place treatment capacity for residual waste until around this time at the earliest, unless some West London tonnage can be piggy-backed on to an existing facility. Therefore, the objective of self-sufficiency can be best supported by bringing forward the roll-out of long term 'comprehensive recycling' schemes to before 2010.

Recognising this situation, ERM and Eunomia decided to extend the modelling process to consider a scenario whereby the ling term Option 4 (the best performing option for all boroughs) was rolled out across West London in place of the 'm id-term' intermediate step, in 2006/07, with the aim of reaching a recycling rate of 40% by 2010. Figure 13 below illustrates the impact of this early roll-out on recycling tonnages as compared to the two-step roll-out discussed above.

Figure 13 - Advanced Roll-out of Option 4



As can be seen from Figure 13, the ultimate destination in 2020 remains the same, but the intermediate mid-term scenario is essentially replaced with an early roll-out of the long term Option 4. This approach does result in a 40% recycling rate in 2010 and appears capable of delivering LATS self-sufficiency until around 2011/12.

However, as modelled it requires the roll-out of Option 4 starting in the next financial year, with all that implies in terms of collection of kitchen waste, cardboard and plastics and reduction of refuse collection to a fortnightly frequency. Such a rapid change in collection systems is difficult to imagine being delivered in practice by all boroughs, given the lead time for decision making through the democratic process, the need in many cases to renegotiate or procure contracts and to procure collection containers and vehicles. Affordability would be an issue in the short term, unless a clear LATS based 'invest to save' business base was successfully made. Perhaps most problematic is that, even in the unlikely event that all of these hurdles were overcome in time, it is not feasible to envisage the infrastructure required by Option 4 (approximate requirements being sorting capacity for 90,000 tonnes of mixed paper, 60,000 tonnes of other dry recyclables and 85,000 tonnes of composting capacity) being developed and commissioned in time for a roll-out to take place during 2006/07.

3.1 Conclusions - Household Collected Scenarios

Although, like all modelling exercises, the outcomes of the scenario modelling exercise is primarily a function of the assumptions that are made, the results produced are in line with expectations based on experience in the industry. The exercise has proved invaluable in helping to show the potential for recycling and composting within the West London Waste Authority area, and therefore should assist in the process of deciding the best options for future kerbside recycling and composting initiatives. The exercise has also provided an evaluation of the composition of residual waste that can be expected, should 'optimal' source separation systems be implemented by the boroughs, and this too should assist the waste disposal authority when it comes to deciding the way forward when it comes to residual waste treatment and disposal. However, a key

4 Modelling Other Waste Streams

As discussed in the introduction to this report, the predicted performance in terms of recycling and composting for the other municipal waste streams were modelled in a less sophisticated way and do not consider the factor of cost. This is principally because the analysis of other waste streams was not conducted as an options assessment as such – rather as an exercise in predicting 'best practice' performance in order to allow a residual waste quantity and composition to be calculated for the *whole* of municipal solid waste (MSW) as opposed to household collected wastes only, which although by far the largest waste stream in West London still accounts for little over 55% of total MSW.

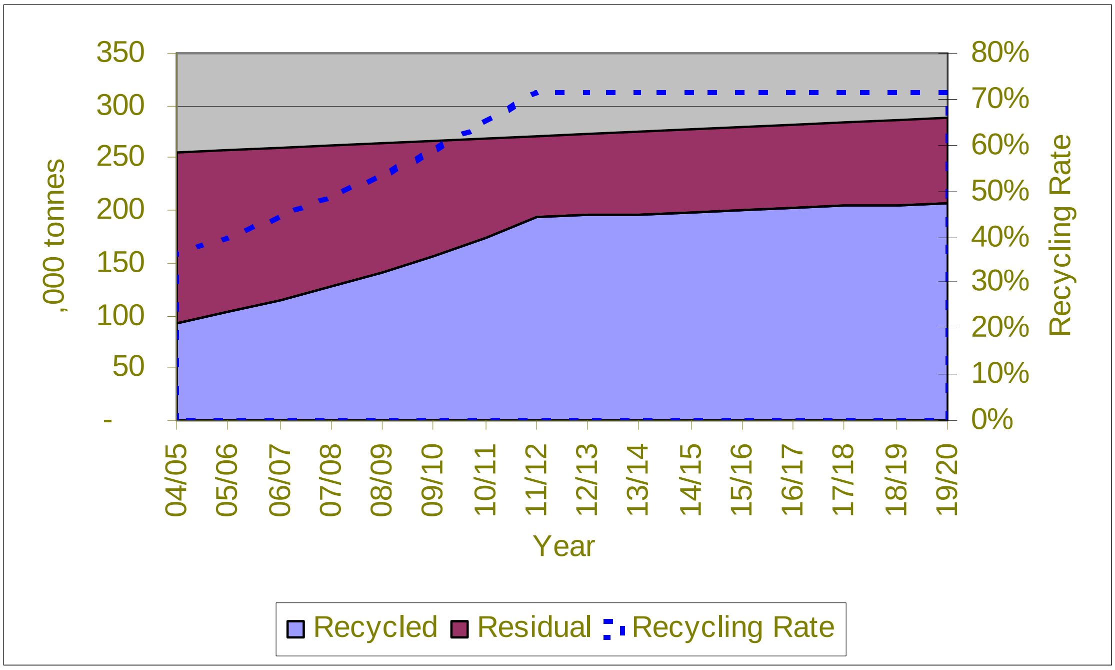
In the case of civic amenity waste (the next largest fraction of MSW in West London, representing around 30% of arisings), best practice is well understood. The modelling of options from a cost/benefit analysis perspective is unnecessary because it is generally recognised that a business case will exist for delivering best practice rates of recycling and composting on CA sites when compared with other options for increasing overall levels of recycling of household waste and diversion of BMW from landfill.

In the case of the other more 'minor' waste streams that make up the remaining 15% or so of MSW in West London, good practice in delivering high rates of recycling sand composting are much less well understood, at least in the UK. However, it has been assumed to be a prerequisite for maximising recycling and composting rates that these minor streams are tackled wherever possible in order to minimise the extent to which their disposal 'dilutes' the high performance aspired to for the 'major' household collected and CA streams.

4.1 Civic Amenity Sites

- Recycling rates of over 80% of inputs have been recorded by several waste disposal authorities in England in recent years. Indeed, recent research has indicated that for many English sites, such rates may well be achievable. However, such high levels of performance appear to be a function of the composition of the waste inputs as much as a result of site layout or management system used. Most of these very high performing sites are located in shires counties and recent research evidence suggests that green garden waste can be expected to arise on these sites in significantly higher proportions than on urban sites, where the difference seems to be made up by less readily separated or recycled materials such as timber (with a high proportion being contaminated, treated or composite) and other DIY waste. For this reason, it has been assumed that the average recycling rate at West London CA sites can be raised fairly quickly from its current relatively low base, but that performance will plateau at around 70% recycling in 2010/11, in time to maximise CA diversion contribution during the LATS period between the 2010 and 2013 Landfill Directive target years. Figure 14 below illustrates the performance projected.

Figure 14 - Assumed recycled and residual civic amenity waste



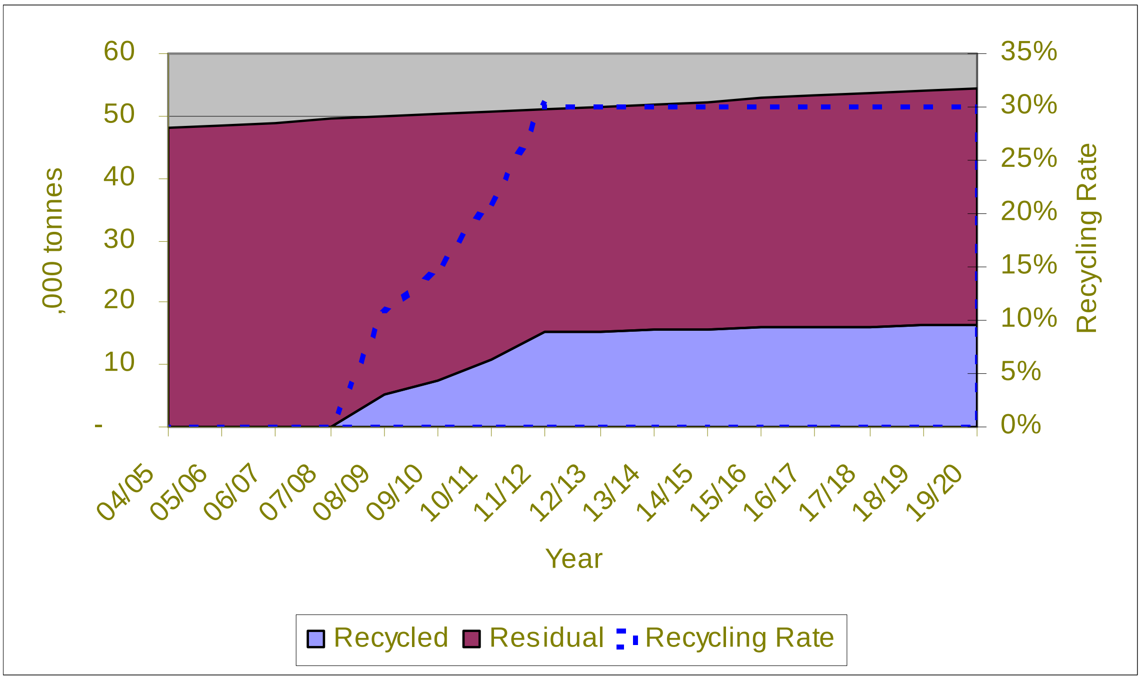
4.2 Other Waste Streams

The following sections consider the contributions that have been projected for the other 'minor' waste streams that make up municipal solid waste. It has been assumed that a proportion of some of these streams can be diverted through source separated recycling and composting initiatives (e.g. applied to special collections of bulky household waste) but that some streams will be unsuited to any recycling through source separation (e.g. clinical waste). Although these waste streams are relatively small in tonnage terms compared to household collected and CA waste, they are never the less significant when combined, accounting for around 15% of West London's municipal waste. It is unlikely that the West London authorities aspirations for recycling and composting could be achieved without targeting these minor waste streams, as not doing so will effectively dilute the impact of schemes targeting the larger streams, requiring them to over-perform in order to give the overall results predicted by the modelling.

4.2.1 Commercial collected waste

It has been assumed that commercial collected waste arisings grow in line with the underlying rate assumed for household collected and most other waste streams. This may not in fact be the case, as LATS may present an incentive to boroughs to divest themselves of involvement in commercial waste collection in order to reduce municipal waste arisings. Alternatively, significant investment in commercial waste recycling initiatives may result in a net LATS benefit for boroughs and the WLWA. However, what is far from certain at this point in time is the approach that Defra and the Environment Agency will ultimately take in resolving the current confusion as to the precise status of commercial waste collected in different ways, more or less on behalf of waste collection authorities. Given this uncertainty, we have assumed that commercial waste recycling initiatives are developed and introduced on a widespread basis during 2008/09, but that performance plateaus at around 30% recycling and composting (i.e. arguably at a relatively low level) in 2011/12. Figure 15 below illustrates this trajectory.

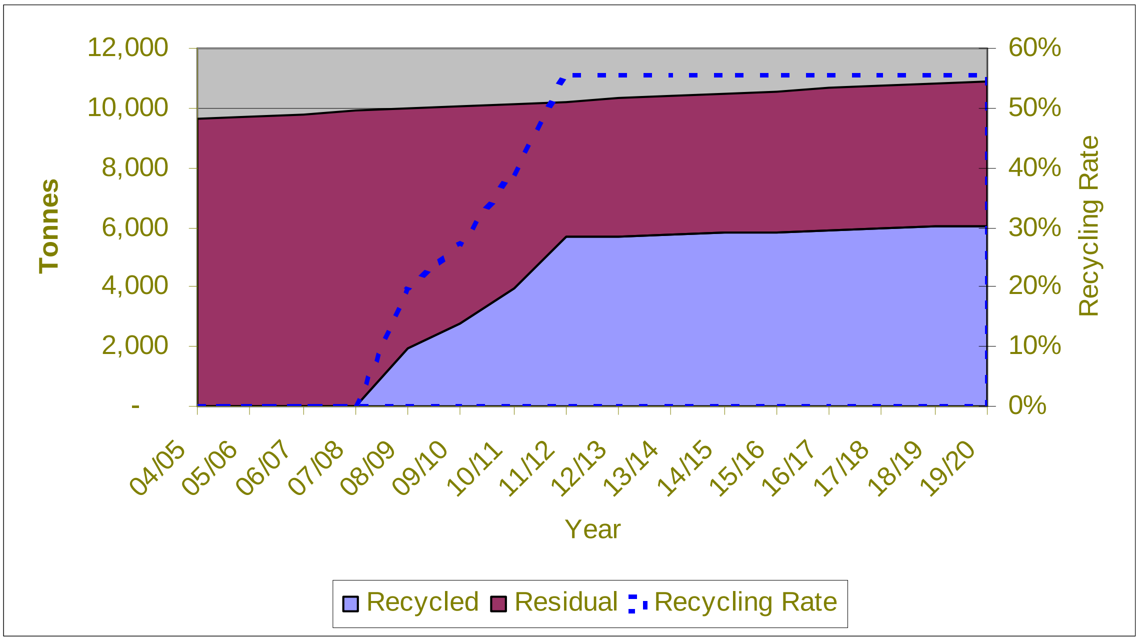
Figure 15 - Assumed recycled and residual commercial collected waste



4.2.2 Municipal buildings waste

Data on waste arisings from municipal buildings is somewhat inconsistent across the boroughs and may be incomplete. In any case, total arisings are small, representing little over 1% of total municipal waste. A similar roll-out period has been considered as for commercial waste (the most equivalent waste stream to municipal buildings waste) but with performance plateau at 55% rather than 30%, reflecting the increased control that the boroughs should be able to exert on production and sortation of waste from municipal buildings. Figure 16 below illustrates this trajectory.

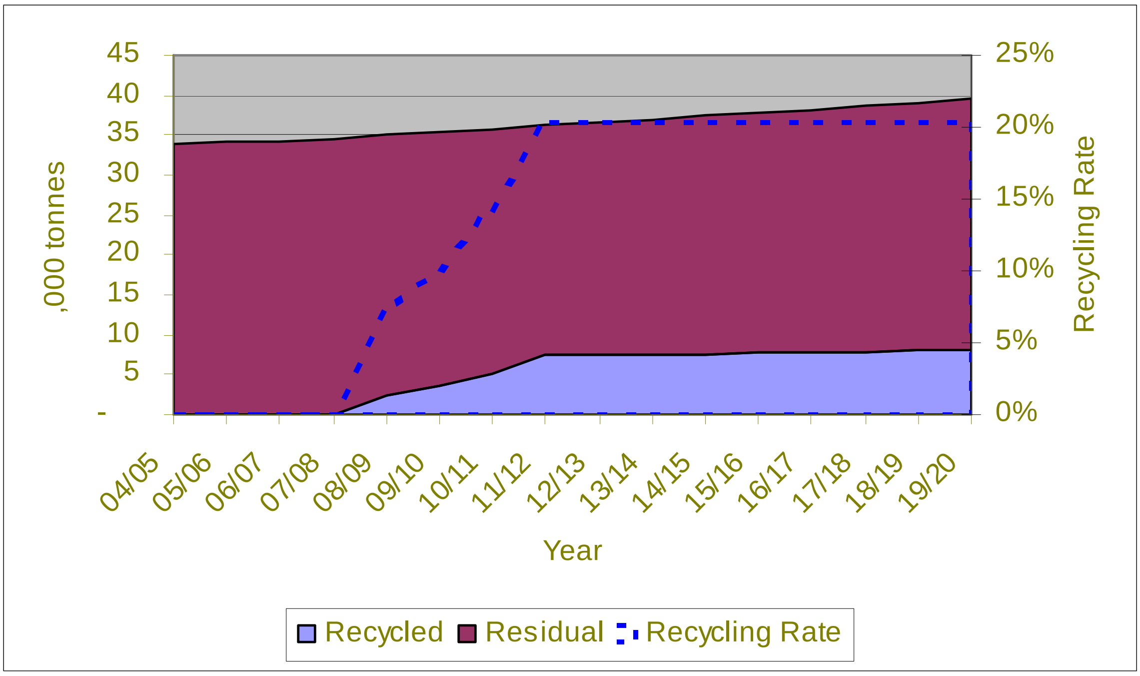
Figure 16 - Assumed recycled and residual municipal buildings waste



4.2.3 Street sweepings and litter

Experiments with various approaches to recycling and composting street sweepings and litter are ongoing in many waste collection authorities across the country. However, none are what could be called 'comprehensive' in nature, and most tend to concentrate on a single initiative, such as collecting waste paper from the exists of tube stations or composting annual leaf fall in autumn. Also, little is known about the composition of street sweepings and litter, or the variation in it's composition between areas. For this reason, we have been unable to do more than estimate in a relatively crude way the proportion of different material that may be p[resent in street sweepings (based on household waste composition, which is the best proxy available) and then to estimate the proportion of those materials that could potentially be recycled or composted through comprehensive litter/sweepings recycling schemes. We have arrived at an estimate of 20% recycling being possible in the long term, with schemes being rolled out in 2008/09 and plateauing in 2011/12. Figure 17 below illustrates this trajectory.

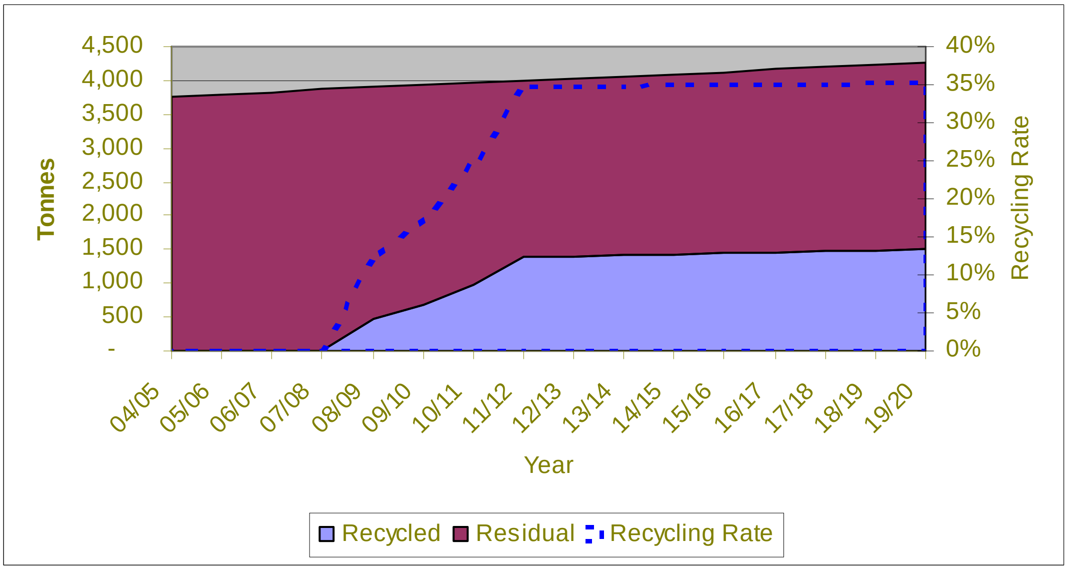
Figure 17 - Assumed recycled and residual street sweepings and litter



4.2.4 Special (bulky) household collections

Recycling schemes for especially collected bulky household waste are well established in a small number of waste collection authorities at the current time. Recycling rates of 30% to 40% appear to be achievable, with the lower rates being indicated for more urban authorities. It has therefore been assumed that schemes roll-out from 2008/09, and plateau in 2011/12 with a recycling rate of around 35%. Figure 18 below illustrates this trajectory.

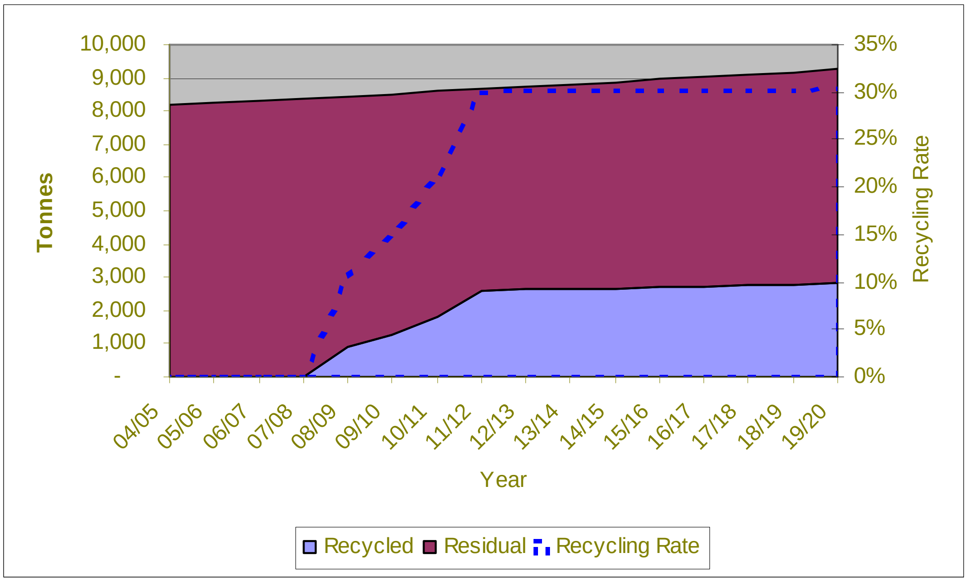
Figure 18 - Assumed recycled and residual bulky household waste



4.2.5 Other municipal waste

Other municipal waste appears to be defined differently by different boroughs and is made up of waste from a number of very minor sources. In total, it amounts to under 1% of municipal waste and it is assumed that by 2011/12, 30% will be being recycled. The trajectory assumed is illustrated in Figure 19 below.

Figure 19 - Assumed recycled and residual other municipal waste



4.2.6 Clinical waste collections and fly-tip removals

Two other waste streams are identified in the baseline data analysis that provided the raw material for this project – collected clinical waste and fly tip removals. We have assumed that none of either of the waste streams will be recycled in the long term.

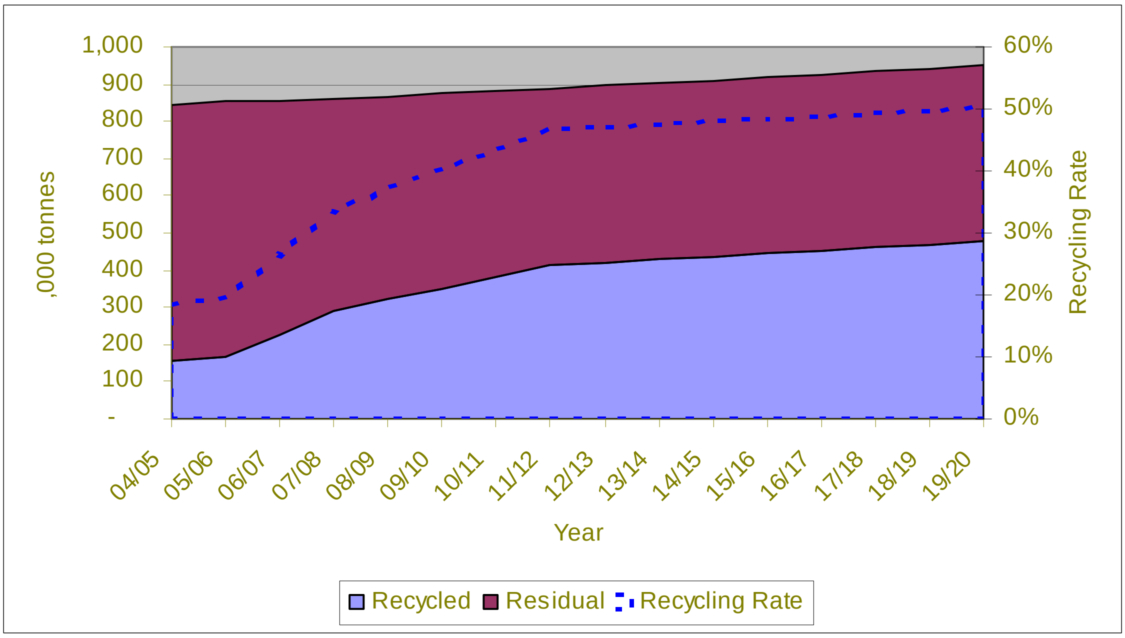
In the case of clinical waste, this is due to its hazardous nature. Most clinical waste collected by the West London boroughs is currently incinerated At a specialist facility and this is likely to continue to be the case. If so, it will be diverted from landfill and in future, as clinical waste incineration technology improves, may have energy recovered from it.

Fly tips are generally composed of relatively recyclable materials and it may be possible to introduce schemes for the recycling of remover fly tips in the future. However, it has been assumed that, due to the public health imperative to remove fly tips as quickly as possible, and their relative insignificance in terms of weight as a waste stream, it would be realistic to assume that no recycling would take place, with any schemes that do materialise being considered as a 'bonus' in recycling terms.

5 Summary of Overall Results and Conclusions

The modelling work has demonstrated that recycling and composting should be capable of managing 50% of West London's municipal waste in the long term and that a recycling rate of 40% in the medium term (i.e. by 2010) is possible. Figure 20 below illustrates the trajectory for all municipal waste if the long term Option 4 is rolled out starting from 2006/07.

Figure 20 - Overall municipal waste recycling trajectory 2004/05 - 2020



However, it is clear that placing an absolute reliance on recycling and composting to deliver LATS self-sufficiency up to 2010 is probably not realistic. The degree of change in collection systems that would be required, along side development of major new recycling initiatives at CA sites and for the minor waste streams, the implications in terms of affordability, decision making through the democratic process and the procurement and good and services required renders the 2006/07 start date almost impossible. The ultimate deal breaker, however, would be likely to be the required level of infrastructure development in terms of materials sorting and composting capacity required.

Despite these probable constraints on roll-out, we would conclude that:

1. A recycling and composting rate of 50% of municipal waste is deliverable in the long term in West London and a local target should be set accordingly;
2. A recycling rate of 40% of municipal waste by 2010 is theoretically feasible, although it would be highly challenging to get there and would probably rely on a substantial element of luck;
3. The benefits offered by a 'two-step' approach to changing collection systems appear to be outweighed by the slowness of such an approach in maximising contribution to LATS self-sufficiency when it is most needed and so the strategy should be to aim to deliver more rapid evolution of collection systems towards the comprehensive approaches modelled for the long term;

4. ‘Compressive’ should be defined as including the collection of all grades of recyclable paper and board, plastics and kitchen waste at a high enough frequency to deliver good capture rates and the collection of refuse on a fortnightly cycle. No high performing scenarios could be developed that did not include all of these components;
5. Despite the acknowledged challenges inherent in meeting the 40% recycling rate in 2010, such a local target should be set and strived for seriously. Intermediate targets should also be set for monitoring purposes, starting with a 28% household waste recycling targets in 2006/07; and
6. The risk of medium term exposure to the LATS market should be managed in part by such a recycling and composting led approach, but should be coupled with the procurement of some ‘bridging’ capacity in terms of residual waste treatment technology, which will be required in any case in the longer term and would, in the shorter term, serve to mitigate the significant risk that recycling rates do not increase as rapidly as desired.

Annex 1: Summary of Performance Assumptions by Scenario

The tables below detail the assumptions used to calculate each scenario for each Borough, based on the process described above. Unique adjustments made to a scenario are noted in the relevant places. The tables are listed by Borough, with the base case, followed by the mid term options, followed by the 5 longer term options.

5.1 A1.1: The London Borough of Brent

Table 22: Baseline

General Data	Data	Notes		
Population	256,073	Based on 2003/4 figures		
Households	102,743	Based on 2003/4 figures		
Residual tonnes	91,795.08			
Recycling tonnes	7,782			
Additional tonnes	303.91			
Total tonnes	99,881			
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	76%	78%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 6 months	N/A	Weekly
Notes				
Container type	44 litre Box	240 Litre Wheeled bin		240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, with binlift		Standard RCV residual with binlift
Notes				

Table 23: Scenario A (Weekly dry recycling & kitchen organics collection)

General Data	Data	Notes		
Population	271,144	Based on growth rate projections		
Households	105,775	Based on growth rate projections		
Total tonnes	104, 537	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	Kitchen	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	15%	89%	100%
Notes				
Frequency of collection	Weekly	Fortnightly for 6 months of year	Weekly	Weekly
Notes				
Container type	44 litre Box	240 Litre Wheeled bin	35 litre bucket with kitchen caddy and bags	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV Green with Binlift	Single operative food waste vehicle	Standard RCV residual with Binlift
Notes				

Table 24: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	271,144	Based on growth rate projections		
Households	105,775	Based on growth rate projections		
Total tonnes	104,537	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans	Garden	Paper	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	100%	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 9 months	Monthly	Weekly
Notes				
Container type	44 litre Box	Reusable PP garden sack	120 litre wheeled bin	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Standard RCV dry recyclables with binlift	Standard RCV residual with binlift
Notes				

Table 25: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	271,144	Based on growth rate projections		
Households	105,775	Based on growth rate projections		
Total tonnes	104,537	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	76%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 9 months	N/A	Weekly
Notes				
Container type	44 litre box	240 Litre Wheeled bin	N/A	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green with binlift		Standard RCV residual with binlift
Notes				

Table 26: Scenario 1 (140 Litre Dry Recycling With Prepay Garden Sack)

General Data	Data	Notes		
Population	298,258	Based on growth rate projections		
Households	110,109	Based on growth rate projections		
Total tonnes	113,320	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	100%	100%
Notes				
Frequency of collection	Fortnightly	Weekly	Fortnightly, for 6 months	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	35 Litre Box & Kitchen Caddy & Bags	Re-usable PP Sacks	180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV dry recyclables with binlift	Single operative food waste vehicle	Standard RCV green, no binlift	Standard RCV residual with binlift
Notes				

Table 27: Scenario 2 (All Wheeled Bin)

General Data	Data	Notes		
Population	298,258	Based on growth rate projections		
Households	110,109	Based on growth rate projections		
Total tonnes	113,320	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen & Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		180 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling with binlift	Standard RCV green with binlift		Standard RCV residual with binlift
Notes				

Table 28: Scenario 11 (Bio-Bin Organic Collection)

General Data	Data	Notes		
Population	298,258	Based on growth rate projections		
Households	110,109	Based on growth rate projections		
Total tonnes	113,320	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 29: Scenario 4 (5 Stream Collection, with Monthly Paper Collection)

General Data	Data	Notes		
Population	298,258	Based on growth rate projections		
Households	110,109	Based on growth rate projections		
Total tonnes	113,320	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	89%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Notes				
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift
Notes				

Table 30: Scenario 10 (5 Waste Stream, Weekly Dry Recycling with Separate Kitchen & Garden)

General Data	Data	Notes		
Population	298,258	Based on growth rate projections		
Households	110,109	Based on growth rate projections		
Total tonnes	113,320	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Proportion of households served	100%	89%	89%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Notes				
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift

5.2 A1.2: The London Borough of Ealing

Table 31: Baseline

General Data	Data	Notes		
Population	311,499	Based on 2003/04 data		
Households	120,000	Based on 2003/04 data		
Residual tonnes	84,215	Based on 2003/04 data		
Recycling tonnes	10,397	Based on 2003/04 data		
Total tonnes	94,612	Based on 2003/04 data		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans, foil, some oil and batteries	Garden	N/A	All except bulky, commercial, and clinical
Proportion of households served Notes	78%	100%	N/A	100%
Frequency of collection Notes	Weekly	Fortnightly for 6 months	N/A	Weekly
Container type Notes	44 litre Box	Eco Sacks		Sacks
Vehicle type Notes	Demountable stillage vehicle	Standard RCV green, no binlift		Standard RCV residual, no binlift

Table 32: Scenario A (Weekly dry recycling & kitchen organics collection)

General Data	Data	Notes		
Population	329,832	Based on growth projections		
Households	123,541	Based on growth projections		
Total tonnes	99,305	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden & card	Kitchen	All except bulky, commercial, and clinical
Proportion of households served Notes	89%	100%	90%	100%
Frequency of collection Notes	Weekly	Fortnightly for 6 months	Weekly	Weekly
Container type	44 litre Box	Eco sack	35 litre bucket with kitchen caddy & bags	240 Litre Wheeled bin
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Single operative food waste vehicle	Standard RCV residual, with binlift

