Best integrated transport options for waste in Scotland

by P Griffiths, A Colston, C Dunkerley, K Hylands, L Rehm, P Tomlinson, M G Winter (TRL Limited) and R Curry, N Gribble (Envirocentre)
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Viridis is committed to optimising energy efficiency, reducing waste and promoting recycling and re-use. In support of these environmental goals, this report has been printed on recycled paper, comprising 100% post-consumer waste, manufactured using a TCF (totally chlorine free) process.
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Executive Summary

In 1999 SNIFFER appointed TRL to carry out a scoping study and develop a research specification for "Best Integrated Transportation Option (Waste) (BITOW)/GIS Assessment, as BPEO guidance for waste management option decisions in Scotland" (Winter et al., 2001).

The key issues in relation to the points set out by SNIFFER were reviewed and key players in terms of BITOW objectives were consulted. The results of these activities were compiled and submitted as a scoping study and associated specification for the main project. The current study has been developed from the scoping study.

The main purpose of this study is to provide a better understanding of the movement of wastes and its effects in Scotland and to provide guidance that enables the identification of locations for the development of waste management facilities. The ultimate aim of the study is to decrease the impacts from the transport of waste.

The study objectives were to:

- Allow interested stakeholders to evaluate the current position of waste transport.
- Allow a strategic view of the movement of waste through the development of options for integrated multi-modal systems.
- Provide guidance on the optimum transport mode.
- Provide information in a form that can be fed into the planning process, at both the strategic and local level, to inform decisions on integrated transport of waste.
- Encourage change and improvement through education.
- Disseminate the findings of the research to industry, government and the others.

The study presents the results of a review of the relative environmental impacts of different transport modes for waste. The legislative and policy background for waste transport is given together with recommendations to develop the appraisal framework for examining waste transport options.

A baseline data review was carried out to collect and validate data for waste transport in Scotland. This included:

- Obtaining handling costs for transfer between different modes of transport.
- Providing information on the number of lorry loads shifted within Scotland.

The data was sourced from the Scottish Waste Management Baseline Assessment (SWMBB) reports, Local Authority Waste Arisings Reports (LAWAS) and SEPA transfer station data. In addition a telephone questionnaire survey of waste hauliers was carried out. Gaps in data were found to impact on the quality of waste data available at the present time.

Cost models were created to examine modal shift of waste for road, rail, canals, and coastal shipping. Road transport has the most complete of the cost models represented, as there was information available to build a comprehensive model including externalities. In the case of rail and waterways, there was less information available and external costs could not be considered.

The results from the cost models suggest that only marginal modal shift is feasible with existing waste infrastructure in Scotland. Between 2002 and 2020, the maximum percentage that can be transferred to rail from road is just 2.3%, while for waterways (canals and coastal shipping) this percentage is only 0.06%. The transfers to rail and water do not bring any benefit in terms of reducing emissions to air. Although the modal potential indicated as a proportion is small it should not be discounted. The savings over a base case of all road transport were in the range of £1 - £4.7 million.

The movement of segregated waste and waste for recovery was beyond the scope of this study. The added value of some of these segregated waste streams has the potential to shift the economics.

The report highlights that the modal transfer figures obtained using rail and waterways from the model, are optimistic as they do not include external costs, the logistic barriers to inter-modality, capacity constraints for alternative modes or problems related to waste consolidation.

The effects of waste consolidation were examined in the cost models by looking at the theoretical case of locating four Supersites in Scotland for all waste disposal. Moving from present infrastructure to Supersites dramatically improves the economics of transport by modes other than road. When looking at the cumulative cycle of 2002-2020 there is potential for shift of 25-40% of the total waste transported for rail, and 5-15% of waste transported by water.
While the modal transfer is significant when examining Supersites the total cumulative cost rises by a huge amount. The total cumulative cost for transport in the all roads base case was 0.39 billion, this rises to a cumulative cost in the all roads Supersite scenario of 1.23 billion.

This study has provided a strategic review of the current waste movements in Scotland and developed the basis of a decision making tool which can be used by waste strategists and planners alike. The model needs to be developed so that it can be applied to specific studies rather than taking a strategic view of the whole of Scotland. The model, while developed to examine the transport from waste transfer station to landfill, could be applied to any waste transport scenario including the transport of segregated waste streams. Recommendations are made on the next steps that need to be taken to develop the cost models into a refined decision making tool as follows:

1. Robust data: For the model to produce robust results the quality of the waste input data must improve.

2. Cost modelling versus LCA: Determine best course of action with regards to cost modelling and LCA. One option would be to develop a model that integrates both techniques. Further environmental externalities would need to be incorporated into the model – particularly for rail and water: e.g. emissions, congestions costs, accident costs.

3. Gather stakeholder support and obtain funding.

4. Refine model: The model would be refined to enable individual cases to be analysed separately. This would be aimed at identifying routes with appropriate infrastructure and capacity to allow waste transfer and/or identifying where infrastructure investment could enable modal transfer. This would involve:
   - Incorporating improved waste data.
   - Validating assumptions.
   - Assessing rail and water mode capacity.
   - Considering consolidation of waste streams.
   - Building a user friendly front end to the model.
1 Introduction

1.1 Background

The management of waste sits at the very heart of sustainable development. Waste is produced in every part of today’s consumer-based society, whether through our own daily lives or through commercial and industrial economic activity. In 2001 8.91 million tonnes (Mt) of waste was sent to landfill in Scotland from a population of 5.1 million people (GRO, 2004). The volume of waste produced annually is set to increase. The National Waste Plan (NWP) (SEPA, 2003c) forecasts waste growth of an average 2% per year as the population and economy continues to grow.

The waste produced must be dealt with in a manner appropriate to safeguarding human health and the environment. It is thus usually transported from its origin to a suitable disposal site, transfer station or treatment centre. In 2001 66% of all waste produced in Scotland was sent to landfill (Chambers et al., 2004). As relatively few such facilities are located in areas adjacent to our towns and cities, waste is often transported over significant distances. The transport of waste has environmental, economic and social impacts that include, but are not limited to:

- Air emissions.
- Use of fuel and resources.
- Odour and noise.
- Congestion.
- Accidents.

In Scotland the majority of waste movements are carried out by road haulage (see Chapter 4). The emissions from road haulage are much higher per tonne and per mile than the comparative emissions from rail transport. The movement of waste by road also contributes to congestion. Road congestion increases the time taken to transport waste, and hence the costs, whilst also impacting on the environment. Options for waste transport other than road haulage, which currently play no part or only a minor part, are rail freight haulage, coastal shipping and inland waterways.

In order to reduce all of the impacts from waste transport in Scotland there is a need to examine the current practices to identify ways in which it can be both optimised and minimised. This involves both examining the potential movement of waste onto different transport modes and reducing the distance the waste travels. Legislative and policy drivers from both the transport and waste sectors support these aims.

Scottish integrated transport policy (see Chapter 3, Section 3.1) aims to:

- Decrease environmental impacts of transport.
- Decrease the transport distances travelled.
- Deliver an integrated, multi-modal approach.

High quality, reliable freight transport is vital to Scotland’s economy. The Scottish Executive (SE) is committed to facilitating a pattern of freight movements that minimises environmental damage through encouraging alternatives to road freight, where possible, and through increasing the efficiency of current road haulage and reducing the number of lorry journeys.

Freight transport is fundamental to economic and social development. The transport of a huge variety of different goods into and around Scotland and the export of goods from Scotland to a variety of destinations are vital to our economic development. They underpin increased prosperity for many. The facility to move freight effectively in response to industry’s needs has always been vital to Scotland’s economic performance.

The SEPA National Waste Strategy (NWS) (SEPA, 2000a) recognises that longer journeys by river or rail may be environmentally preferable to shorter road journeys. A non-statutory target of increasing waste by rail transport by 10% by 2010 has been discussed subsequent to the strategy.

The NWS aims for integrated waste management systems that take into account the need for regional self-sufficiency and the proximity principle. In terms of the planning and development of new waste management facilities the Best Practicable Environmental Option (BPEO) principles must be applied. BPEO identifies the option that provides the most benefit or the least damage to the environment as a whole while remaining economically viable.

To ensure that the impacts from the transport of waste are kept to a minimum, self-sufficiency and proximity principles require that transport is minimised, and waste is dealt with close to where it is produced. In Scotland this may not always be possible and therefore the principles imply that where this is the case different transport modes, with a lower environmental impact, should be used.

The movement of waste therefore needs to be addressed in the same way that integrated transport approaches the transport of people. Transport is viewed as a multi-modal exercise and the optimum mode for a given journey can be determined by examining factors such as cost, waste
characteristics, energy consumption, travel time, travel distance, congestion or environmental performance. As part of an integrated system of waste management it is necessary to develop transport systems which allow for the minimal impact upon the environment and human health but which optimise the management of waste in terms of both cost and environmental control. Alternatives to road transport should be considered to determine whether these provide improvements. This relates to the distances travelled between the point at which wastes arise and the point of treatment or disposal, the methods of transportation and their specific energy costs/environmental impacts, and the alternative transport options which could influence the location and development of future infrastructure needs.

When investigating what changes could be made to optimise the waste transport system the following should be considered.

Location of facilities: The locations of current waste management facilities are a limiting factor when determining if other transport modes can be considered. However, the National Waste Plan (NWP) (SEPA, 2003c) and NWS priority is to increase the amount of waste recycling and therefore the amount of waste sent to facilities other than landfills. Suitable facilities must be developed to recycle wastes and also to deal with the increase in waste production in the future. The location of these facilities will be dictated by contractual issues and economics, waste volumes produced and the distances travelled. Location of new waste management facilities is becoming increasingly difficult due to poor public perception. Few people would choose to have a waste management facility located close to their homes due to concerns ranging from falling house prices to perceived impacts on human health.

Waste distances: Waste distances should be minimised but in order to do this it is necessary to quantify the current position in terms of waste movements. Transporting low value materials over long distances is inappropriate both in terms of the emissions generated and also in terms of the associated economics. Little is to be gained from such transport as the disbenefits in terms of social and economic costs far outweigh the benefits. Rail and water transportation potentially confer significant benefits in both cost and environmental terms over road haulage, particularly over longer distances.

Speed of transport: Not all waste needs to be moved incrementally or quickly – there are opportunities for bulk, homogeneous, non-putrescible wastes to be transported by rail or water over large distances, reducing the overall environmental and social impacts of their transport. Thought must be given to the need for transporting waste using fast modes such as road haulage. There is seldom any need to transport non-putrescible wastes over long distances within a short time frame. Time constraints are only forced through the need to feed a specific process, and thus are dependent upon the input into a particular process. Such factors must be considered in line with waste management licensing issues that allow for the storage of waste materials on site for a specific maximum time period.

Social impacts: Changing the structure of the waste management transport industry to develop marginal environmental improvements through a reduction in road movements could lead to the further development of other socio-economic problems such as unemployment in areas with insufficient inward investment. The impacts upon livelihood must therefore be considered to determine whether these will be impacted through the development of a more environmentally sustainable waste transport system.

Economic impacts: Economic costs must be considered, as there will be little hope of attracting inward investment from the private sector for the development of sustainable waste management facilities if it is uneconomic to do so.

Environmental impacts: The relative environmental impacts of different transport modes must be taken into account.

There exists therefore a need to both describe the physical movement of wastes in terms of costs and environmental impacts and to develop a tool to monitor these costs and impacts over time. In 1999 SNIFFER appointed the Transport Research Laboratory (TRL) to carry out a scoping study and develop a research specification for "Best Integrated Transportation Option (Waste) (BITOW)/GIS Assessment, as BPEO guidance for waste management option decisions in Scotland" (Winter et al., 2001).

TRL reviewed the key issues in relation to the points set out by SNIFFER. Key players in terms of BITOW objectives were consulted. The results of these activities were compiled and submitted as a scoping study and associated specification for the main project. The current study has been developed from this initial feasibility project.

This study builds on the scoping study and aims to go some way to examine waste transport in Scotland and identify what improvements are required to improve its sustainability. The outcomes of this project will provide advice and encouragement to industry to optimise the transport of waste and where appropriate to transfer modes in the interests of greater economic and environmental efficiency and optimisation.
1.2 Scope of the study
The current study undertakes a strategic review of the best integrated transport options for waste, examining road, rail and water borne (coastal and inland waterways) transport options in Scotland including:

- Identification of the main corridors of movement of waste.
- Review and validation of existing transport flow data for wastes throughout Scotland.
- Quantification of transportation issues relating to waste.
- Characterisation of the current road, rail and water transport infrastructure and potential for new facilities (e.g. railhead land banks).
- Comparison of relative environment, social and economic impacts of road, rail and water transport.
- Identification of the potential for the use of other transport modes for the transport of waste including water and rail based systems, and identification of the capacity of such systems.
- Identifying the limiting factors which impact the development of sustainable transport related to waste, including distance travelled.
- Characterisation of the current situation for the movement of waste in terms of overall costs of transport and disposal and associated environmental factors and comparison of this with selected future infrastructure scenarios examined with the view of potential improvements in waste transport.

The study examines the current infrastructure in terms of waste disposal to landfill from transfer stations, and what transport modes are being utilised to effect transport to these locations. Where possible how much waste is transported and of what type is identified by mode. The study does not consider the transport of waste from point of origin at households, businesses and industry to transfer stations. It was considered that this was an area with least scope for modal transfer. The focus is on the transport of mixed waste to disposal although the principles discussed are relevant for the transport of separated waste transported for reprocessing. The required data was sourced from existing and emerging SEPA databases and consultation with industry and government.

Examples of good practice are provided via the provision of case studies. Social issues (such as employment) and the effects of changing waste transport patterns on road traffic were considered throughout the project. Identification of barriers to progress was also considered throughout.

1.3 Aims, objectives and outputs
The main purpose of the study is to provide a better understanding of the movement of wastes and its effects in Scotland and provide guidance that enables the identification of locations for the development of waste management facilities. The ultimate aim of the study is to decrease the impacts from the transport of waste including:

- Reduction in fuel consumption and emissions to air.
- Reduction in road runoff and the leakage of liquid wastes from waste containers into roadside drainage systems.
- Reduction in the number of road miles covered, thereby easing road congestion.
- Reduction in nuisance and local amenity impacts.
- Reduction in road accidents involving lorries.

The main objectives of the study are to:

- Allow interested stakeholders to evaluate the current position of waste transport.
- Allow a strategic view of the movement of waste through the development of options for integrated multi-modal systems.
- Provide guidance on the optimum transport mode based upon:
  - Cost of transport and value of waste.
  - The characteristics of the waste.
  - Energy and fuel consumption.
  - Travel time and distance.
  - Road congestion.
  - Environmental performance.
- Provide information in a form that can be fed into the planning process, at both the strategic and local level, to inform decisions on integrated transport of waste.
- Encourage change and improvement through education.
- Disseminate the findings of the research to industry, government and the others.
The key outputs of the study include:

- Outline generic guidance on planning considerations with respect to waste transport.
- Collation of the available data set on current waste movements in Scotland.
- Development of a cost model to examine planned and theoretical scenarios for waste transport. This includes the costs of transport by mode.

1.4 Audience

The intention of this document is to provide the first step in developing a planning tool to feed directly into the development of future transport policies and strategies for dealing with waste. The document provides a feasible methodology for ensuring that the transportation of waste is carried out in compliance with the tenets of sustainability, which include the need to consider economic circumstances as well as environmental and social issues. The report identifies where there are real opportunities for modal shifts in the waste transport sector. As such, the intended audience will include, but not necessarily be limited to:

- Local and national government as they develop policy and legislation.
- Waste and transport Planners.
- The waste management industry as it determines how best to meet the requirements of the sustainable and integrated management of future wastes.
- The freight/waste transport sector as it develops proposals for the expansion of waste transport and to determine where there may be opportunities to increase their market share.
- Consultants as they advise their clients on the most appropriate means of transporting waste materials.

1.5 Structure of the document

Chapter 2 sets out a summary of the relative environmental, social and economic impacts of different modes of transport. Chapter 3 sets out the planning and policy framework for waste transport. Chapter 4 presents data and discussion on the current waste transport situation in Scotland including identification of the major areas of waste production, waste movements and mode of movement and opportunities for adopting different transport modes for the transport of waste. Chapter 5 gives details of the cost model developed for the study and compares the approach to Life Cycle Analysis (LCA). Chapter 6 presents the results from the waste transport cost model, including what the situation will be in future years if the situation stays as it currently and results from various scenarios. Chapter 7 presents an analysis of the information gathered in the study, draws conclusions, makes recommendations and identifies the next steps in the work.
2 Issues associated with waste transport

This chapter provides an overview of the impacts of the three major modes of freight transport which are, or could potentially be used to carry waste – roads, rail and waterways. It outlines the issues affecting these differing modes to determine the advantages and disadvantages relating to their use. The issues covered include:

- Environmental considerations.
- Socio-economic considerations.
- Economic considerations.

2.1 Environmental issues

Transportation has a wide range of environmental impacts, arising from both the journeys undertaken by road, rail, air or water, and also by the establishment of the vast range of infrastructure that allows the journeys to take place, including roads, bridges, railways, ports, airports, transfer stations, car parks and other features. When assessing the life cycle of a product, transport is a major environmental impact. The transport of waste is no exception to this trend.

The environmental considerations of freight transport are important factors in the comparison between different transport modes. The major issues include:

- Energy use.
- Waste production.
- Noise.
- Emissions to air, water and soil.
- Visual intrusion.
- Land take.
- Biodiversity and nature conservation.

2.1.1 Energy use

Fossil fuels are the primary energy source for transport. In OECD countries alone, the use of fossil fuels for transport increased by more than 45% from 1980 to 1997 and is expected to continue growing (OECD, 2001). The energy used by the five major freight transportation modes, including land, air, is illustrated in Figure 2.1. Apart from air, road transportation is shown to be the least fuel-efficient of these.

The level of fossil fuel use also depends on the energy efficiency of the vehicles which are used. Energy efficiency can vary considerably with the mode of transport. The more efficient freight transport modes are rail and waterways, while road transport is the least efficient in terms of energy use. Waterway transportation is the most efficient in terms of energy use, with rail averaging 42% more energy use per journey, and road transport averaging approximately 300% more energy use per journey (Table 2.1).

2.1.2 Waste production

Solid waste production from freight transport is minimal. The major arisings will come from servicing of the vehicles which is dependent upon the mileage completed.
Table 2.2 Relative noise levels of different transport modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Noise levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>On a lightly used single carriageway (flow of approximately 3,000 vehicles per day with 10% heavy goods vehicles) noise would increase at a property 20 metres from the road by 2-3 dB(A). This would be described as a slight impact. On a busier single carriageway (carrying 10,000 vehicles per day) noise would increase by 1dB and would be described as a negligible impact.</td>
</tr>
<tr>
<td>Rail (complete goods train)</td>
<td>1.42 1 1.71</td>
</tr>
<tr>
<td>Road (25-38l lorry)</td>
<td>3.08 2.57 3.57</td>
</tr>
</tbody>
</table>


and specific service intervals. Road transport will produce the greater arisings due to the total volume of vehicles involved in the transport of freight. Both rail and waterway based transport will have a much smaller impact on waste arisings due to the reduced number of vehicles in operation and the fact that these modes carry much more freight per vehicle.

2.1.3 Noise

Table 2.2 details the relative noise levels for the different transport modes. This information is based on a case study carried out by Eco-balance in 2000 looking at the transport of waste in London. It was calculated that the movement of 858 tonnes of waste per day requires 150 lorry movements, or 3 tug movements, or 2-3 train journeys. Each mode of transport was assessed separately and the potential noise and vibration impacts discussed.

These results indicate that noise will not play a major part in the transport of waste, whatever the transport mode chosen. However, noise is subjective, and a small rise will have a greater impact on some individuals rather than others. Rail appears to promote the highest individual noise level, but this will be intermittent albeit that this in itself can be a contributor to the relative levels of disturbance experienced. Rail transport would also cause the greatest vibration impacts.

2.1.4 Emissions to air, water and soil

2.1.4.1 Air pollution

The transport sector, especially road and air transport, contributes to air pollution, acidification and climate change through emissions of carbon monoxide (CO), carbon dioxide (CO$_2$), nitrogen oxides (NO$_x$), sulphur dioxide (SO$_2$), hydrocarbons (HC), particulate matter (PM), lead (Pb), other heavy metals, and volatile organic compounds (VOC). These pollutants are released during the combustion of fossil fuels, the primary energy source for transport.

Table 2.3 outlines the relative emissions for a selection of the primary air pollutants from the different transport modes. Road transport has by far the greater impact.

Table 2.3 Selected emission estimates for freight transport (kg/t-km)

<table>
<thead>
<tr>
<th>Mode</th>
<th>CO$_2$</th>
<th>NO$_x$</th>
<th>PM$_{10}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>0.193256</td>
<td>0.007146</td>
<td>0.00027</td>
</tr>
<tr>
<td>Rail*</td>
<td>0.033</td>
<td>0.00039</td>
<td>0.00002</td>
</tr>
<tr>
<td>Inland waterways</td>
<td>0.044</td>
<td>0.00079</td>
<td>0.0005</td>
</tr>
</tbody>
</table>


Emissions rates for all transport modes depend on a number of factors including engine type, fuel consumption, vehicle speed, driving conditions, weight of load carried, types of road/river and driving/travelling conditions.

2.1.4.2 Water pollution

Transport causes pollution of water bodies adjacent to transport infrastructure. Runoff from roads contains
hydrocarbons, heavy metals, chemicals used for de-icing, and other chemicals. Effluents from ships cause water pollution. Transport of dangerous goods (hazardous wastes, oil) by all transport modes poses a risk of contamination of soil, water, and wetlands through any spillage.

Ground water quality may also be affected by leaks from underground fuel storage tanks constructed at filling stations. Transport by water affects coastal zones through building the port infrastructure. High-speed ships can cause a serious disturbance in sensitive areas of rivers and seas. The transport of oil and chemicals poses a risk of accidental water and coastal pollution.

2.1.4.3 Soil pollution
Pollution of soils in close vicinity to roads by chromium, lead, and zinc, may be a result of high traffic levels. These metals tend to remain in the soil for several hundred years and cause damage to the soil, micro-organisms and vegetation. Fortunately, these effects are localised on the narrow area on either side of the road.

2.1.5 Visual intrusion
The building of transport infrastructure has visual impacts on landscape, natural resources and townscape. Visual impacts represent the blocking out of light and pleasant views by the transport infrastructure and activities, while aesthetic impacts are concerned with the actual design and style of the transport infrastructure (Button and Rothengatter, 1993). In terms of waste transport it is hard to make relative comparison of the impacts that the different modes may have. New systems of roads, railways and waterways are unlikely to be built purely for waste transport, hence the impacts in landscape, heritage of natural resources and townscape will be negligible. However, new infrastructure such as transfer stations, cranes, docks and railway sidings will be required if waste transport optimisation requires a change from the present situation. Visual impacts will vary depending on the quantity and situation of these new facilities. In addition, any development of facilities relating to waste management, whether for recycling or disposal, may well come up against NIMBY (Not In My Back Yard) syndrome. This will occur not because of the impacts upon the actual townscape, but more with respect to perceived health and environmental impacts.

2.1.6 Land take
Increased land use for transport infrastructure increases pressures on biodiversity due to habitat fragmentation. It also causes an increase in acidification and eutrophication. Land is affected by the transport sector in two ways: directly through building the transport infrastructure, and indirectly by the development stimulated by providing transport avenues (EC, 1999).

One of the most obvious negative effects on land use of the development of transport infrastructure is urban sprawl. The growth of urban areas over the surrounding rural land leads to fragmentation of land use. Urban sprawl causes other problems, such as widespread strip development of the commercial sector, low-density settlements, and dominance of private motor vehicles in the transportation modes (Patowski, 2001). In general, the land take required for highway infrastructure will greatly exceed that for rail and water travel modes.

It is estimated that transport infrastructure consumes 25-30% of land in urban areas in OECD countries (OECD, 2001). In the EU, 93% of total land area used for transport belongs to roads, while rail and airports occupy 4% and 1% respectively (OECD, 2001).

2.1.7 Biodiversity and nature conservation
There are three ways in which the transport sector contributes to biodiversity loss (EC, 1999):

- Direct damage.
- Fragmentation.
- Disturbance.

Loss of habitat is an inevitable consequence of land use change during the construction of the transport infrastructure. However, by careful planning, it is possible to keep the damage at an acceptable level. If the construction is not carefully planned, especially in sensitive areas, it can destroy or seriously damage natural ecosystems, thus causing direct damage through loss of habitats for sensitive plants and animals, which is the main cause of biodiversity loss.

Roads and railways cause fragmentation of habitats, preventing free movement of animals and exchange of genetic material. Habitat fragmentation damages an ecosystem’s stability and health. Habitat fragmentation can also cause corridor restrictions. Corridors are routes that animals use for satisfying their everyday or seasonal needs for food, breeding, and shelter. By cutting through the corridors, the transport infrastructure causes negative pressures on animal populations affecting their feeding or breeding, because they are either reluctant to cross the roads or get killed while crossing them. It is also a case that some animals are attracted to roads for various reasons (more food, shelter from predators, warmth or easier movement) which often leads to increased mortality due to accidental deaths.
Road construction also opens the way for intruding species, disrupting the balance of the ecosystems. Noise, light, and the runoff of hazardous compounds from roads cause disturbance in the ecosystems, and lower the reproduction rates of animals (EC, 1999). Water ecosystems also suffer disruptions caused by the land transport infrastructure. Erosion leads to accumulation of fine earth particles downstream, which affects habitats for fish spawning. Changes in water flow caused by diversions during construction works often have negative effects on plankton, eventually upsetting food chains in the ecosystem. Roads can also cut through the migration routes of fish, causing disruptions in the spawning cycle.

A comparison of different modes in relation to their impacts on biodiversity is extremely difficult to achieve, since levels of biodiversity are area specific. All three modes have shown themselves capable of ecological disruption, especially through the provision of pathways for alien species to migrate and compete with native species. Impacts from the highway network are extensive due to the proliferation of halophilic species on road verges. The rail network has opened up a pathway for the proliferation of the Buddlia shrub, and the canal network has been implicated in the rapid spread of *Elodea Canadensis*.

### 2.2 Socio-economic issues

As with environmental impacts, the range of social impacts is made up of two main components; those which can be attributed to transport movements, and those which can be attributed to the associated infrastructure. Specific data on the social impacts of waste transport are largely unavailable and therefore the issues are considered as relating to general transportation. Socio-economics may play a major role in the promotion of any modal shift for waste transport. The issues which are of most importance to waste transport include:

- Accessibility.
- Health and safety.
- Employment.

#### 2.2.1 Accessibility/severance

Accessibility is concerned with the 'ease of reaching' opportunities (jobs, shops, leisure activities) or the 'ease of being reached' by contacts (such as clients, customers, workers). This takes a number of factors into account such as community severance and social exclusion.

Severance impacts are commonly divided into the 'barrier effect' and the 'longitudinal effect' (Tate, 1997). A barrier effect is the difficulty experienced by people wanting to cross a road or other transport infrastructure as a consequence of traffic flow or highway design. The longitudinal effect is a reduction in the willingness of pedestrians and cyclists to use a particular road arising from feelings of intimidation and danger. Such severance is affected by changes in general traffic levels and speeds, and the number of heavy vehicles including buses.

A modal shift from road to rail or waterway would reduce the numbers of vehicles on the road and consequently potentially reduce severance impacts.

#### 2.2.2 Health and safety

Health and safety issues relate to both accidents caused on the various transport networks, to workers and the public, and to issues relevant to the workers only. Figures for health and safety are considerably lower on both the rail and canal network per kilometre travelled.

Lorries only account for 6% of vehicle kilometres travelled. However, they are responsible for 18% of road deaths; in 1999 HGVs caused 617 out of 3,423 fatalities (Freight on Rail, 2002). There is an expectation that moving freight (including waste) off the road network could have a positive impact upon road injuries as the number of movements would be reduced.

#### 2.2.3 Employment

Introducing a change in the modes of freight or waste transport has the potential to have an impact upon the employment and livelihood of a large number of people involved in the road transport sector. Potential impacts include:

- Jobs would be lost from road freight. These would not be replaced with an equivalent number of jobs in either of the rail or waterway sectors as these modes do not require equivalent numbers of staff per tonne.
- Even with modal transfer road transport is still likely to be required for the first and last leg of journey. Therefore there may be no overall impact on employment numbers.
- The drive towards waste segregation and market creation for recyclates will lead to job creation.

Quantification of the potential impacts on employment is beyond the scope of this study. However, a combination of the changes brought about by waste legislation (see Chapter 3) and modal shift are likely to result in a shift of employment.

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1 Halophilic - salt loving: able to survive in environments with high ionic strength.
2.3 Economic issues

Economics will play a major role in the promotion of any modal shift for waste transport. The issues which are of major importance include:

- Location of facilities.
- Infrastructure.
- Journey length.
- Relative value of waste arisings.
- Congestion.
- Vehicle capacity.

The overall unit cost of transporting waste by the different transport modes has not been considered in this section. This is addressed by the cost modelling presented in Chapter 5 of this report.

2.3.1 Location of facilities

The location of waste management facilities, whether they be transfer stations, waste to energy plants or landfill sites will have a major bearing on the economics of a modal shift for waste transport. Historically these facilities have been located close to road networks to allow for easy access.

To develop other modal opportunities there is a need to determine what facilities are required and where they would need to be located to take account of the use of other transport modes. This suggests the need for the development of new multi-modal waste facilities able to accept waste from a variety of transport modes. This will demand inward investment from the waste management companies who will have to determine whether there is anything to be gained from the utilisation of transport modes other than road. This will in turn be influenced by the attractiveness of the waste management contracts put forward by the local authorities.

In reality inter-modal facilities will require some form of road transport at either or both ends of the route.

2.3.2 Infrastructure

A modal shift in waste transport can only be achieved with a well developed infrastructure. Major investment on behalf of the rail operators and Network Rail will be required to increase the potential for rail transport. This may include the development of new, or the reinstatement of existing, railway infrastructure, necessitating increased investment. Special emphasis also needs to be put onto the development and expansion of transhipment centres as most rail/waterways journeys will involve an in-bound and outbound road leg.

With regards to transport by inland waterway, there are potential limitations due to the costs of infrastructure improvement, and the restrictions of the infrastructure itself, especially where the current lock systems limit the size of freight carrying barges.