Table 33: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	329,832	Based on growth projections		
Households	123,541	Based on growth projections		
Total tonnes	99,305	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans	Garden	Paper	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	100%	100%
Notes				
Frequency of collection	Weekly	Fortnightly for 9 months	Monthly	Weekly
Notes				
Container type	44 litre Box	Eco sack	120 litre wheeled bin	Sack
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Standard RCV dry recyclable, with binlift	Standard RCV residual no binlift
Notes				

Table 34: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	329,832	Based on growth projections		
Households	123,541	Based on growth projections		
Total tonnes	99,305	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans, paper	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	78%	100%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly for 9 months	N/A	Weekly
Notes				
Container type	44 litre Box	240 litre wheeled bin	N/A	Sack
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, with binlift	N/A	Standard RCV residual no binlift
Notes				

Table 35: Scenario 4 (5 Stream Collection, with Monthly Paper Collection)

General Data	Data	Notes		
Population	362,815	Based on growth rate projections		
Households	128,604	Based on growth rate projections		
Total tonnes	107,648	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	90%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Notes				
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift
Notes				

Table 36: Scenario 2 (All Wheeled Bin)

General Data	Data	Notes		
Population	362,815	Based on growth rate projections		
Households	128,604	Based on growth rate projections		
Total tonnes	107,648	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		240 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling, with binlift	Standard RCV green, with binlift		Standard RCV residual, with binlift
Notes				

Table 37: Scenario 6 (Sack Based System)

General Data	Data	Notes		
Population	362,815	Based on growth rate projections		
Households	128,604	Based on growth rate projections		
Total tonnes	107,648	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastics, textiles, glass, cans.	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	89%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, 9 months.	Fortnightly
Notes				
Container type	Sacks	35l Bucket, Kitchen Caddy & Bags	Re-Usable Sacks	Sacks
Notes				
Vehicle type	Standard RCV dry recyclable, no bin lift.	Single operative food-waste vehicle.	Standard RCV, green, no bin lift.	Standard RCV residual, no bin lift.
Notes				

Table 38: Scenario 11 (Bio-Bin Organic Collection)

General Data	Data	Notes		
Population	362,815	Based on growth rate projections		
Households	128,604	Based on growth rate projections		
Total tonnes	107,648	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 39: Scenario 10 (5 Waste Stream, Weekly Dry Recycling With Separate Kitchen & Garden)

General Data	**Data**	**Notes**		
Population	362,815	Based on growth rate projections		
Households	128,604	Based on growth rate projections		
Total tonnes	107,648	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	90%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Notes				
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift

5.3 A1.3: The London Borough Of Harrow

Table 40: Baseline

General Data	**Data**	**Notes**		
Population	208,000	Based on 2003/04 data		
Households	81,990	Based on 2003/04 data		
Residual tonnes	65,995	Based on 2003/04 data		
Recycling tonnes	7,423	Based on 2003/04 data		
Total tonnes	73,418	Based on 2003/04 data		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Proportion of households served	89%	37%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 6 months	N/A	Weekly
Container type	44 Litre Box	240 Litre Wheeled bin		240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, with binlift		Standard RCV residual, with binlift

Table 41: Scenario A (Weekly dry recycling & kitchen organics collection)

General Data	**Data**	**Notes**		
Population	220,241	Based on growth projections		
Households	84,410	Based on growth projections		
Total tonnes	77,059	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden & Card	Kitchen	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	94%	100%	100%
Notes				
Frequency of collection	Weekly	Fortnightly for 6 months	Weekly	Weekly
Notes				
Container type	44 litre box	240 litre wheeled bin	35 litre bucket with kitchen caddy and bags	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Faun rotopress RCV green with binlift	Single operative food waste vehicle	Standard RCV residual, with binlift
Notes				

Table 42: Scenario A1 (Kitchen & Garden Combined)

General Data	**Data**	**Notes**		
Population	220,241	Based on growth projections		
Households	84,410	Based on growth projections		
Total tonnes	77,059	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	89%	94%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Weekly
Notes				
Container type	44 litre box	240 litre wheeled bin		240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Faun rotopress RCV green with binlift		Standard RCV residual with binlift
Notes				

Table 43: Scenario A2 (Recycling Box, No Kitchen)

General Data	Data	Notes		
Population	220,241	Based on growth projections		
Households	84,410	Based on growth projections		
Total tonnes	77,059	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	89%	94%		100%
Notes				
Frequency of collection	Weekly	Fortnightly for 6 months	N/A	Fortnightly
Notes				
Container type	44 litre box	240 litre wheeled bin	N/A	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Faun rotopress RCV green with binlift		Standard RCV residual with binlift

Table 44: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	220,241	Based on growth projections		
Households	84,410	Based on growth projections		
Total tonnes	77,059	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans	Garden	Paper	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	100%	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 9 months	Monthly	Weekly
Notes				
Container type	44 litre box	Reusable PP sack	120 litre wheeled bin	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Standard RCV dry recyclable, with binlift	Standard RCV residual, with binlift

Table 45: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	220,241	Based on growth projections		
Households	84,410	Based on growth projections		
Total tonnes	77,059	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	89	94%		100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Weekly
Notes				
Container type	44 litre box	240 Litre Wheeled bin	N/A	240 Litre Wheeled bin
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, with binlift	N/A	Standard RCV residual, with binlift
Notes				

Table 46: Scenario 1 (140 litre dry recycling with prepay garden sack)

General Data	Data	Notes		
Population	242,266	Based on growth rate projections		
Households	87,869	Based on growth rate projections		
Total tonnes	83,534	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	100%	100%
Notes				
Frequency of collection	Fortnightly	Weekly	Fortnightly, for 6 months	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	35 Litre Box & Kitchen Caddy & Bags	Re-usable PP Sacks	180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV dry recyclables with binlift	Single operative food waste vehicle	Standard RCV green, no binlift	Standard RCV residual with binlift
Notes				

Table 47: Scenario 2 (All Wheeled Bin)

General Data	Data	Notes		
Population	242,266	Based on growth rate projections		
Households	87,869	Based on growth rate projections		
Total tonnes	83,534	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen & Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		180 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling with binlift	Standard RCV green with binlift		Standard RCV residual with binlift
Notes				

Table 48: Scenario 11 (Bio-Bin Organic Collection)

General Data	Data	Notes		
Population	242,266	Based on growth rate projections		
Households	87,869	Based on growth rate projections		
Total tonnes	83,534	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 49: Scenario 4 (5 Stream Recycling, with Monthly Paper Collection)

General Data	**Data**	**Notes**		
Population	242,266	Based on growth rate projections		
Households	87,869	Based on growth rate projections		
Total tonnes	83,534	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	94%	89%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Notes				
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift
Notes				

Table 50: Scenario 10 (5 waste stream, Weekly Dry Recycling with Separate Kitchen & Garden)

General Data	**Data**	**Notes**		
Population	242,266	Based on growth rate projections		
Households	87,869	Based on growth rate projections		
Total tonnes	83,534	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	94%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift

5.4 A1.4: The London Borough of Hillingdon

Table 51: Baseline

General Data	Data	Notes		
Population	246,500	Based on 2003/04 data		
Households	100,404	Based on 2003/04 data		
Residual tonnes	76,279	Based on 2003/04 data		
Recycling tonnes	2,576	Based on 2003/04 data		
Total tonnes	78,855	Based on 2003/04 data		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected Notes	Paper, card, plastic bottles, cans and foil	Garden	N/A	All except bulky, commercial, and clinical
Proportion of households served Notes	90%	94	N/A	100%
Frequency of collection Notes	Fortnightly	Fortnightly (not December)	N/A	Weekly
Container type Notes	Sacks	Re-Usable Sacks	N/A	Sacks
Vehicle type	Comingled recycling bags on residual RCV, no binlft	Standard RCV green, no binlift		Standard RCV residual, no binlift

Table 52: Scenario A (Weekly dry recycling & kitchen organics collection)

General Data	Data	Notes		
Population	261,007	Based on future projections		
Households	103,367	Based on future projections		
Total tonnes	82,766	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, glass, textiles, cans	Garden	Kitchen	All except bulky, commercial, and clinical
Proportion of households served Notes	100%	94%	94%	100%
Frequency of collection Notes	Weekly	Fortnightly, except December	Weekly	Weekly
Container type	44 litre box	Eco sack	35 litre bucket, kitchen caddy & bags	Sack
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Single operative food waste vehicle	Standard RCV green, no binlift

Table 53: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	261,007	Based on future projections		
Households	103,367	Based on future projections		
Total tonnes	82,766	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Plastic bottles, glass, cans and foil	Paper	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	90%	100%	100%	100%
Notes				
Frequency of collection	Fortnightly	Monthly	Fortnightly, for 9 months	Weekly
Notes				
Container type	Sack	120 litre wheeled bin	Eco Sack	Sack
Notes				
Vehicle type	Comingled recycling bags on residual	Standard RCV dry recyclable, with binlift	Standard RCV green, no binlift	Standard RCV residual, no binlift
Notes				

Table 54: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	261,007	Based on future projections		
Households	103,367	Based on future projections		
Total tonnes	82,766	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic bottles, glass, cans	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	87%	100%		100%
Notes				
Frequency of collection	Fortnightly	Fortnightly, for 9 months	N/A	Weekly
Notes				
Container type	Sack	240 litre wheeled bin		Sack
Notes				
Vehicle type	Comingled recycling bags on residual	Standard RCV dry recyclable, with binlift		Standard RCV residual, no binlift
Notes				

Table 55: Scenario 6 (Sack Based System)

General Data	Data	Notes		
Population	287,108	Based on future projections		
Households	107,603	Based on future projections		
Total tonnes	89,720	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastics, textiles, glass, cans.	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	94%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, 9 months.	Fortnightly
Notes				
Container type	Sacks	35l Bucket, Kitchen Caddy & Bags	Re-Usable Sacks	Sacks
Notes				
Vehicle type	Standard RCV dry recyclable, no bin lift.	Single operative food-waste vehicle.	Standard RCV, green, no bin lift.	Standard RCV residual, no bin lift.
Notes				

Table 56: Scenario 2 (All Wheeled Bin)

General Data	Data	Notes		
Population	287,108	Based on future projections		
Households	107,603	Based on future projections		
Total tonnes	89,720	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		180 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling, with binlift	Standard RCV green, with binlift		Standard RCV residual, with binlift
Notes				

Table 57: Scenario 4 (5 Stream Collection, with Monthly Paper Collection)

General Data	**Data**	**Notes**		
Population	287,108	Based on future projections		
Households	107,603	Based on future projections		
Total tonnes	89,720	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	94%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift
Notes				

Table 58: Scenario 11 (Bio-Bin Organic Collection)

General Data	**Data**	**Notes**		
Population	287,108	Based on future projections		
Households	107,603	Based on future projections		
Total tonnes	89,720	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 59: Scenario 10 (5 waste stream, Weekly Dry Recycling with Separate Kitchen & Garden)

General Data	Data	Notes		
Population	287,108	Based on future projections		
Households	107,603	Based on future projections		
Total tonnes	89,720	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Proportion of households served	100%	89%	94%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Notes				
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift

5.5 A1.5: The London Borough Of Hounslow

Table 60: Baseline

General Data	Data	Notes		
Population	212,668	Based on 2003/04 data		
Households	88,327	Based on 2003/04 data		
Residual tonnes	58,808	Based on 2003/04 data		
Recycling tonnes	9,749	Based on 2003/04 data		
Total tonnes	68,557	Based on 2003/04 data		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, textiles, glass, cans, foil, some oil and batteries	Garden	N/A	All except bulky, commercial, and clinical
Proportion of households served	100	100	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Weekly
Notes				
Container type	44 litre Box	Eco Sacks		Sacks
Notes				
Vehicle type	Standard RCV green, no binlift	Standard RCV green, no binlift		Standard RCV residual, no binlift
Notes				

Table 61: Scenario A (Weekly Dry Recycling & Kitchen Organics Collection)

General Data	Data	Notes		
Population	225,184	Based on future projections		
Households	90,934	Based on future projections		
Total tonnes	71,957	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, textiles, glass, cans	Garden	Kitchen	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	91%	100%
Notes				
Frequency of collection	Weekly	Fortnightly	Weekly	Weekly
Notes				
Container type	44 litre Box	Eco sack	35 litre bucket with kitchen caddy and bags	Sack
Vehicle type	Demountable stillage vehicle	RCV standard, green, no binlift	Single operative food waste vehicle	RCV standard, residual, with binlift

Table 62: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	225,184	Based on future projections		
Households	90,934	Based on future projections		
Total tonnes	71,957	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans	Garden	Paper, card	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	100%	100%
Notes				
Frequency of collection	Weekly	Fortnightly, for 9 months	Monthly	Weekly
Notes				
Container type	44 litre Box	Eco sack	120 litre wheeled bin	Sack
Notes				
Vehicle type	Demountable stillage vehicle	RCV standard, green, no binlift	RCV standard, dry recyclable, with binlift	RCV standard, residual no binlift
Notes				

Table 63: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	225,184	Based on future projections		
Households	90,934	Based on future projections		
Total tonnes	71,957	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans, paper, card	Garden	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly, for 9 months		Weekly
Notes				
Container type	44 litre Box	240 litre wheeled bin		Sack
Notes				
Vehicle type	Demountable stillage vehicle	RCV standard, green, with binlift		RCV standard, residual no binlift
Notes				

Table 64: Scenario 4 – (5 Stream Collection, with Monthly Paper Collection)

General Data	Data	Notes		
Population	247,703	Based on future projections		
Households	94,660	Based on future projections		
Total tonnes	78,003	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	91%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Notes				
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift

Table 65: Scenario 2 (All Wheeled Bin)

General Data	Data	Notes		
Population	247,703	Based on future projections		
Households	94,660	Based on future projections		
Total tonnes	78,003	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen & Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		180 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling with binlift	Standard RCV green with binlift		Standard RCV residual with binlift

Table 66: Scenario 6 (Sack Based System)

General Data	Data	Notes		
Population	247,703	Based on future projections		
Households	94,660	Based on future projections		
Total tonnes	78,003	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastics, textiles, glass, cans.	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	90%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, 9 months.	Fortnightly
Notes				
Container type	Sacks	35l Bucket, Kitchen Caddy & Bags	Re-Usable PP Sacks	Sacks
Notes				
Vehicle type	Standard RCV dry recyclable, no bin lift.	Single operative food-waste vehicle.	Standard RCV, green, no bin lift.	Standard RCV residual, no bin lift.
Notes				

Table 67: Scenario 11 (Bio-Bin Organic Collection)

General Data	Data	Notes		
Population	247,703	Based on future projections		
Households	94,660	Based on future projections		
Total tonnes	78,003	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 68: Scenario 10 (5 Waste Stream, Weekly Dry Recycling with Separate Kitchen & Garden)

General Data	Data	Notes		
Population	247,703	Based on future projections		
Households	94,660	Based on future projections		
Total tonnes	78,003	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	91%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Notes				
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift
Notes				

5.6 A1.6: The London Borough Of Richmond Upon Thames

Table 69: Baseline

General Data	Data	Notes		
Population	195,000	Based on 2003/04		
Households	78,000	Based on 2003/04		
Residual tonnes	56,240	Based on 2003/04		
Recycling tonnes	7,852	Based on 2003/04		
Total tonnes	64,092	Based on 2003/04		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden, user pays	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	80%	100%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly	N/A	Weekly
Notes				
Container type	44 litre Box	Sacks		Sacks
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift		Standard RCV residual, no binlift

Table 70: Scenario A (Weekly Dry Recycling & Kitchen Organics Collection)

General data	data	notes		
Population	206,476	Based on future projections		
Households	80,302	Based on future projections		
Total tonnes	67,271	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden	Kitchen	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	91%	100%
Notes				
Frequency of collection	Weekly	Fortnightly, for 6 months	Weekly	Weekly
Notes				
Container type	44 litre Box	Sack	35 litre bucket with kitchen caddy and bags	Sack
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, no binlift	Single operative food waste vehicle	Standard RCV residual, no binlift
Notes				

Table 71: Scenario B (Monthly Paper Collection)

General Data	Data	Notes		
Population	206,476	Based on future projections		
Households	80,302	Based on future projections		
Total tonnes	67,271	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Textiles, glass, cans	Garden	Paper	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	100%	100%	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 6 months	Monthly	Weekly
Notes				
Container type	44 litre Box	Sack	120 litre wheeled bin	Sack
Notes				
Vehicle type	Demountable stillage vehilce	Standard RCV green, no binlift	Standard RCV dry recyclable, with binlift	Standard RCV residual, no binlift
Notes				

Table 72: Scenario C (Free Garden Waste Collection)

General Data	Data	Notes		
Population	206,476	Based on future projections		
Households	80,302	Based on future projections		
Total tonnes	67,271	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, textiles, glass, cans	Garden, user pays	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	80%	100%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Fortnightly for 9 months	N/A	Weekly
Notes				
Container type	44 litre Box	240 litre wheeled bin		Sacks
Notes				
Vehicle type	Demountable stillage vehicle	Standard RCV green, with binlift		Standard RCV residual, no binlift
Notes				

Table 73: Scenario 4 (5 Waste Stream Collection, with Monthly Paper Collection)

General Data	**Data**	**Notes**		
Population	227,124	Based on future projections		
Households	83,592	Based on future projections		
Total tonnes	72,923	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Kitchen plastic, textiles, glass, cans, foil	Paper and card	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	91%	100%
Notes				
Frequency of collection	Weekly	Monthly	Seasonal for 6 months	Fortnighty
Notes				
Container type	44 litre Box, 35 litre bucket with kitchen caddy and bags.	120 Litre Wheeled bin	Reusable PP Sack	Sack
Notes				
Vehicle type	De-mountable stillage vehicle	Standard RCV dry recyclables with bin lift	Standard RCV, green, no bin lift	Standard RCV residual with no bin lift
Notes				

Table 74: Scenario 2 (All Wheeled Bin)

General Data	**Data**	**Notes**		
Population	227,124	Based on future projections		
Households	83,592	Based on future projections		
Total tonnes	72,923	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastic, textiles, glass, cans, foil	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Fortnightly	Weekly	N/A	Fortnightly
Notes				
Container type	180 Litre Wheeled Bin	120 Litre Wheeled Bin & Kitchen Caddy & Bags		180 Litre Wheeled Bin
Notes				
Vehicle type	Standard RCV dry recycling, with binlift	Standard RCV green, with binlift		Standard RCV residual, with binlift
Notes				

Table 75: Scenario 6 (Sack Based System)

General Data	Data	Notes		
Population	227,124	Based on future projections		
Households	83,592	Based on future projections		
Total tonnes	72,923	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, card, plastics, textiles, glass, cans.	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	90%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, 9 months.	Fortnightly
Notes				
Container type	Sacks	35l Bucket, Kitchen Caddy & Bags	Re-Usable Sacks	Sacks
Vehicle type	Standard RCV dry recyclable, no bin lift.	Single operative food-waste vehicle.	Standard RCV, green, no bin lift.	Standard RCV residual, no bin lift.
Notes				

Table 76: Scenario 11 (Bio-Bin Organic Collection)

General Data	Data	Notes		
Population	227,124	Based on future projections		
Households	83,592	Based on future projections		
Total tonnes	72,923	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, all plastics, textiles, glass, cans	Kitchen, Garden & Card	N/A	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	N/A	100%
Notes				
Frequency of collection	Weekly	Fortnightly	N/A	Fortnightly
Notes				
Container type	Sack	120 Litre Bio-bin Wheeled bin		180 Litre Wheeled bin
Notes				
Vehicle type	Standard RCV, dry recycling, no bin lift	Standard RCV, green with bin lift		Standard RCV residual with binlift
Notes				

Table 77: Scenario 10 (5 Waste Stream, Weekly Dry Recycling with Separate Kitchen & Garden)

General Data	**Data**	**Notes**		
Population	227,124	Based on future projections		
Households	83,592	Based on future projections		
Total tonnes	72,923	Adjusted data based on actual tonnages		
System data	**System 1**	**System 2**	**System 3**	**System 4**
Materials collected	Paper, plastics, textiles, glass, cans, foil	Kitchen	Garden	All except bulky, commercial, and clinical
Notes				
Proportion of households served	100%	89%	91%	100%
Notes				
Frequency of collection	Weekly	Weekly	Fortnightly, for six months	Fortnightly
Notes				
Container type	44 Litre Box With Reusable Bag for Paper	35 Litre Bucket with Kitchen Caddy & Bags	Reusable PP sack	180 Litre Wheeled bin
Notes				
Vehicle type	De-mountable stillage vehicle	Single operative food-waste vehicle	Standard RCV, green, no bin lifts.	Standard RCV residual with bin lift
Notes				

Annex 2: Waste Composition Data Used

All figures are in percentages.

Borough	Brent	Ealing	Harrow	Hillingdon*	Hounslow**	Richmond
Recyclable paper	20.21	16.8	17.8	13.90	18.68	19.92
Card	6.17	7.1	6.5	4.90	5.77	3.29
Non recyclable paper	5.91	5.7	6	3.90	5.49	4.37
Plastic bottles	2.50	2.3	2.6	2.10	2.60	3.00
Other plastic	3.19	3.5	2.8	2.70	3.33	3.84
Plastic Film	5.11	3.8	1.7	4.00	4.11	5.83
Textiles	3.06	5.9	2.4	3.20	3.25	1.65
Glass bottles	6.20	9	6.7	7.90	6.94	5.86
Other glass	0.55	0.4	0.3	0.50	0.59	1.1
Ferrous cans	2.16	2	1.9	2.56	1.81	1.18
Non ferrous cans	0.86	0.8	0.6	0.84	0.71	0.55
Other ferrous	0	0.4	0.0	2.90	0.31	0.82
Other Non Ferrous	0	0.4	0.3	0.00	0.29	0.45
Kitchen	21.57	24.1	24.4	22.20	24.02	26.02
Green garden waste	7.57	4.8	17.6	15.30	9.06	6.26
Miscellaneous	14.92	13	8.4	12.90	12.86	15.11

*Data from a national data set produced for WRAP in 2002.

** Derived from composition for Brent, Ealing, Harrow and Richmond.

Annex 3: Options Criteria Analysis

The tables below show the results of the options criteria analysis for each borough. The first table for each borough shows the results of the analysis, which was calculated from the scores in the tables below multiplied by the weighting factor. The analysis was performed separately on the mid term scenarios (A, B, C (and A1 and A2 for Harrow)) and the long term scenarios (1, 2, 4, 6, 10, 11), however, for presentation purposes, the results are shown in the same table.

Brent

Weighting		Brent A	Brent B	Brent C	Brent 1	Brent 2	Brent 4	Bre 10	Bre 11
3	Cost/HH	2.70	3.00	2.85	2.86	2.51	3.00	2.98	2.47
2	Recycling rate	2.00	1.57	1.31	1.74	1.90	2.00	1.43	1.80
1	Arisings	0.98	1.00	0.84	1.00	0.88	1.00	1.00	0.87
2	Biowaste diversion	2.00	1.59	1.39	1.62	1.79	2.00	1.28	1.63
2	Fit with long term	1.83	1.83	1.50					
	Material Targeted	1.00	1.00	1.00					
	Container Type	0.75	0.75	0.75					
	Confusion	1.00	1.00	0.50					
	Total	9.51	8.99	7.88	7.22	7.07	8.00	6.69	6.77

Scenario	Cost (£)	Score
A	128.97	0.9
B	117.23	1
C	123.28	0.95
1	125.73	0.95
2	139.8	0.84
4	120.16	1
10	120.98	0.99
11	141.39	0.82

Scenario	Recycling Rate	Score
A	16.60%	1
B	13.00%	0.79
C	10.80%	0.65
1	36.80%	0.87
2	40.20%	0.95
4	42.40%	1
10	30.20%	0.71
11	38.20%	0.9

Scenario	Arisings Growth	Score
A	0.50%	0.98
B	0.00%	1
C	4.90%	0.84
1	0.00%	1
2	3.70%	0.88
4	0.00%	1
10	0.00%	1
11	3.90%	0.87

Scenario	Biowaste Diversion	Score
A	19.20%	1
B	15.20%	0.79
C	13.40%	0.7
1	39.10%	0.81
2	43.20%	0.9
4	48.30%	1
10	30.90%	0.64
11	39.20%	0.81

Ealing

Weighting		Ealing A	Ealing B	Ealing C	Ealing 2	Ealing 4	Ealing 6	Ealing 10	Ealing 11
3	Cost/HH	2.86	2.78	3	2.45	3	2.41	2.91	2.45
2	Recycling rate	2	1.72	1.71	1.87	2	1.93	1.43	1.73
1	Arisings	1	1	0.9	0.92	1	0.92	1	0.92
2	Biowaste diversion	2	1.45	1.69	1.74	2	1.77	1.26	1.53
2	Fit with long term	1.83	2	1.5					
	Material Targeted	1	1	1					
	Container Type	0.75	1	0.75					
	Confusion	1	1	0.5					
	Total	9.69	8.94	8.8	6.98	8	7.03	6.6	6.63

Scenario	Cost (£)	Score
A	111.77	0.95
B	114.68	0.93
C	106.79	1
2	121.92	0.82
4	103.1	1
6	123.45	0.8
10	106.28	0.97
11	122.08	0.82

Scenario	Biowaste Diversion	Score
A	17.40%	1
B	12.60%	0.72
C	14.70%	0.85
2	42.80%	0.87
4	49.10%	1
6	43.30%	0.88
10	30.90%	0.63
11	37.70%	0.77

Scenario	Recycling Rate	Score
A	15.60%	1
B	13.40%	0.86
C	13.30%	0.85
2	40.90%	0.93
4	43.80%	1
6	42.40%	0.97
10	31.40%	0.72
11	38.00%	0.87
1	0.00%	1
2	3.70%	0.88
4	0.00%	1
10	0.00%	1
11	3.90%	0.87

Scenario	Arisings Growth	Score
A	0%	1
B	0%	1
C	3%	0.9
2	2%	0.92
4	0%	1
6	2%	0.92
10	0%	1
11	3%	0.92
1	39.10%	0.81
2	43.20%	0.9
4	48.30%	1
10	30.90%	0.64
11	39.20%	0.81

Figure 21: Harrow

Weighting		Har A	Har A1	Har A2	Har B	Har C	1	2	4	10	11
3	Cost/HH	2.67	2.63	2.77	2.99	3.00	2.84	2.30	2.95	3.00	2.30
2	Recycling rate	2.00	1.94	1.41	1.51	1.85	1.61	2.00	1.90	1.39	1.87
1	Arisings	0.78	0.78	0.77	1.00	0.67	1.00	0.77	1.00	1.00	0.76
2	Biowaste diversion	1.90	1.92	1.26	1.43	2.00	1.54	2.00	1.89	1.28	1.82
2	Fit with long term	1.67	1.50	1.50	1.83	1.33					
	Material Targeted	1.00	1.00	1.00	1.00	1.00					
	Container Type	0.50	0.50	0.50	0.75	0.50					
	Confusion	1.00	0.75	0.75	1.00	0.50					
	Total	9.02	8.78	7.72	8.77	8.86	6.98	7.07	7.75	6.67	6.74

Scenario	Cost	Score
A	127.17	0.89
A1	128.42	0.88
A2	123.09	0.92
B	114.74	1
C	114.47	1
1	122.17	0.95
2	142.89	0.77
4	117.61	0.98
10	115.85	1
11	143.03	0.77

Scenario	Arisings Growth	Score
A	6%	0.78
A1	7%	0.78
A2	7%	0.77
B	0%	1
C	10%	0.67
1	0%	1
2	7%	0.77
4	0%	1
10	0%	1
11	7%	0.76

Scenario	Recycling Rate	Score
A	19.80%	1
A1	19.20%	0.97
A2	14.00%	0.71
B	14.90%	0.75
C	18.30%	0.93
1	39.50%	0.8
2	49.10%	1
4	46.70%	0.95
10	34.10%	0.69
11	45.90%	0.93
11	3.90%	0.87

Scenario	Biowaste Diversion	Score
A	20%	0.95
A1	20%	0.96
A2	13%	0.63
B	15%	0.72
C	21%	1
1	40%	0.77
2	52%	1
4	49%	0.95
10	33%	0.64
11	47%	0.91
11	39.20%	0.81

Figure 22: Hillingdon

Weighting	Criteria	Hillingd'n A	Hillingdon B	Hillingdon C	2	4	6	10	11
3	Cost/HH	2.96	3	2.95	2.4	2.92	2.46	3	2.34
2	Recycling rate	1.96	1.44	2	1.97	1.82	2	1.38	1.84
1	Arisings	0.87	0.94	0.71	0.78	1	0.79	1	0.77
2	Biowaste diversion	1.92	1.24	2	2	1.86	1.89	1.29	1.79
2	Fit with long term	2	1.83	1.5					
	Material Targeted	1	1	1					
	Container Type	1	0.75	0.75					
	Confusion	1	1	0.5					
	Total	9.72	8.46	9.17	7.15	7.6	7.14	6.67	6.75

Scenario	Cost	Score
A	113.11	0.99
B	111.71	1
C	113.51	0.98
2	130.24	0.8
4	111.37	0.97
6	127.79	0.82
10	108.39	1
11	132.13	0.78

Scenario	Arisings Growth	Score
A	4%	0.87
B	2%	0.94
C	9%	0.71
2	6%	0.78
4	0%	1
6	6%	0.79
10	0%	1
11	7%	0.77

Scenario	Recycling Rate	Score
A	20.10%	0.98
B	14.80%	0.72
C	20.50%	1
2	46.60%	0.98
4	43.20%	0.91
6	47.40%	1
10	32.80%	0.69
11	43.60%	0.92
2	49.10%	1
4	46.70%	0.95
10	34.10%	0.69
11	45.90%	0.93
11	3.90%	0.87

Scenario	Biowaste Diversion	Score
A	23.00%	0.96
B	14.90%	0.62
C	23.90%	1
2	52.30%	1
4	48.70%	0.93
6	49.50%	0.95
10	33.70%	0.64
11	46.90%	0.9
2	52%	1
4	49%	0.95
10	33%	0.64
11	47%	0.91
11	39.20%	0.81

Figure 23: Hounslow

Weighting	Criteria	Hounslow A	Hounslow B	Hounslow C	2	4	6	10	11
3	Cost/HH	2.95	3	2.98	2.5	3	2.5	2.97	2.54
2	Recycling rate	1.95	1.93	2	1.93	1.97	2	1.43	1.8
1	Arisings	1	1	0.82	0.86	1	0.86	1	0.85
2	Biowaste diversion	2	1.82	2.01	1.88	2	1.86	1.32	1.67
2	Fit with long term	2	2	1.5					
	Material Targeted	1	1	1					
	Container Type	1	1	0.75					
	Confusion	1	1	0.5					
	Total	9.9	9.75	9.31	7.17	7.97	7.23	6.72	6.86

Scenario	Cost	Score
A	110.08	0.98
B	108.25	1
C	108.82	0.99
2	124.37	0.83
4	106.67	1
6	124.44	0.83
10	107.69	0.99
11	123.04	0.85

Scenario	Arisings Growth	Score
A	0%	1
B	0%	1
C	5%	0.82
2	4%	0.86
4	0%	1
6	4%	0.86
10	0%	1
11	5%	0.85

Scenario	Recycling Rate	Score
A	17.60%	0.97
B	17.40%	0.96
C	18.00%	1
2	43.00%	0.96
4	43.90%	0.99
6	44.50%	1
10	31.90%	0.72
11	40.00%	0.9
11	45.90%	0.93
11	3.90%	0.87

Scenario	Biowaste Diversion	Score
A	20.50%	1
B	18.70%	0.91
C	20.60%	1
2	46.30%	0.94
4	49.20%	1
6	45.90%	0.93
10	32.50%	0.66
11	41.20%	0.84
11	47%	0.91
11	39.20%	0.81

Figure 24: Richmond

Weighting	Criteria	Richmond A	Richmond B	Richmond C	2	4	6	10	11
3	Cost/HH	2.72	2.91	3	2.58	3	2.53	2.96	2.54
2	Recycling rate	2	1.47	1.66	1.87	1.96	2	1.47	1.73
1	Arisings	1	1	0.87	0.9	1	0.91	1	0.89
2	Biowaste diversion	2	1.25	1.62	1.8	2	1.86	1.37	1.56
2	Fit with long term	2	2	1.5					
	Material targeted	1	1	1					
	Container type	1	1	0.75					
	Confusion	1	1	0.5					
	Total	9.72	8.63	8.65	7.16	7.96	7.3	6.8	6.73

Scenario	Cost	Score
A	113.81	0.91
B	107.2	0.97
C	104.19	1
2	128.86	0.86
4	113.2	1
6	130.83	0.84
10	114.64	0.99
11	130.68	0.85

Scenario	Arisings Growth	Score
A	0%	1
B	0%	1
C	4%	0.87
2	3%	0.9
4	0%	1
6	3%	0.91
10	0%	1
11	3%	0.89

Scenario	Recycling Rate	Score
A	18.70%	1
B	13.70%	0.73
C	15.50%	0.83
2	41.80%	0.94
4	43.70%	0.98
6	44.60%	1
10	32.70%	0.73
11	38.70%	0.87
11	45.90%	0.93
11	3.90%	0.87

Scenario	Biowaste Diversion	Score
A	22.60%	1
B	14.10%	0.63
C	18.30%	0.81
2	46.00%	0.9
4	51.10%	1
6	47.50%	0.93
10	35.10%	0.69
11	40.00%	0.78
11	47%	0.91
11	39.20%	0.81

Annex 4: Commodity Prices Used

The tables below show the commodity prices that were used in the model. The prices for the base cases, mid and long term scenarios are shown. It has been assumed that for the intermediate years, the commodity prices have remained the same. This is with the exception of residual waste, where the landfill tax escalator has been included, and gate fees have been assumed to increase. For the long term scenario 4, the prices for paper and card have been adjusted since mixed paper and card commands a lower price than paper alone, and in scenario 4, paper and card are co-mingled. For the long term scenarios 1, 2, 6 & 11, these are co-mingled based dry recycling systems which go to a materials recycling facility (MRF). Prices have been adjusted downwards for paper and textiles owing to the potential for glass contamination. However, the prices for plastic have been increased, since the MRF will enable separation of plastics and therefore enable a higher price to be gained overall. In scenario 2 garden and kitchen waste are collected together; and in 11 and Harrow mid term A1, kitchen waste, garden waste and card is collected together. Where any material is collected with kitchen waste, all materials must go to in-vessel composting for recovery, and pay the same price (assumed to be £50 per tonne).