It will fall to the operators and strategists to determine whether waste management provides an appropriate market for the investment necessary to provide a significant shift from road. It may prove that the transport of waste is of too low value to justify the necessary investment.

2.3.3 Journey length

Road transport is ideal for relatively short journeys. Both waterway and rail transport become more economic with distance. Both rail and water usually require a road leg at the beginning and end of the journey. These road legs generate additional transhipment cost. With increasing distances this cost becomes more and more irrelevant. Therefore rail or water transport over short distances can only be economically viable if no transhipment is required: i.e. consigner and/or consignee dispose to a port or railhead.

The argument in favour of using road transport for freight is that it is appropriate for shorter journeys than rail. There appears to be a strong negative correlation between road and rail usage with road freight predominating over distances of less than 50 miles and rail predominating for distances greater than 400 miles. This is illustrated in Figure 2.2.

Because of the size of the country and its geography, most of the journeys for waste transportation would be well under 250 miles. However, Freight on Rail (www.freightonrail.org.uk) cite several examples of short, viable freight journeys, including one for waste transportation, currently operating on the UK rail network (Freight on Rail, 2002):

- 12 miles – Coal transportation from Selby colliery to Ferrybridge Power Station in Yorkshire.
- 19 miles – Aggregates from Greenwich to Kings Cross.
- 40 miles – Waste removal from Cricklewood to Bedfordshire.
- 60 miles – Container traffic between Felixstowe and Tilbury.
- 93 miles – Container traffic between Southampton and Barking.

There also occurred a movement of waste from Edinburgh to Dunbar over a distance of just 27 miles.
2.3.4 Relative value of waste arisings

In general, waste arisings are low value materials. Thus, transportation will make up a greater contribution to the costs of dealing with waste than for higher value freight goods. The low value also plays a major part in the overall costing of new infrastructure to account for waste transport as the final relative costs may outweigh the perceived benefits.

Consideration is required in determining whether the movement of waste onto other modes will provide an overall benefit which is equal to the costs of the modal shift. It may be better to concentrate on the movement of other freight goods as waste only makes up about 5% of the total freight movements within Scotland.

Policy makers will need to consider the overall significance of these movements against movement of other materials, and not taken as a separate issue. The overall environmental and socio-economic benefits may prove better served if those materials which make up the bulk of freight transport are considered for a modal shift alongside or in lieu of waste arisings.

2.3.5 Congestion

Congestion on the road network has a major economic impact as goods take longer to get to their destination. Costs are accrued through lost time and fuel consumption which can never be recovered. Increased volume of traffic on the Scottish road network will only exacerbate this problem further as car ownership increases and more goods are moved throughout the country.

Waste arisings are forecast to increase. Continuation of movement of waste by road will lead to a higher number of HGV journeys, an increase in traffic volumes and thus contribute towards increased congestion.

Improvements can only be made through a reduction in the freight carried by road, by major diversions onto the rail or waterway network, or through further major infrastructure development. Waste, because it is usually not time dependent may prove a suitable material for movement off road, although congestion can also be reduced by exploiting non-busy times on the road network to transport waste. It is worth noting however that off-peak, and particularly night time transfer and transport gives rise to other impacts such as new noise and nuisance.

2.3.6 Vehicle capacity

A typical freight train can move over 1,000 tonnes of goods, equivalent to 50 HGVs on the road. This is a significant advantage in terms of cost and speed, especially as the road network is likely to become more rather than less congested over the next twenty years. In addition, the costs will decrease for rail transport if the volumes transported increase, which will in turn provide further economic advantage.

Capacity is also an issue where there is insufficient control over road freight movements and empty vehicles return to depots after depositing their loads. This issue is very difficult to deal with for road transport of waste as reverse logistics do not necessarily tally with the materials being carried, primarily due to concerns over potential contamination of goods. Containerisation maybe one possible approach to dealing with this issue, but equally contamination of containers may also present a problem.

2.4 Comparing the modes

Table 2.4 outlines the different issues set out above and places an estimate as to those modes which provide a major, moderate or low influence (in comparative terms).
In environmental terms road transport appears to be the least desirable transport mode in comparison with rail and water transport. This stands in contrast to the economic evaluation. At least from a micro-economic perspective road transport certainly has advantages over other transport modes unless the transport distances are very long. It also provides a certain flexibility which is not given in rail and water transport. In the macro-economic view this cost-advantage has disappeared. These relative impacts are discussed further in Chapter 6.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Road</th>
<th>Rail</th>
<th>Waterway</th>
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<tbody>
<tr>
<td><strong>Environmental</strong></td>
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<tr>
<td>Energy use</td>
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<td>Waste production</td>
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<tr>
<td>Noise</td>
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<td>-</td>
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<tr>
<td>Emissions to air, water and soil.</td>
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<tr>
<td>Visual intrusion</td>
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<tr>
<td>Land take</td>
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<tr>
<td>Biodiversity and nature conversation</td>
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<tr>
<td><strong>Socio-economic</strong></td>
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<td>Accessibility</td>
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<td>Health and safety</td>
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<td>Employment</td>
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<tr>
<td><strong>Economic</strong></td>
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<tr>
<td>Location of facilities</td>
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<tr>
<td>Infrastructure</td>
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<tr>
<td>Journey length</td>
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<tr>
<td>Relative value of waste arisings</td>
<td>-</td>
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<tr>
<td>Congestion</td>
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<tr>
<td>Vehicle capacity</td>
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</tbody>
</table>

Key:
- Likely to have a major impact
- Likely to have a moderate impact
- Likely to have a low impact
3 Planning and policy framework for waste transport

This chapter provides a review of environmental and planning policy, legislative and organisational change that will have a bearing upon the delivery of waste management facilities over the next 10-20 years. Implications for the transport of waste are discussed. General guidelines on an appraisal framework addressing modal shift of waste transport are presented.

3.1 Transport policy

Continued economic development places pressure on the freight transport sector, as more materials need to be moved. This in turn will impact upon the current network, increasing the problems currently faced (see Chapter 2). The SE has realised that this will not contribute to a sustainable economy within Scotland, and have developed a policy which aims to deliver efficient integrated transport.

The Scottish Transport Green Paper (SE, 1997a) sets out the objectives for transport policy as a need to:

- Provide competitive and sustainable modes of transport to enable journeys which offer speed, reliability, safety and convenience.
- Take into account the needs for deprived, rural, remote and island communities.
- Enhance the competitiveness of the economy.
- Protect, and where possible enhance, the environment, quality of life, safety and public health, taking account of wider costs and benefits by minimising:
  - Pollution.
  - Noise.
  - Danger and intrusion.
  - Use of non-renewable resources.
- Keep public expenditure to a level which is affordable.

The Transport White Paper (SE, 1998) sets out the vision for integrated transport in Scotland. The policy outlined in this document sees integrated transport policy encompassing:

- Integration within and between different modes of transport allowing easy movement of people and goods.
- Integration of transport with the environment.
- Integration between transport and land-use planning at the Scotland and local level, so that the two work together to support more sustainable travel choices and reduce the need to travel.
- Integration of transport and policies for education, health and wealth creation to provide for a fairer, more inclusive society.

The White Paper sets out the main challenges to integrated transport in Scotland. These include:

- Physical geography: The prevalence of mountains, lochs and firths limits the choice of routes and possible engineered solutions, keeping transport corridors to the valley floors.
- Population settlement pattern: high population densities throughout the Central Belt and the North East create pressure on the urban road network which impacts on the movement of freight. In contrast, the low density areas such as the Highlands and Islands create difficulties due to the distance involved in travelling from one settlement to the next.
- Geographic peripherality: The maintenance of the current economic position despite Scotland lying in a peripheral economic position will require improvements in the transport infrastructure.

The paper states that the long term vision for Scotland requires that:

- There is a reduction in non-essential road based traffic in key parts of town and city centres.
- Consideration is given to more sustainable forms of transport particularly within towns and cities in lieu of road transport.
- There is a reduction in social exclusion through increased accessibility to public transport for those without a car.
- Any integrated transport network is geared to the needs of the Scottish economy.
- There is a reduction in dependence upon road freight movements, particularly for longer journeys.
- There is tighter control of traffic volumes in locations requiring a reduction in noise and air pollution.
- Future development accounts for the needs for accessible public transport and the existing road network.
- An accessible, sustainable and affordable rural transport system maintains and promotes the growth of remote and rural communities.
• Existing, and any new, strategic roads are maintained to a high standard with the emphasis on improved safety and reliability of journey times.

• The impact of roads on the countryside and the environment is reduced.

• Congestion charging is considered as a means of controlling the use of urban and strategic inter-urban roads with the revenues being used for transport initiatives that deliver value for money.

• A partnership approach is adopted between Government, the local authorities and transport providers and users.

A ‘New approach to transport in Scotland’ (SE, 2003a) sets out proposals for the way the transport system in Scotland will be managed and improved. The document sets out the role for the newly established agency, Transport Scotland. The roles of Transport Scotland include working for an integrated, multi-modal approach to services and sustainable transport as a central goal. The document reiterates the SE commitment to transport integration and sustainable development.

Transport policy in Scotland therefore is a key driver in influencing the way wastes are transported in Scotland. In summary the key policy aims in relation to waste transport are:

• Decrease environmental impact.

• Decrease transport distances.

• Investigate alternative transport modes to road.

• Work with the location of facilities in terms of land use planning.

• Deliver an integrated, multimodal approach.

3.2 Waste policy and legislation

The direction of waste policy and regulations will have a significant impact on waste transport influencing the location, amount and type of wastes arising to be transported.

3.2.1 Guiding principles

The main guiding principles of waste policy are summarised below. Any approach to waste transport should aim to follow these principles.

Sustainable development

Sustainable development is defined as ‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’ (World Commission on Environment and Development, 1987).

Planning should encourage sustainable development by:

• Promoting regeneration and the full and appropriate use of land, buildings and infrastructure.

• Promoting the use of previously developed land and minimising Greenfield development.

• Conserving important historic and cultural assets.

• Protecting and enhancing areas for recreation and natural heritage.

• Supporting better access by foot, cycle and public transport, as well as by car.

• Encouraging energy efficiency through the layout and design of development.

• Considering the lifecycle of development from the outset.

• Encouraging the prudent use of natural resources.

Waste hierarchy

The waste hierarchy ranks the different waste management options, giving a broad indication of their relative environmental benefits and disadvantages. The hierarchy is a conceptual framework that acts as a guide to the waste management options that should be used when assessing the BPEO. In dealing with waste five options should be examined in the following order, starting with the most preferable: reduction, reuse, recycling/material recovery, energy recovery, and landfill.

Best practicable environmental option (BPEO)

The environmental impacts of different waste management options vary widely and the application of the BPEO will assist in determining the most sustainable method of waste management to meet local requirements.

BPEO is defined as (Royal Commission on Environmental Pollution, 1988):

‘the outcome of a systematic consultative and decision making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes for a given set of objectives, the option that provides the most benefits, or least damage to the environment, as a whole, at acceptable cost, in the long term as well as in the short term.’
The BPEO procedure aims to ensure that the waste management option chosen is environmentally sustainable, but also considers whether the cost of that option is in proportion to the environmental benefits gained.

**Proximity principle**

The proximity principle advocates that all waste should be disposed of, or otherwise managed, as close as is practicable to the point at which it is generated.

**Self-sufficiency**

The concept of self-sufficiency requires that the majority of waste should be treated or disposed of within the region in which it is produced and is managed as near as possible to its place of production (the ‘Proximity Principle’). Thus each region must plan for facilities with sufficient capacity to manage the quantity of waste likely to arise in that region over at least a 10-year period.

There is a requirement for the waste hierarchy and the principles of proximity and self-sufficiency to be adhered to in future waste management planning. The outcome of employing these principles is as yet unknown, but a common interpretation of them is that waste management facilities will become more local, and smaller. It is not clear how this will affect the quantity of waste transport overall (Commission of the European Communities, 2003).

### 3.2.2 Waste policy

The principles outlined in Section 3.2.1 feed into waste policy. This section provides an overview of key elements of policy, legislative and organisational drivers that impact upon waste management activities that will inform the waste planning context over the next 10 or more years.

Many of these regulations are likely to have either a direct or indirect impact on waste transport and handling facilities over a relatively short-term with recent EU Directives typically allowing for up to 3 years for adoption by the Member States. Clearly the introduction of Scottish regulations has a much more immediate effect.


This Directive established a framework for the management of waste across the Community. The Framework Directive established a waste management hierarchy and requires Member States to adopt this hierarchy by encouraging, in order of priority:

- The prevention or reduction of waste production and its harmfulness.
- The recovery of waste, including recycling, re-use or reclamation, or the use of waste as a source of energy.
- Disposal.

As well as regulating the disposal and recovery of waste, the Directive requires Member States to establish an integrated and adequate network of disposal installations, and to prepare and implement waste management plans.


The primary aim of this Directive is to provide for measures, procedures and guidance to prevent or reduce the negative effects on the environment, and the risks to human health, from landfilling of waste. It requires Member States to take a number of measures to achieve this aim, including treating waste before landfilling it, phasing out co-disposal (the mixing of hazardous waste with non-hazardous waste) and exercising controls over site closure and after-care (OJEU, 1999).

The Landfill (Scotland) Regulations 2003 (SE, 2003c) address how Landfill Directive will be implemented in Scotland. Some key implications of this legislation relating to planning for waste management include:

- All permitted landfills will be brought into the IPPC regime.
- Co-disposal of special and non special wastes in landfills from 15 July 2004 will no longer be permitted. At the time of writing SEPA has not received an application for a landfill which would be classified as a landfill for hazardous waste. This means that from 15 July 2004 there will be no landfill in Scotland able to accept hazardous waste (SEPA, 2004b).
- Non-mineral mining waste will be covered by regulations which translate the Landfill Directive into Scottish Law.
- Corrosive wastes are generally banned from landfill, along with larger quantities of liquid wastes.

The Landfill Directive will ban the landfilling of virtually all tyres from July 2006, so that alternatives to landfill must be found by this date.

A study investigating Local Authority Waste Management Costs (SECRU, 2000) considers the cost implications to local authorities of implementing the Landfill Directive targets for the reduction in biodegradable municipal waste (BMW) disposed to landfill. The modelling approach taken came to the following conclusions:
That an increase in waste management costs of around 20% by 2010, and 35-40% by 2020 relative to baseline waste management costs in these years (i.e. the costs assuming no Landfill Directive), is likely to occur.

The modelling in the study has determined that Energy from Waste (EfW) is, with the exception of the more remote and less densely populated authorities, the lowest cost means of diverting BMW from landfill.

Diverting BMW from landfill is likely to increase waste management costs by up to 40% by 2020, which will require budgeting for. The transport component of such costs may be significant.

Aggregates levy
The levy aims to address the environmental costs associated with quarrying operations (noise, dust, visual intrusion, loss of amenity and damage to biodiversity). The aim is to reduce demand for aggregate and encourage the use of alternative materials, including wastes, where possible (HM Customs and Excise, 2004).

Landfill tax
This tax aims to encourage waste producers to produce less waste, recover more value from waste, for example through recycling or composting and to use more environmentally friendly methods of waste disposal. The tax applies to active and inactive waste, disposed of at a licensed landfill site. There are two rates of tax:

The lower rate of £2 per tonne applies to certain inactive (or inert) wastes

The standard rate (currently £15 per tonne), applies to all other taxable waste (HM Customs and Excise, 2004).

This Directive provides measures and procedures to prevent and, if prevention is not a practicable option, to reduce negative effects on the environment and human health related to air, soil and water pollution caused by the incineration of hazardous waste. The Directive sets out operating conditions and emission limit values for hazardous waste incineration plants.

Shipments of Wastes (OJEU, 2004)
Under this proposed regulation prior written notification and consent for all shipments of waste destined for disposal, and of hazardous and semi-hazardous waste destined for recovery will be required.

Shipment of non-hazardous waste destined for recovery only requires that certain information is made available to accompany the shipments and neither notification nor consent is required in relation to such shipments.

The proposal also clarifies that a shipment has to be controlled ‘all the way to the end’ - meaning until completion of final recovery and disposal. This will ensure that waste cannot be left at an interim facility untreated and unmonitored. Final treatment in terms of final recovery and disposal must thus be proven before the shipment can be considered completed and thus ‘released’ from further controls under this regime (Europa, 2003).

Waste Incineration Directive (OJEU, 2000a)
The main aim of Waste Incineration Directive is to prevent and limit negative environmental effects by emissions into air, soil, surface and ground-water, and the resulting risks to human health, from the incineration and co-incineration of waste. Such wastes will include municipal waste, clinical waste, hazardous waste, general waste and waste derived fuels, but exclude facilities plants burning only animal carcasses (which are regulated by the Animal Waste Directive 90/667/EC (OJEU, 1990)) and in many circumstances, vegetable and wood waste.

The Regulations apply immediately to all new incinerators and will apply to all existing installations from December 2005, implementation being carried out mainly under the existing Pollution Prevention and Control (PPC) permit regime.

Waste Management Licensing (HMSO, 2003b)
There are a number of significant implications from the amended Waste Management Licensing Regulations 1994. Regulation 17 of the regulations removes the requirement for a waste management licence for some low risk waste management activities, listed below:

- Composting.
- Storage and spreading of sewage sludge.
- Waste recovery at a sewage treatment works.
- Burning of dunnage (protective wooden casing material) at a dockside.
- Burning waste in the open.

The rationale for these proposed changes is to ensure that they:

- Encourage genuine recovery operations.
- Prevent abuse.
Deliver better enforcement and inspection arrangements.

Continue to provide protection of the environment and human health.

One of the Scottish Executive’s key waste policy objectives is to increase the volume of organic waste that is composted, thereby reducing pressure on landfill capacities in line with the Landfill Directive. The current composting exemption restricts operations to places where the waste is produced or where the compost is to be used, thereby preventing the ‘pooling’ of operations between communities, for example. The first amendment proposes to allow the scope of this exemption to be widened to all general composting, within quantity limits.

The proposed 2003 amendments to the Waste Management Licensing regulations seek to allow ‘pooling’ of general composting waste, therefore promoting this type of waste management operation. Allowing the spreading of sewage to industrial crops increases the potential for this management practice to be employed. Burning of wooden casing material at docksides reduces the requirement for this type of waste to be transported.

Environment 2010: Our Future, Our Choice (Commission of the European Communities, 2001)

The Sixth Environment Action Programme of the European Community identifies four environmental areas to be tackled for improvements:

One of the four areas of priority action for the EU Sixth Programme relates to the sustainable use of natural resources and the management of wastes. It is considered that since waste volumes are predicted to continue rising, waste prevention would be required through the encouragement of recycling and recovery of wastes. The increasing volumes of waste generated must also be disposed of safely. Waste often represents a loss of valuable resources, many of which are scarce and could be recovered and recycled to help reduce the demand for virgin raw materials. A significant reduction in the quantity of waste going to final disposal and in the volume of hazardous waste generated are intended within the lifetime of the programme. Some of the targets are:

- Reduce the volumes of waste going to final disposal by 20% by 2010 compared to 2000, and in the order of 50% by 2050; and
- Reduce the volumes of hazardous waste generated by around 20% by 2010 compared to 2000 and in the order of 50% by 2020.

There has also been emphasis on making producers responsible for managing their products when they become wastes and on reducing the content of hazardous substances in the products. Another action has been to identify policies and instruments to encourage the creation of markets for recycled materials.

Single waste stream legislation

There are a number of EU Directives that are particular to specific waste streams that have recently been or are about to be implemented in the UK:

- EU End of Life Vehicle Directive (OJEU, 2000b). This introduces from January 2006 a reuse, recovery and recycling target of 85% by average vehicle weight.
- EU WEEE Directive (OJEU, 2003a). This Directive aims to prevent the generation of waste electrical and electronic equipment (WEEE) and to promote reuse, recycling and other forms of recovery.
- EU RHOS Directive, (OJEU, 2003b). This restricts the use of lead, mercury, cadmium, hexavalent chromium and certain brominated flame retardants (polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs)) in the manufacture of new electrical and electronic equipment from 1 July 2006.

The implication these Directives is that there is a general shift towards greater waste segregation and recovery which will require more complex waste transport.

3.2.3 Other relevant policy

EU Thematic Strategy on sustainable use of natural resources

The thematic strategies are part of the Sixth Community Environment Action Programme. The strategies set out aim to develop environmental policy for complex priority problems. The objective of the natural resources strategy is ‘ensuring that the consumption of resources and their associated impacts do not exceed the carrying capacity of the environment and breaking the linkages between economic growth and resource use’ (Europa, 2004).

Renewables Obligation (Scotland) (SE, 2002c)

The Scottish Executive is fully committed to increasing the amount of energy generated in Scotland from renewable sources. The Renewables Obligation (Scotland), or ROS, will obliged all licensed electricity suppliers in Scotland to obtain renewables obligation certificates (ROCs) sufficient to cover a specified proportion of the electricity supplied to their customers in Scotland (SE, 2002c).
Potential adaptation strategies for climate change in Scotland (SE Central Research Unit, 2001). The Programme sets out the policies that will reduce emissions of greenhouse gases in Scotland and help to deliver the UK Kyoto commitment to reduce 1990 emissions by 12.5% by 2008-2012, and contribute to the UK domestic goal of reducing carbon dioxide emissions by 20% by 2010.

**Environmental Liability (CEC 2002)**

The proposal for a Directive on environmental liability with regard to the prevention and remedying of environmental damage aims to enforce the polluter pays principle. Operators who cause pollution to waters covered by the Water Framework Directive, damage to biodiversity protected at community and national levels and land contamination which causes serious harm to human health, would be held responsible for restoring the damage caused, or made to pay for the restoration.

Waste management operators in the collection, transport, recovery and disposal of waste and hazardous waste, supervision of such operations and after-care of disposal sites are potentially liable under the Directive for the costs of preventing or restoring the environmental damage.

The European proposals on environmental liability would increase the emphasis on delivering good environmental performance in the waste management sector. By firmly directing liability, operators are likely to seek methods of disposal with lower environmental risk and locations that are less environmental sensitive as well as measures to minimise any environmental risks during the transport, transfer and disposal of waste. With regards to the transport of waste, options will need to be considered in terms of the risk of spillage or contamination to the environment along the route. Waste disposal licences in the UK already place responsibility for site remediation on the operator. The implementation of the Directive will act to enforce this responsibility.

Environmental Liability will require risk assessment to be undertaken in relation to new and existing waste management and transportation operations. This undertaking will have to be addressed by companies and Government, since liability for the clean-up costs of any accidents will have to be borne by either of these two bodies.

**Eurovignette (CEC, 2003)**

The European Commission has proposed changing EU road infrastructure charging rules so that authorities can link the price of freight transport use to factors including environmental impacts. The proposals follow a draft Directive on road tolling interoperability.

The Commission plans would overhaul the 1999 Eurovignette Directive, which sets ground rules and minimum charges for heavy goods transport on the trans-European network so that:

- Authorities can vary charges according to engine emissions, congestion levels, time of day and sensitivity of the surrounding environment.
- Amend the charging rules from 12 tonnes under the Eurovignette Directive to 3.5 tonnes.
- The revenue raised is used for the benefit of the transport sector.
- Allow an increase in charges by up to 25% in ‘particularly sensitive regions’ with the extra revenue then available for cross-financing of other transport infrastructure such as rail.

While the Eurovignette applies to the trans-European network, Member States can extend the rules to other roads. The Eurovignette proposals could increase the risk of charges being applied to waste movements by road and particularly for those vehicles that do not comply with modern environmental standards or those passing through environmentally sensitive areas.

**Waste and emissions trading act (HMSO, 2003a)**

This Bill takes forward the UK’s policies on both waste management and climate change. The aim of the Waste and Emissions Trading Bill is to help the UK to meet its obligations under the European Landfill Directive and further develop the statutory framework for emissions trading schemes.

Part 1 of the Bill sets up the framework requiring local authorities to reduce progressively the amount of biodegradable waste they send to landfill, through an innovative system of tradable landfill allowances.

In the planning stages for new waste facilities, the requirements of Air Quality Regulations should be carefully considered. Air Quality levels for different pollutants have to be met nationally, hence the likely emissions from new facilities should be considered cumulatively. Site selection and hence transport patterns could well be influenced by air quality considerations where the facility risks affecting air quality.

**Local Air Quality Management (LAQM) (SE Environment Group, 2003)**

Cutting road transport emissions is a key part of LAQM. The policy framework at both Scottish and UK level has already led to significant improvements in local air...
quality and will continue to do so in the future. There several measures that have, or will be introduced to maintain these levels of improvement, that will apply to the transport of waste. These are summarised below.

The UK Government continues to use tax-based measures to reduce vehicle emissions. These include:

- Fuel duty differentials to encourage people to use cleaner fuels, including alternative fuels such as bio diesel, compressed natural gas (CNG) and liquefied petroleum gas (LPG).
- Since 1 April 2001, Vehicle Excise Duty (VED) has been graduated according to levels of \( CO_2 \) emissions, with the least polluting paying less in road tax;
- VED concessions on buses and lorries. In December 2001, the UK Government implemented a new VED structure for goods vehicles, reflecting more closely the environmental impacts and road wear that different types of goods vehicles cause.

To encourage the sustainable market for clean fuel vehicles, the SE funds the Energy Saving Trust’s Powershift Programme (Transport Energy, 2004a) and associated autogas+ Programme in Scotland. The Powershift Programme contributes towards the additional cost of purchasing gas or electric vehicles that offer emissions advantages over their petrol and diesel equivalents. Under autogas+ a wide range of petrol engine vehicles are eligible for grants towards the cost of conversion to run on LPG.

The SE launched the CleanUp Programme (Transport Energy, 2004b) in Scotland in November 2002. The Programme aims to reduce pollution from HGVs, buses, taxis, and other commercial vehicles operating in Scotland by providing grants towards the cost of fitting them with emissions reduction equipment or converting them to run on alternative fuels.

Emissions from shipping can be an issue for local authorities with major ports. Also, as emissions from other sources decline, global emissions from shipping are becoming more and more significant, with this source expected to account for 60% of total \( SO_2 \) emissions in the EU by 2010.

### Road user charging

With the introduction of charging for lorries to be introduced in 2008 (HM Customs and Excise, 2004), the movement of waste along congested routes is likely to incur additional costs that may not wholly be offset by a change in vehicle excise duty.

As road haulage accounts for over 90% of the total waste transported within Scotland the implications of charges upon the routing or scheduling of waste transfers using road could be significant. Given that road congestion is one of the reasons that rail is used to transfer waste from Edinburgh to Dunbar, a change in the economics of waste transfer could increase the use of modes other than the road.

While road user charging for freight may stimulate a move towards the use of other modes, should it be introduced for private cars then it may release congestion such that the delay costs for moving waste are reduced even allowing for lorry charging. It is envisaged that although there are likely to be some general principles that would apply to waste transfers, in practice, the implications are likely to be corridor specific, recognising the balance between new infrastructure, congestion and the availability of alternative modes.

The introduction of a mandatory charge for driving a vehicle in a specific area may result in vehicles ‘skirting around the edge of zones’, increasing congestion outside the zone and possibly having an influence on the economics of waste management facilities depending upon their location.

#### River Basin Districts- Proposals for Scotland (SE, 2003b)

Under the EC Water Framework Directive SEPA will have to produce a River Basin Management Plan (RBMP) for each river district. This will outline the state of water bodies within the river basin and the measures needed to reach good status in these water bodies. This is likely to have far reaching implications on activities that abstract or discharge water or which pose a pollution threat or alter local hydrology. Waste management facilities could be affected particularly where they pose a risk of leachate or polluted runoff.

The RBMPs will take into account any impacts waste facilities or the movement of waste may have upon the status of water bodies within the River Basin District. Where the water objectives are at risk then constraints on waste facilities are possible, this may then become a locational issue that affects waste transport.

### 3.2.4 Implications of the policy and legislative framework for the transport of wastes

Policy and legislation is driving a more diverse arrangement of waste management facilities. Waste management strategies need to include a combination of waste prevention measures, material recycling, energy recovery, and disposal options in line with targets set in the Landfill Directive and producer responsibility regulations.

As responsibility for waste is moved to the producer of waste and an increasing variety of waste management facilities is established for particular wastes, so the network of waste movements is likely to become more
complex. This has the potential to lead to an increasingly dispersed array of waste transport origins and destinations. One strategy would be to concentrate waste management facilities at MRFs and hence result in fewer waste transport movements.

The development of regional delivery partnerships addressing a wider variety of transport options may lead to an increasing array of options by which waste may be transported, although it is clear that these options will only emerge where freight movements are associated with other transport flows.

The European Commission is generating key policy, legislative and financial drivers for change in the transport, planning and treatments of wastes. These drivers are leading to increasing levels of control in dealing with wastes. These drivers are summarised below:

- Move towards segregation of waste streams and processing of wastes.
- Enhancing legislative frameworks to promote economies of scale – e.g. pooling of organic wastes for composting.
- Enabling waste trading through tradable landfill allowances.
- Promoting and focusing research on inter-modal transport.
- Encouraging short distance marine shipping.
- Environmental planning controls, driving towards increased effective environmental planning at a strategic level to support increasingly stringent environmental controls upon projects.

Supporting the interventions of the European Commission, the SE is providing the following policy drivers:

- Increased emphasis towards multi-organisation planning for both transport and wastes.
- Establishing a clear policy framework in which land use plans must address long-term waste management issues.
- Interventions in road infrastructure, particularly to address congestion, thereby aiding road-based freight movements.
- Changes to road-freight transport costs through lorry charges and possibly road user charges, while also providing funding to enhance the efficiency and environmental performance of HGVs.
- Recognition that the rail network is at 80% capacity and that increased provision for passenger movements could compromise freight movements.
- Policy and financial framework that increasingly favours canal and coastal shipping.

These drivers suggest a trend towards an increasingly integrated approach towards waste management and its relationship to transport. Indeed, satisfying one part of the sustainability equation through local smaller scale waste management facilities may compromise the economies of scale needed to deliver a rapid decline in the quantities of waste being landfilled. The economies of scale needed to deal with waste could well suggest a need for combination at source collection and segregation sites as well as larger processing facilities (recycling, composting, refuse derived fuel (RdF), EfW, landfill and incineration). The conclusion from this is that industrial and business estates may develop local waste handling, possibly linked to estate heat generation schemes, thereby minimising the movement of wastes. In contrast for bulk wastes, there may well be the longer distance movement of wastes being either segregated at source, the transfer station or the point of destination.

With an increasing emphasis upon inter-modal waste movements, this suggests that waste transfer stations or segregation facilities should be situated in close proximity to trunk roads and rail/canals/ports.