Table 78: Commodity Prices for Base Case, Mid Term & Long Term Scenarios

Commodity	Base Case*	Mid Term**	Long Term 1	Long Term 2	Long Term 4	Long Term 6	Long Term 10	Long Term 11
Paper	35	35	30	30	25	30	35	30
Cardboard	10	10	10	10	-	10	10	-50
Plastic bottles	50	50	120	120	50	120	50	120
Plastic Film	150	150	150	150	150	150	150	150
Textiles	30	30	25	25	30	25	30	25
Glass bottles	11	11	11	11	11	11	11	11
Other glass	11	11	11	11	11	11	11	11
Steel cans	75	75	75	75	75	75	75	75
Alu cans	650	650	650	650	650	650	650	650
Lead-acid batt's	25	25	25	25	25	25	25	25
Kitchen	- 50	- 50	- 50	- 50	- 50	- 50	- 50	- 50
Garden	- 20	- 20	- 20	- 50	- 20	- 20	- 20	- 50
Landfill tax	- 15	- 30	- 33	- 33	- 33	- 33	- 33	- 33
Landfill gate fee	- 30	- 32	- 35	- 35	- 35	- 35	- 35	- 35

* applies to all except Harrow, where card is priced -£20 since it is collected with garden waste and so the prices for garden and card are the same.

** applies to all except Harrow, where card is priced -£20 for A and A2 since it is collected with garden waste and so the prices for garden and card are the same. For A1 the price of card and garden waste drops to -£50 as kitchen waste, garden waste and card are all collected together; and so all have to be treated via in-vessel composting

Technical Report 3

Assessment of Options for Residual Waste Management

CONTENTS

1 ASSESSMENT OF OPTIONS FOR RESIDUAL WASTE MANAGEMENT

1.1 INTRODUCTION

This report presents the background, methodology and outcomes of a series of assessments of options for the management of residual municipal solid waste (MSW) (1) arising in the constituent Boroughs of the West London Waste Authority (WLWA).

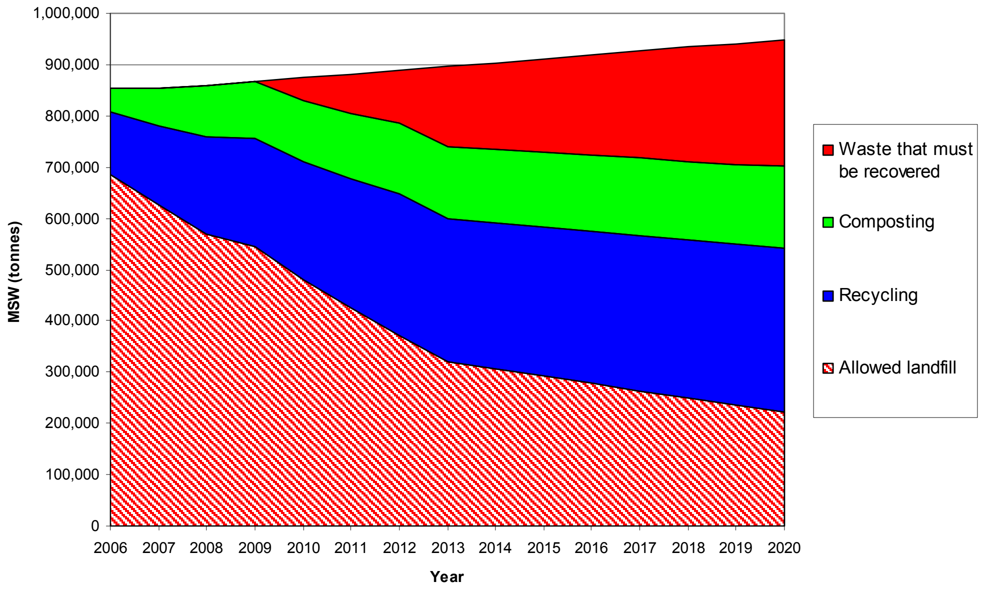
Separate modelling exercises have been carried out to investigate the extent to which waste minimisation and recycling and composting can contribute to WLWA's statutory targets. Through these it was recognised that, even with a high rate of recycling and composting, reaching 50% of MSW in 2020, significant additional efforts will be needed to divert further biodegradable municipal waste (BMW) from landfill, in order to meet the requirements of the Landfill Directive.

The Landfill Directive contains national targets aimed at reducing the amount of BMW disposed to landfill. To ensure that the UK meets these targets, the Government has set BMW disposal allowances for each waste disposal authority. These are controlled by provisions made under the Waste and Emissions Trading Act 2003 and have a direct impact on WLWA's Strategy for management of BMW. The Act provides a framework for the Landfill Allowance Trading Scheme (LATS), a system whereby tradable landfill allowances will be allocated to waste disposal authorities each year. Government has indicated that a fine of £150 per tonne of excess BMW landfilled is likely to be levied if local authorities do not have sufficient permits to cover the waste they landfill.

Figure 1.1 shows that, assuming the optimal rate of recycling and composting is achieved, the recovery of additional residual waste will become a requirement from 2009 onwards, in order to comply with LATS allowances.

(1) Municipal solid waste (MSW) includes all household waste, as well as other waste streams such as trade wastes, fly-tipped materials and abandoned vehicles. 'Residual' MSW refers to the waste that remains following the separation of materials for recycling and composting, by kerbside, civic amenity or bring bank collections.

Figure 1.1 Residual Waste Management Requirements



An assessment of the possible options that are available to address this need was carried out in two separate stages:

1. **Assessment of Alternative Technology Options.** In order to carry out a balanced assessment of the technologies available for managing residual MSW, it was necessary to place them on a common scale for comparison. WLWA's current waste management contract runs until 2008, at which point a new contract will be let. The technologies being assessed have different lead times, with an Energy from Waste (EfW) facility likely to require the longest period, of between 4.5 - 8 years (1). In the light of this, the assessment of technology options considered the implications of introducing new facilities in 2013 and addressed the associated costs and benefits of managing residual waste arisings between 2013 and 2020 (2). The aim of this first stage of the assessment process was therefore to determine the technology option/s that best meet WLWA's need to manage residual waste, irrespective of when it might be brought on line.

2. **Assessment of Integrated Options for Residual Waste Management**. The outcome of the first assessment stage was used as a basis to develop appropriate integrated options for the management of residual waste across the entire Strategy period (2005 to 2020). The appraisal of these options formed the second stage of the assessment process.

(1) Annex F, Strategy Unit Report – Delivering the Landfill Directive: The role of new and emerging technologies. 2002
(2) This endpoint is in line with the scope of the Joint Municipal Waste Management Strategy (JMWMS) and ensures the WLWA's need to meet its compulsory target to divert Biodegradable Municipal Waste (BMW) from landfill in 2020, under Article 5 of the Landfill Directive.

1.2 *ASSESSMENT METHODOLOGY*

The same seven-step methodological approach was used to carry out each of the two assessment stages.

1. set the overall aim of the assessment, subsidiary objectives and the criteria against which the performance of different options will be measured;

2. identify all the viable options;

3. assess the performance of these options against the criteria;

4. value performance;

5. balance the different objectives or criteria against one another;

6. evaluate and rank the different options; and

7. analyse how sensitive the results are to variations in the assumptions made or the data used.

This approach provides a rational basis for balancing objectives and determining the best environmental option, whilst taking account of what is feasible and what is an acceptable cost. It is also in line with the procedure set out in *Waste Strategy 2000* for assessing the Best Practicable Environmental Option (BPEO).

Step 1 of the approach is common to both stages of the assessment process and is described once, in the following sub-section. The remaining steps, 2-7, vary between the two assessment stages and, for clarity, the method and results are presented separately, in *Sections 2* and *3*.

1.3 *STEP 1: AIM AND ASSESSMENT CRITERIA*

1.3.1 *Aim*

The overall assessment was strategic in its approach, rather than site-specific, and consequently its aim was to identify the type/s of technology that may best meet the need to manage WLWA's residual MSW over time. Neither stage of the assessment addressed site-specific issues associated with individual locations, and so cannot justify the selection of particular sites for individual facilities.

Arisings of MSW across the Authority were approximately 839 427 tonnes in 2003/04.

To account for the timescale required for WLWA to let a new waste management contract, and for a new facility to be commissioned, the first stage of the assessment assumed that major new facilities will be introduced in 2013 (and in subsequent years, where appropriate) and addressed the management of wastes arising between 2013 and 2020 only.

To ensure that the need to meet relevant LATS targets was covered, the second stage of the assessment addressed the management of wastes arising between 2005 and 2020.

1.3.2 Objectives and Performance Criteria

The assessment procedure requires that the performance of alternative options is assessed against key objectives, reflected through a range of criteria, in order to identify the option/s, that perform best overall. As well as environmental criteria, regard was also given to technology and financial costs, in order to ensure that proposals are practicable.

The Office of the Deputy Prime Minister's (ODPM) guidance on *Strategic Planning for Sustainable Waste Management* (1) was used as the basis for criteria selection, with some modifications resulting from feedback gained at the first WLWA and Constituent Boroughs Waste Forum, held on 18th January 2005. As a result of consultation at the Waste Forum, it was considered that the following criteria were of less importance and so were not used in the assessment:

- employment;
- visual impact; and
- local amenity.

The selected criteria also reflect the Sustainability Criteria developed by the Mayor in the London Plan(2) and that are likely to be used in drafting Sub-Regional Development Frameworks, local development plan documents, and when considering planning applications.

(1) Strategic Planning for Sustainable Waste Management '*Guidance on Option Development and Appraisal*'. ODPM October 2002. Section 2, Page 20.
(2) London Plan (2004), Policy 2A.1 Sustainability criteria

1.3.3 *Final List of Appraisal Criteria*

The list of criteria used in the assessment is given in *Table 1.1*.

Table 1.1 *Appraisal Criteria*

Appraisal Criterion	
Environmental	Practicability/Social
Resource depletion	Landtake
Air pollution (acidification)	Cost
Greenhouse gas emissions (climate change)	Reliability of delivery (likelihood of implementation & flexibility of contractual arrangements)
Emissions which are injurious to public health	Liability of end product
Extent of water pollution	Compliance with policy
Transport: distance and mode	

1.4 *OPTION DEVELOPMENT*

A series of key modelling assumptions were considered during the development and assessment of options for residual waste management. These are:

- waste growth;
- recycling and composting rates;
- waste treatment technologies;
- waste composition; and
- option constraints.

1.4.1 *Waste Growth*

The growth rate for MSW production assumed in this assessment is based on the average growth rate experienced across WLWA between 2000/01 and 2003/04 [1]. This equates to a year-on-year increase in MSW arisings of 0.8%. This rate is significantly below rates that are commonly cited for MSW growth and reflects a baseline level of waste minimisation that is expected to occur across the Authority. The implications of further waste minimisation being achieved will be addressed during sensitivity analyses.

1.4.2 *Recycling and Composting*

A separate modelling exercise was conducted to determine the potential impact that kerbside and civic amenity (CA)/bring site collection systems could make to the achievement of statutory recycling and composting targets and Landfill Directive targets (through the Landfill Allowance Trading Scheme (LATS)). The exercise was carried out in conjunction with the WLWA constituent Boroughs and focused on designing a system that increased the source separation of materials for recycling and composting to a degree which

(1) Further details regarding the prediction of growth can be found in *Technical Report 1*

goes far beyond that envisaged in the short term. Resulting recycling and composting rates reach 50% in 2020. Full details regarding the methodology and outcomes of the exercise can be found in *Technical Report 3*.

1.4.3 *Waste Treatment Technologies*

A brief explanation of the main technologies being considered for residual waste treatment, beyond recycling and composting, is given in *Table 1.2*.

Mechanical Biological Treatment (MBT) Considerations

There is currently some uncertainty as to the level of performance that can be achieved by MBT, with regard to the loss of biodegradability resulting from the process. The Environment Agency is currently carrying out a consultation process, focusing on how bio-treated outputs from MBT will contribute to LATS diversion targets (1). Until this has been clarified, it is difficult to determine, with certainty, how this will impact on performance.

A 6% loss of BMW through MBT processing was modelled during the assessment. This was used as a worst case scenario as it was assumed that the MBT plant would be configured to maximise the drying of waste to produce a Refuse Derived Fuel (RDF) for combustion. A scenario was also developed to test the sensitivity of this assumption, by assessing the consequences of a failed RDF market. In this case, it was assumed that the MBT plant would be configured to reduce further the biodegradable content of the output to landfill and a 38% loss in BMW was assumed.

Full details of the assumptions made concerning technologies are provided in *Annex A*.

(1) Assessing the diversion of biodegradable municipal waste from landfill by mechanical biological treatment and other options, Environment Agency, November 2004.

Table 1.2 Brief Description of Waste Treatment Technologies

Technology	Description
Anaerobic Digestion (AD)	Anaerobic digestion is undertaken in conditions that encourage the natural breakdown of organic matter by bacteria in the absence of air. The process generates a biogas that is rich in methane and carbon dioxide, and that can be used as a source of renewable energy to meet on-site power and process heat requirements. Depending on the feedstock used, a digestate can also be produced, which may contain valuable nutrients. After a process of aeration and maturation it can often be used as compost. However, if it is not of a suitable standard, this will require disposal to landfill.
Mechanical Biological Treatment (MBT)	MBT systems involve a combination of the mechanical sorting of materials for recycling and the biological treatment of biodegradable material in residual waste. It is a treatment technology rather than disposal, producing residues that must be managed at other facilities. Systems can be configured in a number of ways to deliver different outcomes. The aim will be to maximise the diversion of recyclable materials and to stabilise compostable materials or to separate a refuse derived fuel (RDF). The majority of material entering an MBT facility will leave either as a 'stabilised' residue that requires landfill, or as an RDF that will require combustion in a power station, cement kiln, incinerator or other suitable facility in order to recover energy.
Autoclaving	Autoclaving sterilises residual waste through the application of high temperature steam and 'cooks' biodegradable material to produce a biomass fibre. This is a treatment technology rather than disposal, producing residues that must be managed at other facilities. The process cleans metals and aids separation of plastics and heavy fractions to assist recycling. The fibre material may find use as a secondary material, particularly in building products and packaging, or may be used as a fuel for co-firing. The fibre could also be composted to use in remediation applications.
Gasification	Waste is shredded to give an appropriate surface-to-volume ratio and metals are removed. The process is divided into a primary chamber, where the gasification of the solid fuel takes place, and a secondary gas combustion chamber. The primary chamber is fed with waste and primary air, and is heated by an oil-heated grate. The slag discharged from the end of the grate is cooled in a water-basin. After the combustible gases have left the primary chamber, secondary air and re-circulated flue gas are added to obtain the desired combustion profile. Exhaust gases are cleaned prior to their release to atmosphere.
Energy from Waste (EfW)	There are a number of EfW technologies available. These methods include moving grate incineration, fluidised bed and rotary kiln incineration, pyrolysis and gasification. There are many operating conventional moving grate incinerators in the UK and Europe. There are a smaller number of fluidised bed facilities, including the Dundee & Allington plant (under construction), and a rotary kiln facility in Grimsby. All of these technologies are designed to generate power, and often heat, through the combustion of waste or a synthetic fuel.

1.4.4 *Waste composition*

The waste compositions that were assumed during the assessment are shown in *Table 1.3* and *Table 1.4*.

Table 1.3 ***Civic Amenity Site Arisings***

Material	% of CA Arisings†
Paper	1.62%
Cardboard	2.70%
Non recyclable paper	0.48%
Recyclable plastic bottles	0.30%
Other dense plastic	0.30%
Plastic Film	0.30%
Textiles	1.10%
Glass bottles	1.9%
Other glass	0.9%
Steel cans	0.24%
Alu cans & foil	0.08%
Other ferrous	7.20%
Other non-ferrous	0.48%
kitchen	0.30%
garden	23.50%
Miscellaneous	24.00%
Timber	10.50%

† Based on composition typologies developed for Defra with Network Recycling, derived from National Assessment of CA Sites Project 2003/04.

Table 1.4 ***Other MSW Arisings*** [(1)]

Material	% of Other MSW Arisings†
Paper	17.88%
Cardboard	5.76%
Non recyclable paper	5.29%
Recyclable plastic bottles	2.49%
Other dense plastic	3.22%
Plastic Film	4.10%
Textiles	3.38%
Glass bottles	7.31%
Other glass	0.55%
Steel cans	1.97%
Alu cans & foil	0.74%
Other ferrous	0.71%
Other non-ferrous	0.23%
kitchen	23.57%
garden	9.88%

† Compositions for Brent, Ealing, Harrow and Hounslow derived from data supplied from their own survey results (adjusted to fit the single classification system used). Hillingdon's composition is based on UK data by Parfitt (2002) and Hounslow's was derived from an average of the 4 districts with their own data.

(1) Includes household collected waste, street sweepings, special collections etc

1.4.5 Option Constraints

Constraints were used to screen out 'non-starter' options from both of the assessment stages. This was a necessary initial step as there is little point in performing a detailed calculation of the impacts of an option that does not meet the Authority's needs.

During the initial sieve of options, the key constraint identified was that all options should deliver within the allowances provided under LATS, without the Authority needing to purchase additional allowances or incur penalties. There is little point in assessing an option such as a 'do nothing' scenario, essentially 16% recycling and composting, and 84% landfill for the next 20 years, as this will not achieve the above targets.

A WLWA and constituent Borough Waste Forum was held in March 2005 to discuss the proposed options. The technologies assessed, and the criteria against which options should be assessed, were agreed at the meeting.

2 *STAGE 1 - ASSESSMENT OF ALTERNATIVE TECHNOLOGY OPTIONS*

2.1 *STEP 2: IDENTIFY TECHNOLOGY OPTIONS*

Seven alternative technology options for the management of WLWA's residual waste were developed. All meet the Authority's LATS targets for the diversion BMW from landfill. The seven options are intended to be illustrative rather than precise, and are set out to provide an assessment of the range of alternative technologies available.

The options are comprehensive in terms of both including a wide range of alternative technologies and investigating the impact/benefit of splitting tonnages between a larger number of plant.

The number of plant has been examined only for MBT facilities in order to keep the scenarios to a manageable number. However, the intention was that the conclusions reached regarding the how well different numbers of MBT facilities performed would provide a general understanding of the likely impacts that might arise from employing a greater number of facilities whichever technology is used. For example, a benefit of employing six plants, rather than two, might be reduced distances that the waste has to be transported for treatment or disposal and an increased equity if a treatment facility were to be sited in each Borough. These generic benefits would be delivered by any of the technologies. Similarly, the economies of scale that may be achieved through the development of a larger facility, as opposed to several smaller ones, are applicable to many technologies, albeit not necessarily to an equal extent.

The options are based on the total forecast arisings of MSW across WLWA between 2013 and 2020 and so take into consideration:

- predicted recycling and composting rates (as discussed in *Section 1.4.2*);
- the yearly throughput of residual MSW required to enable a treatment technology to meet WLWA's LATS requirements over the period (taking into consideration the fate of all residues from the treatment process); and
- the remaining quantity of waste that the Authority is permitted to landfill.

The finalised options are summarised in *Table 2.1* and shown graphically in *Figure 2.1* to *Figure 2.7* below. The recycling and composting rates given in *Table 2.1* illustrate the amount of material collected separately for reprocessing. Some of the treatment technologies also produce material suitable for recycling and composting. This material is included as part of the assessment and is in addition to the recycling and composting rates given below [1].

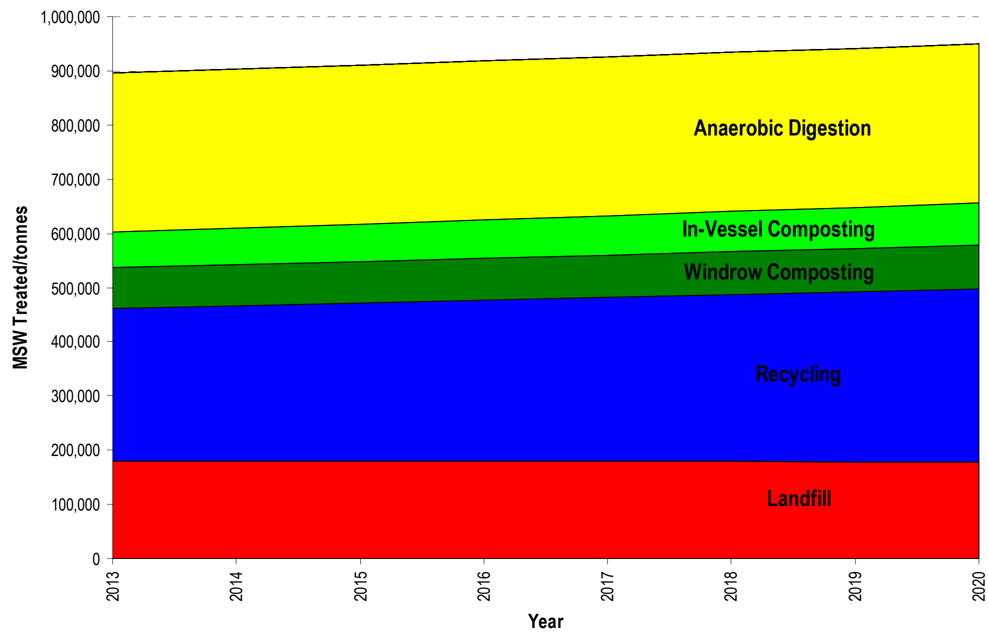
Full lists of all technology assumptions made are provided in *Annex A*.

Table 2.1 Summary Table for Alternative Technology Options for WLWA

	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**
Recycling & Composting (% of MSW in 2020)	50%	50%	50%	50%	50%	50%	50%
Anaerobic Digestion	✓						
Gasification		✓					
Autoclaving			✓				
Energy from Waste				✓			
MBT with RDF to Cement Kiln					✓	✓	✓
Number of Residual Waste Treatment Plants	1	1	1	1	1	2	6
Landfill	✓	✓	✓	✓	✓	✓	✓

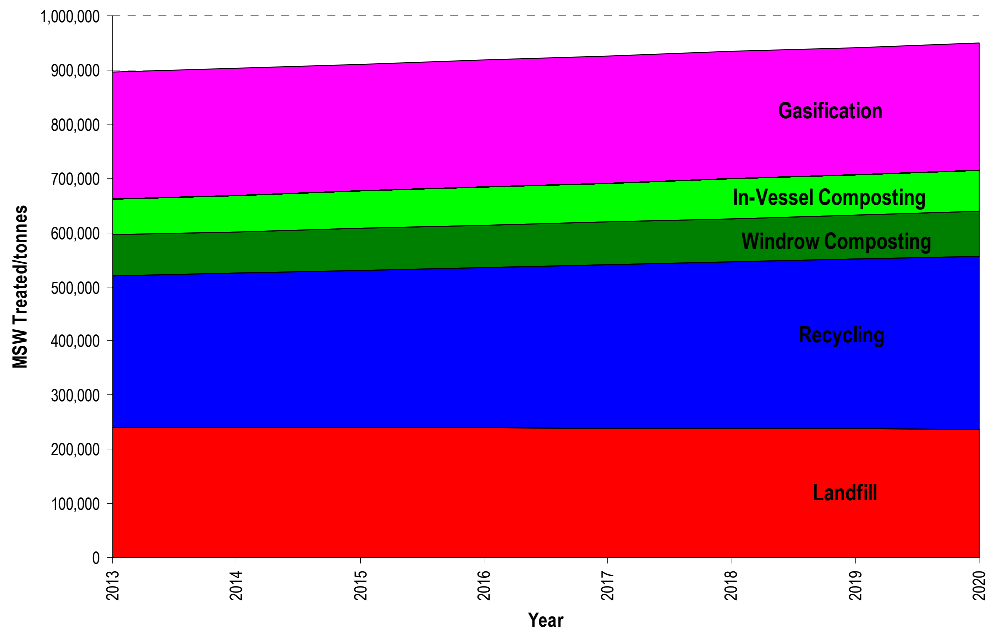
(1) Recycling and composting rates are based on the optimal scenario for recycling and composting, as determined during recycling and composting options appraisal.

Figure 2.1 *Option 1: One Anaerobic Digestion Facility*



Option 1 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one anaerobic digestion facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the anaerobic digestion process will produce a digestate that will be used for landspread, a biogas that will be combusted on site and residual waste that will be sent for landfill.

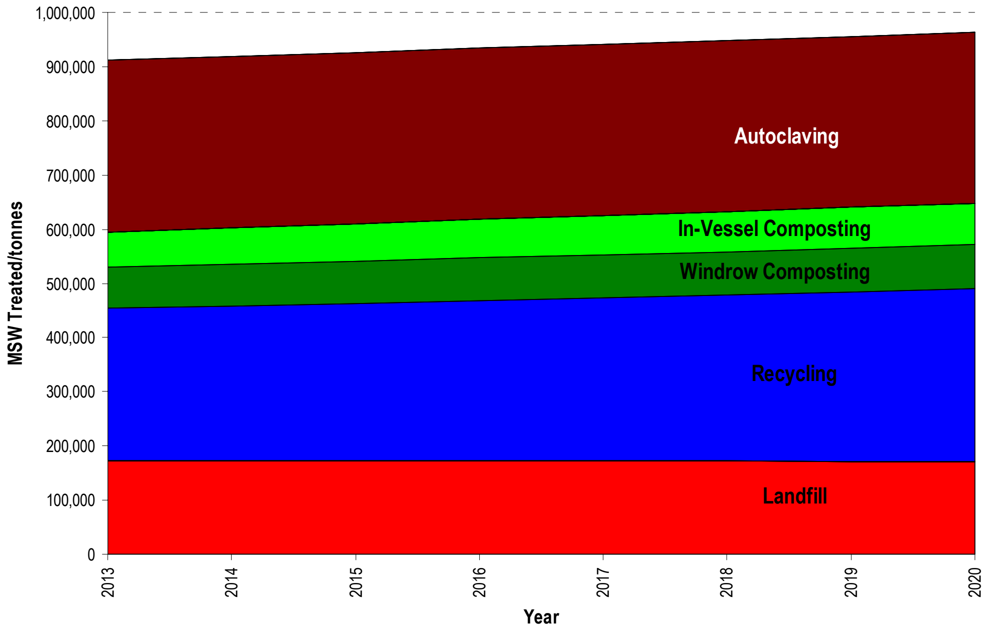
Figure 2.2 *Option 2: One Gasification Facility*



NB – gasification throughput includes inputs of oxygen and natural gas required for the process

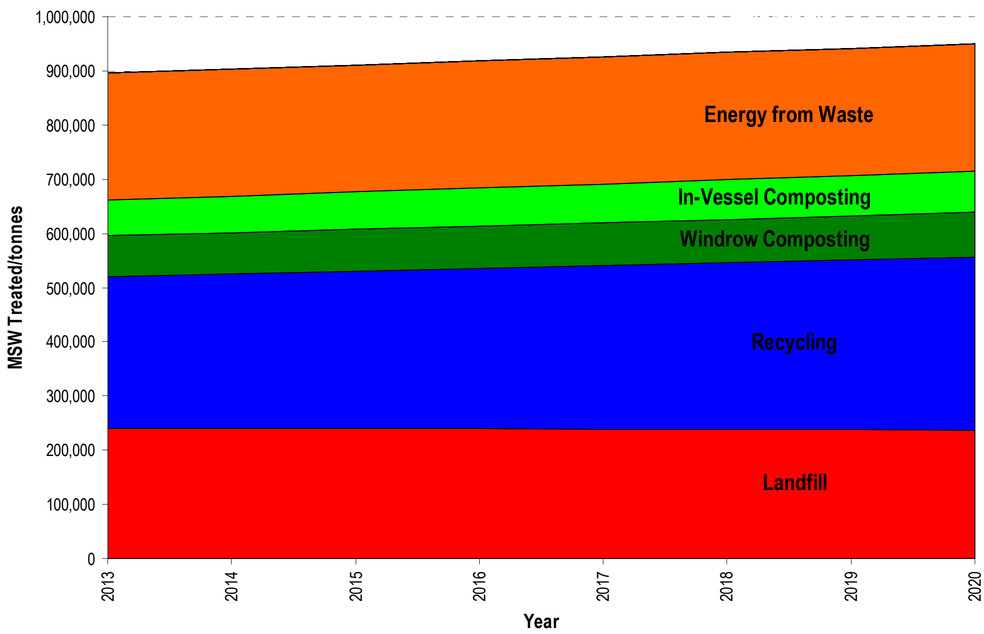
Option 2 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one gasification facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the gasification process will produce a syngas product that will be combusted on site and a number of separated materials for recycling.

Figure 2.3 *Option 3: One Autoclaving Facility*



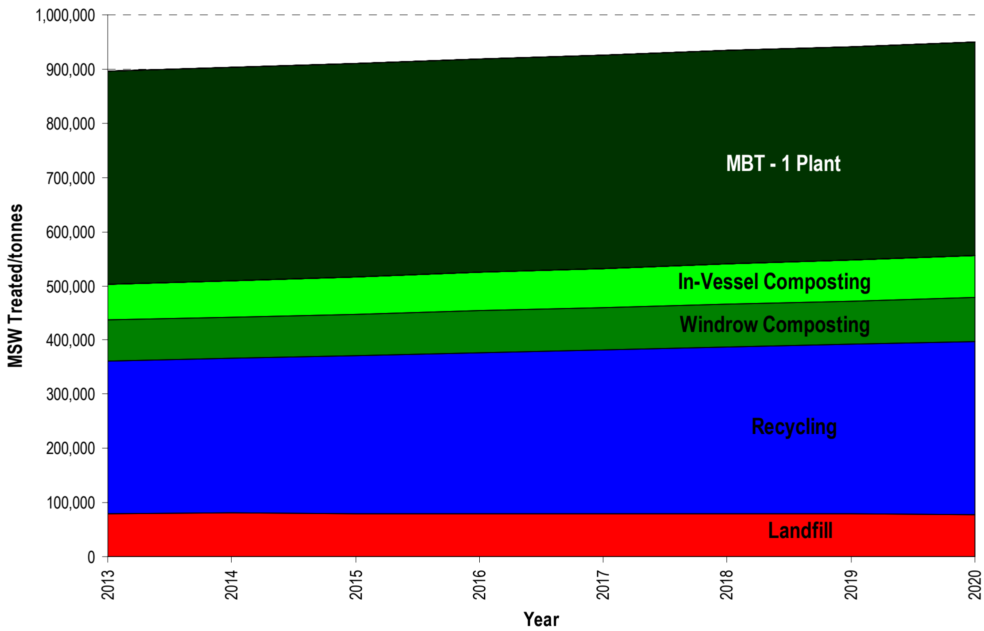
Option 3 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one autoclaving facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the autoclaving process will separate a number of materials for recycling and produce a refuse derived fuel (RDF) that will be sent to a cement kiln for combustion, as well as residual waste that will be sent for landfill.