The development of waste management and land use plans to realise such facilities will need to address not only existing legislation and guidance, but also take cognisance of the Water Framework Directive (2000/60/EC) (OJEU, 2000c) and the Strategic Environmental Assessment Directive (2001/42/EC) (OJEU, 2001) as well as the policy drivers promoting sustainable development.

The implications of the Water Framework Directive could have a bearing upon either the site selection process or the investment needed to control the risk of leachate or polluted runoff, particularly for facilities located in high risk floodplains or near to watercourses. Directives dealing with incineration and air quality may also have a bearing upon the location of waste processing facilities and energy recovery plants due to control on emissions and local air quality constraints.

### 3.3 Transport and land use planning

As transport policy, infrastructure and land use planning are crucial to both the siting of waste facilities and the ease of movement of waste between waste management facilities, so this section provides a brief review of the current structure in Scotland and changes in these areas.
3.3.1 The planning system

The SE controls the overall management of planning in Scotland. The main legislation is the Town and Country Planning (Scotland) Act 1997 (SE, 1997b). In association with related primary and secondary legislation this governs the day-to-day operation of the system. The main functions of the SE relating to planning are to:

- Maintain and develop the legislative framework.
- Provide policy guidance and advice.
- Take decisions on structure plans, some major planning applications and appeals.
- Oversee the operation of the system.

Local authorities are usually the planning authority for an area and their responsibilities include:

- Preparing development plans.
- Deciding on most applications for planning consents.
- Taking action against development that has been carried out without consent or in contravention of conditions.

The general principle under which the planning system operates in Scotland is that decisions should be taken at the local administrative level unless there are strong reasons for taking them at a higher level. The primary objectives of the planning system are included in SPP1 (SE, November 2002) and are as follows:

- to set the land use framework for promoting sustainable economic development;
- to encourage and support regeneration; and
- to maintain and enhance the quality of the natural heritage and built environment.

Effective planning involves partnership working, community involvement and dialogue and negotiation with developers to enable a high quality of development on the ground.

Development plan policy is an important means of implementing the transport strategy and planning policies for an area should take full account of the relevant Regional or Local Transport Strategy. As such, LTSs and development plan policies should be developed having regard to one another.

Development plan policies should make connections to related projects and programmes which impact on land and the environment including the area waste plans (AWPs) (SE, November 2002).

Structure plans

The structure plan provides a long-term vision of the development requirements of an area, looking forward at least 10 years. The requirement for a structure plan will be removed in changes to the planning system outlined in Section 3.3.2.

Local plans

The local plan sets out detailed policies and specific proposals for the development and use of land that should guide day-to-day planning decisions. It identifies effective opportunities for development and encourages inward investment in an area. The aim is to exert a positive influence over land use decisions. Local plan policies:

- Allocate land relating to different development types: e.g., housing, business and industry, retailing, transport, leisure and recreation and mineral extraction.
- Ensure conservation of the built, natural and cultural heritage.
- Ensure the improvement of the physical environment.
- Take account of integrated transport issues and requirements.
- Push forward urban and rural regeneration.

3.3.2 Recent developments

The planning system in Scotland has for the last couple of years been undergoing extensive review and amendments.

The SE carried out a review of strategic planning in 2002. An outcome from the review was the proposed changes to development planning, including the removal of requirements for structure plans covering all parts of Scotland. City Regional Plans (CRPs) will be prepared for the four city regions within Scotland and that elsewhere a single tier development plan will be prepared. In addition, the role of supplementary planning guidance in the planning system will be increased.
CRPs will be focused on the strategic spatial issues that need attention and investment. They will cover housing, transport, employment and the environment. Detailed policy guidance for specific areas will be provided in the relevant local development plan. The CRP will identify major areas and priorities for development, redevelopment and regeneration consistent with conserving and enhancing relevant resources such as natural and cultural heritage. They will be the strategy for the spatial development of key land, property and infrastructure requirements; short (5 years), medium (10 years) and long term (20 years).

The proposals for CRPs will be finalised alongside the development of Regional Transport Partnerships, even though these may cover different areas. This will help to ensure consistency of objectives and a strategic view across the delivery of services, wherever possible.

**National planning framework (SE, 2004c)**

The National planning framework sets out a guide the spatial development of Scotland to 2025. It sets out a vision of Scotland in which other plans and programmes can share and to which they can contribute. It is not intended to be a prescriptive blueprint, but will be a material consideration in framing planning policy and making decisions on planning applications and appeals. It will be taken into account by the SE and its agencies in policy and spending decisions.

Within the framework waste management and transport are highlighted as key issues and drivers for change. The key aims of the strategy for Scotland’s spatial development to 2025 are:

- to increase economic growth and competitiveness;
- to promote social and environmental justice; and
- to promote sustainable development and protect and enhance the quality of natural and built environments.

The key elements of the spatial strategy to 2025 in relation of waste transport and management are:

- to support the development of Scotland’s cities as the main drivers of the economy;
- to spread the benefits of economic activity by promoting environmental quality and connectivity;
- to strengthen external links;
- to highlight long-term transport options and promote more sustainable patterns of transport and land use;
- to provide the facilities to meet waste recycling targets.

The framework states that transport issues will have to be addressed from the outset in planning for future development. Development plan land allocations will require to be appraised against the capacity of the transport network; where economic growth demonstrates a need for additional supportive transport infrastructure, delivery mechanisms which maintain the balance between development and the transport network will be necessary.

The framework also states that progress towards more sustainable modes and patterns of transport will involve encouraging the transfer of freight traffic from road to rail and water, and the provision of the necessary intermodal facilities. The SE wants to encourage a move away from thinking based on single modes of transport towards truly integrated door-to-door solutions.

The Opportunities for Developing Sustainable Freight Facilities in Scotland (MDS Transmodal, 2002) study recommends that a number of strategic freight interchanges should be developed to support modal shift. Significant freight-generating uses should be located as close to the rail network, strategic freight facilities and ports as possible.

The framework goes on to discuss the need for new waste management infrastructure. It states that SEPA has identified indicative locational requirements for the period to 2013. In the Central Belt Market Area, comprising Ayrshire, Glasgow and the Clyde Valley, Stirling and the Forth Valley and Edinburgh and the Lothians, local authorities will have to work closely together to ensure that facilities are sited in appropriate locations, to identify the most sustainable transport options, and to avoid duplication and achieve economies of scale. Relevant considerations in the siting of facilities will include the proximity principle and their relationship to the transport network and remaining landfill sites. Modern treatment and transfer centres are contained facilities which can be accommodated on industrial estates. Where possible, they should be located close to the population centres they serve. They should be linked to landfill sites in a ‘hub and spoke’ arrangement, where possible by rail.

**Scottish Planning Policy (SPP) 17: Planning for transport (SE, 2004a)**

The consultative draft of SPP 17 Planning for Transport (consultation ended April 2004) will, when finalised, replace NPPG9 The Provision of Roadside Facilities on Motorways and Other Trunk Roads in Scotland, NPPG17 Transport and Planning, and SPP17 Transport and Planning Maximum Parking Standards Addendum to NPPG17.
The main points of interest with regards to waste transport are as follows:

- For the transport network to most effectively support the economy, land use planning should assist in reducing the need to travel; in creating the right conditions for greater use of sustainable transport modes; and in restricting adverse environmental impacts.

- The interaction of accessibility, transport and the development strategy should be considered early in the planning process. Land allocations should take account of transport opportunities and impacts alongside consideration of economic competitiveness, sustainable development, social justice, environmental quality and design objectives.

- Strategic land use plans should be co-ordinated with Regional and Local Transport Strategies, relate the settlement strategy to the capacity of the strategic transport network, and identify where economic growth or regeneration requires additional transport infrastructure.

- Local development plans should relate new land allocations to transport opportunities and constraints.

- Planning authorities should encourage freight by rail or water wherever it can provide a feasible alternative to road for all or part of the journey. Development plans should allocate sites for manufacturing, processing, distribution or warehousing, which are readily accessible not only to the strategic road network, but also to suitable rail facilities, wharves and harbours. Consideration should be given to the need to plan for new or expanded rail freight interchanges as a means of facilitating the movement of freight by rail and reducing the transport journey by road. Planning authorities should, in consultation with transport providers, identify existing operational or disused sites adjacent to infrastructure which may be capable of being developed for uses requiring rail or water borne freight access.

- Where rail or water borne freight are not feasible, development which attracts significant movements of road freight (such as large scale warehousing distribution depots and some forms of manufacturing) should be located away from congested inner areas and from residential areas. They should have direct access to the local distributor road network and good links to the strategic road network.

**The National Waste Plan (NWP) 2003 (SEPA, 2003c)**

The NWP is the keystone for the implementation of the Scottish National Waste Strategy (SEPA, 2000a). The plan brings together the Area Waste Plans (AWPs) prepared by each of the local authorities covering the whole of Scotland. There are 11 AWPs across Scotland, which all seek the reduction of waste at source. The national target is for local authorities to recycle 25% of waste by 2006 and 55% by 2020 through household collection and participation in recycling. Currently the AWPs only cover the management of municipal wastes. In addition AWPs have no statutory basis in primary legislation. Currently the Convention of Scottish Local Authorities (COSLA) is discussing with SE the possibilities of incorporating the AWPs into the statutory planning system. AWPs must set out clearly the spatial and land use implications of their proposals and development plans must then address and resolve these issues.

There are currently about 110 landfill sites licensed to take municipal waste in Scotland of which about 70 are currently used for disposal of municipal waste. Due to the Landfill Directive, the indication is that it is likely that this number will reduce to not more than 45 beyond 2007 and perhaps only 20 by 2020. The NWP identifies the need for new facilities from the eleven AWPs. These are based on BPEO targets, and are listed in Table 3.1, presented by waste planning area. These are due to provide a total capacity of 1.5 Mtpa, by 2020. These facilities will impose additional pressures on the land-use system, and will require a robust policy and land use framework to deliver the necessary waste management systems.

The Landfill Directive requires that Member States develop strategies to reduce the amount of biodegradable wastes sent to landfill sites. The Scottish targets have yet to be finalised following the recent publication of the UK Wastes and Emissions Trading Act (HMSO, 2003a). The consultation for a landfill allowance scheme in Scotland closed in March 2004 (SE, December 2003).

**Environmental assessment of development plans: interim planning advice (SE, August 2003)**

With the introduction of the Directive 2001/42/EC (OJEU, 2001) of the European Parliament and Council, ‘on the assessment of the effects of certain plans and programmes on the environment’, all new City Regional Plans (CRPs), local plans, and any other types of land use and development plan introduced as a result of the review of strategic planning, started after 21st July 2004 must be subject to an assessment of their likely significant effects on the environment. The Directive requires an examination of a plan's objectives, policies and proposals in relation to broader environmental aims, identifying their likely consequences and, through an iterative process of assessment and
adjustment, preventing or reducing the likely significant effects of the plan on the environment.

The interim planning advice provides an overview of this process and how an assessment should be undertaken. The interim guidance draws specific attention to the following sustainable development principles:

- Where potential damage to the environment is both uncertain and significant, precautionary action may be necessary.
- Decisions should be based on the best possible scientific information and analysis of risks.
- Ecological impacts must be considered particularly where resources are non-renewable or effects may be irreversible.
- Cost implications should be brought home directly to those responsible.

The Directive requires that evidence should be provided to state how environmental protection objectives set at international, Community or Member State level that are relevant to the plan have been taken into account during preparation of the plan. The interim guidance sets out objectives and criteria to ensure compliance with the Directive’s requirements. These objectives and criteria, summarised below, can be expected to emerge as key issues in the location of waste management facilities and the transport of waste:

- Respect land form, natural processes and systems.
- Protect and use soils in a sustainable way.

### Table 3.1 Predicted new waste facility requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orkney &amp; Shetland</td>
<td>Composting facility and non-hazardous waste landfill site.</td>
</tr>
<tr>
<td>Western Isles</td>
<td>Waste transfer station. Composting facility on south island.</td>
</tr>
<tr>
<td>Highlands</td>
<td>MRF within the Inner Moray Firth area, preferably next to railhead.</td>
</tr>
<tr>
<td></td>
<td>Multiple composting facilities across region.</td>
</tr>
<tr>
<td></td>
<td>EfW within the Inner Moray Firth area, preferably next to railhead.</td>
</tr>
<tr>
<td></td>
<td>New landfill for non-hazardous wastes required within the Inner Moray Firth area.</td>
</tr>
<tr>
<td>North East</td>
<td>MRF within Aberdeen City.</td>
</tr>
<tr>
<td></td>
<td>EfW within Aberdeen City.</td>
</tr>
<tr>
<td></td>
<td>New landfill capacity.</td>
</tr>
<tr>
<td>Tayside</td>
<td>1 or 2 MRF for Dundee and Perth preferably next to railhead.</td>
</tr>
<tr>
<td></td>
<td>Composting facilities.</td>
</tr>
<tr>
<td></td>
<td>New landfill site.</td>
</tr>
<tr>
<td>Forth Valley</td>
<td>Central composting facility.</td>
</tr>
<tr>
<td></td>
<td>MRF and MWPF needed.</td>
</tr>
<tr>
<td>Fife</td>
<td>MRF.</td>
</tr>
<tr>
<td></td>
<td>Composting facilities.</td>
</tr>
<tr>
<td></td>
<td>CHP or shared facility.</td>
</tr>
<tr>
<td>Lothian &amp; Borders</td>
<td>MRF.</td>
</tr>
<tr>
<td></td>
<td>Composting facilities.</td>
</tr>
<tr>
<td></td>
<td>MWPF.</td>
</tr>
<tr>
<td></td>
<td>Pyrolysis, gasification, RdF.</td>
</tr>
<tr>
<td></td>
<td>Unspecified constraints on landfill capacity.</td>
</tr>
<tr>
<td>Ayrshire, Dumfries and Galloway</td>
<td>9 Civic amenity sites.</td>
</tr>
<tr>
<td></td>
<td>Up to 5 composting facilities.</td>
</tr>
<tr>
<td>Glasgow and Clyde Valley</td>
<td>Civic amenity sites.</td>
</tr>
<tr>
<td></td>
<td>Expansion of existing MRF/MWPF up to 2013 new facilities needed beyond.</td>
</tr>
<tr>
<td></td>
<td>Expansion of up to 4 composting facilities with new facilities needed by 2013.</td>
</tr>
<tr>
<td></td>
<td>Pyrolysis, gasification, RdF needed by 2013.</td>
</tr>
<tr>
<td></td>
<td>New landfills needed to maintain 10 year capacity.</td>
</tr>
<tr>
<td>Argyll &amp; Bute Valley</td>
<td>Composting facilities at existing sites.</td>
</tr>
<tr>
<td></td>
<td>Upgrading civic amenity sites.</td>
</tr>
</tbody>
</table>

Key: CHP: combined heat and power; EfW: energy from waste; MRF: materials recycling facility; MWPF: mixed waste processing facility; RdF: refuse derived fuel.
• Protect and enhance the water environment including coastal and river systems.

• Protect, enhance and where necessary restore (specified) species and habitats.

• Protect, enhance and where necessary restore landscape character, local distinctiveness and scenic value.

• Protect, enhance and create green spaces important for recreation and biodiversity.

• Regenerate degraded environments.

• Respect urban form, settlement pattern and identity.

• Protect, enhance and where necessary restore building character and townscape.