Figure 2.4 ***Option 4: One Energy from Waste Facility***



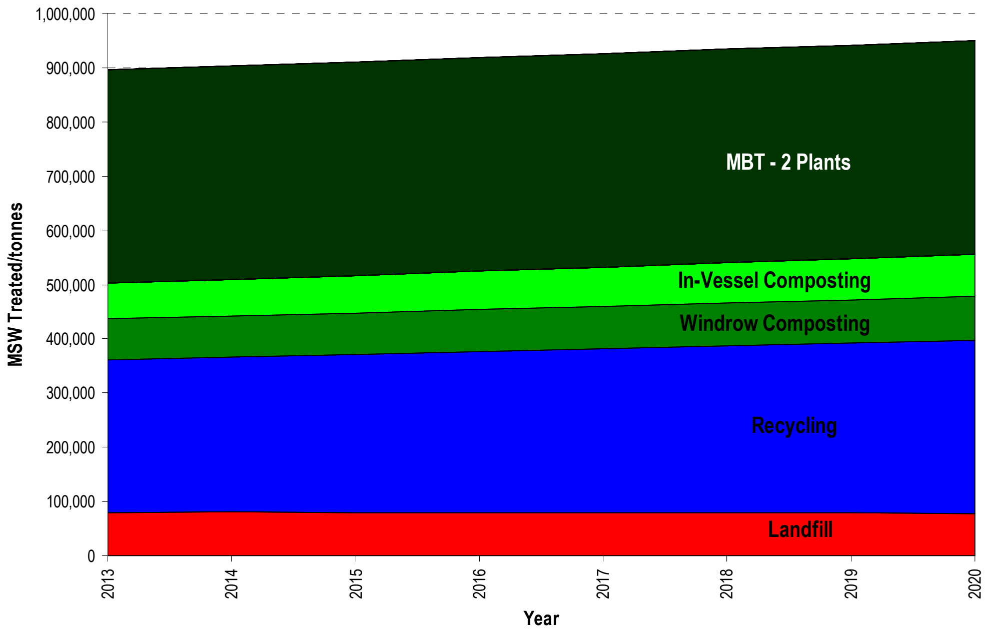
Option 4 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one EfW facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the process will separate ferrous metals for recycling, produce a bottom ash that will be recycled as aggregate and a fly ash that will classed as hazardous waste and require treatment at a hazardous landfill site.

Figure 2.5 ***Option 5: One MBT Facility***



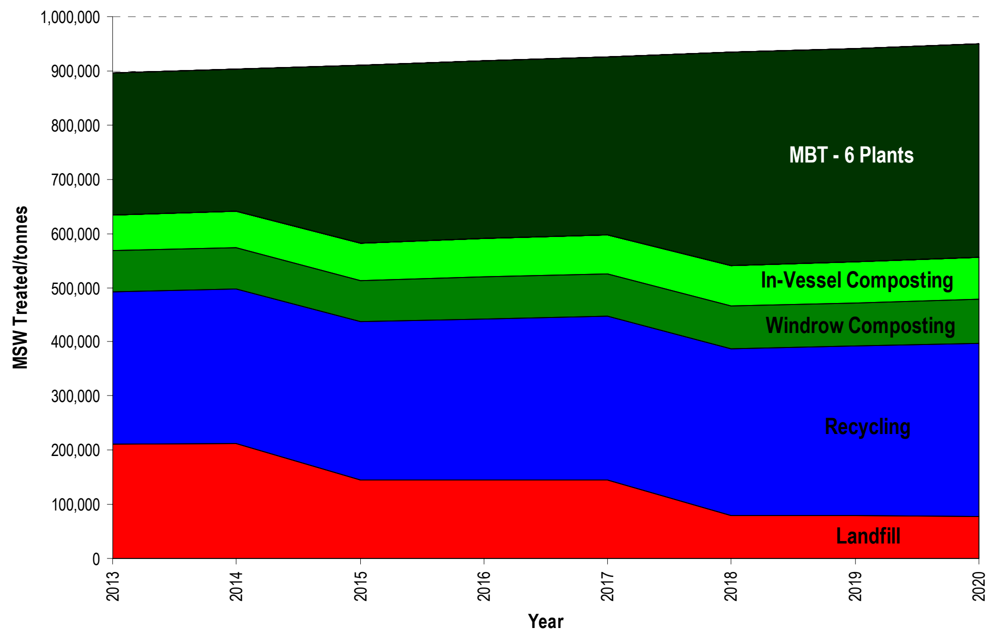
Option 5 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one large MBT facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF that will be sent to a cement kiln for combustion, as well as residual waste that will be sent for landfill.

Figure 2.6 *Option 6: Two MBT Facilities*



Option 6 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; two equally sized MBT facilities; and landfill, to the maximum allowed under LATS. In comparison with option 5, this option demonstrates the impact/benefit of splitting the tonnage between two MBT plants. Both facilities will need to come on line in 2013, however, in order to meet WLWA's LATS requirements. It was assumed that both MBT plants will separate a number of materials for recycling and produce an RDF that will be sent to cement kilns for combustion, as well as residual waste that will be sent for landfill.

Figure 2.7 Option 7: Six MBT Facilities



Option 7 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; six MBT facilities; and landfill, to the maximum allowed under LATS. In comparison with options 5 and 6, this option demonstrates the impact/benefit of splitting the tonnage between six MBT plants, with one located in each Borough. Four of the facilities will need to come on line in 2013, in order to meet WLWA's LATS requirements. Another facility will be required in 2015 and the final facility in 2018. It was assumed that each MBT plant will separate a number of materials for recycling and produce an RDF that will be sent to cement kilns for combustion, as well as residual waste that will be sent for landfill.

2.2 *STEP 3: ASSESS THE PERFORMANCE OF THE OPTIONS AGAINST THE CRITERIA*

This section explains the methods used for the assessment of the performance of options against each criterion, as well as presenting the results of the appraisal.

A detailed analysis of the results is included below, followed by a summary of the performance of the alternative waste management options against the criteria, in *Table 2.26*.

2.2.1 *Resource Depletion*

Resource depletion is an important concern because current levels of consumption of non-renewable resources are assumed to be unsustainable. Non-renewable resources are natural, and essentially limited. For example, iron ore and fuels such as crude oil and natural gas, as opposed to renewable resources, such as paper from sustainably managed forests. The scope of this assessment includes the phenomena cited in *Box 2.1*.

Box 2.1 Scope of Assessment of Resource Depletion

Grid electricity	Resources were consumed in order to generate the grid electricity that powers the waste management facilities. Any electricity generated by the waste management facilities was assumed to offset grid electricity generation.
Diesel generation	Some facilities use diesel-powered machinery to process the waste, so it is necessary to know what resources are used in generating diesel.
Steam generation	Autoclaving uses steam, whose generation requires resource consumption in a gas fired boiler.
Material recycling	In recycling (for example) aluminium, there are significant energy savings by comparison with the extraction of aluminium from bauxite. The resource depletion burdens of recycling versus virgin production were ascertained, so that the difference could be credited to those processes that included material recycling.
Transportation	Significant amounts of fuel are used in moving the waste from facility to facility, and these must be included in the resource depletion calculations.

Methods and Assumptions Used

WISARD (1) determines non-renewable resource depletion as the 'Abiotic Depletion Factor' (ADF) for the extraction of individual minerals and fossil fuels. This is based on concentration reserves and rate of de-accumulation, and expresses the results in 'kg antimony equivalents/kg extraction'.

For this study, we have simplified the process by assessing the depletion of coal, natural gas and crude oil as proxies for the ADF. Since these are the major resources affected by the options assessed, it is assumed that this represents a valid means of performing the analysis.

(1) ***WISARD*** is the Environment Agency's life cycle assessment software for waste management. Details of the ***WISARD*** software can be found in *Annex F*.

Calculation of the Impact Scores

ERM calculated the resource requirements (tonnes of diesel, kWh of electricity, tonne-kilometres waste transported, etc.) of the various facilities and processes involved in each option. It was then a case of applying the emission factors (which provide emissions per tonne of diesel, etc.), in order to determine the emissions associated with the activities. These emission factors are presented in *Annex B*.

Figures for the three depleted materials (coal, crude oil and natural gas) were then combined. *CML 2000* (1) provides resource depletion figures for the three species, in terms of kilograms of antimony. These can be compared, as shown in *Table 2.2*, to generate a single figure representing the resource depletion of each of the options, in terms of '*tonnes of crude oil equivalents*'.

Table 2.2 ***Resource Depletion Equivalents(†)***

Resource	1 kg antimony	1 kg crude oil	Units
Antimony	1	0.020	kg
Coal	74.627	1.500	kg
Natural gas	53.476	1.075	m^3
Crude oil	49.751	1	kg

(†) Data from CML 2000

Results

The resource depletion results are presented in *Table 2.3*, in thousands of tonnes of crude oil equivalents. The total scores for all waste management routes that are involved in each option are ranked underneath.

Table 2.3 ***Resource Depletion Scores (in ,000 tonnes of Crude Oil Equivalents) for each Option***

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Source-separated recycling	-880	-880	-880	-880	-880	-880	-880
Windrow	4	4	4	4	4	4	4
In-vessel composting	4	4	4	4	4	4	4
AD	-73	-	-	-	-	-	-
MBT	-	-	-	-	-716	-716	-611
Autoclave	-	-	-827	-	-	-	-
EfW	-	-	-	-388	-	-	-
Gasification	-	-362	-	-	-	-	-
Landfill	-17	-24	-16	-24	-24	-24	-28
Total score	**-962**	**-1258**	**-1715**	**-1283**	**-1612**	**-1612**	**-1511**
Rank	7	6	1	5	2	2	4

(1) CML 2000 - Centre of Environmental Science - Leiden University (CML), Leiden, The Netherlands.

Note that all of the total scores for each option are negative values. This is because the combination of activities involved in each option results in a net *reduction* in resource depletion. The processing of dry recyclable materials at material recovery facilities (MRFs) is a particularly good example of this, as the energy used sorting the materials is very small in comparison with the benefit from using recycled rather than virgin materials.

Although *Table 2.3* shows that material recycling delivers the most significant resource depletion benefit, the fact that all seven options have equivalent recycling rates means that this contribution does not help greatly in discriminating between the options.

To understand the differences between the options, we have to look at the various treatment technologies for residual waste. The anaerobic digestion option (1) delivers a resource depletion benefit due to the energy recovered from the biogas, but this is relatively modest in comparison with the other technologies. The autoclaving and MBT options (3, 5, 6 and 7) do better, because of the materials recycled and the energy recovered from the combustion of the RDF product. Autoclaving results in a higher rate of recovery of materials for recycling than MBT and the resource benefit resulting from this makes option 3 the highest scoring for this criterion.

EfW and gasification perform less well against this criterion as the energy recovered from these processes is assumed to displace the production of grid electricity. In comparison, the energy recovered from burning RDF in cement kilns is assumed to displace the combustion of coal. This coal displacement delivers a resource depletion benefit greater than the displacement of grid electricity production.

2.2.2 *Air Pollution (Acidification)*

Acidification is the process whereby air pollution (mainly ammonia, sulphur dioxide and nitrogen oxides) results in the deposition of acid substances. 'Acid rain' is best known for the damage it causes to forests and lakes. Less well known are the many ways it affects freshwater and coastal ecosystems, soils and ancient monuments. Acid deposition can increase the environmental mobility of metals, resulting in the pollution of water sources and increased uptake of metals by fauna and flora.

Gases contributing to acidification are aggregated according to their acidification potential. These potentials have been developed for potentially acidifying gases such as SO_2, NO_x, HCl, HF and NH_3, on the basis of the number of hydrogen ions that can be produced for a given amount of a substance, using SO_2 as the reference substance.

As well as having resource depletion implications, all of the activities cited in *Box 2.1* are also associated with SO_2 emissions. There are two additional considerations, highlighted in *Box 2.2*.

Box 2.2 *Additional Scope of Assessment of Acidification*

Diesel usage	In addition to the SO_2 emissions when diesel is generated, there are also emissions when it is consumed.
Plant emissions	Some of the waste management options involve combustion, with the attendant SO_2 emissions.

Method and Assumptions Used

Extensive experience by ERM and others in assessing the acidification impact of integrated waste management processes has found SO_2 emissions to be the greatest contributor to the acidification impact, with NO_x emissions the second largest contributor (1). Both NO_x and SO_2 emissions are the result of combustion processes and the emission of one is considered an indicator for the presence of the other (2). When determining the contribution to acidification impact, 1kg of SO_2 has a greater acidifying impact than 1kg of NO_x (3).

Hence for this study, we have focused solely on SO_2 emissions as a proxy for all the acidifying gases. It is assumed that SO_2 emissions alone are satisfactorily indicative of the overall acidification potential of the options.

Calculation of the Impact Scores

In the resource depletion section, it was mentioned that ERM calculated the resource requirements (tonnes of diesel, kWh of electricity, tonne-kilometres waste transported, etc.) of the various facilities and processes. The same activities, the generation and use of diesel, the generation of electricity (eg using coal-fired power stations) and the transport of waste, also result in emissions of acidifying gases, including SO_2. As with the resource depletion calculations, it was then a case of applying the emission factors. These can be found in *Annex B*.

Results

The acidification results are presented in *Table 2.4*, in tonnes of SO_2 equivalents. The total scores for all waste management routes that are involved in each option are ranked underneath.

(1) Enviros Aspinwall (January 2002) arc21 - Consultation Waste Management Plan
(2) http://www.aeat.co.uk/netcen/airqual/naei/annreport/annrep99/index.htm [05Jan05 @ 11:44]
(3) CML 2 Baseline 2000, Institute of Environmental Sciences (CML), University of Leiden, the Netherlands, 2000.

Table 2.4 Acidification Scores (in tonnes of SO_2 Equivalents) for each Option

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Source-separated recycling	-8452	-8452	-8452	-8452	-8452	-8452	-8452
Windrow	14	14	14	14	14	14	14
In-vessel composting	13	13	13	13	13	13	13
AD	-310	-	-	-	-	-	-
MBT	-	-	-	-	-10 055	-10 055	-8579
Autoclave	-	-	-8260	-	-	-	-
EfW	-	-	-	-2459	-	-	-
Gasification	-	-7582	-	-	-	-	-
Landfill	-112	-150	-106	-150	-156	-156	-177
Total score	-8847	-16 156	-16791	-11 034	-18 635	-18 635	-17 181
Rank	7	5	4	6	1	1	3

As with resource depletion, we see that all scores result in net *reductions* in acidification, as the activities offset the generation of SO_2 by other processes, such as the extraction of raw materials or the generation of power by alternative means. Material recycling is again the biggest saving, but its contribution to each option is constant. As such, the alternative treatment facilities provide the differentiation between the options.

The anaerobic digestion option (1), while delivering benefits, performs worst again, because there is only a modest level of energy recovery from the process.

The MBT options (5-7) perform best this time, followed by the autoclaving option (3). All four of these options benefit from replacing coal in the cement kilns, because of the SO_2 emissions associated with burning coal, but the higher calorific value of the RDF produced by MBT results in this technology scoring highest for this criterion. Option 7 performs less well than options 5 and 6 as MBT plants are introduced sequentially, over the period 2013 to 2020, and consequently produce less RDF over the total period.

2.2.3 Greenhouse Gas Emissions

Human activities have altered the chemical composition of the atmosphere through the build-up of greenhouse gases, primarily CO_2, CH_4, and N_2O. The higher the concentration of these gases, the higher the heat-trapping capability of the earth's atmosphere. As a result, temperatures and sea levels are expected to rise.

Method and Assumptions Used

Gases contributing to the greenhouse effect are aggregated according to their impact on radiative warming, compared to CO_2 as the reference gas. Characterisation factors as developed by the Intergovernmental Panel on Climate Change (IPCC) were selected, the figures being shown in *Table 2.5*.

Table 2.5 Greenhouse Gas Characterisation Factors (†)

Gas	Formula	Characterisation factor	Units
Carbon dioxide	CO_2	1	CO_2 equivalent
Methane	CH_4	21	CO_2 equivalent

(†) Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide/kg emission.

For the CO_2 emissions, a firm distinction was made between 'renewable' and 'non-renewable' sources of CO_2, with only the latter (from the combustion of fuels and plastics) taken as making a contribution to the greenhouse gas figures. Clearly, CO_2 is CO_2: however, it is assumed that the effect of releasing carbon from renewable sources is neutral because these releases are balanced by uptakes in the short-term, mainly in agro-forestry systems. By contrast, releases from non-renewable sources are only balanced out over geologic time periods.

Calculation of the Impact Scores

The calculation of the impact scores followed the same pattern as for resource depletion and acidification. The emissions factors for the two gases were scaled according to the total amount of resource consumption, and then converted into CO_2 equivalents using the figures in *Table 2.5*.

Results

The greenhouse gas emission results are presented in *Table 2.6*, in thousands of tonnes of CO_2 equivalents. The total scores for all waste management routes that are involved in each option are ranked underneath.

Table 2.6 *Greenhouse Gas Emission Scores (in ,000 tonnes of CO_2 Equivalents) for each Option*

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Source-separated recycling	-1640	-1640	-1640	-1640	-1640	-1640	-1640
Windrow	14	14	14	14	14	14	14
In-vessel composting	13	13	13	13	13	13	13
AD	-199	-	-	-	-	-	-
MBT	-	-	-	-	-1289	-1289	-1100
Autoclave	-	-	-1667	-	-	-	-
EfW	-	-	-	-666	-	-	-
Gasification	-	-623	-	-	-	-	-
Landfill	177	227	166	227	235	235	267
Total score	-1634	-2008	-3114	-2051	-2666	-2666	-2446
Rank	7	6	1	5	2	2	4

The trend set by resource depletion and acidification is continued with greenhouse gas emissions. The figures are all negative and they are once more dominated by the benefits of source-separated recycling, while the fine differentiation comes from the energy implications and additional recovery of materials from the different treatment processes. The option that includes anaerobic digestion again performs worst, because of the moderate level of energy recovery from the process.

The autoclaving option (3) scores the highest against this criterion, with the MBT options (5 and 6) coming second, as with the resource depletion criterion. Once more, the higher recovery of materials for recycling, together with the recovery of energy from the combustion of RDF, leads to a greater displacement of CO_2 equivalent emissions.

2.2.4 *Emissions which are Injurious to Public Health*

A significant cause of public concern surrounding the construction of a new waste management facility is the perceived health effects that may result for the local community. There are numerous reports in the public domain, frequently presenting conflicting opinions on the relative merits of different technologies.

To try to demystify the situation, Defra recently published a health effects report [(1)] that aimed to bring together in one place, information from all the studies conducted to date. Although there are a number of data gaps (notably on composting and emerging technologies such as autoclaving), this is the

(1) *Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes*, Enviros Consulting Ltd and University of Birmingham with Risk and Policy Analysts Ltd, Open University and Maggie Thurgood, 2004, available at http://www.defra.gov.uk/environment/waste/health-effects/index.htm [01Jun04 @ 15:13]

best reference information that is available and ERM has used it as the basis for assessment in this study.

Method and Assumptions Used

The specific starting point was Table 4.5 of the Defra report, on page 206, which is reproduced in *Table 2.8* below. This quantifies, to the degree possible from the data sources, the various health impacts that might be expected to occur as a result of waste management operations.

As can be seen, the table presents impacts for six classes of process: composting; MBT; anaerobic digestion; pyrolysis/gasification; incineration; and landfill. Autoclaving is missing, and there are actually no impacts for composting. To cover all the technologies used in this assessment, it was necessary to extrapolate data from these processes, and the associated approximations are presented in *Box 2.3*. These assumptions are used to generate the data in *Table 2.9*.

Box 2.3 Health Impact Technology Assumptions

Autoclaving:	Autoclaving is a sterilisation process, neither biological (MBT) nor combustion (incineration). It has been assumed that the health effects of autoclaving are similar to those of anaerobic digestion, and those figures have been used.
Composting:	Given that the release of bioaerosols from composting plants can be an issue, it has been decided to assign to composting the higher of the impacts in each category from the most similar processes, MBT and anaerobic digestion.
Landfill:	Data is given on six different landfill types, using flares or engines at small, medium and large sites. A typical value has been deduced by averaging the impacts from medium-sized flare and medium-sized engine landfill sites.
Cement Kiln:	A number of the options send RDF from MBT or autoclaving processes to a cement kiln. This is outside the remit of the Defra study, so we have assumed that impacts from a cement kiln are similar to those from an EfW facility.

The figures in *Table 2.9* apply to health impacts as waste is treated by the different technologies, so impacts from multiple stage processes must be added together. If, for example, residual waste from an MBT plant is sent to a cement kiln, then the health impacts from both processes are taken into account in the calculations. The offset health impacts of energy production during combustion processes are not taken into account in this assessment, however. Similarly, the benefits of recycling are not taken into account, in terms of an offset health impact of material (paper, glass etc.) production.

Comparing the Impacts

Clearly, a 'death brought forward' is more serious than a 'respiratory admission' and therefore the columns in *Table 2.9* cannot be totalled. Moreover, some processes do not have estimated impacts for all four categories, and therefore an aggregate health impact is difficult to ascertain.

The World Health Organisation (WHO), as part of its Global Burden of Disease project, has developed a table of Disability Weights associated with various conditions [(1)]. Illnesses, referred to in general as *sequelae*, are rated on a scale from 0.0 (perfect health) to 1.0 (death). ERM used this dataset to determine scores for the four health effects listed, as explained in *Table 2.7*. These figures are used in *Table 2.10* to calculate the final scores for each waste management technology.

Table 2.7 Health Impact Disability Weighting Assumptions

Health Impact	**Discussion**	**Disability Weighting**
Deaths brought forward:	There is no analogous category in the WHO disability weights to 'deaths brought forward', so ERM selected *terminal cancers* as an equivalent malady.	0.809
Respiratory admissions:	Respiratory diseases are divided between lower and upper respiratory diseases, but since the Defra report mentions both types, an average has been taken of the three non-zero sequelae (*upper respiratory episodes*, *pharyngitis* and *chronic lower respiratory sequelae*).	0.149
Cardiovascular admissions:	The Defra report cites a large number of cardiovascular sequelae, and disability weightings for these, where available, have been averaged for this impact. The sequelae included are: *congestive heart failure, acute myocardial infarction, angina pectoris, first-ever stroke, myocarditis, pericarditis, endocarditis* and *cardiomyopathy.*	0.260
Additional cancer cases:	Similarly, the Defra report was scanned to determine which cancers were included in this category, resulting in the inclusion of "*cancers of the stomach, colon, rectum, liver, pancreas, trachea, bronchus, lung, melanoma and other skin, breast, cervix uteri, corpus uteri, ovary, prostate gland and bladder, leukaemia, lymphomas and multiple myeloma* in the estimation".	0.165

(1) http://www3.who.int/whosis/burden/manual/other/GBD90 Disability Weights.zip [08Jun04 @ 19:11]

Table 2.8 *Estimated Health Impacts due to Emissions to Air (per Million (10^6) Tonnes of Waste Processed)* (†)

Health Effects	Composting	MBT	Anaerobic Digestion	Pyrolysis / Gasification	Incineration / Cement Kiln	Landfill – Medium + Flare (‡)	Landfill – Medium + Engine (‡)
Deaths brought forward	No Data	0.018	0.0015	0.031	0.064	0.015	0.012
Respiratory admissions	No Data	0.050	0.072	0.293	1.5	0.024	0.11
Cardiovascular admissions	No Data	No Data	No Data	0.0055	0.0004	0.0013	0.001
Additional cancer cases	No Data	No Data	0.0000011	0.000019	0.00002	0.000048	0.00005
Data quality	n/a	Poor (3)	Moderate (5)	Moderate (6)	Moderate (6)	Poor (4)	Poor (4)

(†) Figures multiplied by 10^6 versus the report, to show their relative values more clearly.

(‡) Data is given in the report for small, medium and large landfill in these two categories – six in all.

Table 2.9 *Estimates of Health Impacts due to Emissions to Air (per Million (10^6) Tonnes of Waste Processed), as Modified by ERM* (†)

Health Effects	Composting	MBT	Anaerobic Digestion	Autoclaving	Incineration / Cement Kiln	Active Landfill – Medium
Deaths brought forward	0.018	0.018	0.0015	0.0015	0.064	0.014
Respiratory admissions	0.072	0.050	0.072	0.072	1.5	0.067
Cardiovascular admissions	No Data	No Data	No Data	No Data	0.0004	0.0012
Additional cancer cases	0.0000011	No Data	0.0000011	0.0000011	0.00002	0.000049

(†) Figures multiplied by 10^6 versus the report, to show their relative values more clearly.

Table 2.10 *Health Impact Scores with Disability Weightings Factored into the Calculations*

Health Effects	Deaths brought forward	Respiratory admissions	Cardiovascular admissions	Additional cancer cases	Final 'score' (†)
Composting	0.018	0.072	No Data	0.0000011	0.0085
MBT (‡)	0.018	0.050	No Data	No Data	0.011
Anaerobic digestion	0.0015	0.072	No Data	0.0000011	0.0040
Pyrolysis/gasification	0.031	0.29	0.0055	0.00019	0.017
Incineration/ cement kiln	0.064	1.5	0.0004	0.00002	0.069
Autoclaving (‡)	0.0015	0.072	No Data	0.0000011	0.0040
Landfill	0.014	0.067	1.15	0.00049	0.0053
Disability weighting	*0.809*	*0.149*	*0.260*	*0.165*	

(†) The final 'score' is calculated by summing the products of each of the impacts and their disability weighting, and represents a relative value that combines the number and severity of incidents resulting from the handling of a common unit weight of waste by the stated waste management technique. Put simply, the final 'score' is the number of 'death equivalents' per million tonnes of waste throughput.

(‡) The impacts for MBT and Autoclaving only reflect the plants themselves, and not the possible treatment of the RDF or Fibre residues.

Applying the Impact Scores to the Options

In order to apply the calculated impact scores to the options, it is necessary to multiply the final health effect scores by the amount of waste being handled by that technique, and sum for each option.

Results

The results of applying the impact factors to the throughputs of each facility type within each option are presented in *Table 2.11*. The totals are ranked at the bottom of the table.

Table 2.11 Health Impacts Scores for each Option

	Option						
Technology	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Windrow composting	0.005	0.005	0.005	0.005	0.005	0.005	0.005
In-vessel composting	0.005	0.005	0.005	0.005	0.005	0.005	0.005
AD	0.009	-	-	-	-	-	-
MBT	-	-	-	-	0.035	0.035	0.03
Autoclave	-	-	0.01	-	-	-	-
RDF	-	-	0.1	-	0.073	0.073	0.062
EfW	-	-	-	0.129	-	-	-
Gasification	-	0.05	-	-	-	-	-
All Landfill	0.013	0.01	0.011	0.01	0.01	0.01	0.011
Total	**0.032**	**0.07**	**0.131**	**0.15**	**0.128**	**0.128**	**0.113**
Rank	1	2	6	7	4	4	3

(†) Impact per million tonnes processed – see methodology section for derivation of figures

The biggest impact factor is associated with EfW plants. It therefore follows that the option that involves this treatment technology, option 4, is rated the poorest for health effects. The health effects associated with treatment of RDF are also considered to be high and lead to the autoclaving option being ranked second worst, as this option produces the largest quantity of RDF.

The highest scoring option is the anaerobic digestion option 1, because it produces no RDF requiring treatment, and the technology is in enclosed buildings and not associated with emissions leading to significant health risks.

2.2.5 *Landtake*

As with the considerations in *Section 2.2.1*, land is also a finite resource. The emphasis of Government policy is to 'recycle' the use of land and buildings through brownfield site development and re-use of buildings. Some waste management options are more 'land hungry' than others.

This criterion considers the amount of land that would be required to be given up on a long-term basis. The assessment estimates the average annual landtake requirements, of each option, over the eight-year period, from 2013-2020. Landtake was measured using professional judgment based on the typical size of different facilities.

Method and Assumptions Used

The assessment estimates the landtake requirements of waste treatment and disposal facilities for each option.

Assumptions used to underpin this assessment, including an estimate of landtake (in hectares) for each facility type, are given in *Annex C*. These figures have been used to determine the total landtake that each management option will require. The landtake requirements of proposed facilities for each option have been summed and then averaged, to provide an average landtake figure for each option for each year.

The option with the lowest landtake requirement has been awarded the highest rank of 1, the option with the highest landtake requirement has been given the lowest performance ranking of 7, and all other options have been ranked according to their position within this range.

Results

A summary of the potential 'total landtake' for all options is given in *Table 2.12*, indicating an average annual landtake ranging from 75.79ha to 87.54ha.

Table 2.12 Average Annual Landtake over Period for West London Options (ha)

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Recycling	11.51	11.51	11.51	11.51	11.51	11.51	11.51
Windrow	27.07	27.07	27.07	27.07	27.07	27.07	27.07
IVC	0.85	0.85	0.85	0.85	0.85	0.85	0.85
AD	3.99	0	0	0	0	0	0
MBT	0	0	0	0	4.10	5.40	9.19
Autoclave	0	0	3.91	0	0	0	0
Incineration	0	0	0	3.27	0	0	0
Gasification	0	7	0	0	0	0	0
Landfill	44.11	33.09	33.09	33.09	33.09	35.84	33.09
Total	**87.54**	**79.52**	**76.43**	**75.79**	**76.62**	**77.92**	**84.46**
Rank	7	5	2	1	3	4	6

The EfW option (4) has the lowest landtake requirement (75.79ha) and has subsequently been awarded the highest rank of 1. In comparison, the anaerobic digestion option (1) has the lowest ranking because of its requirements for landfilling residual waste from the process.

The difference in landtake requirements between the MBT options is partially due to the different numbers of MBT facilities.

2.2.6 *Extent of Water Pollution*

Methods and Assumptions Used

For assessing the environmental risk to water (bodies) for the proposed options, ERM used the Environment Agency's OPRA (Operator & Pollution Risk Appraisal) for Waste scoring methodology.

The OPRA model is based on the consideration of the likelihood of problems arising and a measure of their consequences. Evaluation of risk involves firstly the probability of an occurrence of an undesirable event and, secondly, the consequence of such an event. The OPRA system is comprised of two elements:

- environmental appraisal; and
- operator performance appraisal.

Since this risk assessment is for hypothetical waste management options, the operator performance appraisal will not be carried out.

The various types of waste management operations are considered in terms of sources of pollution, inherent risks at these sites and the potential longer-term impacts. Two main categories are used for the environmental appraisal:

- source based – type of facility, input of waste and control & containment; and
- target based – human dwellings, groundwater and surface water.

The OPRA methodology allocates a score for each of the subcategories shown above. The scores range from 1 to 60: the higher the score, the higher the potential risk.

The source based score is set by three parameters: type of facility; waste input; and control & containment. For type of facility for example, a special waste landfill site will score high (60), as it receives the most toxic and persistent waste. An inert landfill site will receive a low score (10) on the other hand. For input of waste, the scoring is based on the annual tonnage received. The scores range between 20 for up to 50 000 tonnes and a score of 2 for over 50 tonnes.

Control & containment linked to actual plant operation cannot be assessed, and therefore an average score of 5, per waste management facility was given to all options. A score of 5 presupposes that there is a Quality Assurance (QA) system in place and two control mechanisms such as liners and/or gas controls, leachate containment, etc.

ERM has decided to apply an average (1) target score to the human dwellings, groundwater and surface water target-based categories, as no sites or potential sites have been identified and therefore proximity cannot be calculated. The average target score is based on the average scores for human dwellings, groundwater and surface water. The respective scores for these are 15, 10 and 7, which totals to 32. These assumed averages are midpoint values of the available scores. If the total target score varies, it is due to the number of facilities, ie the higher the score, the more facilities are used in the option.

The human dwellings subcategory attempts to categorise the risk by reference to the distance from the edge of the site and the consequence of an incident by considering sensitivity. In terms of sensitivity, there are three categories:

- high – domestic dwellings, schools, hospitals, SSSIs and beaches;
- medium – offices, industrial units, footpaths, motorways; and
- low – minor roads and public open space.

Therefore, relating these categories to the distance from the proposed sites will result in scores from 20 for the 'high' category and within 50 metres and a score of 1 for the 'low' category at a distance above 500 metres.

OPRA Groundwater scoring uses the Groundwater Vulnerability maps and Ground Protection Zones (GPZ). The scoring is based on the distance from GPZ.

For surface water, the system is based on River Ecosystem (RE) classification. The scoring is based on the RE classification system (high, medium and low) and the distance to the surface water target. The 'high' category surface water body which is adjacent to the waste management facility scores 15, the 'low' category which is further than 250 meters away scores 1.

To assess the options, further assumptions had to be taken in order to proceed. For the environmental appraisal in OPRA, there are 24 possible facility types. ERM matched up the technologies used in the options with types of facility in OPRA, shown the table below.

(1) This is the average given by the Environment Agency for England and Wales

Table 2.13 ***Type of Facility***

Facility	OPRA Description	Score
Recycling	Materials Recycling Facility (A15)	15
Windrow	Composting Facility (A22)	15
In-vessel composting	Biological Treatment (A23)	15
AD	Biological Treatment (A23)	15
MBT	Biological Treatment (A23)	15
Autoclave	Physical Treatment (A16)	15
Incineration	Incinerators (A18)	20
Gasification	Incinerators (A18)	20
Coal Displacement	Incinerators (A18)	20
Landfill	Household Waste Landfill (A4)	40
Hazardous Landfill	Special Waste &/or co-disposal Landfill (A1/A2)	60

Calculation of the Impact Scores

In order to score the type of facility, one needs to know the quantity of facilities that will be applied for each option. For instance, in all seven options, there are always a consistent number of MRFs and composting plants, while the number of treatment plants varies between one and six facilities.

Scores were worked out for each year, as in each option further facilities are added in certain years. However, in order to facilitate comparison, the total score for source and target were averaged for all the years assessed.

Results

Table 2.14 shows the result of the water assessment for the alternative technology otpions.

Table 2.14 ***Water Assessment Results***

				Option			
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total score	1276	1184	1256	1273	1256	1328	1577
Rank	5	1	2	4	2	6	7

Overall, there are no significant differences between the alternative technologies with regard to the risk to water. The reason why some options perform better than others is mainly due to the number of facilities. For example, options 6 and 7 score worse than the other options because of the higher number of MBT plants.

In accordance with this, the gasification option (2) scored particularly well in comparison with other options because gasification produces limited outputs or residues that require further treatment.

The anaerobic digestion and EfW options (1 and 4 respectively) score relatively poorly due to their additional landfill requirements. This is because the anaerobic digestion option requires a relatively high total landfill capacity and EfW requires some, albeit small, hazardous landfill capacity.

2.2.7 Total Road Kilometres

The total expected road distance travelled in each option has been calculated. These figures can give an indication of the local transport impacts associated with each option, for example, road traffic congestion and accidents.

Method and Assumptions Used

To estimate the total road distance travelled for each indicative option, a number of assumptions have had to be made. Although the assessment is not site-specific, assumptions on indicative reprocessing, treatment and disposal locations have had to be made in order to allow transport distances to be calculated. These assumptions are listed in *Annex D*.

Distances to and from facilities have been measured using a Geographical Information System (GIS). The distance given represents a linear line of travel between points.

The tonnages of waste travelling to each facility have been identified. To establish the number of lorry movements to each facility, the tonnages have been divided by 22. This reflects the assumption that bulker lorries, with an average load of 22 tonnes, will be used to transport the waste. To establish the total road transport distance for each option, the estimated distances have multiplied the number of lorry movements.

Results

The total transport results, in kilometres, are shown in *Table 2.15*. The gasification and EfW options (2 and 4 respectively) perform well against this criterion because the treatment processes employed in these options do not involve significant 'post treatment' transport. The anaerobic digestion option (3) performs worst against this criterion due to the large amount of onward transport of materials following initial treatment.

Table 2.15 Total Road Transport Distance for each Option (te-km)

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total distance	1 606 937	1 437 299	1 988 056	1 451 107	1 746 894	1 660 354	1 609 500
Rank	3	1	7	2	6	4	5

2.2.8 *Financial Costs*

A problem commonly associated with data on the financial costs of waste management activities is the acquisition of detailed, reliable and up-to-date information, and the necessity of relying on small and dated data sets in forecasting future costs. In addition, some technologies are not as well established as others, resulting in additional difficulties in making accurate cost predictions. Another significant barrier is that this information is often commercially sensitive and so not readily available. Assumptions underpinning the estimation of financial costs in this assessment can be found in *Annex E*.

Method and Assumptions Used

The principal cost elements used in this assessment are for waste collection and waste treatment/disposal. Costs are based on current costs as at 2005 and are stated in 2005 prices. No allowance for inflation has been made. The exception to this is the landfill tax, which has been assumed to increase to £35/t by 2012.

Costs associated with each option have been assessed on a gate fee basis. A gate fee represents a unit (one tonne) payment made by a waste producer/carrier to the service provider. These gate fees have been collected from a variety of sources in the waste industry.

There are considerable uncertainties associated with the market value of products from the autoclaving process. This has meant that is difficult to attribute a gate fee to autoclaving. For the purposes of this assessment, the costs associated for this technology have been based on likely gate fees for new technologies.

The evaluation does not consider separately the capital costs associated with the development of a new facility as it has been assumed that they will be borne by the operator and are thus incorporated in the gate fee.

The total costs per tonne for each option over the eight-year period, 2013-2020, have been estimated. This total includes both consideration of gate fees and collection costs. The option that provides the least expensive waste management option has been awarded the highest ranking of 1, the most costly option has been given the lowest ranking of 7 and the remaining options have been ranked accordingly within the range.

Results

Table 2.16 presents an estimate of the total costs for each option over the eight-year period per tonne of waste, including consideration of gate fees and collection costs.

Table 2.16 ***Breakdown Average of Collection and Disposal Costs for West London Waste Management Options***

Technology	Options						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Source-separated recycling	321 289 614	321 289 614	321 289 614	321 289 614	321 289 614	321 289 614	321 289 614
Windrow	84 444 458	84 444 458	84 444 458	84 444 458	84 444 458	84 444 458	84 444 458
IVC	73 294 385	73 294 385	73 294 385	73 294 385	73 294 385	73 294 385	73 294 385
AD	198 257 231	0	0	0	0	0	0
MBT	0	0	0	0	234 251 832	259 857 217	243 784 159
Autoclave	0	0	251 761 926	0	0	0	0
Incineration	0	0	0	137 332 391	0	0	0
Gasification	0	174 144 699	0	0	0	0	0
Landfill	200 175 273	182 446 129	175 750 573	188 234 569	137 835 607	137 835 607	170 509 842
Total Costs	877 460 960	835 619 285	906 540 955	804 595 416	851 115 895	876 721 280	893 322 457
Total (£/tonne)	**119**	**113**	**123**	**109**	**115**	**119**	**121**
Rank	5	2	7	1	3	4	6

NB– output costs from the modelling process are presented in full (to nine significant figures) but are not intended to convey precision.

One factor that is common to all options is the landfill tax, which is included in the landfill cost per tonne. The low costs associated with incineration technologies led to the EfW option (4) providing the least expensive waste management and being awarded the highest ranking (1). This provides waste management for the eight-year period at an estimated average cost of £109 per tonne. The gasification and MBT options (2 and 5 respectively) also perform well against this criterion, with the overall average cost of waste treatment at under £115 per tonne.

The higher RDF rates from autoclaving result in option 3 providing the most expensive waste management option, costing around £123 per tonne to dispose or treat waste over the eight-year period. This option has therefore been given the lowest rank (7). Option 7 also performs poorly against this criterion, partly because of the higher gate fees and taxes associated with landfill which has increased the overall costs associated with this option.

2.2.9 *Reliability of Delivery*

Reliability of delivery is a criterion that encompasses a number of subsidiary factors. The key issues are: the probability of securing planning permission for new facilities; and the prospects for technologies that are not entirely proven.

Method and Assumptions Used

A simple method has been derived to encompass the main elements relating to reliability of delivery identified above.

Probability of Securing Planning Permission

To assess the probability of securing planning permission against each option, the number of sites required for treatment technologies has been reviewed. Options requiring larger number of treatment facilities have been given a lower score. This takes into account the logistics, time and cost involved in obtaining planning permissions.

Table 2.17 Scores Attributed to Number of Treatment Facilities

Number of treatment facilities required	Score
1	3
2 or 3	2
4 >	1

Proven Technologies

There is a long history of waste management technologies being presented in the market as a new and advantageous solution to the waste problem, only for obstacles to their successful implementation and operation to emerge at a later date. Such technologies should not be disregarded. However, it is prudent to account for risks associated with delivery in practice, albeit that this is difficult to assess in advance. In addition, it is often harder to secure financial backing for facilities that have not been proven in the UK, or that have not been shown to work at large scale or on feedstock with the same characteristics as the intended waste stream. The scores identified in *Table 2.18* below have been attributed to each option.

Table 2.18 Points Attributed to Proven Technologies

Development state	Score
Proven on a large scale in the UK	4
Proven on a large scale in Europe	3
Proven on a small scale in the UK	2
Proven on a small scale in Europe	1

Results

The two scores have been weighted equally and added together to give a final score (highest rank = best performance for this criterion). The EfW option (4) is shown to rank highest for this criterion (*Table 2.19*). This is due to EfW being an established technology and the requirement of fewer treatment facilities. Options 6 and 7 score poorly due the higher number of facilities needed.

Table 2.19 ***Reliability of Delivery Results for MSW Options***

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total option score	1.67	1.33	1.33	2.00	1.67	1.17	0.67
Rank	2	4	4	1	2	6	7

2.2.10 Compliance with Waste Policy

This criterion assesses the ability of each of the options to manage waste in accordance with UK waste policy. Nevertheless, key constraints were established during the initial development of options to ensure that each of the options complies with the statutory LATS targets and meets, or exceeds, statutory BVPI targets. As such, these requirements have been excluded from the assessment of this criterion.

In *Waste Strategy 2000*, the government suggests that the principle of the waste hierarchy should be embraced. The waste hierarchy seeks to promote an integrated approach to waste management. It reflects the fact that the best option for dealing with waste is to reduce the amount created, followed by re-use and then recovery, which includes recycling, composting and EfW. Only when these options have been exhausted should waste be disposed of to landfill. The aim is to move up the hierarchy to ensure better environmental protection and meet statutory targets.

Table 2.20 presents the 'score' that has been awarded to each technology according to its position in the hierarchy. The most preferred is the removal of the problem through waste reduction and minimisation. These scores have been used to determine the performance of each option.

Table 2.20 ***Ranking System for Waste Policy Criterion***

Waste treatment/disposal facility	Waste hierarchy score
Waste reduction & minimisation	5
Recycling & composting	4
Anaerobic digestion	3
Recovery	3
Energy from waste/gasification	3
Landfill	1

Method and Assumptions Used

Autoclaving and MBT have been excluded from the ranking system as they do not provide an end treatment, but an interim treatment process. Where options have included the use of autoclave or MBT technology to manage waste, the final recovery or disposal of the outputs have been evaluated.

For each option, rank given to each technology has been multiplied by the amount of waste treated by that technology (expressed as a percentage total waste managed by that option) over the whole eight-year period. These figures have been summed to provide a total score for each option.

The highest scoring option employed treatment facilities that manage waste at the top of the waste hierarchy, and, as a result, has been awarded the highest overall rank (1). The option that scored least well relies on managing waste lower down the waste hierarchy and was allocated the lowest rank (7). Again, all other options were ranked according to their position within this range.

Results

Table 2.21 presents the total quantities of waste as a percentage managed by each technology for each option. These percentages were multiplied by the waste hierarchy rank for each technology over the whole eight-year period (rather than just the maximum recycling rate achieved for example). The average recycling and composting levels vary significantly between the options. This is because the figures in *Table 2.21* include not only waste recycled at kerbside, but also any recycling that takes place as part of the treatment process. These figures have been summed to provide a total score for each option.

Table 2.21 Waste Managed by Each Technology (%) for West London Options

Waste technology	**Option**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Recycling/composting	60	49	54	49	53	53	52
Recovery	6	0	19	0	22	22	19
Energy from waste	0	25	0	25	0	0	0
Landfill	33	26	28	26	26	26	29

NB – Total may not equal 100% due to rounding

Recovery in this table refers primarily to the recovery of end products from technologies, ie Option 3 'recovery' relates to the combustion of fibre resulting from autoclaving and Options 5 to 7 'recovery' relates to the combustion of RDF following MBT treatment.

Table 2.22 presents the performance scores for each option. The MBT options (5 and 6) employed treatment facilities that manage waste at the top of the waste hierarchy and had low volumes to landfill, and as a result have been awarded the highest overall rank (1).

Table 2.22 ***Compliance with Waste Policy to Determine Performance Score for MSW Options***

Waste technology	Option 1	2	3	4	5	6	7
Recycling/composting	242	195	214	195	210	210	208
Recovery	19	0	56	0	65	65	56
Energy from waste	0	76	0	76	0	0	0
Landfill	33	26	28	26	26	26	29
Total	**294**	**297**	**298**	**297**	**301**	**301**	**293**
Rank	6	4	3	4	1	1	7

The multi-plant MBT and anaerobic digestion options (7 and 1 respectively) scored least well because they involve managing waste lower down the waste hierarchy as well as less overall recycling.

2.2.11 End Product Liability

This criterion considers the risks associated with finding a market willing to accept the end products arising from the technologies employed by each option. Some waste management technologies have greater risks associated with the management of end products because the markets for these materials are unproven or under-developed. The methodology used to assess the likely risks associated with the markets for end products is outlined below.

Method and Assumptions Used

The end product(s) from each technology have been awarded a score based on the current risk associated with markets willing to accept it. These risks have been estimated using professional judgement.

Table 2.23 presents the 'score' that has been awarded to end product markets. A high score (0.20) indicates a higher risk of finding a market willing to accept an end product. A low score (0.01) indicates that markets for end products are stable and well established. These scores have been used to determine the performance of each option.

Table 2.23 End Product Liability Score

End Product & Destination	Key Issues	Risk of Finding a Market	End Product Liability Score
RDF to off site combustion eg cement kiln	• Limited proven capacity • Competition with other fuels • Stringent quality & demand patterns	HIGH	**0.20**
Hazardous material to landfill	• End of co-disposal leading to significant decrease of hazardous waste landfills in England.	MED	**0.09**
Markets for composting and landspreading – generic	• Animal by products regulations • Increase in production from local authorities • Swamping of stable local markets	MED	**0.07**
Markets for recyclables – generic	• Increase in production of recyclate from producers and local authorities • Lack of local reprocessing facilities • Lack of demand for recycled products	MED	**0.05**
RDF to on-site combustion, or combustion in a WLWA facility	• Relatively limited issues	LOW	**0.02**
Non-hazardous material to landfill	• Relatively limited issues	LOW	**0.02**

The highest risk of finding a market is associated with the use of RDF for energy recovery (in an off-site facility). This is primarily because the market for substitute fuels has been very buoyant in the last few years with the arrival of cheaper fuel substitutes such as meat and bone meal. As markets for energy become more liberalised, markets for calorific value will become more competitive and the likelihood of finding an outlet willing to accept a material increases [(1)].

For each option, the tonnages of each end product (as a percentage of total waste managed) have been multiplied by the end product liability score. These figures have been summed for each end product over the eight-year period to provide a total score for each option.

The option with the lowest risk score employs treatment facilities that have established markets willing to accept end products and, as a result, has been awarded the highest overall rank (1). The option with the highest risk score relies on managing waste by technologies that have less established markets willing to accept end products and was allocated the lowest rank (7). Again, all other options were ranked according to their position within this range.

(1) Refuse Derived Fuel, Current Practice and Perspectives. By WRc, to the European Commission–Directorate General Environment. July 2003.

Results

Table 2.24 presents the total quantities of each end product as a percentage of the total waste managed by each option.

Table 2.24 ***End Products from each Technology (Expressed as a % of Total Waste Managed)***

End Products	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
All recyclables	32	39	37	42	36	36	36
Compost/landspread	28	16	16	16	16	16	16
RDF	-	-	20	-	14	14	12
Hazardous residues to landfill	-	-	-	0.6	-	-	-
Non-hazardous residues to landfill	14	-	10	-	17	17	14

The percentages were multiplied by the end product liability score and these figures summed to provide a total score for each option, as shown in *Table 2.25*.

Table 2.25 ***End Product Liability Performance Scores***

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total score	**3.86**	**3.09**	**7.12**	**3.31**	**6.15**	**6.15**	**5.66**
Rank	3	1	7	2	5	5	4

The gasification option (2) was the highest performing option with regard to end product liability, as the process produces comparatively less output requiring further management.

The technologies producing RDF performed significantly worse against this criterion, as these products require an end market, for which there is currently considerable uncertainty. For this reason, the autoclaving option (3) and MBT options (5-7) scored poorly in terms of liability of end product. Option 7 accumulated a score lower than options 5 and 6 as MBT plants are introduced sequentially, over the period 2013 to 2020, and consequently produce less RDF over the total period.

2.2.12 *Summary of Alternative Technology Option Results*

The performance of the alternative technology options against the criteria is summarised in *Table 2.26*. The performance matrix is a valuable aid to decision-making in itself, in indicating the relative advantages and disadvantages of the options. However, direct use of the results it contains is difficult because of the matrix's complexity and the use of different units. The performance of each option for each criterion is also ranked, with the rank shown in brackets in *Table 2.26*.

Table 2.26 Alternative Technology Options - Summary of Results

Criterion	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Depletion of resources (,000 tonnes of crude oil equivalents)	-962 (7)	-1258 (6)	-1715 (1)	-1283 (5)	-1612 (2)	-1612 (2)	-1511 (4)
Air pollution (acidification) (tonnes of sulphur dioxide equivalents)	-8847 (7)	-16 156 (5)	-16 791 (4)	-11 034 (6)	-18 635 (1)	-18 635 (1)	-17 181 (3)
Greenhouse gas emissions (,000 tonnes of carbon dioxide equivalents)	-1634 (7)	-2008 (6)	-3114 (1)	-2051 (5)	-2666 (2)	-2666 (2)	-2446 (4)
Emissions which are injurious to public health (health impacts score)	0.0325 (1)	0.0700 (2)	0.1308 (6)	0.1496 (7)	0.1277 (4)	0.1277 (4)	0.1134 (3)
Landtake (ha)	87.54 (7)	79.52 (5)	76.43 (2)	75.79 (1)	76.62 (3)	77.92 (4)	84.46 (6)
Extent of water pollution (water assessment score)	1276 (6)	1184 (3)	1179 (1)	1273 (5)	1179 (1)	1251 (4)	1500 (7)
Total road kilometres (te-km)	1 606 937 (3)	1 437 299 (1)	1 988 056 (7)	1 451 107 (2)	1 746 894 (6)	1 660 354 (5)	1 609 500 (4)
Financial cost (£ per tonne)	118.89 (5)	113.22 (2)	122.83 (7)	109.01 (1)	115.32 (3)	118.79 (4)	121.03 (6)
Reliability of delivery (total option score)	1.67 (2)	1.33 (4)	1.33 (4)	2.00 (1)	1.67 (2)	1.17 (6)	0.67 (7)
Compliance with policy (total option score)	294 (6)	297 (4)	298 (3)	297 (4)	301 (1)	301 (1)	293 (7)
Liability of end product (total option score)	3.86 (3)	3.09 (1)	7.12 (7)	3.31 (2)	6.15 (5)	6.15 (5)	5.66 (4)

2.3 *STEP 4 – VALUE PERFORMANCE*

Assigning a rank to the performance of the options places all the criteria on a common index. This helps in considering which option is likely to offer the best overall performance, but looses the resolution of quantitative data. However, criterion scores can be converted to 'value', a measure of performance that retains the cardinal nature of the data, whilst still allowing performance against all criteria to be placed on a common scale.

The 'value' of each performance score can be assessed by converting actual scores into a scale of 0-1, where 0 is the worst performance and 1 the best (in practice, any convenient scale could be employed). This simplifies the performance matrix in *Table 2.26*, retaining the cardinal nature of the data, whilst allowing performance against all criteria to be placed on a common scale. The valued performance data is presented in *Table 2.27*. Note that the unit is now 'value' for each criterion, and a higher value is preferred to a lower value (the reverse being true for ranked data).

Table 2.27 ***Alternative Technology Options - Value***

Criterion	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Depletion of resources	0.00	0.39	1.00	0.43	0.86	0.86	0.73
Air pollution (acidification)	0.00	0.75	0.81	0.22	1.00	1.00	0.85
Greenhouse gas emissions	0.00	0.25	1.00	0.28	0.70	0.70	0.55
Emissions which are injurious to public health	1.00	0.68	0.16	0.00	0.19	0.19	0.31
Landtake	0.00	0.68	0.95	1.00	0.93	0.82	0.26
Extent of water pollution	0.70	0.98	1.00	0.71	1.00	0.78	0.00
Total road kilometres	0.69	1.00	0.00	0.97	0.44	0.60	0.69
Financial cost	0.29	0.70	0.00	1.00	0.54	0.29	0.13
Reliability of delivery	0.75	0.50	0.50	1.00	0.75	0.38	0.00
Compliance with policy	0.13	0.47	0.60	0.47	1.00	1.00	0.00
Liability of end product	0.81	1.00	0.00	0.95	0.24	0.24	0.36

2.4 STEP 5 – BALANCE THE CRITERIA AGAINST ONE ANOTHER

2.4.1 The Need to Weight Criteria

The valuation of the performance of each option against the assessment criteria in *Table 2.27* simplifies the performance data in *Table 2.26*. Each criterion is now reported in terms of the common index of 'value'. However, each option has different advantages and disadvantages, and it is not possible simply to use *Table 2.27* in order to identify a best fitting technology. Identifying a preferred requires that the relative significance of the assessment criteria is established in order to interpret and weight the valued performance data (1).

Decision analysis techniques, such as the multi-criteria assessment method suggested in *Waste Strategy 2000,* elicit and apply weights to reflect the relative significance of criteria, rather than assuming all criteria are equal. This step was recognised in the Royal Commission on Environmental Pollution (RECP)'s First Report (2), where the need for transparency in reporting a decision, and the value judgements which necessarily underlie it, was highlighted.

Appropriate weight sets are not widely published. Nevertheless, the emphasis placed by RCEP on a systematic approach demands that better fitting technology options be justified by reference to a thorough and

(1) First Report of the Royal Commission on Environmental Pollution, 1971.
(2) First Report of the Royal Commission on Environmental Pollution, 1971.

transparent assessment of the impacts of alternatives. The identification of a consultative dimension to the procedure also suggests that the relative significance of assessment criteria should be included in the determination of the better fitting options. Indeed, the Government pointed to the need to refer to '*local environmental, social and economic preferences*' as part of the framework it identified in *Waste Strategy 2000* (1).

Following this guidance, the opinions of key stakeholder in West London were sought. This was achieved through consultation with the Community Panel and senior officers from each of the Boroughs.

2.4.2 *Consultation with the Community Panel*

The West London Boroughs utilised a specially recruited panel of residents to develop the initial weightings for the criteria. The panel were recruited by an independent market research consultancy to be as representative as possible of the West London population as a whole, in terms of gender, ethnicity, age and employment status. The panel consisted of 21 residents, drawn in broadly equal numbers from the six Boroughs (with a slight bias in favour of the largest Boroughs by population).

The Community Panel concept was to begin with, as much as possible with such a small sample size, a group that was representative of the average level of waste knowledge and awareness of the population as a whole. However, opinions of the panel were not sought in this 'raw' state. Rather, the panel were taken through a training seminar that provided them with objective information on the issues of waste management techniques and technologies, waste legislation and regulation and wider social and environmental issues associated with the production of waste. The training seminar took place over most of one Saturday and all 21 panel members attended.

Over the following three weeks, panel meetings were held every Thursday evening for two hours. At the first of these, the panel were introduced to the options to be evaluated and criteria options were discussed.

At the following meeting, the panel produced a 'long list' of evaluation criteria and these were compared to the high level criteria produced by ERM to ensure that they were consistent and able to be measured. At the end of that session, the panel members selected their three 'most important' criteria, in order of preference.

At the final session, the panel was grouped into four groups based on their 'voting preferences' from the previous meeting. Each group then produced an overall weighted criteria set and over the course of the session a consensus was reached across the panel as to the overall weightings that they wished to go forward for evaluation. This weight set was then normalised to create a

(1) *Waste Strategy 2000*, Part 2, paragraph 3.6, Page 28. DETR, May 2000.

final weight set that provided an adequate width of weighting range to ensure that the criteria would be well differentiated in the evaluation.

2.4.3 *Consultation with Officers*

In April 2005, an interactive workshop was held with relevant borough officers [(1)] was held to ensure that the officer's views were included in the weightset. The workshop enabled the officers to obtain a clearer understanding of each criterion, and how they might impact on the options. Each individual officer was asked to distribute points across all of the criteria [(2)], in accordance to how significant they though each to be. This produced individual weight sets for each officer. These were combined to produce the 'officer weight set' given in *Annex H*.

2.4.4 *Derived Weight Sets*

Weights for each assessment criterion derived from the Community Panel and Officer workshop were combined to derive the combined Officer and Community Panel weight set shown in *Table 2.28* [(3)] . The criterion awarded the greatest weight was 'financial cost', followed by 'reliability of delivery'. The criterion awarded least weight was 'landtake'.

Table 2.28 Combined Weight Set Derived from Officer and Community Panel Consultation

Criterion	Weight
Depletion of Resources	0.07
Air pollution (acidification)	0.08
Greenhouse Gas Emissions	0.08
Emissions Injurious to Public Health	0.09
Landtake	0.05
Extent of Water Pollution	0.06
Total Road Kilometres	0.05
Financial Cost	0.16
Liability of End Product	0.09
Reliability of Delivery	0.15
Compliance with Waste Policy	0.11

2.5 STEP 6 – EVALUATE AND RANK THE OPTIONS

The weight set shown in *Table 2.28* has been applied to the valued performance data presented in *Table 2.27*. In doing so, the relative importance of the assessment criteria is accounted for, and the weighted valued performance can be totalled to yield a total weighted value for each option.

(1) All West London boroughs were represented at the workshop, except for Ealing who were unable to attend. A similar exercise, with the appropriate explanation, was emailed to two officers at Ealing, but no response has been received.
(2) Twenty points were given to each officer to distribute across the criteria. A maximum of six points could be given to each criterion.
(3) The individual weight sets can be found in *Annex H*

A set of results from this process is presented in *Table 2.29*. This employs the weights derived from the combined Community Panel and Officer weight set. In the final row, the total weighted valued performance is shown. The higher the number, the higher the overall performance of an option.

The table indicates that, for this set of weights, MBT (option 5) is identified as the highest scoring technology option, followed by EfW (option 4). It should be noted that there is very little difference between the weighted scores for these two options, however. Gasification (option 2) also performs well in the assessment.

The assessment has also concluded that a larger facility may be beneficial to a number of small/ medium sized facilities, as option 7, with multiple MBT plants, performs the least well of the three MBT options. Criteria covering issues of economies of scale, reliability of delivery and environmental performance influenced this conclusion.

Table 2.29 ***Weighted Valued Performance for Alternative Technology Options Using Combined Officer and Community Weight Set***

Criterion	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**
Depletion of resources	0.000	0.026	0.066	0.028	0.057	0.057	0.048
Air pollution (acidification)	0.000	0.062	0.068	0.019	0.083	0.083	0.071
Greenhouse gas emissions	0.000	0.021	0.082	0.023	0.057	0.057	0.045
Emissions which are injurious to public health	0.093	0.063	0.015	0.000	0.017	0.017	0.029
Landtake	0.000	0.032	0.044	0.047	0.044	0.038	0.012
Extent of water pollution	0.048	0.063	0.052	0.049	0.052	0.040	0.000
Total road kilometres	0.038	0.054	0.000	0.053	0.024	0.032	0.037
Financial cost	0.046	0.112	0.000	0.161	0.087	0.047	0.021
Reliability of delivery	0.113	0.075	0.075	0.151	0.113	0.057	0.000
Compliance with policy	0.015	0.054	0.068	0.054	0.113	0.113	0.000
Liability of end product	0.071	0.088	0.000	0.083	0.021	0.021	0.032
TOTAL							
Weighted Scores	**0.424**	**0.649**	**0.469**	**0.666**	**0.668**	**0.563**	**0.294**
Rank	**6**	**3**	**5**	**2**	**1**	**4**	**7**
Value	**0.35**	**0.95**	**0.47**	**0.99**	**1.00**	**0.72**	**0.00**

2.6 STEP 7 – ANALYSE THE SENSITIVITY OF THE RESULTS

To test the robustness of MBT (option 5) as the highest scoring technology option, a number of sensitivity analyses were carried out. The aim of this step was to ensure that a false degree of precision is not implied when a credible variation in one or more parameters might easily change the results.

2.6.1 *Sensitivity Analysis of Weighting Results*

As explained in *Section 2.4*, there are few published weight sets available that are relevant to the assessment process. As well as the individual Officer and Community Panel weight sets, ERM is able to provide weight sets that were derived as part of stakeholder consultation processes in North Yorkshire and the City of York. These specific weight sets can be found in *Annex H.*

Table 2.30, *Table 2.31*, *Table 2.32* and *Table 2.33* below show the impact of applying different weight sets to the valued results shown in *Table 2.27*.

Table 2.30 Total Weighted Performance of Alternative Technology Options Using the WLWA Constituent Borough Officers Weight Set

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total Weighted Scores	0.44	0.64	0.39	0.74	0.66	0.53	0.23
Rank	5	3	6	1	2	4	7
Value	0.42	0.81	0.31	1.00	0.84	0.59	0.00

Table 2.31 Total Weighted Performance of Alternative Technology Options Using the WLWA Community Panel Weight Set

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total Weighted Scores	0.40	0.66	0.55	0.59	0.68	0.59	0.36
Rank	6	2	5	4	1	3	7
Value	0.14	0.93	0.59	0.73	1.00	0.74	0.00

Table 2.32 Total Weighted Performance of Alternative Technology Options Using the North Yorkshire Members & Officers Weight Set

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total Weighted Scores	0.43	0.62	0.46	0.67	0.62	0.51	0.33
Rank	6	2	5	1	3	4	7
Value	0.30	0.86	0.38	1.00	0.85	0.53	0.00

Table 2.33 Total Weighted Value Performance for Alternative Technology Options Using the City of York Members & Officers Weight Set

	Option						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Total Weighted Scores	0.41	0.62	0.41	0.67	0.64	0.54	0.29
Rank	6	3	5	1	2	4	7
Value	0.31	0.87	0.31	1.00	0.92	0.66	0.00

Table 2.30, Table 2.32, and *Table 2.33* show that when the Officer, North Yorkshire and City of York weight sets are applied, the single MBT facility is no longer the highest scoring technology option. Instead the EfW option (4) scores highest. This is because the Officer, North Yorkshire and City of York weight sets give more weight to financial cost.

2.6.2 *Sensitivity of RDF to Combustion Assumption*

The relatively strong environmental performance of the MBT technology is dependant upon the assumption that the RDF produced as part of the process is sold and used as a fuel in a cement kiln. Although the issues regarding this assumption have been highlighted in the reliability of delivery and liability of end product criteria, it is important to ensure consideration is given to its actual significance.

Two further options, S1 and S2, have been assessed as part of sensitivity analyses. These options consider the implications of two alternative end-routes for the RDF produced by the MBT process:

- **S1** - RDF is exported to an EfW plant for combustion;
- **S2** – there is no market for the RDF produced and it is sent to landfill.

It must be noted that option S2 does not meet the key constraint placed upon all other options as, from 2015 onward, it **does not meet WLWA's LATS targets.**

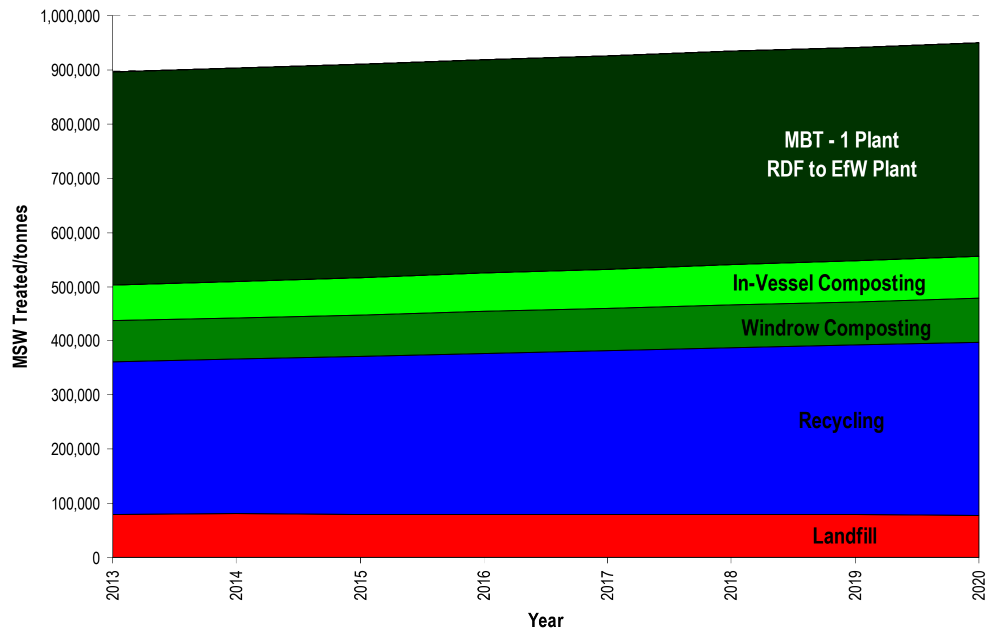
2.7 ASSESSMENT OF OPTIONS S1 AND S2

Table 2.34 provides a summary of the additional options, compared to the original options, 1-4. Options 5-7 were not included in this comparison, as they consider the original assumption, that RDF produced by MBT will be sent to a cement kiln for combustion. The additional options are further detailed in *Figure 2.8* and *Figure 2.9*.