• Protect, enhance and where necessary restore the historic environment.

• Improve design quality in new development.

• Reduce energy consumption.

• Facilitate renewable energy.

• Reduce the need for travel and journey length.

• Encourage walking, cycling and use of public transport.

• Reduce waste.

• Protect the environment from pollution.

With regards to freight the guide suggests that local authorities can promote sustainable distribution patterns by:

• Identifying suitable locations in development plans for freight-generating uses.

• Protecting sites and routes which could help promote infrastructure for freight movement, such as freight interchanges.

• Promoting rail and water-based freight movements by seeking opportunities for freight generating development to be served by rail or water through the location of new development, and by protecting rail and waterway connections.

• Working in partnership with freight operators, businesses and developers to ensure freight movements and deliveries strike a balance between the interests of business and the local economy and those of local residents.

• Permitting freight traffic to use bus lanes within congested urban centres to avoid slow running and incorporating loading/unloading bays into the design of developments and road layouts.

The period for consultation on this guidance has been extended to June 2004.

Planning Advice Note (PAN) 63 – waste management planning (SE, February 2003)

Through this PAN the SE requires development plans to take account of new guidelines set out in the AWPs. The guidance notes that whilst AWPs and the NWP are not land use planning documents, they are material considerations carrying significant weight that planning authorities should take into account when preparing their development plans and determining applications.

The local authorities within each Waste Strategy Area have the responsibility for the land use planning aspects of the need for waste management facilities. In cases where land needed for the management of waste arising in one local authority area is to be provided in another local authority area, the planning authorities concerned must prepare a joint statement indicating their agreement. Therefore, under these circumstances planning authorities must consider whether and how urgently development plans should be altered in order to take account of new requirements identified by the AWP.

A key theme of the PAN is to promote sustainable waste management in decisions relating to the locations of new waste management facilities. Examples of potential locations for larger facilities include the following:
Industrial area, especially those containing other heavy or specialised industrial uses.

- Degraded, contaminated or derelict land.

- Working and worked out quarries.

- Existing landfill sites where, for instance, Energy from Waste (EfW), materials reclamation or composting facilities may be conveniently located.

- Existing or redundant sites or buildings.

- Sites previously occupied by other types of waste management facilities.

- Other suitable sites located close to railways or water transport wharves, or major junctions in the road network.

The advice note states that development plans should make it clear that there will be a presumption against applications for EfW facilities, which treat unsorted wastes or carry out incineration without energy recovery.

There should be a presumption in favour of proposals for waste management development that are consistent with the policies and objectives of the development plan.

All the significant environmental effects of a development project must be included in an EIA, as well as those related to potential accidents, and an outline of the main alternatives studied and the reasons for the choice.

The advice note states that there may be significant planning, environmental, operational and economic advantages when:

- Waste management facilities can be located close to where the wastes arise.

- Different types of waste management facilities can be located close together or co-located on one site.

- Rail or water transport can be used instead of road vehicles.

- Use is made, as far as possible, of the major road and motorway network rather than local roads, for bulk waste movement.

3.3.3 Summary and implications

Planning policy is driving the following:

- Multi modal transport solutions.

- Modal shift away from road transport.

- Achieving economies of scale.

- Integrating land use and transport planning.

The trend in land use planning will take on a more integrated approach to the use of land, hence waste management facilities should increasingly be considered alongside urban development. Increased development pressures are expected in the Central Belt.

Planning authorities need to consider AWPs and adopt a positive planning approach to the promotion of sustainable waste management by facilitating suitable locations for waste management facilities in locations that reduce the need to transport waste.

Working across administrative boundaries and joint working arrangements should help ensure effective strategic planning for the movement of waste and siting of waste facilities.

Increasing land values in the central belt are likely to lead to higher density housing and reduced availability of brown field land. As a result it could become increasingly difficult to locate waste facilities close to the origin of the waste.

Proposed waste management facilities are likely to be refused planning permission on functional floodplains, areas that have a record of flooding or where green belt constraints apply or have been applied in the recent past. However, an enhanced plan making process to deliver the SEA Directive may enhance the longer term delivery of suitable sites.

Consultation and public involvement in plan making activities may result in siting waste facilities away from the local area and increase the need for waste transportation.

In terms of the planning requirements, there will be a need under the SEA Directive for all options to be examined both in terms of the mix of waste management measures, their location and potentially their scheduling where this may give rise to a qualitative difference in environmental performance. The process of linking the AWPs to the development plans will need to be explicitly explored with assessments of the significant environmental effects taking account of site related impacts, transport impacts and the broader strategic implications associated with resource management.

3.4 Appraisal of waste management and transportation options

This section deals with the broad issues of guidance associated with sustainable waste strategies in order to help to define the opportunities to enhance the available guidance in Scotland.
3.4.1 Land use and environmental risk appraisal

This section provides a brief overview of the likely type and level of environmental risk that could be encountered when locating new waste management facilities and increasing the use of rail and water transport to move waste. It should be appreciated that this analysis is inevitably at a very broad level of analysis as specific sites and local environmental constraints have not been identified. Some recognition has been taken of the contribution of waste movements to and from such facilities in this risk appraisal.

Increasing water or rail movements where existing facilities are in place would not give rise to major environmental constraints. However, on some sections of the rail network which are currently at or approaching capacity (see Section 4.2), capacity constraints may increase the frequency of night time rail freight movements potentially increasing noise levels to nearby communities. This could become of greater concern as the EU develops daughter Directives to address noise. At this scale of analysis it is difficult to generalise the environmental and planning requirement that the various strategies and waste management requirement may stimulate. Waste management facilities can be typified as being potential bad neighbour activities exploiting low value land. However, it should be recognised that a properly managed and developed facility is no different from any other light industrial facility. Site selection would tend to favour those locations already recognised as being suitable for such activities, although it is also preferable to investigate locations offering direct access to waterways or the rail network.

Table 3.2 provides a high level review of the environmental issues associated with these competing strategies.

3.4.2 Recent guidance on sustainable waste strategies

Table 3.3 reviews some of the main guidance available on delivering sustainable waste strategies. They generally focus upon the broad policy tools rather than the specific methods needed to assess competing options.

It would appear from this brief review that the available guidance is not structured to provide a systematic and robust appraisal framework by which the national, regional and local environmental trade-offs can be examined. Further the appraisal frameworks do not capture the differing environmental characteristics of the alternative transport modes associated with the movement of waste. There are no explicit mechanisms by which the transport implications of the waste strategies are captured and incorporated into the appraisal processes. Some of the guidance documents, however, recommend the use of certain techniques.

In terms of assessing the merits of one strategy to those of an alternative, using tools which allow for trade-offs to be accounted for, some of the documents in Table 3.3 are of particular use. The EEA’s Catalogue of Methods and Tools (ETCWM, 2003a) aids the tool selection process in relation to the issue. Table 3.4 takes some issues highlighted earlier in this chapter, and indicates which tools would be appropriate to address them.

Both the UK and Scottish waste strategies recommend the use of Life Cycle Analysis (LCA) to measure the environmental performance of different system proposals. Multi Criteria Analysis (MCA) is recommended for use in an assessment of the BPEO. NPPG 10 (ODPM, undated) recommends the use of Environmental Impact Assessment (EIA) to appraise plans relating to individual waste management facilities.

The NWS: BPEO (SEPA, 2000c) outlines a comprehensive methodology for the appraisal of waste management systems options, based upon a set of national decision criteria. For each criterion, appropriate methods of either quantitative or qualitative appraisal are recommended. For example, for the decision criteria of ‘risk of accidents’, quantitative risk assessment is recommended.

None of these documents explicitly contain appraisal methods. Some however, recommend the use of others that exist depending on the scope of issues that require assessment. The most useful document which provides this solution is the Catalogue of Methods and Tools (ETCWM, 2003a).

3.4.3 Outline appraisal framework

This section outlines the scope of an appraisal framework to support the preparation of waste plans and policies that result in a more sustainable option for the siting of waste facilities having also taken into account the transport of waste. This would include the implications of using different transport modes and changing the nature of the waste flows.

The factors that need to be considered within an appraisal framework are given in Table 3.5. This table is not intended to be exhaustive. The health, noise, odour, air pollution, visual, loss of property value can all interact in a cumulative manner to adversely affect a community in close proximity to a waste transfer station. Measures are needed to identify such impacts at a strategic scale.
Table 3.2 Environmental and planning issues associated with changing the transport of wastes

<table>
<thead>
<tr>
<th>Measure</th>
<th>Potential impacts</th>
<th>Assessment/planning issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increased rail movement of waste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail capacity constraints may lead to increased night-time movements, potential local noise problems and potential conflict with future EU noise Directives.</td>
<td>Need to identify where rail freight capacity constraints exist and where night-time movements could cause concerns.</td>
<td></td>
</tr>
<tr>
<td>Rail transfer stations likely to require disused rail land and new land take. Disused land often targeted for Brownfield redevelopment possibly for housing. High density housing often in close proximity. Greenfield sites experience typical problems associated with new land take.</td>
<td>Apart from usual issues associated with bad-neighbour development the implications of making up trains, shunting etc. will need to be assessed.</td>
<td></td>
</tr>
<tr>
<td>Feasible reception rail-head may constrain site selection process compared to road served option.</td>
<td>Development plans ought to evaluate sites for inter-modal waste transfer and ensure their protection where key part to a sustainable waste strategy.</td>
<td></td>
</tr>
<tr>
<td><strong>Increased water movement of waste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement of wastes by canal would generate additional revenues to deliver maintenance and improvements.</td>
<td>Identify where sub-economic enhancements to the canal network would be deliverable, with the addition of waste transfer traffic thereby leveraging wider benefits.</td>
<td></td>
</tr>
<tr>
<td>Wharf facilities for waste transfer barges could compromise disused sites with high ecological value</td>
<td>Map ecological profile of canal network to identify risk sites.</td>
<td></td>
</tr>
<tr>
<td>Waste transfer facilities may conflict with the desire to attract more leisure use of the canals.</td>
<td>Incorporate proposed leisure proposals for canal network with waste transfer proposals to identify potential conflicts.</td>
<td></td>
</tr>
<tr>
<td>New canals and links with river systems could create new waste transfer corridors that benefit more than just waste transfer uses.</td>
<td>Examine additional opportunities for new movement patterns as well as implications for water transfer between catchments.</td>
<td></td>
</tr>
<tr>
<td>Increased canal traffic may require works that affect listed canal structures.</td>
<td>Map heritage profile of canal network to identify sites at risk.</td>
<td></td>
</tr>
<tr>
<td><strong>Increased short sea shipping</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short sea shipping of waste may necessitate new port handling facilities possibly on mudflats or ecologically sensitive coastal ecosystems.</td>
<td>The assessment of short sea shipping of wastes should include an assessment of constraints by coastal ecosystems.</td>
<td></td>
</tr>
<tr>
<td>Air quality issues may be of concern at existing ports and additional traffic may compromise air quality standards.</td>
<td>Where Air Quality Management Areas include port facilities then the implications of additional emissions from ships and other modes should be assessed.</td>
<td></td>
</tr>
<tr>
<td>The landward facilities and transport infrastructure connections may require enhancement to deal with increased sea-borne freight.</td>
<td>Consider the needs for new landward infrastructure during the port assessment process.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3.3 Guidance on sustainable waste strategies

<table>
<thead>
<tr>
<th>Aims</th>
<th>Key points relating to new waste facilities, waste transport &amp; waste planning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparing a waste management plan. A methodological guidance note, ETCWM, 2003b</strong></td>
<td>Guidelines aim to provide a tool for waste management planning and promote the development of more coherent and appropriate planning practices across the EU Member States, in compliance with the requirements of the relevant EU legislation. Concerns waste planning only, specifically what should be included in a waste plan, including which waste streams, time, stakeholder participation, and the relationship to other plans. EU legislation relevant to waste plans, as covered in Section 2.2.1 of this document is also outlined. In Scotland, the National Waste Plan and Area Waste Plans have already been produced, hence this document would have already been considered.</td>
</tr>
<tr>
<td><strong>Reference manual on strategic waste prevention, OECD, 2000</strong></td>
<td>This document acts as a systematic decision support tool. It sets out to support government efforts toward developing, applying, and evaluating waste prevention policy programmes. Promotes self assessment for waste prevention. A central argument in the Reference Manual is that governments will have difficulties in achieving a significant de-coupling of waste generation from growth in Gross Domestic Product unless they direct rigorous attention to three core activities: 1) quantitative waste prevention target setting, 2) the selection and implementation of appropriate instruments, and 3) the evaluation of waste prevention programme performance in environmental, economic and social terms.</td>
</tr>
<tr>
<td><strong>Core performance elements of the guidelines for environmentally sound management of wastes, OECD, 2002</strong></td>
<td>Provides an elaborated attempt in developing the generic ‘Core Performance Elements of ESM Guidelines’ that would be applicable to recovery of waste, including the preceding transport, storage, treatment and subsequent storage, transport and disposal of residues, and providing the basis for the environmentally sound management (ESM) of recoverable wastes. The Core Elements are quite general in nature, but would be good to use as ‘code of practice’ for new recovery facilities. 1. Adequate regulatory infrastructure and enforcement should exist to ensure compliance with applicable regulations. 2. The recovery facility should be authorised. 3. The recovery facility should take adequate measures to safeguard occupational and environmental health and safety. 4. The recovery facility should have an applicable environmental management system in place. 5. The recovery facility should have an operative monitoring, recording and reporting programme. 6. The facility shall have an appropriate and operative training programme for the personnel. 7. The recovery facility should have an information exchange programme to optimise recovery. 8. The recovery facility should have a verified emergency plan. 9. The recovery facility should have a plan for closure and after-care.</td>
</tr>
<tr>
<td><strong>A regulatory strategy for siting and operating waste transfer stations, NEJAC et al., 2000</strong></td>
<td>Prime consideration is ‘environmental justice’ in which a breach of environmental justice would be defined as ‘the disproportionate siting of waste transfer facilities in low-income communities and communities of colour’. A framework is suggested to avoid future breaches of environmental justice which includes stakeholder involvement, impact analyses and a permitting system.</td>
</tr>
<tr>
<td><strong>Assessment of information related to waste and material flows - a catalogue of methods and tools, ETCWM, 2003a</strong></td>
<td>Aims to help practitioners select the appropriate methodological tools for addressing the main policy questions related to waste and material flows. A brief overview of available tools for assessing information relevant to waste and material flows is given. The main conclusions are presented below and give some idea of which decision support tools to use when.  ● An indicator framework on waste and material flows is needed as a prerequisite for integrated environmental assessment.  ● Develop information and assessment tools on selected waste and material streams.  ● LCA to be used for assessments of products and processes.  ● GIS and remote sensing for spatial issues.</td>
</tr>
</tbody>
</table>

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Continued ....
Table 3.3 (Continued) Guidance on sustainable waste strategies

<table>
<thead>
<tr>
<th>Aims</th>
<th>Key points relating to new waste facilities, waste transport &amp; waste planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodegradable waste management in Europe, EEA, 2001</td>
<td>There is a need for good quality and consistent information to enable the tracking of BMW (partly to demonstrate compliance with targets), and also to define exactly what BMW consists of. Some countries have already diverted a considerable amount of BMW from landfill; these countries apply an integrated approach to waste management, and employ a wide range of techniques. The three principal alternatives in use are incineration with energy recovery (mainly of bagged waste), central composting (mainly of garden wastes and, to a lesser extent, food wastes), and material recycling (mainly for paper and cardboard wastes). Source separation or separate collection should be considered as strategies to meet the targets of the Directive. The question of establishing stable markets for compost and recycled materials should be carefully considered when devising a BMW strategy. Imposing bans on certain materials going to landfill, and landfill taxes are key instruments to ensure diversion takes place.</td>
</tr>
</tbody>
</table>

Waste strategy 2000, Defra, 2000

This strategy describes the UK government’s vision for managing waste and resources better. It sets out the changes needed to deliver more sustainable development, through the decoupling of waste production from economic growth. Where waste is created it must be dealt with by more sustainable waste management practices - through recycling, composting or using it as a fuel. Scotland has its own National Waste Strategy. In relation to waste facility siting, the most relevant section of this document relates to the Best Practicable Environmental Option (BPEO) for waste and associated principles.