Table 2.34 Summary Table for Residual Waste Options for WLWA

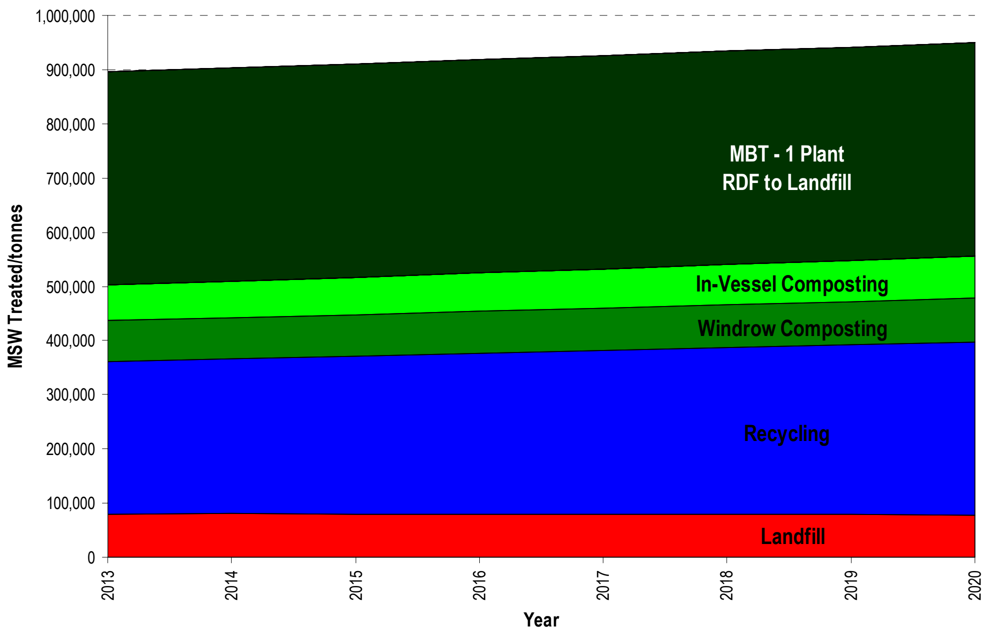
	Option 1	Option 2	Option 3	Option 4	Option S1	Option S2
Recycling & Composting (% of MSW in 2020)	50%	50%	50%	50%	50%	50%
Anaerobic Digestion	✓					
Gasification		✓				
Autoclaving			✓			
Energy from Waste				✓		
MBT					✓	✓
Fate of RDF	-	-	Cement Kiln	-	EfW Plant	Landfill
Number of Residual Waste Treatment Plants	1	1	1	1	1	1
Landfill	✓	✓	✓	✓	✓	✓

Figure 2.8 Option S1: One MBT Facility, with RDF to EfW Plant



Option S1 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one large MBT facility introduced in 2013; and landfill, to the maximum allowed under the Landfill Directive. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF that will be sent to an EfW plant for combustion, as well as residual waste that will be sent for landfill.

Figure 2.9 ***Option S2: One MBT Facility, with RDF to Landfill***



Option S2 employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one large MBT facility introduced in 2013; and landfill, to the maximum allowed under the Landfill Directive. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF, as well as residue waste that will be sent for landfill. It was assumed that no market for the RDF combustion was available, however. Instead, the plant was configured to increase the performance of the process, in terms of loss of BMW, from 6% to 38% (see *Section 1.4.3*) and the RDF was sent to landfill.

2.7.1 *Assessment of the Performance of Options S1 and S2 against the Criteria*

Section 2.2 explains the methods and assumptions used for the assessment of the performance of options against each criterion. A summary of the results is presented in *Table 2.35* below, with ranks in brackets, followed by an analysis of the performance of options S1 and S2 against the criteria.

Table 2.35 Alternative Technology Options (including S1 and S2) - Summary of Results

Criterion	Option 1	Option 2	Option 3	Option 4	Option S1	Option S2
Depletion of resources (,000 tonnes of crude oil equivalents)	-962 (6)	-1258 (4)	-1715 (1)	-1283 (2)	-1262 (3)	-990 (5)
Air pollution (acidification) (tonnes of sulphur dioxide equivalents)	-8847 (6)	-16156 (2)	-16791 (1)	-11034 (4)	-11571 (3)	-9767 (5)
Greenhouse gas emissions (,000 tonnes of carbon dioxide equivalents)	-1634 (5)	-2008 (3)	-3114 (1)	-2051 (2)	-1740 (4)	-1375 (6)
Emissions which are injurious to public health (health impacts score)	0.0325 (1)	0.0700 (3)	0.1308 (5)	0.1496 (6)	0.1279 (4)	0.0640 (2)
Landtake (ha)	87.54 (5)	79.52 (4)	76.43 (2)	75.79 (1)	76.62 (3)	98.70 (6)
Extent of water pollution (water assessment score)	1276 (4)	1184 (1)	1256 (2)	1273 (3)	1345 (5)	1373 (6)
Total road kilometres (te-km)	1,606,937 (4)	1,437,299 (1)	1,988,056 (6)	1,451,107 (2)	1,539,423 (3)	1,778,823 (5)
Financial cost (£ per tonne)	118.89 (4)	113.22 (2)	122.83 (6)	109.01 (1)	115.32 (3)	121.90 (5)
Reliability of delivery (total option score)	1.67 (2)	1.33 (5)	1.33 (5)	2.00 (1)	1.67 (2)	1.67 (2)
Compliance with policy (total option score)	294 (5)	297 (4)	298 (2)	297 (3)	301 (1)	258 (6)
Liability of end product (total option score)	3.86 (4)	3.09 (1)	7.12 (6)	3.31 (2)	6.15 (5)	3.73 (3)

Results for Option S1 and S2

In comparison with option 5 (one MBT plant with RDF to cement kiln), option S1 performed poorly in all three environmental criteria (resource depletion, air pollution (acidification) and greenhouse gas emissions), as the energy recovery associated with combusting RDF in an EfW facility is assumed to offset the production of grid electricity. In comparison, the energy recovered from burning RDF in cement kilns is assumed to displace the combustion of coal. This coal displacement delivers a resource depletion, acidification and greenhouse gas emission benefits greater than the displacement of grid electricity production.

Option S1 also scored relatively poorly against the water pollution criterion, due to an additional requirement to send residues to a hazardous landfill site following the combustion of RDF in an EfW facility.

With the exception of the transport criterion (total road kilometres), option S1 was ranked the same as its equivalent, option 5, for all of the other criteria assessed. Option S1 performed well in terms of transport due to the proximity of an available EfW facility, in comparison to the closest cement kiln.

Option S2 scored poorly against the majority of criteria, due to its dependence on landfill. Landfilling of RDF performed badly as it is a poor use of resources, takes up a greater area of land, has greater associated water pollution implications, results in increased cost due to landfill taxes and is low down on the waste hierarchy.

Option S2 scored comparatively well in terms of health impacts as landfill has a relatively low rate of emissions that are considered injurious to public health. It also scored well in terms of the liability of end products as landfill capacity is relatively secure.

2.7.2 *Value Performance*

The 'value' of each performance score was assessed by converting actual scores into a scale of 0-1, where 0 is the worst performance and 1 the best (in practice, any convenient scale could be employed). The valued performance data is presented in *Table 2.36*. Note that the unit is now 'value' for each criterion, and a higher value is preferred to a lower value (the reverse being true for ranked data).

Table 2.36 Alternative Technology Options (including S1 and S2) - Value

Criterion	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option S1**	**Option S2**
Depletion of resources	0.00	0.39	1.00	0.43	0.40	0.04
Air pollution (acidification)	0.00	0.92	1.00	0.28	0.34	0.12
Greenhouse gas emissions	0.15	0.36	1.00	0.39	0.21	0.00
Emissions which are injurious to public health	1.00	0.68	0.16	0.00	0.19	0.73
Landtake	0.49	0.84	0.97	1.00	0.96	0.00
Extent of water pollution	0.51	1.00	0.62	0.53	0.15	0.00
Total road kilometres	0.69	1.00	0.00	0.97	0.81	0.38
Financial cost	0.29	0.70	0.00	1.00	0.54	0.07
Reliability of delivery	0.50	0.00	0.00	1.00	0.50	0.50
Compliance with policy	0.84	0.90	0.93	0.90	1.00	0.00
Liability of end product	0.81	1.00	0.00	0.95	0.24	0.84

2.7.3 *Evaluating and Ranking the Options*

A set of results from this process is presented in *Table 2.37*. This employs the combined weight sets derived from the WLWA Constituent Borough Officers and Community Panel (see *Section 2.4.4*). The table indicates that the highest scoring technology option is now EfW (option 4).

Table 2.37 ***Weighted Valued Performance for Alternative Technology Options (including S1 and S2) Using Combined Officer and Community Weight Set***

Criterion	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option S1**	**Option S2**
Depletion of resources	0.000	0.026	0.066	0.028	0.026	0.002
Air pollution (acidification)	0.000	0.077	0.083	0.023	0.029	0.010
Greenhouse gas emissions	0.012	0.030	0.082	0.032	0.017	0.000
Emissions which are injurious to public health	0.093	0.063	0.015	0.000	0.017	0.068
Landtake	0.000	0.023	0.039	0.046	0.045	0.000
Extent of water pollution	0.032	0.063	0.039	0.033	0.009	0.000
Total road kilometres	0.038	0.054	0.000	0.053	0.044	0.021
Financial cost	0.046	0.112	0.000	0.161	0.087	0.011
Reliability of delivery	0.075	0.000	0.000	0.151	0.075	0.075
Compliance with policy	0.095	0.102	0.105	0.102	0.113	0.000
Liability of end product	0.071	0.088	0.000	0.083	0.021	0.074
TOTAL						
Weighted Scores	**0.46**	**0.64**	**0.43**	**0.71**	**0.48**	**0.26**
Rank	**4**	**2**	**5**	**1**	**3**	**6**
Value	**0.45**	**0.84**	**0.37**	**1.00**	**0.50**	**0.00**

2.7.4 *Sensitivity Analysis of Weighting Results (including S1 and S2)*

Table 2.38, *Table 2.39*, *Table 2.40* and *Table 2.41* show the impact of applying different weight sets to the valued results shown in *Table 2.37*. When the Officer, North Yorkshire and City of York weight sets are applied, EfW (option 4) remains the highest scoring technology option. When the Community Panel weight set is applied, gasification (option 2) scores more highly.

Table 2.38 ***Total Weighted Performance of Alternative Technology Options Using the WLWA Constituent Borough Officers Weight Set***

	Option					
	1	**2**	**3**	**4**	**S1**	**S2**
Total Weighted Scores	0.51	0.63	0.35	0.81	0.52	0.28
Rank	4	2	5	1	3	6
Value	0.44	0.65	0.12	1.00	0.45	0.00

Table 2.39 ***Total Weighted Performance of Alternative Technology Options Using the WLWA Community Panel Weight Set***

	Option					
	1	**2**	**3**	**4**	**S1**	**S2**
Total Weighted Scores	0.41	0.64	0.51	0.61	0.45	0.24
Rank	5	1	3	2	4	6
Value	0.43	1.00	0.67	0.91	0.51	0.00

Table 2.40 ***Total Weighted Performance of Alternative Technology Options Using the North Yorkshire Members & Officers Weight Set***

	Option					
	1	**2**	**3**	**4**	**S1**	**S2**
Total Weighted Scores	0.43	0.59	0.38	0.70	0.41	0.29
Rank	3	2	5	1	4	6
Value	0.36	0.73	0.23	1.00	0.30	0.00

Table 2.41 ***Total Weighted Value Performance for Alternative Technology Options Using the City of York Members & Officers Weight Set***

	Option					
	1	**2**	**3**	**4**	**S1**	**S2**
Total Weighted Scores	0.49	0.64	0.39	0.74	0.50	0.25
Rank	4	2	5	1	3	6
Value	0.49	0.79	0.28	1.00	0.51	0.00

2.8 IMPLICATIONS FOR STAGE TWO: INTEGRATED OPTIONS ASSESSMENT

Results of the alternative technology assessment identify MBT as the highest scoring technology option for WLWA's residual waste. However, sensitivity analyses have shown that these results are sensitive to a number of key assumptions made during the modelling procedure.

If alternative weight sets are used to balance the relative importance of the assessment criteria, EfW becomes the highest scoring technology on the majority of occasions. Similarly, if it is assumed that the cement kiln market for RDF from MBT fails, EfW again becomes the highest scoring technology when the majority of alternative weight sets are applied.

In light of this, and with regard to the general uncertainties and ongoing consultation surrounding MBT [1], it is considered that the residual waste management options comprising the second stage of assessment should encompass both technologies: MBT and EfW. The Environment Agency is currently carrying out a consultation process, focusing on how bio-treated outputs from MBT will contribute to LATS diversion targets [2]. Until this has been clarified, it is difficult to determine, with certainty, how this will impact on performance.

(1) Assessing the diversion of biodegradable municipal waste from landfill by mechanical biological treatment and other options, Environment Agency, 2004.
(2) Assessing the diversion of biodegradable municipal waste from landfill by mechanical biological treatment and other options, Environment Agency, November 2004.

3 STAGE 2 - ASSESSMENT OF INTEGRATED WASTE MANAGEMENT OPTIONS FOR WLWA

3.1 STEP 2: IDENTIFY RESIDUAL WASTE MANAGEMENT OPTIONS

A series of six integrated options for residual waste management were developed, based on the highest scoring technologies identified during stage one of the assessment, MBT and EfW. The options encompass all reasonable means of meeting WLWA's LATS targets over the Strategy period, 2005-2020, and can be broadly split into two categories, according to the lead technology:

- MBT-based options. Two possible options were identified for the use of MBT as lead technology. The first was to introduce a small MBT plant prior to 2013, and the second was to introduce the larger MBT facility earlier on in the Strategy period, in order to meet LATS requirements in 2010; and

- EfW-based options. Four possible options were identified for the use of EfW as lead technology. It was not considered possible to introduce an EfW plant earlier than 2013 and, as such, each option considers the introduction of an EfW plant in 2013, together with an alternative method of diverting wastes from landfill between 2010 and 2013, in order to meet LATS requirements. These include exporting wastes to an existing EfW plant, or introducing a small MBT plant and scaling down the size of EfW required from 2013. An option that investigates the implications of taking no action until 2013, and facing LATS penalties, was also considered.

The six options are intended to be illustrative rather than precise. They reflect the total forecast arisings of MSW across WLWA between 2005 and 2020 and so take into consideration:

- predicted recycling and composting rates as discussed in *Section 1.4.2*;

- the yearly throughput of residual waste to treatment facilities required to meet LATS targets over the period (taking into consideration the fate of all residues from the treatment process); and

- the remaining quantity of waste that the Authority is permitted to landfill.

The finalised options are summarised in *Table 3.1* and shown graphically in *Figure 3.1* to *Figure 3.6* below. The recycling and composting rates given in *Table 3.1* illustrate the amount of material collected separately for reprocessing. Some of the treatment technologies also produce material suitable for recycling and composting. This material is included as part of the assessment and is in addition to the recycling and composting rates shown (1).

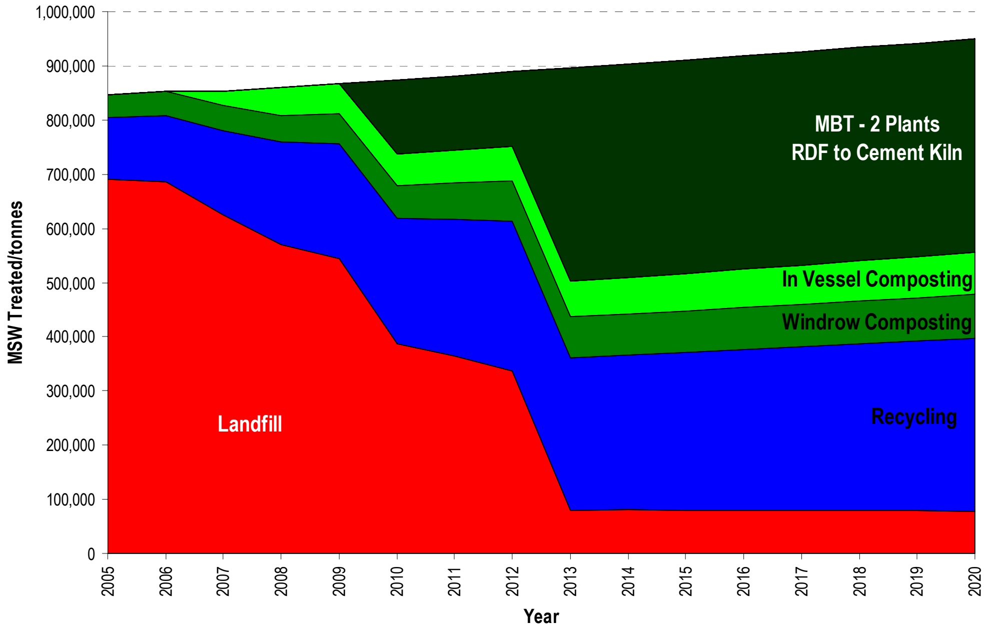
Full lists of all technology assumptions made are provided in *Annex A*.

Table 3.1 Summary Table of Integrated Residual Waste Management Options for WLWA

	Year	Option A	Option B	Option C	Option D	Option E	Option F
Recycling & Composting %	2010	40	40	40	40	40	40
	2015	48	48	48	48	48	48
	2020	50	50	50	50	50	50
MBT with RDF to Cement Kiln	2010	16	45			16	
	2015	43	43			15	
	2020	41	41			14	
MBT with RDF to EfW %	2010						16
	2015						15
	2020						14
In-house Energy from Waste (EfW) %	2010			0	0	0	0
	2015			26	26	17	17
	2020			25	25	16	16
Exported EfW %	2010			2			
	2015			0			
	2020			0			
Number of Treatment Plants		2	1	1	1	2	2
Landfill %	2010	44	15	58	60	44	44
	2015	9	9	26	26	20	20
	2020	8	8	25	25	19	19

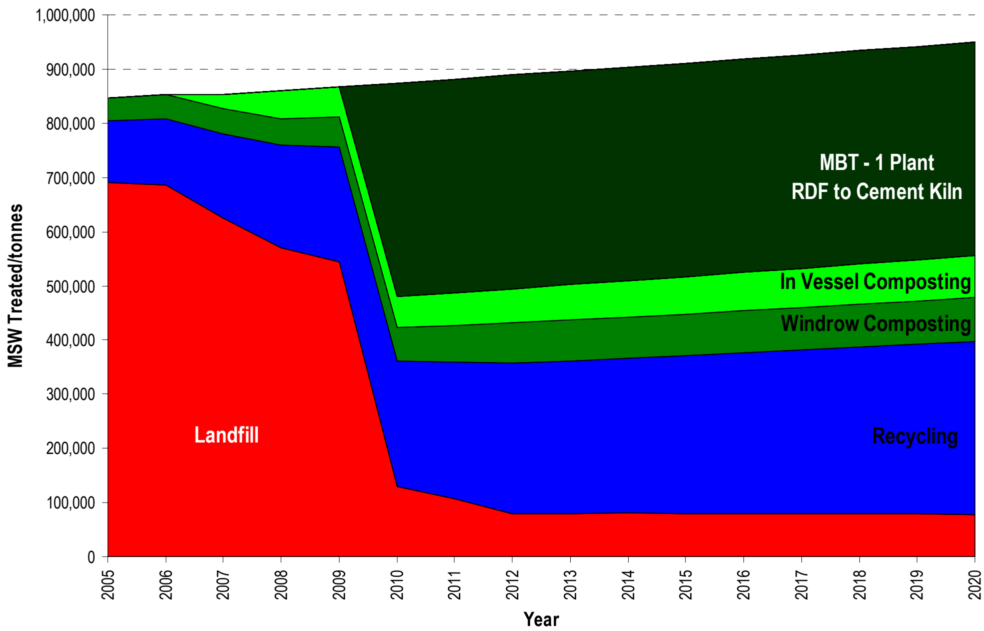
(1) Recycling and composting rates are based on the optimal scenario for recycling and composting, as determined during recycling and composting options appraisal.

Figure 3.1 *Option A*



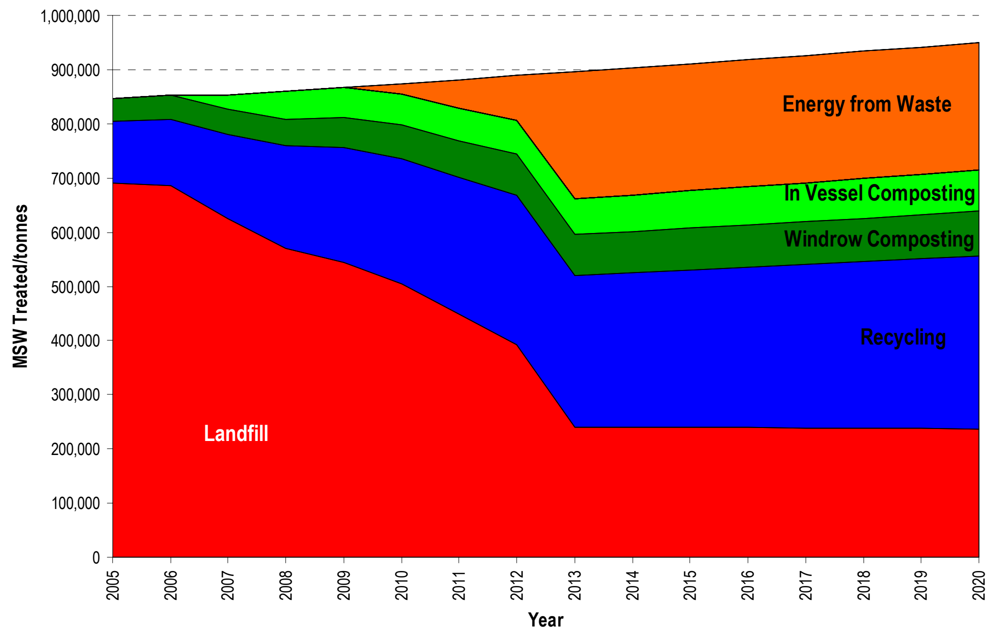
Option A employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one small MBT plant introduced in 2010; one large MBT plant introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the MBT plants will separate a number of materials for recycling and produce an RDF that will be sent to a cement kiln for combustion, as well as residual waste that will be sent for landfill.

Figure 3.2 *Option B*



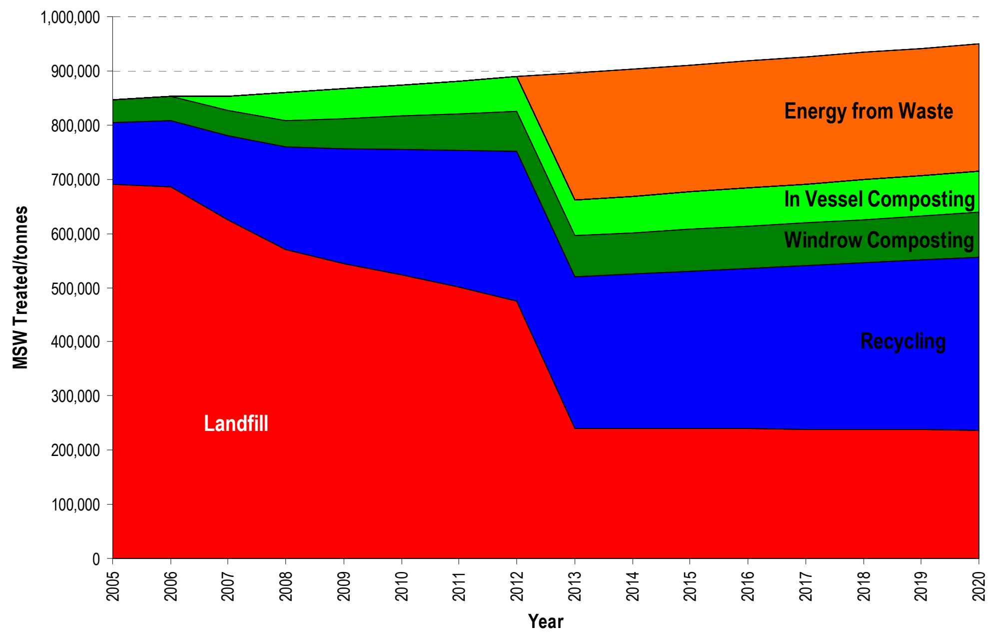
Option B employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one large MBT plant introduced in 2010; and landfill, to the maximum allowed under LATS. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF that will be sent to a cement kiln for combustion, as well as residual waste that will be sent for landfill.

Figure 3.3 ***Option C***



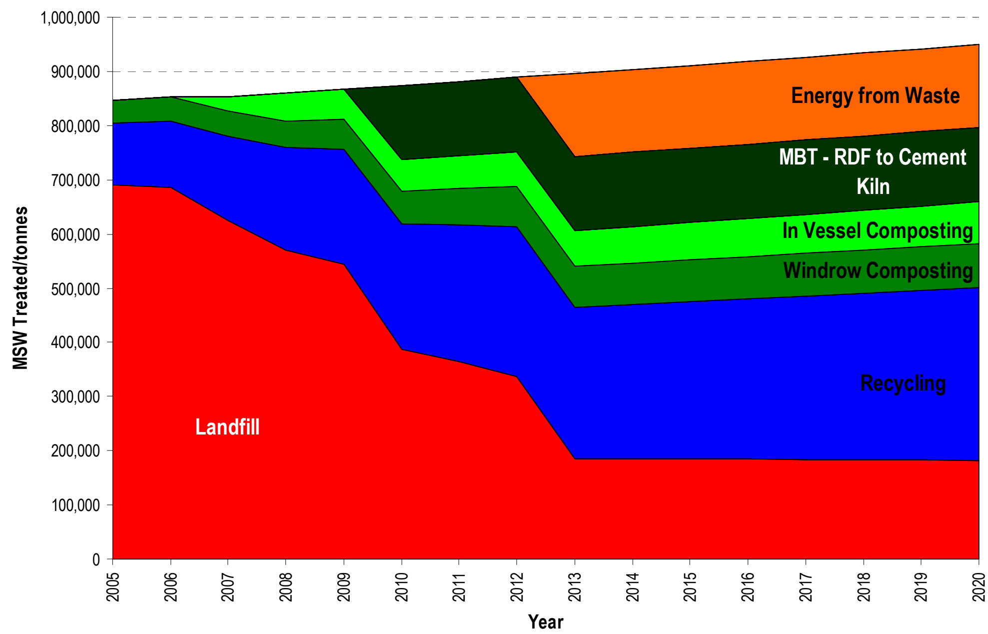
Option C employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one EfW facility introduced in 2013; and landfill, to the maximum allowed under LATS. Under this scenario the need to divert additional waste from landfill between 2010 and 2013 will be met by exporting this tonnage to an existing EfW facility. It was assumed that both EfW plants will separate ferrous metals for recycling, produce a bottom ash that will be recycled as aggregate and a fly ash that will classed as hazardous waste and require treatment at a hazardous landfill site.

Figure 3.4 *Option D*



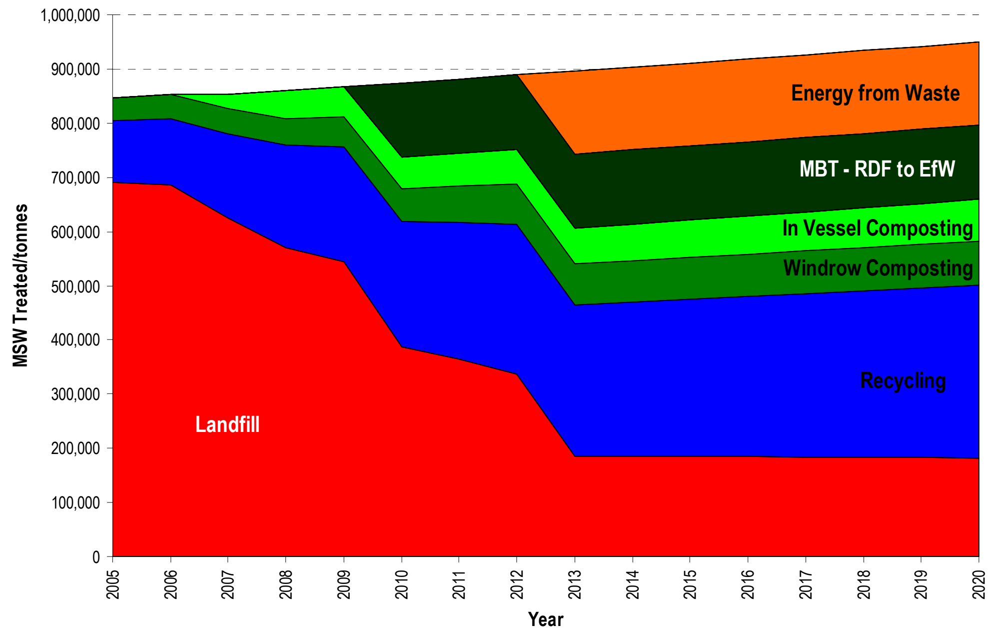
Option D employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one EfW facility introduced in 2013; and landfill, to the maximum allowed under LATS. This scenario examines the implications of WLWA choosing not to divert additional waste between 2010 and 2013. As such, this scenario **does not meet LATS requirements** in 2010, 2011 and 2012. It was assumed that the EfW process will separate ferrous metals for recycling, produce a bottom ash that will be recycled as aggregate and a fly ash that will classed as hazardous waste and require treatment at a hazardous landfill site.

Figure 3.5 *Option E*



Option E employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one small MBT facility introduced in 2010; one EfW facility introduced in 2013; and landfill, to the maximum allowed under LATS. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF that will be sent to a cement kiln for combustion, as well as residual waste that will be sent for landfill. It was assumed that the EfW process will separate ferrous metals for recycling, produce a bottom ash that will be recycled as aggregate and a fly ash that will classed as hazardous waste and require treatment at a hazardous landfill site.

Figure 3.6 *Option F*



Option F employs a mixture of a high recycling and composting rate, reaching 50% by 2020; one small MBT facility introduced in 2010; one EfW facility introduced in 2013; and landfill, to the maximum allowed under the Landfill Directive. It was assumed that the MBT process will separate a number of materials for recycling and produce an RDF that will be sent to the EfW facility for combustion (prior to 2013 an alternative market will need to be found), as well as residue waste that will be sent for landfill. It was assumed that the EfW process will separate ferrous metals for recycling, produce a bottom ash that will be recycled as aggregate and a fly ash that will classed as hazardous waste and require treatment at a hazardous landfill site.

3.2 STEP 3 – ASSESS THE PERFORMANCE OF THE OPTIONS AGAINST THE CRITERIA

A detailed analysis of the performance of the alternative waste management options against the criteria outlined in *Section 1.3.3* is included below. The performance results are also summarised in *Table 3.15*. The majority of the criteria use the same assessment methodology as described in *Section 2.2*. However, where differences occur, they are described below.

3.2.1 Resource Depletion

The methods and assumptions used in calculating the criterion of resource depletion are detailed in *Section 2.2.1*.

Results

The resource depletion results are presented in *Table 3.2*, in thousands of tonnes of crude oil equivalents. The total scores for all waste management routes that are involved in a particular option are ranked underneath.

Table 3.2 Resource Depletion Scores (in ,000 tonnes of Crude Oil Equivalents) for each Option, by Technology

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Recycling	-1394	-1394	-1394	-1394	-1394	-1394
Windrow	7	7	7	7	7	7
In-vessel composting	6	6	6	6	6	6
MBT	-810	-987	-	-	-343	-35
EfW	-	-	-419	-388	-253	-393
Landfill	-82	-76	-82	-83	-81	-81
Total score	**-2272**	**-2443**	**-1881**	**-1851**	**-2057**	**-1890**
Rank	2	1	5	6	3	4

Both MBT and EfW deliver significant resource depletion benefits due to the separation of materials for recycling and the energy recovered from combustion. The options that are comprised predominantly of treatment by combustion in an EfW plant (C and D) perform less well against this criterion. However, as the energy recovered from EfW is assumed to displace the production of grid electricity. In comparison, the energy recovered from burning RDF in cement kilns is assumed to displace the combustion of coal. This coal displacement delivers a resource depletion benefit greater than the displacement of grid electricity production.

Option B performs best against this criterion as this option results in the greatest production of RDF over the time period, as a large MBT facility is built early on.

3.2.2 *Air Pollution (Acidification)*

The methods and assumptions used in calculating the criterion of air acidification are detailed in *Section 2.2.2*.

Results

The acidification results are presented in *Table 3.3*, in tonnes of SO_2 equivalents. The total scores for all waste management routes that are involved in a particular option are ranked underneath.

Table 3.3 ***Acidification Scores (in tonnes of SO_2 Equivalents) for each Option, by Technology***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Recycling	-13 584	-13 584	-13 584	-13 584	-13 584	-13 584
Windrow	24	24	24	24	24	24
In-vessel composting	20	20	20	20	20	20
MBT	-11 372	-13 842	-	-	-4813	-509
EfW	-	-	-2660	-2459	-1604	-2534
Landfill	-519	-484	-520	-532	-515	-515
Total score	**-25 431**	**-27 867**	**-16 720**	**-16 532**	**-20 473**	**-17 099**
Rank	2	1	5	6	3	4

As with resource depletion, we see that all scores result in net reductions in acidification, as the activities offset the generation of SO_2 by other processes, such as the extraction of raw materials or the generation of power by alternative means.

The MBT options (A and B) again perform best, as the RDF production associated with these options displaces SO_2 emissions from alternatively burning coal in cement kilns. The benefit from this is significantly greater than that associated with the displacement of grid electricity, as is assumed for EfW.

The increased quantity of RDF produced in option B results in it being the highest scoring for this criterion.

3.2.3 *Greenhouse Gas Emissions*

The methods and assumptions used in calculating the criterion of greenhouse gas emissions are detailed in *Section 2.2.3*.

Results

The greenhouse gas emission results are presented in *Table 3.4*, in thousands of tonnes of CO_2 equivalents. The total scores for all waste management routes that are involved in a particular option are ranked underneath.

Table 3.4 ***Greenhouse Gas Emission Scores (in ,000 tonnes of CO_2 Equivalents) for each Option, by Technology***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Recycling	-2640	-2640	-2640	-2640	-2640	-2640
Windrow	24	24	24	24	24	24
In-vessel composting	21	21	21	21	21	21
MBT	-1460	-1781	-	-	-619	-105
EfW	-	-	-721	-666	-435	-507
Landfill	783	729	785	804	778	778
Total score	**-3272**	**-3647**	**-2531**	**-2458**	**-2871**	**-2429**
Rank	2	1	4	5	3	6

The trend set by resource depletion and acidification is continued with greenhouse gas emissions. The figures are all negative and they are once more dominated by the energy implications of the different options.

The MBT option B is the highest scoring, with option A coming second, as with the resource depletion and acidification criteria. Once more, the displacement of coal combustion in cement kilns leads to a greater offset of CO_2 equivalent emissions. Option B produces a greater quantity of RDF over the Strategy time period and so realises a greater benefit.

The options that predominantly comprise EfW (C and D) score poorly for the third time, but this time the worst performing option (F) involves both EfW and MBT (producing RDF for combustion in an EfW plant). This is due to the relatively higher emissions of CO_2 equivalents from the EfW plant in option F, in comparison with options C and D – a result of the higher plastic content of the RDF that is combusted in the plant.

3.2.4 Emissions which are Injurious to Public Health

The methods and assumptions used in calculating the criterion of emissions which are injurious to public health are detailed in *Section 2.2.4*.

Results

The results of applying the impact factors to the throughputs of each facility type are presented in *Table 3.5* of each of the technologies that may be involved in the option. The totals are ranked at the bottom of the table.

Table 3.5 Health Impacts Scores for each Option, by Technology

	Option					
Technology	**A**	**B**	**C**	**D**	**E**	**F**
Recycling	-	-	-	-	-	-
Windrow	0.009	0.009	0.009	0.009	0.009	0.009
In-vessel composting	0.008	0.008	0.008	0.008	0.008	0.008
MBT	0.039	0.048	-	-	0.017	0.017
RDF	0.082	0.1	-	-	0.035	-
Incineration	-	-	0.14	0.129	0.084	0.119
Landfill	0.033	0.031	0.034	0.035	0.033	0.033
Total	**0.171**	**0.195**	**0.190**	**0.180**	**0.186**	**0.186**
Rank	1	6	5	2	3	3

(†) Impact per million tonnes processed – see methodology section for derivation of figures

The biggest impact factor is associated with the combustion of residual waste and RDF, either in an EfW plant, or cement kiln. The MBT option, A, produces relatively less RDF over time, as the large plant is not introduced until later in the Strategy period. As such, option A is the highest scoring option with respect to health impacts.

Perhaps surprisingly, the alternative MBT option, B, is ranked poorest for health effects. This is due to the combined impact of the large MBT plant being introduced early on in the Strategy period, and the larger quantity of RDF produced from this plant.

3.2.5 *Landtake*

The methods and assumptions used in calculating the landtake criterion are detailed in *Section 2.2.5*.

Results

A summary of the potential 'total landtake' for all options is given in *Table 3.6*, indicating an average annual landtake ranging from 78.86ha to 83.25ha.

Table 3.6 ***Average Annual Landtake over Period for West London Options (ha)***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Recycling	9.11	9.11	9.11	9.11	9.11	9.11
Windrow	23.13	23.13	23.13	23.13	23.13	23.13
IVC	0.64	0.64	0.64	0.64	0.64	0.64
MBT	2.79	2.56	0.00	0.00	1.43	1.43
Incineration	0.00	0.00	2.04	1.43	1.19	1.77
Landfill	46.87	43.43	47.56	48.94	46.87	46.87
Total	**82.54**	**78.86**	**82.48**	**83.25**	**82.36**	**82.94**
Rank	4	1	3	6	2	5

Option B has the lowest landtake requirement (78.86ha) and has subsequently been awarded the highest rank of 1. This is primarily due to its relatively lower landtake requirements for waste being disposed of directly to landfill. Option D has the lowest ranking because of its high requirements for landfilling and the earlier introduction of a larger facility.

3.2.6 *Extent of Water Pollution*

The methods and assumptions used in calculating the criterion of water pollution are detailed in *Section 2.2.6*.

Results

Table 3.7 shows the water pollution scores for the residual waste management options.

Table 3.7 ***Water Pollution Scores for each Option***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total score	**1270**	**1204**	**1246**	**1233**	**1317**	**1295**
Rank	4	1	3	2	6	5

Overall, there is no significant difference between MBT and EfW with regard to the risk to water. The reason why some options perform better than others is mainly due to the number of facilities involved. Options A, E and F model the initial introduction of a small MBT plant, followed by additional facility in 2013. As a result, these options score poorly.

Option B performs best in terms of water pollution, as it involves the treatment of waste in only one MBT plant (with RDF requiring further combustion in a cement kiln). Option D is ranked second as it involves only one EfW plant, but hazardous residues are produced that will require some, albeit small, albeit small, hazardous landfill capacity. This requirement is slightly higher in option C, as EfW is utilised from 2010.

3.2.7 Total Road Kilometres

The methods and assumptions used in calculating the total road kilometres criterion are detailed in *Section 2.2.7*. Although the assessment is not a site-specific assessment, assumptions on indicative reprocessing, treatment and disposal locations have had to be made in order to allow transport distances to be calculated. These assumptions are listed in *Annex D*.

Results

The total transport results, in kilometres, are shown in *Table 3.8*.

Table 3.8 Total Road Transport Distance for each Option (te-km)

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total distance	27 788 543	27 954 653	25 683 685	25 963 525	26 152 418	23 924 451
Rank	5	6	2	3	4	1

Options C and D perform well against this criterion because the treatment processes employed in these options do not involve significant 'post treatment' transport. However, option F performs best overall as the RDF produced by the MBT process is recovered locally, and in comparison to options C and D, this option also has reduced transportation associated with disposal to landfill.

Options A and B perform worst against this criterion due to the large amount of onward transport of materials following initial treatment.

3.2.8 Financial Costs

The methods and assumptions used in calculating the landtake criterion are detailed in *Section 2.2.8*. Assumptions underpinning the estimation of financial costs in this assessment can be found in *Annex E*.

Results

Table 3.9 presents an estimate of the total costs for each option over the period per tonne of waste, including consideration of gate fees and collection costs.

Table 3.9 ***Breakdown Average of Collection and Disposal Costs for West London Waste Management Options***

Technology	Options					
	A	B	C	D	E	F
Recycling	529 939 152	529 939 152	529 939 152	529 939 152	529 939 152	529 939 152
Windrow	143 584 734	143 584 734	143 584 734	143 584 734	143 584 734	143 584 734
IVC	113 479 795	113 479 795	113 479 795	113 479 795	113 479 795	113 479 795
MBT	277 012 222	322 025 539	0	0	124 208 885	105 816 082
Incineration	0	0	148 516 737	137 332 391	95 703 441	118 442 393
Landfill	549 284 119	494 486 630	614 300 719	628 891 825	582 159 855	583 692 451
LATS Penalties	0	0	0	14 964 450	0	0
Total Costs	1 613 300 023	1 603 515 851	1 549 821 138	1 568 192 348	1 589 075 862	1 594 954 608
Total (£/tonne)	**113**	**112**	**108**	**110**	**111**	**112**
Rank	6	5	1	2	3	4

NB– output costs from the modelling process are presented in full (to nine significant figures) but are not intended to convey precision.

One factor that is common to all options is the landfill tax, which is included in the landfill cost per tonne. Fines associated with LATS penalties have been included in this assessment at £150 per tonne. Option D is the only option to incur this additional cost.

The low costs associated with incineration technologies led to option C providing the least expensive waste management and awarded the highest ranking (1). This provides waste management for the 16-year period at an estimated average cost of £108 per tonne. Option D also performs well against this criterion, despite having to pay LATS penalties for a limited amount of waste, with the overall average cost of waste treatment at under £110 per tonne.

3.2.9 Reliability of Delivery

The methods and assumptions used in calculating the reliability of delivery criterion are detailed in *Section 2.2.9*.

Results

The scores for 'proven technology' and 'probability of securing planning permission' have been weighted equally and added together to give a final score (highest rank = best performance for this criterion). Option C and D are shown to rank highest for this criterion (*Table 3.10*). This is due to incineration being an established technology and the requirement of fewer treatment facilities. Options A, E and F score poorly due the higher number of facilities needed.

Table 3.10 ***Reliability of Delivery Results for MSW Options***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total option score	1.17	1.67	2.00	2.00	1.33	1.33
Rank	6	3	1	1	4	4

3.2.10 *Compliance with Waste Policy*

The methods and assumptions used in calculating the compliance with waste policy criterion are detailed in *Section 2.2.10*.

Results

Table 3.11 presents the total quantities of waste as a percentage managed by each technology for each option. These percentages were multiplied by the waste hierarchy rank for each technology over the whole 16-year period (rather than just the maximum recycling rate achieved for example). The average recycling and composting levels vary between the options. This is because the figures in *Table 3.11* includes not only waste recycled at kerbside, but also any recycling that takes place as part of the treatment process. These figures have been summed to provide a total score for each option.

Table 3.11 ***Waste Managed by Each Technology (%) for West London Options***

	Option					
Waste technology	**A**	**B**	**C**	**D**	**E**	**F**
Recycling/composting	43	44	41	41	42	42
Recovery	13	15	0	0	5	5
Energy from waste	0	0	14	13	9	9
Landfill	44	41	45	46	44	44

Recovery in this table primarily refers to the recovery of end products from technologies, ie Option A, B, E and F 'recovery' relates to the combustion of RDF following MBT treatment.

Table 3.12 presents the performance scores for each option. Option B employed treatment facilities that manage waste at the top of the waste hierarchy and had low volumes to landfill, and as a result has been awarded the highest overall rank (1).

Table 3.12 ***Compliance with Waste Policy to Determine Performance Score for MSW Options***

Waste technology	Option					
	A	B	C	D	E	F
Recycling/composting	174	176	165	165	169	169
Recovery	38	46	0	0	16	16
Energy from waste	0	0	43	39	26	26
Landfill	44	41	45	46	44	44
Total	**256**	**263**	**252**	**250**	**254**	**254**
Rank	2	1	5	6	3	3

Options D and C scored least well because they involve managing waste lower down the waste hierarchy as well as less recycling.

3.2.11 *End Product Liability*

The methods and assumptions used in calculating the criterion of end product liability are detailed in *Section 2.2.11*.

Results

Table 3.13 presents the total quantities of each end product as a percentage of the total waste managed by each option. The percentages were multiplied by the end product liability score and these figures summed to provide a total score for each option.

Table 3.13 ***End Products from each Option (Expressed as a % of Total Waste Managed)***

End Products	Option					
	A	B	C	D	E	F
All recyclables	30	30	33	33	32	32
Compost/landspread	14	14	14	14	14	14
RDF to external market	8	10	-	-	4	1
RDF to WLWA facility	-	-	-	-	-	3
Hazardous residues to landfill	-	-	0.33	0.33	0.22	0.3
Non-hazardous residues to landfill	10	12	-	-	4	4

Table 3.14 presents the total performance scores for each option.

Table 3.14 ***End Product Liability Performance Scores***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total score	**4.32**	**4.74**	**2.62**	**2.62**	**3.36**	**2.92**
Rank	5	6	1	1	4	3

Option B performed worst against this criterion because it requires markets for RDF, for which there are considerable associated uncertainties. Options A and E also scored poorly against this criterion for the same reason, relying on the existence of a market for RDF.

Although option F also results in RDF production, it is assumed that the RDF will be combusted in the the Authority's own EfW facility, thus removing the need to find a market for the material. For this reason, option F scores relatively well against this criterion and has the second highest ranking.

Options C and D performed best against this criterion, as the EfW process produces comparatively less output requiring further management. For those residues that are produced, there are relatively well established markets.

3.2.12 *Summary of Integrated Residual Waste Management Option Results*

The performance of the alternative waste management options against the criteria is summarised in *Table 3.15*, with ranks shown in brackets.

Table 3.15 ***Integrated Residual Waste Management Options – Results Summary***

Criterion	**Option A**	**Option B**	**Option C**	**Option D**	**Option E**	**Option F**
Depletion of resources (,000 tonnes of crude oil equivalents)	-2272	-2443	-1881	-1851	-2057	-1890
	(2)	(1)	(5)	(6)	(3)	(4)
Air pollution (acidification) (tonnes of sulphur dioxide equivalents)	-25 431	-27 67	-16 720	-16 532	-20 473	-17 099
	(2)	(1)	(5)	(6)	(3)	(4)
Greenhouse gas emissions (,000 tonnes of carbon dioxide equivalents)	-3272	-3647	-2531	-2458	-2871	-2429
	(2)	(1)	(4)	(5)	(3)	(6)
Emissions which are injurious to public health (health impacts score)	0.171	0.195	0.190	0.180	0.186	0.186
	(1)	(6)	(5)	(2)	(3)	(3)
Landtake (ha)	82.54	78.86	82.48	83.25	82.36	82.94
	(4)	(1)	(3)	(6)	(2)	(5)
Extent of water pollution (water Assessment score)	1270	1204	1246	1233	1317	1295
	(4)	(1)	(3)	(2)	(6)	(5)
Total road kilometres (te-km)	27 788 543	27 954 653	25 683 685	25 963 525	26 152 418	23 924 451
	(5)	(6)	(2)	(3)	(4)	(1)
Financial cost (£ per tonne)	112.79	112.10	108.35	109.63	111.09	111.50
	(6)	(5)	(1)	(2)	(3)	(4)

Criterion	Option A	Option B	Option C	Option D	Option E	Option F
Reliability of delivery (likelihood of implementation) (total option score)	1.17 (6)	1.67 (3)	2.00 (1)	2.00 (1)	1.33 (4)	1.33 (4)
Compliance with policy (total option score)	256 (2)	263 (1)	252 (5)	250 (6)	254 (3)	254 (3)
Liability of end product (total Option score)	4.32 (5)	4.74 (6)	2.62 (1)	2.62 (1)	3.36 (4)	2.92 (3)

3.3 *STEP 4 – EVALUATE AND RANK THE OPTIONS*

The benefit of valuing performance data was described earlier in *Section 2.3.* The valued performance data for the residual waste management options is presented in *Table 3.16.* Note that the units are now 'value' for each criterion, a higher value is preferred to a lower value (the reverse being true for ranked data).

Table 3.16 Integrated Residual Waste Management Options - Value

	Option					
Criterion	**A**	**B**	**C**	**D**	**E**	**F**
Depletion of resources	0.71	1.00	0.05	0.00	0.35	0.06
Air pollution (acidification)	0.79	1.00	0.02	0.00	0.35	0.05
Greenhouse gas emissions	0.69	1.00	0.08	0.02	0.36	0.00
Emissions which are injurious to public health	1.00	0.00	0.21	0.63	0.38	0.38
Landtake	0.16	1.00	0.17	0.00	0.20	0.07
Extent of water pollution	0.42	1.00	0.63	0.74	0.00	0.19
Total road kilometres	0.04	0.00	0.56	0.49	0.45	1.00
Financial cost	0.00	0.15	1.00	0.71	0.38	0.29
Reliability of delivery	0.00	0.60	1.00	1.00	0.20	0.20
Compliance with policy	0.46	1.00	0.17	0.00	0.35	0.35
Liability of end product	0.20	0.00	1.00	1.00	0.65	0.86

3.4 *STEP 5 – BALANCE THE CRITERIA AGAINST ONE ANOTHER*

The need to weight the criteria was reported in *Section 2.4.*

The weightings derived for each assessment criterion during the consultation exercises described in *Section 2.4.2* and *Section 2.4.3* are shown in *Table 3.17* . The criterion awarded the greatest weight was 'financial cost', followed by 'reliability of delivery'. The criterion awarded least weight was 'landtake'.

Table 3.17 ***Combined Weight Set Derived from Officer and Community Panel Consultation***

Criterion	Weight
Depletion of Resources	0.07
Air pollution (acidification)	0.08
Greenhouse Gas Emissions	0.08
Emissions Injurious to Public Health	0.09
Landtake	0.05
Extent of Water Pollution	0.06
Total Road Kilometres	0.05
Financial Cost	0.16
Liability of End Product	0.09
Reliability of Delivery	0.15
Compliance with Waste Policy	0.11

3.5 *STEP 6 – EVALUATE AND RANK THE OPTIONS*

The process of applying weights to valued performance was described in *Section 3.5*. The weight set shown in *Table 3.17* has been applied to the valued performance data presented in *Table 3.16.*

A set of results from this process is presented in *Table 3.18* below.

Table 3.18 ***Weighted Valued Performance for Residual Waste Options Using Combined Officer and Community Weight Set***

Criterion	Option A	Option B	Option C	Option D	Option E	Option F
Depletion of resources	0.047	0.066	0.003	0.000	0.023	0.004
Air pollution (acidification)	0.065	0.083	0.001	0.000	0.029	0.004
Greenhouse gas emissions	0.057	0.082	0.007	0.002	0.030	0.000
Emissions which are injurious to public health	0.093	0.000	0.019	0.058	0.035	0.035
Landtake	0.008	0.047	0.008	0.000	0.009	0.003
Extent of water pollution	0.026	0.063	0.039	0.047	0.000	0.012
Total road kilometres	0.002	0.000	0.031	0.027	0.024	0.054
Financial cost	0.000	0.025	0.161	0.114	0.061	0.046
Reliability of delivery	0.000	0.090	0.151	0.151	0.030	0.030
Compliance with policy	0.052	0.113	0.019	0.000	0.039	0.039
Liability of end product	0.018	0.000	0.088	0.088	0.057	0.076
TOTAL Weighted Scores	**0.37**	**0.57**	**0.53**	**0.49**	**0.34**	**0.30**
Rank	**4**	**1**	**2**	**3**	**5**	**6**
Value	**0.24**	**1.00**	**0.84**	**0.69**	**0.13**	**0.00**

For this set of weights, option B is identified as the highest scoring, integrated option for WLWA's residual waste management. This option assumes a recycling and composting rate of 50% by 2020 and a proportion of waste going to an MBT facility from 2010, with the RDF going to a cement kiln for combustion. Residual waste will be sent to landfill.

3.6 *Step 7 – Analyse the Sensitivity of the Results*

To test the robustness of option B as the highest scoring residual waste management option, a number of sensitivity analyses were carried out. The aim of this step was to ensure that a false degree of precision is not implied when a credible variation in one or more parameters might easily change the results.

3.6.1 *Sensitivity Analysis of Weighting Results*

As with *Section 2.6.1*, the individual Officer and Community Panel weight sets, together with the results of public consultation in North Yorkshire and the City of York have been applied to the value performance results shown in *Table 3.16*. The results of this exercise are shown in *Table 3.19*, *Table 3.20*, *Table 3.21* and *Table 3.22.*

Table 3.19 Total Weighted Performance of Residual Waste Management Options Using the WLWA Constituent Borough Officers Weight Set

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total Weighted Scores	0.28	0.52	0.63	0.56	0.36	0.35
Rank	6	3	1	2	4	5
Value	0.00	0.67	1.00	0.78	0.22	0.19

Table 3.20 Total Weighted Performance of Residual Waste Management Options Using the WLWA Community Panel Weight Set

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total Weighted Scores	0.45	0.62	0.42	0.42	0.32	0.26
Rank	2	1	3	4	5	6
Value	0.53	1.00	0.45	0.43	0.16	0.00

Table 3.21 Total Weighted Performance of Residual Waste Management Options Using the North Yorkshire Members & Officers Weight Set

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total Weighted Scores	0.36	0.51	0.58	0.53	0.36	0.31
Rank	5	3	1	2	4	6
Value	0.20	0.77	1.00	0.85	0.20	0.00

Table 3.22 Total Weighted Value Performance for Residual Waste Management Options Using the City of York Members & Officers Weight Set

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total Weighted Scores	0.34	0.50	0.55	0.49	0.37	0.34
Rank	5	2	1	3	4	6
Value	0.03	0.77	1.00	0.69	0.13	0.00

Table 3.20 shows that applying the Community Panel weight set to the original valued results does not have any affect on the outcome of the assessment. However, when the weight sets from the Officer, North Yorkshire and the City of York are applied, option B no longer results as the highest scoring option and instead, option C performs best. This is because the Officer, North Yorkshire and the City of York weight sets give more weight to the financial cost, reliability of delivery and liability of end product criteria.

3.6.2 Sensitivity of Results to RDF Combustion Assumption

The relatively strong environmental performance of the MBT technology is dependant upon the assumption that the RDF produced as part of the process is sold and used as a fuel in a combustion process. Although the issues regarding this assumption have been highlighted in the reliability of delivery and liability of end product criteria, it is important to ensure sufficient consideration is given to its significance. If the market for RDF combustion in cement kilns fails to materialise, this option cannot exist.

If the RDF produced in the MBT options were to have to be landfilled, then the Authority's landfill diversion targets are unlikely to be met. The consequence would be greater environmental impact, an increase in costs as a result of the landfill tax, and potentially fines as a result of exceeding LATs allowances.

The assessment of options S1 and S2 in *Section 2.7.1* showed that the stage 1 assessment results were sensitive to the assumption that RDF is combusted in a cement kiln. MBT was no longer found to be the highest scoring technology option when it was assumed that the cement kiln market failed and the RDF was either combusted in an EfW facility, or sent to landfill. The result of this, second stage of assessment is similarly sensitive to this assumption.

3.6.3 *Sensitivity of Results to Planning Assumption*

An analysis was carried in order to determine whether results were sensitive to the assumption that options requiring larger numbers of treatment facilities should score poorly in terms of reliability of delivery. This assumption was made to take account of the logistics, time and cost involved in obtaining planning permission for waste treatment facilities. WLWA has two sites that currently house waste transfer stations and could potentially be developed to site treatment facilities, and so obtaining planning permission for additional facilities may not hinder the reliability of delivering these options.

It was found that altering this assumption had a significant affect on results, as shown in *Table 3.23* below. Option A becomes the highest scoring option, whereby two MBT facilities are introduced, the first being a small plant to address LATS requirements from 2010, with a larger facility coming on line in 2013. Option E (one small MBT plant (with RDF to cement kiln) to address LATS from 2010, plus EfW from 2013) also performs comparatively well and becomes the highest scoring EfW option.

Table 3.23 ***Total Weighted Performance of Residual Waste Management Options - Discounted Planning Assumption***

	Option					
	A	**B**	**C**	**D**	**E**	**F**
Total Weighted Scores	0.48	0.48	0.45	0.41	0.46	0.42
Rank	1	2	4	6	3	5
Value	1.00	0.98	0.59	0.00	0.69	0.20

3.6.4 *Waste Minimisation Considerations*

Waste minimisation is an integral part of WLWA's Strategy. Constituent Boroughs have individually stipulated a number of initiatives as part of their waste minimisation strategies. In particular, the promotion of home composting has been widely undertaken as a means of reducing household waste generation. This, baseline level of waste minimisation currently occurring across the Authority has been taken into account in the forecasting of waste growth (discussed in *Section 1.4.1*).

The Strategy development process has built on this by investigating further options for waste reduction and re-use. A number of potential options were considered and an estimation of the amount and composition of waste potentially diverted as a result of each was made (1). The results of this exercise were applied to the arisings assumed for this, second stage of assessment, in order to determine if waste minimisation has the potential to influence the performance of options for residual waste management.

(1) Full details regarding the methodology and outcomes of the exercise can be found in *Technical Report 2*.

As expected, it was found that additional efforts to reduce waste arisings resulted in a lower capacity requirement for residual waste. This carried associated benefits for each of the options, in terms of overall performance. It did not, however, have any effect on the relative performance of options. Option B remained the highest scoring option when the Officer and Community Panel and individual Community Panel weights sets were applied. Option C again became the highest scoring option when the Officer, North Yorkshire and City of York weight sets were applied.

3.7 *RESULTS SUMMARY*

Results of the assessment of integrated waste management options identify option B – the introduction of one large MBT facility in 2010 – to be the option that may best meet WLWA's residual waste needs. However, it has been shown that this result is sensitive to a number of key assumptions made during the modelling procedure. In particular:

- if alternative weight sets are used to balance the relative importance of the assessment criteria, option C scores the higher value on the majority of occasions. This option models the outcome of commissioning one EfW facility in 2013 and exporting waste to an external EfW facility prior to 2013, to meet LATS requirements;

- EfW is likely to again become the better fitting waste treatment technology if it is assumed that the cement kiln market for RDF from MBT fails, as detailed analyses from the first stage of assessment have shown;

- if it assumed that the reliability of delivering an option is not significantly affected by the number of treatment plants required, the introduction of a small MBT facility to address LATS requirements from 2010 performs well. Based on the combined weight set provided by WLWA Constituent Borough Officers and the Community Panel, option A becomes the highest scoring option. This option models the outcome of introducing one small MBT facility in 2010 and one large.

Annex A

Technology Assumptions

A1 TECHNOLOGY CALCULATION ASSUMPTIONS

A1.1 INTRODUCTION

In order to perform some of the calculations and assessments in the assessment process, it was necessary to make some assumptions about how the processes operate and their outcomes. The assumptions made for each process are detailed below. Reference is made a few times to the *Defra Health Effects Report*, whose details are provided in the footnote here (1).

A number of the facilities require the same general data, such as electricity demand/output and other utility usage. The basic data, where calculations are simple, are presented in *Table A1.1*. As can be seen, the data are assumed to be proportional to the weight of waste processed, so no economies of scale are factored into these calculations.

Table A1.1 Summary of General Technology Data Assumptions

Technology	**Input**			**Output**	
	Electricity Demand	**Diesel Usage**	**Steam Usage**	**Electricity**	**SO_2**
MRF	24.97	0	0	0	0
Composter	0.104	7.44	0	0	0
AD	0	0.4	0	143.89	see text
MBT (†)	65	0	0	0	0
Autoclave (‡)	23.89	0	510.7	0	0
EfW	0	1.2	0	820 (†)	90.53
Gasification	0	1.2	0	514 (*)	0
Landfill	0	1	0	see text	see text
Cement	30.3	0	0	0	90.53
Unit per te of waste	*KWh*	*l diesel*	*MJ*	*kWh*	*g*

All data from ***WISARD***, apart from:
(†) *Fichtner* - Modern Energy Recovery Plant for MSW
(‡) *Mercia Waste Management*
(*) Thermoselect

A1.2 RECYCLING/COMPOSTING

Data regarding the relative percentage of MSW separated for recycling and composting were derived from the modelling exercise outlined in *Annex G*.

It was assumed that the recyclates would be separated at a clean MRF, while the composting plant would be covered and the compost aerated.

The *Defra Health Effects Report* does not have any data on composting health effects in its Table 4.5, so, in order to take account of the possible health effects of this extra activity, it is necessary to estimate an impact for composting. Given that the release of bioaerosols from composting plants can be an issue, it has been decided to assign to composting the higher of the impacts in each category from the most similar processes, MBT and anaerobic digestion.

A1.3 *ENERGY FROM WASTE FACILITIES*

ERM modelled all energy from waste (EfW) plants to be new facilities, with all the state-of-the-art emission controls that that entails. Data from *Fichtner* was used to model the energy generation, yielding 820 kWh/tonne waste, based on a waste calorific value of 11 MJ/kg (assumed to be the same for all EfW options).

In addition to the information in *Table A1.1*, it is necessary to estimate the fossil CO_2 emissions from burning plastics. *SIMAPRO* was used to calculate that each tonne of plastic burnt would generate, on average, 2.283 tonnes of fossil CO_2.

A number of other assumptions regarding the EfW process, and fate of residues, were made:

- It was assumed that 80% of the incoming ferrous metals were separated from the waste stream for recycling.

- The process was assumed to produce two other residues, the relative quantities of which are dependent on the composition of the incoming waste: bottom ash for recycling as aggregate (approximately 38% of throughput); and fly ash to be sent to a hazardous landfill site (approximately 2% of throughput).

- The landtake associated with the landfill of hazardous residues was assumed to be negligible.

A1.4 *MECHANICAL BIOLOGICAL TREATMENT (MBT) FACILITIES*

WISARD does not have any data for an MBT plant, but the majority of the parameters in *Table A1.1* are zero. The key statistic is the energy demand, which ERM took from an estimate by *Fichtner* to be 65 kWh per tonne of waste. In order to model the waste composition and material flows, some additional assumptions were made, as follows:

- for the majority of MBT options a 6% loss of biodegradability of input waste through carbon emissions was modelled. This was assumed to equate to loss of material from the putrescible and paper/card waste fractions. A scenario was also derived to assess the consequences of a failed RDF market (option S1). In this case, it was assumed that the MBT

(1) Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes, Enviros Consulting Ltd and University of Birmingham with Risk and Policy Analysts Ltd, Open University and Maggie Thurgood, 2004, available at http://www.defra.gov.uk/environment/waste/health-effects/index.htm [01Jun04 @ 15:13]

plant will be configured to further reduce the biodegradable content of the output to landfill and a 38% loss in biodegradability was assumed;

- 100% of textiles, fines, plastics and miscellaneous combustible material reports to the high-CV fraction;

- 90% of ferrous and non-ferrous removal for recycling; and

- 99% glass removal (to model extraction of grit/glass through MBT).

A1.5 AUTOCLAVING

Autoclaving is another new process that is not modelled in ***WISARD***. Information is rather limited in the public domain on autoclaving, so ERM was obliged to makes some assumptions, as follows:

- autoclaving does not destroy waste; 100% of input weight (plus additional water that is added during the process) is sent to one of three fates:
  - recycling;
  - convertion to fibre for use as a refuse-derived fuel and combusted in a cement kiln; and
  - sent to inert landfill.

the moisture content of the fibre is 50%; this is made up of a combination of moisture in the incoming waste and steam used in the process;

- the *Defra Health Effects Report* does not include data for autoclaving activities. Autoclaving is a sterilisation process, neither biological (MBT) nor combustion (incineration). For the purposes of this study, it has been assumed that the health effects of autoclaving are similar to those of anaerobic digestion, and those figures have been used.