NPPG 10: planning and waste management, ODPM, undated

This guidance note provides advice about how the land-use planning system should contribute to sustainable waste management through the provision of the required waste management facilities in England and explains how this provision is regulated under the statutory planning and waste management systems. The roles of different organisations in producing waste management strategies in England are stated in this document, alongside what needs to be taken account of in producing these documents, which are:

- Obligations required by European legislation (as discussed in Section 2.2.1).
- The policies and principles of waste management set out in the Government's emerging waste strategy (the BPEO and associated principles).
- National and regional planning guidance on waste (covered in Section 3.4).
- Strategies prepared by the Regional Technical Advisory Bodies (RTABs) (these documents are not produced in Scotland).

The National Waste Strategy, SEPA, 2000a

The purpose of the National Waste Strategy is to provide a framework within which Scotland can reduce the amount of waste which it produces and deal with the waste that it does produce in a more sustainable manner. The main driver for action in this area is the statutory framework, whereby European Directives have been translated into UK or Scottish law. The strategy does not provide any guidance on methods by which to deliver an assessment of alternative waste management strategies.
### Table 3.3 (Continued) Guidance on sustainable waste strategies

<table>
<thead>
<tr>
<th>Aims</th>
<th>Key points relating to new waste facilities, waste transport &amp; waste planning</th>
</tr>
</thead>
</table>
| NWS: Best Practicable Environmental Option, SEPA, 2000c | The BPEO culminates from a lengthy stepwise process. The process involves determining baselines for different waste types, then defining local decision criteria from a set of national decision criteria which embraces environmental, economic, social, political, and practicability factors. A set of waste management options is then listed, appraised, and short listed as a set of integrated waste management options. The BPEO is then determined from the list by means of stakeholder consultation. Transport implications, including potential increases in, mode, and new infrastructure requirements are mentioned in relation to several of the decision criteria as a point of consideration. The criteria include:  
- Global climate change.  
- Local amenity.  
- Natural heritage; and  
- Risk of accidents. |

**Area Waste Plans. 2003. Waste Management Areas, SEPA 2004a**

Area Waste Plans are required to:  
- Identify and detail facility requirements.  
- Demonstrate that these facilities are the BPEO.  
- Provide a framework for identifying the needs of industrial waste producers.  
- Establish a context for investment confidence.  
- Promote better integration and understanding between all the key stakeholders.  
- Improve transparency and public confidence in decision making.  

These documents present the outcomes of the BPEO process for each WPA. No assessment methods are provided but serve as a material consideration for the planning system.

**Sustainability indicators for waste, energy and travel, SE Central Research Unit, 2001b**

Provides a series of sustainability indicators against which the performance of the waste sector can be benchmarked.  

The indicators are of use in state of the environment type reporting rather than the evaluation of alternative spatial and transport strategies as proposed in Chapter 4 of this report.
Table 3.4 Appropriate assessment tools

<table>
<thead>
<tr>
<th>Assessment/Planning issues</th>
<th>Key theme(s)</th>
<th>Appropriate tool(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map heritage profile of canal network to identify sites at risk.</td>
<td>Mapping.</td>
<td>GIS.</td>
</tr>
<tr>
<td></td>
<td>Spatial awareness.</td>
<td>Remote sensing.</td>
</tr>
<tr>
<td>Need to assess efficiencies and impacts to optimise a network of waste transfer facilities.</td>
<td>Modelling transport.</td>
<td>Simulation models.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Life Cycle Analysis.</td>
</tr>
<tr>
<td>Objectives and targets to be incorporated within land use and waste plans.</td>
<td>Measuring progress.</td>
<td>Indicators.</td>
</tr>
</tbody>
</table>


Table 3.5 Factors to consider in a waste option appraisal framework

<table>
<thead>
<tr>
<th>Local versus regional/national effects</th>
<th>Waste handling activities</th>
<th>Transport of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Potentially local disbenefits will accrue from waste management activities, but these are accepted for the wider community benefit. The benefits that result from changing the way in which waste is moved and the facilities to deal with this waste will increasingly need to be presented in a manner that commands confidence that the BPEO has been considered. Indicators that report the benefits should be explored.</td>
<td>• Prevailing wind direction.</td>
<td>• Increased accident risk from additional HGV traffic.</td>
</tr>
<tr>
<td>• Given the potential long term disbenefits that local communities will experience from waste facilities, an appraisal framework would need to recognise any compensatory activities that might be established for the local communities.</td>
<td>• Emissions, including the combined effect of emissions from neighboring sites.</td>
<td>• Emissions from diesel vehicles.</td>
</tr>
<tr>
<td>• There is a need to address the issues raised in the US report ‘A Regulatory Strategy for Siting and Operating Waste Transfer Stations’ (NEJAC et al., 2000) since it raises many issues of natural justice that individual communities may experience.</td>
<td>• Dust.</td>
<td>• Congestion and delay caused by additional HGV traffic.</td>
</tr>
<tr>
<td></td>
<td>• Noise.</td>
<td>• Risks to protected ecological areas from new infrastructure for waterborne waste traffic.</td>
</tr>
<tr>
<td></td>
<td>• Traffic patterns and adequate space for truck movement.</td>
<td>• Impact on tourism related traffic from waterborne waste traffic.</td>
</tr>
<tr>
<td></td>
<td>• Buffer zones.</td>
<td>• Impact of rail freight on night-time noise annoyance at transfer facilities and along the rail routes.</td>
</tr>
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<td></td>
<td>• Minimum site size requirements.</td>
<td>• Hours of operation.</td>
</tr>
<tr>
<td></td>
<td>• Use of existing buildings/facilities.</td>
<td></td>
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<tr>
<td></td>
<td>• Evaluation of alternative sites.</td>
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<td></td>
<td>• Waste volume projections.</td>
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</tr>
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<td></td>
<td>• Waste stream characterization.</td>
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<td></td>
<td>• Materials recovery and processing.</td>
<td></td>
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<td></td>
<td>• Public versus commercial waste streams.</td>
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<td></td>
<td>• Technology selection.</td>
<td></td>
</tr>
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<td></td>
<td>• Community concerns including public participation.</td>
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<td></td>
<td>• Transitional land uses.</td>
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<td></td>
<td>• Proximity to rail service and navigable waterways.</td>
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<td></td>
<td>• Computability with Green Belt policy.</td>
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<td></td>
<td>• Site access.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Operational lifetime.</td>
<td></td>
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<td></td>
<td>• Flood potential.</td>
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</tbody>
</table>

Transport of waste in appraisal frameworks

While the appraisal issues associated with the transfer of waste identified above are relatively self-evident, the process of incorporating these issues within appraisal and planning practice may be less clear cut.

At one level it will require those involved in waste planning to explicitly consider alternative modes of transport and their relative all-round performance while also considering alternative locations for the waste processing facilities. There may well be a trade-off to be made between potential locations that are suitable for only one mode of transport and others which are suitable for other modes. This would then tend to suggest that the relative environmental, economic and operational performance of the transport links should play a role in the waste processing site selection process.

It is suggested that site selection processes should not just consider the availability of multi-modal choices for waste transport, but should also explore the impacts associated with the use of that mode. For example, this could include impacts on wildlife habitats, as well as noise and land use impacts. Essentially, the impacts from canal and short-sea shipping are associated with the waste transfer stations. In the case of rail, additionally
there is the need to consider the operational impacts upon a congested rail network and any increase in annoyance from night-time movements.

A further issue to address is that of single function waste facilities versus multi-function facilities. Multi-function facilities generate the economies of scale that can justify investment in alternate modes of waste transport and hence attention should focus upon giving priority to sites that are served by rail or water.

Relative impact of different modes of transport

It is not possible to generalise whether different modes of waste transport are preferable over others, since that argument can only be made when all other impacts associated with the waste handling and processing sites are equal. It also assumes that the impact per tonne/km is independent of total distance travelled and the corridors being examined. Clearly rail or water cannot substitute for the innate flexibility that of road transport. With a diverse array of individual waste streams and destinations, road transport offers many advantages. However, where wastes are being transferred the same distance within the same corridor, then the impacts of competing modes may be more evident. Even then, the noise impact of say night-time rail movements may cause greater annoyance than the impact of the vehicles transferring the waste by road as they generally form a small percentage of HGV traffic and an even smaller percentage of total traffic (see Section 2.1.3).

Short sea shipping may give rise to increasing pressures on valued ecosystems next to ports or generate pollution in air quality management areas. Unless wastes are being processed at the ports, then landward transport impacts must also be considered.

Given the low value of many waste materials, movement by sea or inland waterways has attractions and potentially gives rise to reduced environmental and community impacts provided those impacts associated with the waste transfer/handling facilities were acceptable. As Brownfield sites are often associated with ports and canals, so there would appear to be utility in exploring port areas and canals in which to locate multi-functional waste processing facilities. The issue may then be one of competing land use agendas with the establishment of waterside housing or marinas being in conflict with waste transfer stations.

Indicators for waste transport

Assuming a national desire to move waste by modes other than roads, an indicator could be applied at the national scale, such as tonne/km by mode. However, given the intimate relationship with waste transfer facility site selection and the impacts associated with the mode itself, a wider set of indicators would be needed to consider the impact on sustainable development of a modal shift. Such indicators could include:

- Extent to which waste movements use congested sections on transport networks.
- The number of accidents, annoyance due to noise or tonnes of pollutants emitted by mode.
- Extent of conflict in the location of waste transfer facilities with protected/ designated sites/areas.
- Extent of conflict with land use planning objectives.

Barriers

It is at the higher spatial scales that the aggregate benefits of reduced road accidents, lower emissions, reduced congestion delivered by a modal shift away from road become apparent. The environmental performance of the different modes of waste transport become less clear cut when actual routes and facilities are being considered as local factors, such as rail capacity or the need for new wharfing facilities in an area identified for regeneration, become apparent. This would suggest that any national desire to transfer waste by modes other than roads for wider transport and environmental gains may be impeded by local considerations. Hence some form of intervention could be needed to promote a modal shift in waste transport.

Efforts will be needed to address the local planning and environmental barriers to the achievement of a modal shift in waste transport. Such efforts need to focus upon capturing and reporting the wider benefits of a modal shift with the individual waste planning decisions. Essentially, this would require not only an explicit means of estimating the wider benefits, but also an explicit weighting between national/regional and local decision making issues. This then raises questions of environmental justice particularly when one community (often a low income community) has to bear the costs of the strategy for the benefit of the wider community.

Intervention may come in the form of an explicit planning requirement that would place a sequential planning test that favours multi-functional waste facilities that are primarily served by water or rail. A further approach would be to influence the economics of water and rail waste transport. Grants are already available, but they may only influence decisions on waste transport at the margin, particularly when the canal or rail infrastructure may require major capital investments. This suggest that a more strategic approach is needed to investment in short sea shipping, rail and water transport, which considers the opportunities for waste transport not just from a transport perspective, but also in terms of the type, scale and location of waste processing facilities.
4 Characteristics of Scottish waste transport

4.1 Summary of transport infrastructure characteristics for road, rail and water

The following sets out an overview of the transport characteristics for road, rail and water in Scotland particularly in relation to waste transport. A great deal of background information was collated for this study in the form of position papers. It has not been possible to include all of this information in the final report.

Studies have been carried out in Scotland investigating ways of using the Caledonian, Crinan, Forth & Clyde, and Union Canals to move waste from transfer stations: from places where waste is generated to where it is disposed. There is a waste transfer station near the Clyde canal in East Dunbartonshire. It is considered that of all the canals, the Caledonian Canal has existing freight facilities and easier access, which would permit the slow movement of bulk, non-time sensitive cargo by barge in the coming years.

The study by MDS Transmodal Limited (2002) entitled ‘Opportunities for developing Sustainable Freight Facilities in Scotland’, states that British Waterways believe there is potential for the movement of domestic waste on the Caledonian Canal if an incinerator (to replace a landfill site at Inverness) is located adjacent to the canal.

There are Lowland Canals, as well as Highlands and Islands Canals which are incorporated in to local development plan development strategies, promoting restoration, preservation and encouraging freight and recreational uses. There are also major river estuaries where waste barges could be routed along the River Forth, River Clyde and Firth of Tay. The Millennium Link between Edinburgh and Glasgow is undergoing restoration. The MDS Transmodal study also states that due to access restrictions and lack of demand, the scope for using the Crinan, Union or Forth & Clyde Canals is likely to be limited, although there may be niche markets for waste traffic.

The Association of Inland Navigation Authorities (2001) in a report entitled ‘A Strategy for Freight on Britain’s Inland Waterways’; states there are opportunities for niche markets to be created, such as the movement of gravel from quarry to processing plant, transfer of waste from collection point to incinerator or landfill site.

Domestic waste accounted for 1.0 Mt of rail freight in 2000, with bulk containerised waste being carried from a refuse transfer station in Edinburgh to a landfill site near Dunbar (MDS Transmodal, 2002). This flow is over a relatively short distance and requires road haul at one end of the transport chain. There are significant environmental benefits to be gained from the development of inter-modal rail services from the Central Belt to Aberdeen, Inverness and further north. Gauge enhancement work may be required between Aberdeen and the Central Belt, as well as between Dumfries and the West Coast Main Line to allow the intermodal traffic to develop.

Scotland is covered by a road, rail and inland waterways network. However, the three networks are not equally developed. The road network in Scotland features approximately 11,000km of trunk and major roads (SE, 2003d). The rail network however is only 2,700km long and the water network suitable for carrying freight 665km respectively.

The road network is relatively extensive to the south and in the heavily populated lowlands and Central Belt regions. It is displayed in Figure 4.1. To the north and in coastal regions the road network is less developed and routes are typically less direct as a result. The road network links all towns and cities in Scotland with waste treatment facilities and there are many specialist waste transport operators in this market.

From stakeholder interviews it is clear that motorways and A-roads carry the vast majority of waste transport in Scotland as they are typically direct and offer relatively low journey times. With much of the population and a high proportion of waste treatment facilities concentrated in the lowlands region around Glasgow, Edinburgh, Perth, Dundee, Stirling, Kirkcaldy, the routes connecting these settlements are particularly heavily used.

Similarly the rail network is most extensive in the South, Central Belt and Lowlands. The network is displayed in Figure 4.2. It can be split into 11 separate routes. Each of these has different characteristics in terms of loading gauge, axle load restrictions and line speed. All these characteristics affect the ability of the route to accommodate waste trains. This variability of the network can reduce flexibility and causes difficulty in terms of planning.