A1.6 ANAEROBIC DIGESTION (AD)

The AD plant was modelled on the high solids option from ***WISARD***. The composition of the biogas is given in *Table A1.2*.

Table A1.2 Anaerobic Digestion – Biogas Composition

Gas	Formula	Composition (g/kg)
Methane	CH_4	564
Carbon Dioxide	CO_2	339
Hydrogen Sulphide	H_2S	0.245

As the methane is combusted, and the carbon dioxide is biogenic, the only emission of concern is the hydrogen sulphide, which is combusted with the biogas in the generator, to produce sulphur dioxide. This is therefore dependent on the biodegradable content of the incoming waste stream, as is the electricity generation rate. It was assumed that all of the paper/card and putrescibles and 50% of the textiles are biodegradable. The generation factors that result are as follows:

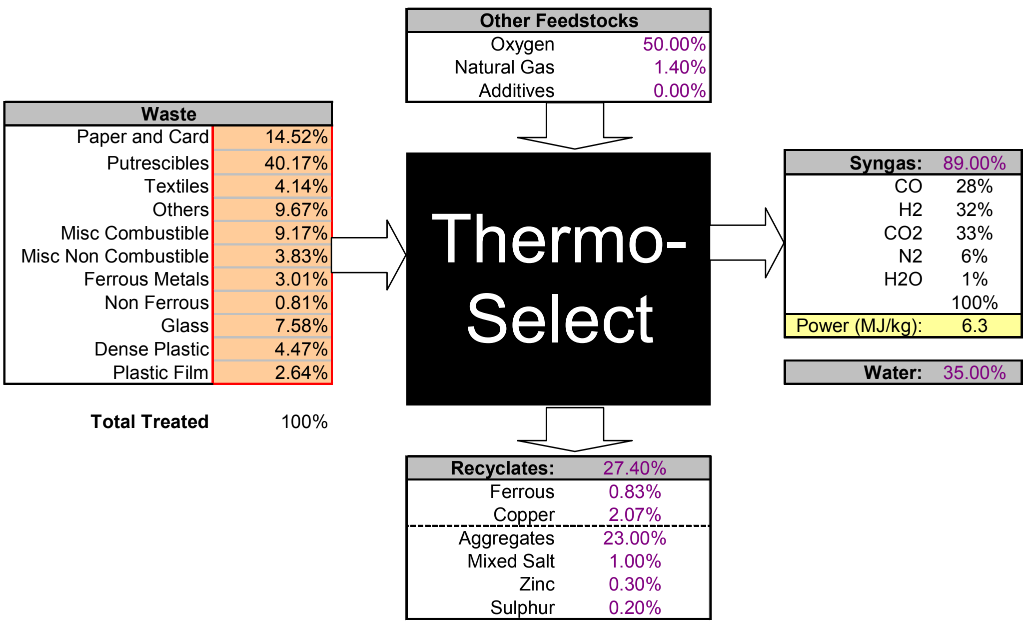
- SO_2 generation rate: 132.8 g / te of biodegradable waste
- Electricity generation rate: 208.2 kWh / te of biodegradable waste

The AD process generates two product streams – a digestate and a residue – and the options, where applicable, assumed that the digestate is suitable for landspreading, but the residue is not, and must be sent to landfill. No metal recovery was assumed in the modelling as data were not available.

A1.7 GASIFICATION

Again, gasification does not appear in ***WISARD*** and information on the technologies is rather limited. ERM used data from Thermoselect to model the gasification plant, as presented in *Figure A1.1*.

Figure A1.1 Gasification Mass Balance



Data extracted from: http://www.thermoselect-karlsruhe.de/mengen.html [26Jul04 @ 15:19]
..combined with presentation provided by Thermoselect

A1.8 LANDFILL

The landfill model used from ***WISARD*** was for a large, wet, composite-lined landfill. A number of assumptions were made, in order to complete the modelling, based upon the rate of generation of gases and the fate of the landfill gas. Firstly, it was assumed that the gases generated were dependent on the incoming waste composition, as shown in *Table A1.3*.

Table A1.3 Landfill Gas Generation (kg Gas per tonne Waste Component)

Waste Component	Generation of CH_4	Generation of SO_2
Putrescibles	43.5	14.2
Paper/Card	97.8	31.8

Secondly, it was assumed that the landfill gas' fate was as given in *Table A1.4*.

Table A1.4 Landfill Gas Fate

Fraction	Fate
23%	Discharged
37%	Flared
40%	To Gas Engine

Finally, the gas engines were assumed to have an efficiency of 32.5%, with methane having a CV of 50.0 MJ/kg. With this information, it is possible to calculate (for example) the electricity generation, as shown in *Box A1.1*.

Box A1.1 Formula for the Calculation of Landfill Engine Electricity Generation

$$\begin{matrix}\text{Electricity}\\ \text{Generation}\end{matrix} = \begin{matrix}\text{Waste}\\ \text{Throughput}\end{matrix} \times \left[(\text{CH}_4 \text{ per te} \times \%)_{\text{Paper}} + (\text{CH}_4 \text{ per te} \times \%)_{\text{Putrescibles}}\right] \times \begin{matrix}\text{\% to Gas}\\ \text{Engine}\end{matrix} \times \begin{matrix}\text{Engine}\\ \text{Efficiency}\end{matrix} \times \begin{matrix}\text{CV of}\\ \text{Methane}\end{matrix}$$

The *Defra Health Effects Report* provides data on six different landfill types in its *Table 4.5*, using flares or engines at small, medium and large sites. For the purposes of estimating the health effects of landfills in this study, we have taken the average values for the two types of medium-sized facilities.

Annex B

Emission Factors

Table B1.1 Resource Depletion, Acidification and Greenhouse Gas Emission Factors Used in Stage 1 and 2 Assessments

Activity	Coal Usage / kg	Crude Oil Usage / kg	Natural Gas Usage / m^3	SO_2 Generation / g	CO_2 Generation / g	CH_4 Generation / g	Basis
Grid Electricity	0.238	0.006	0.074	1.62	590.4	2.07	per kWh generated
Coal Electricity	0.635	0.0088	0.0074	4.17	1010	4.4	per kWh generated
Diesel Generation	0.01912	0.9185	0.00255	2.30	421.68	3.70	per litre generated
Diesel Usage	-	-	-	0.76	2640	0.16	per litre consumed
Steam Generation	0.00066	0.00023	0.03480	0.0401	71.2	0.201	per MJ generated
Transportation	0.0121	0.0649	0.00165	0.493	207	0.352	per te-km in a 22-tonne truck
Material Recycling							
Plastic	-0.011	0.7811	1.032	6.123	1701	3.09	per kg recycled
Glass	0.0916	0.19996	0.00216	2.42	465	0.783	per kg recycled
Aluminium	2.62	1.2466	0.197	54.76	9070	20.25	per kg recycled
Ferrous	1.008	0.0634	0	3.32	1810	8.77	per kg recycled
Aggregate	0.00109	0.00148	0.000586	0.0209	8.46	0.0112	per kg recycled
Paper	0.04	0.0828	0.00931	3.54	367	0.629	per kg recycled

Annex C

Landtake Requirements

Table C1.1 Landtake Requirements (Hectares)

Plant Size / kte	MRF	Windrow Composting	In-Vessel Composting	MBT	EfW	Coal Displacement	Dirty MRF	Land Application / Other Treatment	Simple Combustion
10	0.44	4.51	1.02	1.44	0.83	0.83	0.44	10.72	0.83
20	0.81	9.02	2.07	1.51	0.94	0.94	0.81	10.76	0.94
30	1.18	13.54	3.11	1.58	1.05	1.05	1.18	10.79	1.05
40	1.55	18.06	4.16	1.65	1.16	1.16	1.55	10.83	1.16
50	1.92	22.57	5.21	1.72	1.27	1.27	1.92	10.86	1.27
60	2.29	27.09	6.25	1.79	1.38	1.38	2.29	10.89	1.38
70	2.66	31.60	7.30	1.86	1.50	1.50	2.66	10.93	1.50
80	3.03	36.12	8.34	1.93	1.61	1.61	3.03	10.96	1.61
90	3.39	40.63	9.39	2.00	1.72	1.72	3.39	10.99	1.72
100	3.76	45.15	10.43	2.07	1.83	1.83	3.76	11.03	1.83
110	4.13	49.66	11.48	2.14	1.94	1.94	4.13	11.06	1.94
120	4.50	54.18	12.52	2.21	2.05	2.05	4.50	11.10	2.05
130	4.87	58.70	13.57	2.28	2.16	2.16	4.87	11.13	2.16
140	5.24	63.21	14.61	2.35	2.27	2.27	5.24	11.16	2.27
150	5.61	67.73	15.66	2.42	2.38	2.38	5.61	11.20	2.38

Annex D

Transport Assumption

D1 TRANSPORT ASSUMPTION

D1.1 COLLECTION

The road distance involved in collecting the waste is assumed to be the same for each option and thus not assessed.

D1.2 RECYCLING

All recycled material is assumed to arise from three transfer/MRF/ bulking stations:

- Victoria Road;
- Transport Avenue; and
- Brent – Generay.

The assumed locations for the recyclate reprocessing facilities are:

- Paper to Severnside Recycling, Maidenhead, Berkshire;
- Glass to ECT British Glass, Harlow;
- Textiles to LM Barry, London;
- Metals to Corus, London; and
- Plastic via Grundons to Lindons, West Yorkshire.

D1.3 LANDFILL

All waste travelling for disposal to landfill is assumed to arise at the three transfer stations indicated above.

MSW waste to be landfilled is assumed to go to the Calvert Landfill in Buckinghamshire.

D1.4 TREATMENT

It has been assumed that equal percentages of total waste destined for some form of treatment arises from three transfer stations indicated above.

The exception is for Option 7 where waste for treatment is assumed to arise from the centre point of each of the 6 boroughs; the same location as the treatment facility locations for this option.

The treatment facility locations for all other options are identified below:

- The treatment facility location for Options 1 to 5, S1 and S2 is at Victoria Road; and

- The treatment facilities for Option 6 are located at Victoria Road and Transfer Avenue.

D1.5 *POST TREATMENT*

RDF produced at the Autoclaving or MBT facilities in Options 5, 6 & 7 is assumed to go to the Northfleet cement kiln.

RDF produced in the MBT facility in option S1 is assumed to go to the Slough Power Station.

RDF produced in the MBT facility in Option S2 is assumed to go the Calvert Landfill in Buckinghamshire.

Bottom Ash produced as a result of EfW is assumed to be recycled on site.

Residue produced in the Anaerobic Digestion facility in Option 1 and the LCV fraction produced in the MBT facilities in options 5 to 7 and S1 and S2 is assumed to go the Calvert Landfill in Buckinghamshire.

Fly ash from the incineration process is assumed to go to Calvert Landfill in Buckinghamshire.

All recyclate produced in the various treatment processes are assume to go to the same locations as identified in *Section D1.2*.

Annex E

Financial Assumptions

E1 FINANCIAL ASSUMPTIONS

Table E1.1 Financial Assumptions

	Capacity	Euro[(a)]	£ [(a)]	Sources
Collection Costs				
HH Waste		51.83	33.17	
HH Recyc		159.05	101.79	
HH Composting		159.05	101.79	
Disposal Costs (Gate Fees)				
MRF	40ktpa	51	32.64	Costs Obtained from Eunomia Research/
Compost		43.37	27.76	Costs Obtained from Eunomia Research
Average MRF/Compost			30.20	
Landfill		19.2	12.29	Costs Obtained from Eunomia Research
Scenario 1 (£15 tax)			27.29	Costs Obtained from Eunomia Research
Scenario 2 (£35 tax) by 2010			47.29	Costs Obtained from Eunomia Research
Inert Landfill (£2 tax)			14.29	Costs Obtained from Eunomia Research
EfW	160 ktpa		42.00	EFW: A Good Practice Guide (November 2003) The Chartered Institution of Waste Management, page 11.
AD	>60 ktpa	79.92	51.15	Costs Obtained from Eunomia Research/ Greenfinch suggests £40-50 per tonne
	41-60 ktpa	82.592	52.86	Costs Obtained from Eunomia Research/ Greenfinch suggests £40-50 per tonne
	21-40 ktpa	95.104	60.87	Costs Obtained from Eunomia Research/ Greenfinch suggests £40-50 per tonne
	<20 ktpa	121.952	78.05	Costs Obtained from Eunomia Research/ Greenfinch suggests £40-50 per tonne
MBT – Sorting/Mechanical Treatment			36.72	Costs Obtained from Eunomia Research
MBT – RDF Treatment			50.00	Professional Judgement
New Technology (Autoclave, Gasification)			52.50	http://www.number-10.gov.uk/su/waste/report/downloads/al.pdf
Assumptions				
Excludes all capital and operating costs.				
Assumes that collection costs associated with C&D and C&I waste are born by the producer.				
The assessment does not consider the costs associated with WTS and CA sites.				
Exempt sites are assumed to have no cost.				
Costs associated with Recovery for C&I have been excluded from this assessment.				

(a) Universal Conversion = 0.64

Table E1.1 presents the underlying figures and assumptions used to estimate costs associated with each of the options. Waste disposal costs were estimated from research, government publications, and experience of working within the waste management sector. These figures were then used to extrapolate gate fees as a function of plant capacities.

Table E1.2 presents underlying landfill tax assumptions used during the financial assessment of the options.

Table E1.2 Landfill Tax Assumptions

	Landfill tax active	Landfill tax inert	Hazardous waste premium
1995			£ 60.00
2003	£ 13.00	£ 2.00	£ 60.00
2004	£ 14.00	£ 2.00	£ 60.00
2005	£ 15.00	£ 2.00	£ 60.00
2006	£ 18.00	£ 2.00	£ 60.00
2007	£ 21.00	£ 2.00	£ 60.00
2008	£ 24.00	£ 2.00	£ 60.00
2009	£ 27.00	£ 2.00	£ 60.00
2010	£ 30.00	£ 2.00	£ 60.00
2011	£ 33.00	£ 2.00	£ 60.00
2012	£ 35.00	£ 2.00	£ 60.00
2013	£ 35.00	£ 2.00	£ 60.00
2014	£ 35.00	£ 2.00	£ 60.00
2015	£ 35.00	£ 2.00	£ 60.00
2016	£ 35.00	£ 2.00	£ 60.00
2017	£ 35.00	£ 2.00	£ 60.00
2018	£ 35.00	£ 2.00	£ 60.00
2019	£ 35.00	£ 2.00	£ 60.00
2020	£ 35.00	£ 2.00	£ 60.00

Annex F

WISARD Outline

F1 WISARD: AN OUTLINE

F1.1 INTRODUCTION

WISARD (Waste: Integrated Systems Analysis for Recovery and Disposal) is a waste management software tool developed for the Environment Agency of England and Wales by the Ecobilan Group (PriceWaterhouseCoopers).

The software employs a life cycle assessment (LCA) approach to forecasting the potential environmental impacts associated with user-specified integrated waste management systems. Accordingly, the software addresses potential impacts stemming from all stages in the management and processing of waste, including waste collection, transport, treatment and disposal activities, taking account of the associated infrastructure, together with the avoided impacts associated with materials and energy recovery.

F1.2 WISARD DEVELOPMENT

WISARD's development originates in 1994, when the then Wastes Technical Division of the Department of the Environment (now part of the Environment Agency) began a programme of research to quantify the environmental burdens (1) and related impacts, of management options for waste from cradle to grave, using a LCA framework. The initiative was aimed at providing a thorough and unbiased basis for comparing the environmental costs and benefits of waste management strategies and of options for individual waste types. The first report from the series examined how life cycle inventories for waste management could be developed (CWM 128/97 and 128A/97).

The programme's deliverables were aimed at informing two areas of policy development: national waste management policies and, in particular, the waste strategy for England and Wales; and waste management planning at the level of development planning and regional planning conferences.

WISARD's underlying software platform and interface is also used by Eco-Emballages in France, by the Scottish Environmental Protection Agency (SEPA) and by authorities in New Zealand. In each case, separate databases have been employed to reflect national circumstances, including energy sources etc.

(1) 'Burden' is a LCA term used to describe a demand made by a system on its environment, ie energy and raw material inputs, and outputs in the form of emissions, wastes and by-products.

F1.3 *WISARD DATA*

The software tool manipulates large databases, or life cycle inventories, which describe the environmental burdens associated with each of the activities of which an integrated waste management system is comprised, on a unit basis. For example, per tonne of waste collected. The inventories are multiplied according to the system defined by the user (eg 100 000 tonnes waste collected) and the burdens are then aggregated across the whole system and related to environmental impacts such as global warming and air acidification.

WISARD uses 'foreground' data on waste management activities (generally the most significant parts of the systems examined), together with 'background' data on materials and energy production (usually less important). Most of the foreground data were collected by the Agency's contractors as part of its life cycle research programme for waste management, under six separate projects [(1)]. The resulting inventories were peer reviewed by experts in the individual fields concerned, and the reports published, together with the review and project record, as PR P1/392/2 - 7. Guidelines for the collection and reporting of the data were also provided by the Agency to ensure compatibility and consistency (PR P1/392/8). ***WISARD*** provides information pages on sources and underlying assumptions for foreground data sets to aid data transparency.

Background data for ***WISARD*** were provided by the Ecobilan Group. Many of these data sources are standard life cycle references in the public domain, whilst others have been collected by the Ecobilan Group and are confidential. There is no information provided on the sources and underlying assumptions for these data. Although the background data were not peer reviewed, the software itself was subjected to a wider peer review by a panel of life cycle and waste management authorities (PR P1/392/1).

F1.4 *COVERAGE OF ENVIRONMENTAL IMPACTS*

In common with other life cycle tools, ***WISARD*** considers a set of environmental impacts which are generally global in nature because the sources of burdens considered are many and disparate. The ***WISARD*** Reference Guide [(2)] notes that the software has limitations in its assessment of environmental impact: specifically, it does not address *"human or environmental safety, legal compliance issues or nuisance issues (eg litter, dust and visual amenities)."* The Guide clearly states that *"there are other tools such as risk assessment and environmental impact assessment, which should be used for other functions such as assessing the safely of particular processes or the siting of particular waste handling or treatment plants."*

(1) Waste transport & other vehicle use, landfill, composting & anaerobic digestion, recycling and waste collection & separation.
(2) WISARD Reference Guide, Version 3.3, May 2000, Ecobilan - WM3.4r1, page 9.

The Environment Agency's Strategic Waste Management Assessments, published in November 2000, use ***WISARD*** to investigate the environmental impacts associated with future waste management scenarios for the planning regions of England and Wales. The report is restricted to four environmental impacts: air acidification, depletion of non-renewable resources; greenhouse effect and photochemical oxidant formation, which are *"…commonly associated with waste management systems."*, in order *"…to highlight the differences that result from managing the same waste in different ways"*.

Annex G

Addendum: Equality of Impact across WLWA Area

G1 EQUALITY OF IMPACT

G1.1.1 Introduction

At the Waste Forum held on 18 January 2005, one of the discussion groups raised the '*equality of impact across boroughs*' as a criterion to be used in the assessment of residual waste management facilities. This was prompted by a desire to 'share the pain' of facilities described as being a consideration of economic and social impacts of one large facility in one borough, or several smaller facilities spread across a number of boroughs.

At the second Forum meeting (held on 21 March 2005) this criterion was further discussed by all participants and there was some debate on its purpose and usefulness. In particular, there was concern that the criterion would not actually assist in developing the Strategy. A conclusion that facilities should be evenly distributed throughout the boroughs presupposes that each of those facilities would be located within the centre of each borough. However, if it was located on the edge of a borough then that borough and its neighbour would both be impacted by that development. The Strategy will not be site specific and does not specify where facilities may be built. As such, the Waste Forum of 21 March agreed that this issue should not be a criterion on its own, but considered more broadly, or in conjunction with other criteria.

The criterion of '*equality of impacts across boroughs'* seems to encompass a number of issues, including: proximity principle; planning risk; sharing the pain; and local amenity impacts. As such, it is not readily possible to assess this criterion as a separate matter, because it implicitly involves discussion of several other criteria that are already assessed individually. Instead, this criterion has been managed in two ways: through the options developed; and through this discussion of the criterion.

The original set of options included seven different scenarios: five options considered one plant of different technology types; two options considered multiple plant, using MBT as a proxy technology. As such, option 6 considered two plant, and option 7 considered five plant. In order to incorporate the '*equality of impacts across boroughs*' criterion, and base the assessment more closely to the situation of the WLWA, option 7 was amended to consider the impacts of six plant (there are six constituent boroughs comprising the WLWA).

Whilst this discussion does not contribute to the overall scores for each option, it does identify the key components of the criterion and consider how these relate to each other. This is intended to contribute more generally to identification of the preferred residual waste management option.

G1.1.2 Proximity Principle and Transport

The proximity principle requires that waste be disposed of as near to its place of origin as possible. The principle recognises both the desire to avoid passing the environmental costs of waste management to communities that are not responsible for its generation, and the aim of reducing the environmental costs of transporting waste. However, regarding its first component, it is clear that it is impracticable for all wastes to be managed at their point of arising. As a result, the need to secure appropriate sites for treatment and disposal is an important corollary to the desire for proximate management. Furthermore, more dispersed, larger facilities offer the opportunity for securing economies of scale in both capital and operating costs with minimal additional environmental burdens.

The proximity principle can make the link between the waste hierarchy and BPEO. Where the BPEO for a waste stream is towards the lower end of the waste hierarchy, this can often be because the environmental impact or cost of transport to a distant reprocessing facility or market outweighs the benefit of recovering the waste. Planners may need to consider the mode of transport and not just the distance: a longer journey by river or rail may be environmentally preferable to a shorter road journey (1).

In relation to the second component of the proximity principle, transport of wastes by water or rail is generally environmentally preferable to transport by road. Indeed, because of the environmental advantages of water and rail, it may be preferable to transport wastes by these methods, even when the journey by road is shorter. Currently, much of the waste disposed of by the WLWA is transported by rail, travelling to a landfill site at Sutton Courtenay in Oxfordshire. However, within each of the boroughs waste is generally transported by road. It is extremely expensive and logistically difficult to transport waste in small amounts or over short distances by rail and not practical, within West London, to use the river.

Transport costs and carbon dioxide emissions associated with local collection of waste are relatively independent of final treatment, be it landfill, mass burn incineration, mechanical biological treatment etc. The important issue is whether or not it is better to transport waste over a long distance to gain economy of scale for the operation of large thermal treatment plants (2).

(1) Waste Strategy 2000. DETR, May 2000. Paragraph 3.6, page 28.
(2) Thermal methods of municipal waste treatment. Biffaward. 2003. Box: Transport costs versus the economy of scale. Page 42.

G1.1.3 *Reliability of Delivery*

Reliability of delivery is a criterion that encompasses a number of subsidiary factors. The key issues include: the probability of securing planning permission for new facilities; the prospects for technologies that are not entirely proven; the difficulty of engaging the public in source separation of materials for recycling; and the need for the development of markets for recovered materials.

A greater number of small facilities have implications for site availability and the ability to deliver the required infrastructure. West London does not have an excess number of sites waiting to be developed, and gaining planning permission, even for quite small plant, is not and easy process. Clearly, expecting six sites to be built and become operational requires site identification, acquisition and the grant of consent to be undertaken a multiple of times. This situation is detrimental to the likelihood of those six plants being delivered, which obviously has consequences for implementation of that option.

G1.1.4 *Economies of Scale*

The perceived advantages of larger facilities are that fewer of them are needed, they can be located where they would not cause undue nuisance from noise, odour and other impacts (not everyone will welcome even a small recycling and composting plant on every street corner), and economies of scale would mean that more money can be spent on measures.

Economies of scale are gained through larger plants as shown in the tables and graphs over the following pages which use anaerobic digestion (AD) as an example technology. This is illustrated in *Table 1.1* and *Figure 1.1* below.

It is important to remember that the Investment Price is actually million Euro.

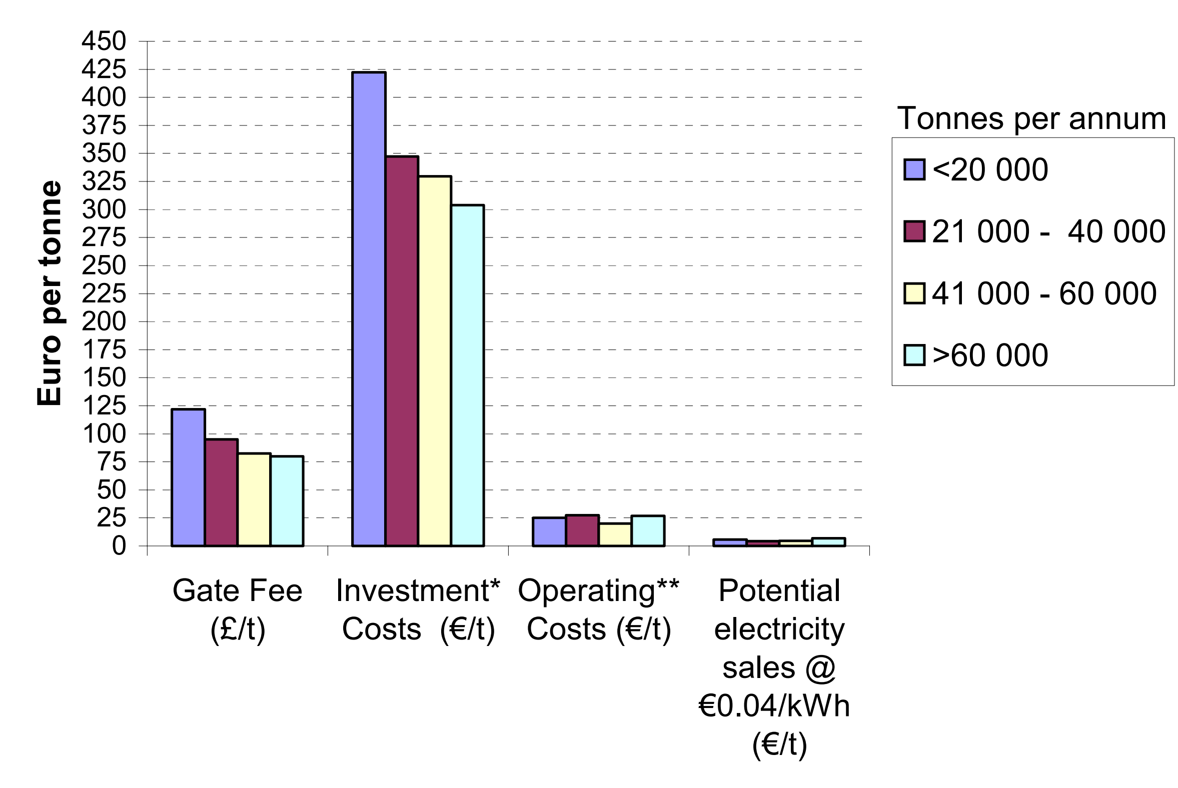
Table 1.1 Economies of scale for AD plant treating MSW [1]

Capacity of Plant (000t/a)	Gate Fee (£/t)	Investment* Costs (€/t)	Operating** Costs (€/t)	Potential electricity sales @ €0.04/kWh (€/t)
<20 000	121.952	422.4	24.992	5.84
21 000 - 40 000	95.104	347.2	27.408	4.32
41 000 - 60 000	82.592	329.6	19.936	4.528
>60 000	79.92	304	26.72	6.944

* building, civil and maintenance equipment
** fixed and variable

(1) Final Report to Directorate General Environment, European Commission. Costs for Municipal Waste Management in the EU. Eunomia Research & Consulting Ltd. 2002. Annex A. Table 169, page A-267.

Figure 1.1 Economies of scale for AD plant treating MSW



* building, civil and maintenance equipment
** fixed and variable

Table 1.1 and *Figure 1.1* above indicate the reduction in gate fee and investment costs with increased plant size. They even show how the potential for energy sales can increase with plant size.

Economies of scale are important because larger sites enable energy efficiencies to be made which can be more significant than the environmental burdens resulting from the increased transport of waste.

'By current standards, a large thermal treatment plant would have a capacity of 500 000 tpa, while a small plant would have a capacity of 50 000 tpa. Handling 30Mt of MSW in the UK by thermal treatment would require about 60 large treatment plants or 600 smaller units. Taking the land area of England, Scotland and Wales as 143 124 km2, then the average journey to take waste to one of the 60 treatment plants would be 24 km as the crow flies. By road, the average round trip is likely to be about 64 km. On the same basis, the round trip for 600 small treatment plants would be 19 km. As this is the distance appropriate to local collection vehicles, no additional transport would be required for this scenario, except for removal of ash.

The option of 60 large treatment facilities would require articulated lorries to transport waste from local collection centres. The carbon dioxide emissions for such vehicles are about 1.35 kg of carbon dioxide per 1.6 km. This means that additional carbon dioxide emissions for utilising large waste treatment facilities would be 2.7 kg carbon dioxide per tonne of MSW. This is trivial compared with the gross emission of 101 t of carbon dioxide per tonne of MSW resulting from thermal conversion of its carbon content. The additional 2.7 kg of carbon dioxide emissions would easily be *recovered by the smallest of efficiency gains arising from the economy of scale. The additional cost for transportation must be offset against capital savings and operating costs for one large plant against 10 small plants.'* [(1)]

The economies of scale can also be illustrated for EfW plants. See *Table 1.2.*

Table 1.2 ***Size of EfW plant and gate fees***

Size of EfW Plant (kt/yr)	Capital Cost Range (£m)	Gate Fee Range (£/t)
50	15 – 20	55
100	25 – 35	45
200	40 – 60	40
400	75 - 100	30

G1.1.5 Conclusions

The desire to achieve equity across the WLWA area encompasses the proximity principle's aim of local responsibility for waste produced. This discussion clearly indicates that more facilities, spread throughout the WLWA area, enable waste to be managed closer to its source.

However, what is also clear is that this aim should be taken in context with other key principles; it is not an over-riding issue of itself. What is most important is to ensure that an adequate network of sites is provided to manage West London's waste in the most effective manner.

(1) Thermal methods of municipal waste treatment. Biffaward. 2003. Box:Transport costs versus the economy of scale. Page 42.

Annex H

Sensitivity Weight Sets

H1 SENSITIVITY WEIGHT SETS

H1.1 WLWA WEIGHT SETS

Table H1.1 Weight Set Derived from the Community Panel

Criterion	**Weight**
Depletion of Resources	0.08
Air Acidification	0.12
Greenhouse Gas Emissions	0.11
Emissions which are Injurious to Public Health	0.13
Landtake	0.08
Extent of Water Pollution	0.09
Total Road Kilometres	0.06
Financial Cost	0.11
Liability of End Product	0.04
Reliability of Delivery	0.10
Compliance with Waste Policy	0.06

Table H1.2 Weight Set Derived from the WLWA Constituent Borough Officers Workshop

Criterion	**Weight**
Depletion of Resources	0.05
Air Acidification	0.04
Greenhouse Gas Emissions	0.06
Emissions which are Injurious to Public Health	0.05
Landtake	0.01
Extent of Water Pollution	0.03
Total Road Kilometres	0.04
Financial Cost	0.21
Liability of End Product	0.13
Reliability of Delivery	0.20
Compliance with Waste Policy	0.17

H1.2 NORTH YORKSHIRE COUNTY COUNCIL WEIGHT SET

Table H1.3 Weight Set Derived from Member and Officer Consultation in North Yorkshire

Criterion	**Weight**
Depletion of Resources	0.09
Air Acidification	0.05
Greenhouse Gas Emissions	0.16
Emissions which are Injurious to Public Health	0.08
Landtake	0.01
Extent of Water Pollution	0.05
Total Road Kilometres	0.05
Financial Cost	0.19
Liability of End Product	0.12
Reliability of Delivery	0.16
Compliance with Waste Policy	0.04

H1.3 CITY OF YORK COUNCIL WEIGHT SET

Table H1.4 Weight Set Derived from Member and Officer Consultation in the City of York

Criterion	**Weight**
Depletion of Resources	0.07
Air Acidification	0.03
Greenhouse Gas Emissions	0.13
Emissions which are Injurious to Public Health	0.09
Landtake	0.00
Extent of Water Pollution	0.02
Total Road Kilometres	0.09
Financial Cost	0.22
Liability of End Product	0.08
Reliability of Delivery	0.13
Compliance with Waste Policy	0.14