Inland waterways in Scotland link the majority of large population centres and, in many cases provide direct access to urban centres. The network consists of four main canals and three major rivers. Currently freight is only transported on the River Clyde, the River Forth, the River Tay and the Caledonian Canal. Figure 4.2 illustrates these canals in relation to the locations of landfill sites and waste transfer stations. This is due to restrictions to the type of vessels that can access the canals and ports and also the natural advantages of road transport.
Figure 4.1 Primary routes and waste management facilities
(SE, Licence number: 100020540 200)
Figure 4.2 Schematic representation of the Scottish Rail Network

© Scotrail (Scotrail, 2004)
Most of the ports and harbours in Scotland exist to serve general cargo or the fishing industry. Ten of the major ports have facilities capable of handling waste containers currently installed. Five of the facilities feature a dedicated railhead. This eliminates the requirement for a road transport leg in any transfer of waste containers from water to rail. Most ports and harbours have direct access to the trunk road network though quality of access can vary considerably.

Only the ports of Grangemouth, Greenock and Leith are tri-modal facilities in that they have container handling and storage facilities, straightforward access to the trunk road network and a dedicated railhead.

4.2 Current constraints for road, rail and water

The design and location of waste management facilities in Scotland generally have been chosen with consideration for access to the trunk road network. Waste transport by road is only constrained by the network’s capacity. Although the network of single track roads in less populated regions of Scotland is limited in terms of vehicle weight and dimensions, articulated vehicles and drawbar combinations can travel on most of these routes. The possibilities for carrying waste by rail or on inland waterways however are more limited.

Some of the waste transfer stations located in major towns and cities may be accessible via inland waterways. However, the majority of landfill sites to which waste is sent are not located close to canals or rivers.

Waste transport on inland waterways is also constrained by the characteristics and dimensions of the waterways network itself:

- The type of vessel that can use inland waterways is restricted according to the vessel’s dimensions. The length, beam, height and draught of vessels are limited by the design of the infrastructure. Additionally, canals have very specific limits on the payload that can be transported. The use of small vessels may compromise the viability of a system.

- Canals feature locks to overcome the problem of topographical differences along their routes. However, locks can take a considerable period of time to pass through, making accurate planning of freight flows difficult.

Waste transport on the rail network is constrained in similar ways as on the inland waterways. Like many consolidation and distribution centres in the UK, waste management facilities in Scotland generally have not been located with consideration for access to the rail network. Therefore transport via these facilities on rail requires an additional road leg and thus additional handling cost and time.

There are restrictions in terms of loading gauge and axle load. However, the loading gauge on most lines is not a problem for the transport of waste and municipal waste has a low weight to volume ratio. It is, therefore, unlikely that the maximum route availability will present a constraint to operations. However, other wastes, such as wood and concrete could well be precluded from certain routes for weight reasons.

Additionally all lines are governed by speed restrictions. Some lines may impose relatively low speeds for freight trains to minimise potential damage to the track and structures. Due to the relatively slow speeds at which freight trains operate, however, line speed will rarely compromise the viability of freight train operations.

The transport of waste by rail is possibly most constrained by the network capacity. The current utilisation of network capacity in Scotland is not uniform (see Figure 4.4). There are some areas, such as Strathclyde and Fife, where demand is such that additional paths could not be found without the risk of compromising network performance. However, much of the network capacity in Scotland is not fully utilised. There are many routes, especially towards the North and the west coast of Scotland for which less than 30% of available capacity is currently used (see Figure 4.4). Typically network utilisation is high in those areas where waste volumes are large.

Although waste transport on inland waterways and by rail is constrained by a number of factors there is some potential for a modal shift.

The Caledonian Canal may provide some potential for transporting waste by barge due to unrestricted access to the existing freight facilities. British Waterways believe that there is potential for the movement of domestic waste on the canal if a waste to energy plant (to replace a landfill site at Inverness) is located adjacent to the canal. Canal-side facilities would be required at the major settlements along the route and lay-by berths would be needed at locks so that the freight carrying barges can wait for pleasure craft to negotiate locks.

Due to access restrictions and lack of demand, the potential use of the Crinan, Union and Forth and Clyde Canals is limited, although there are some niche markets for waste traffic. There are significant flows of freight on Scottish inland waterways when movements up river estuaries, such as the river Forth, the river Clyde and the Firth of Tay are taken into account.
Figure 4.3 Canals, waste transfer stations and landfill sites in Scotland
(SE, Licence number: 100020540 200)
As mentioned before waste management facilities in Scotland generally have been located with consideration for access to the trunk road network. However, many trunk roads in Scotland follow similar routes to railways. Therefore a number of waste management facilities can be found close to railways. Although, transfer stations are concentrated close to towns and cities, landfill sites are located further from settlements, often in disused quarries and open cast mines. Some of these may have had railheads installed in the past to transport material from the site. It is possible that such facilities could be used to transport waste material to landfill.

### 4.3 Infrastructure changes

This section reviews some of the current planned transport infrastructure changes for Scotland that may impact on the transport of waste arisings.

**Multi-modal studies**

In December 2000 the Scottish Executive commissioned multi-modal transport corridor studies (SE, January 2003b). Those studies which may impact the transport of waste are summarised in Table 4.1.

In summary, it is likely that the transport programme has the potential to free up rail freight capacity on the Airdrie to Bathgate Line and improvements to the A8, A80, A725 and local measures to the M74 scheme could ease freight movements in general including waste transport.

**Freight facility grants**

Under the Government’s Freight Facilities Grant Scheme, grants are available towards the capital costs of rail and inland waterway freight equipment in cases where the traffic would otherwise move by road. The Scheme includes projects involving coastal and short sea shipping routes. Awards of grants for new freight facilities will remove more than 23 million lorry miles per year from Scotland’s roads (SE, 2004d). Re-opening the...
Stirling – Alloa – Kincardine line will provide a new rail freight route across Central Scotland. Moving coal between Hunterston and Longannet power station on this line will free capacity on the Forth Bridge for passenger services. Large quantities of timber are now being moved by rail and water.

**Highways**

The SE report, ‘Building Better Transport’ (SE, March 2003a) acknowledges the increased investment to be made in transport infrastructure.

The Scottish Road Haulage Modernisation Fund has also been provided with £5m to upgrade vehicles, making them more fuel efficient and environmentally friendly and also to train operators so they save money in terms of fuel. While this measure would have no direct impact on the transport of waste, in general terms the measures will enhance the efficiency of road freight and decrease environmental impact.

**Rail**

The SE issued in March 2003 the results of a study entitled ‘Scottish Strategic Rail Study’ (SE, March 2003c). The area for this study stretches south from Inverurie and Aberdeen in the North East to include all of the Central Belt, with a southern boundary stretching from Ayr on the west coast and Dunbar on the east. The

---

**Table 4.1 Multi-modal studies**

<table>
<thead>
<tr>
<th>Location</th>
<th>Decision</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airdrie to Bathgate rail line.</td>
<td>The Airdrie to Bathgate rail line to be double-tracked with frequent through services from west of Glasgow through to Edinburgh.</td>
<td>Potential to increase rail freight capacity.</td>
</tr>
<tr>
<td>A8 Between Baillieston and Newhouse.</td>
<td>Upgrading to dual three-lane equivalent motorway standard, to be operational prior to 2010.</td>
<td>Will remove a pinch point and free up road transport.</td>
</tr>
<tr>
<td>Motherwell to Cumbernauld rail service.</td>
<td>Increased passenger train frequency.</td>
<td>Possibly - reduced potential capacity for freight on that route.</td>
</tr>
<tr>
<td>A80 between Stepps and Haggis.</td>
<td>Upgrading to D2 and D3 motorway standard.</td>
<td>Will remove a pinch point and free up road transport.</td>
</tr>
<tr>
<td>Complementary local measures to the M74 completion scheme.</td>
<td>Support bus priorities, reallocation of road space, junction improvements and network of recommended routes for HGVs, localised traffic management measures, improvements for pedestrians.</td>
<td>Free up freight movement by road.</td>
</tr>
<tr>
<td>Control over the form of development near trunk road junctions.</td>
<td>Planning Advice Note and a Guide to Transport Assessment to be issued in 2003 which will address the issue of ensuring that development adjacent to junctions.</td>
<td>Will remove a pinch point and free up road transport.</td>
</tr>
<tr>
<td>Complementary freight measures.</td>
<td>The SE will undertake research into means to improve the efficiency of freight movement through reduced empty running and more inter-urban travel at night and will continue to support, and fund through FFG as appropriate, suitable development at sites with the potential for connection to the rail network.</td>
<td>Potentially. Broadly supportive of increasing the movement of waste by rail.</td>
</tr>
<tr>
<td>A725 Bellshill Bypass and Raith Interchange.</td>
<td>An investigation into ways of improving the performance of the trunk road network at Shawhead Interchange on the A8, along the A725 Bellshill Bypass, and including Raith Interchange on the M74 will be undertaken as part of the delivery phase for the upgrading of the A8 between Baillieston and Newhouse.</td>
<td>Will remove a pinch point and free up road transport.</td>
</tr>
</tbody>
</table>

Source: SE, January 2003b.
study does not include the Highland Main Line to Inverness, but it takes account of the implications of services that cross all of the study boundaries including those to England.

The report identifies sections of the network that are currently operating at over 80% capacity. As a result of background economic, demographic and social change, the number of rail journeys within the study area is expected to increase by 35% - from around 48m in 2000 to over 65m by 2020. The effects were expected to extend beyond the study area to routes such as the Highland line. The report notes that providing the system capacity to cope will require a significant commitment of resources.

Among the rail projects identified in ‘Building Better Transport’ that are in addition to those identified from the Multi-Modal Studies are the following:

- New rail freight hub at Grangemouth.
- Improved services on the Shotts Line.

Rail improvements are largely focused on increasing passenger transport.

**Waterways**

The SE has issued a document ‘Scotland’s Canals: An Asset for the Future’ (SE, 2002a) in order to raise public awareness of Scotland’s recently renewed canal network and to encourage debate over the regeneration, sustainable development and leisure potential the network offers. The report also aims to stimulate links between Government departments and public bodies and to give the private and voluntary sectors a context within which they can maximise their contribution to the future development of the canals.

The report notes that SE wants British Waterways (BW), in consultation with local authorities, to identify realistic and sustainable development proposals for the network. These include increasing canals freight role.

BW is looking at a number of possibilities including the carriage of timber along the Caledonian Canal. In addition, a timber project at Ardrishaig (at the entrance to the Crinan) is contributing to the modal shift from road to water. BW is also considering submitting a Freight Facilities Grant bid for improvements that will allow a further increase in traffic. Examples of modal shift work achieved by BW are given in Table 4.2.

The SE considers proposals for moving freight from roads to inland waterways under its Freight Facilities Grant Scheme that is extended through the Transport (Scotland) Act 2001 to include coastal and short-sea shipping routes.

The promotion of inland waterway shipping increases the potential for moving low value goods by water particularly if facilities are established alongside rivers and canals to serve niche markets.

Enhancements to the canal network should increase opportunities for the movement of freight by waterways. This may benefit waste movements where opportunities exist to site waste management facilities adjacent to canal or riverside wharfs.

### 4.4 Baseline waste transport data review

This baseline data review has been carried out for a number of key aspects of waste haulage in Scotland. The results are a fundamental part of understanding the aspects of current behaviour which are currently working effectively with respect to BPEO and cost efficiency.

The data presented here have been collected from various sources including SEPA and industry. These data have directly fed into the development of scenarios presented in Chapter 6.

The objectives of this phase of the study were to:

- Collect and validate data for waste transport in Scotland in 1998:
  - by type (household, commercial, industrial, C&DW, Special);
  - by mode (road, rail, water);
  - by distance;
  - by origin and destination;
  - by weight.
- Obtain data to describe the average transport lengths for the different waste categories.
- Obtain the handling costs for transfer between different modes (road to rail; rail to road; road to canal etc.).
- Provide information on the number of lorry loads shifted within the different waste strategy areas (excluding collection, but taken from transfer to final site for disposal, reprocessing etc.).

The methodology and results are outlined in the following sections. An accompany report has been produced which gives further detail on the waste data and the waste data validation process. This report should be referred to if

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2 The report ‘Best integrated transport options for waste: waste transport data review’ can be downloaded from www.viridis.co.uk.
further information on the methodology is required or for detailed examination of the waste transport data used in the cost modeling outlined in Chapter 5.

### 4.4.1 Waste arisings

Data were collated on waste in Scotland in the first instance from the Scottish Waste Management Baseline Assessment (SWMBAs) as part of the National Waste Strategy. SWMBAs were the starting point for developing Area Waste Plans. Note that this dataset was used to produce the report 'Scotland’s Footprint' (Chambers et al., 2004). The collection methods and recording of waste arisings appears to have been undertaken in different ways by all of the WSAs. As a consequence there are problems with the data as collected. At the time of writing these data are the most comprehensive and complete available for Scotland.

Once collated these data were validated against waste arising data from two sources. These sources are:

- Local Authority Waste Arising Reports (LAWAs) (SEPA, 2001 & 2003a).
- SEPA transfer station data on waste input and outputs from transfer stations across Scotland, based on quarterly returns submitted to SEPA by companies transporting waste (SEPA, 2003b).

The validation process has therefore been carried out on the basis of the following:

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**Encore Aggregates – transfer to C&DW and recycled aggregates**

**Stakeholders:** British Waterways, Encore Environmental Aggregates.

**Date:** June 2003

**Location:** Union Canal, Scotland.

**Brief description of the project:** The trial involved moving recycled aggregates from Lin’s Grave, which is near the Almond Aqueduct of the Union Canal into central Glasgow at Firhill Basin. It was the first commercial load to travel along the Union Canal for seventy years, the first to use the Forth & Clyde since its closure in December 1962, and the first ever to use the Falkirk Wheel.

**Tonnage:** 20 tonnes recycled aggregate.

**Barriers and opportunities:** The trial successfully demonstrated the possibility of transporting freight on the Union Canal. No conflicts arose between the leisure and commercial uses of the canals.

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**Feasibility Study For A WEEE Recycling & Reprocessing Facility At Twechar, East Dunbartonshire**

**Stakeholders:** The study was funded by East Dunbartonshire Council, Glasgow City Council, SEPA and British Waterways. The study was prepared by EnviroCentre. In addition many organisations were consulted as part of the feasibility study including SEPA and SE.

**Date of study:** April to June 2004.

**Location:** Twechar and the Forth and Clyde Canal, Scotland.

**Brief description of project:** The feasibility study established that there was a strong political and commercial opportunity for the development of a Resource Recovery Facility managing WEEE at Twechar. An aspect of the study was to establish the feasibility of moving WEEE by waterway from a number of different local authority locations (within the Glasgow & Clyde Valley Area Waste Group).

**Tonnage:** A number of different haulage scenarios were modelled, with the maximum for canal transport involving the movement of 120 tonnes per week (5,760 tonnes per annum).

**Barriers and opportunities:** The haulage of material to Twechar requires an integrated management approach, where key stakeholders work in partnership to make sufficient quantities of material available. This commitment extends to being prepared to develop canal-side loading and unloading facilities. The development of one facility in East Dunbartonshire and one in Glasgow would provide the basis for a viable facility. Similar infrastructure developments in West Dunbartonshire, Renfrewshire and Inverclyde, making material available at reduced costs, would serve to make the Twechar facility more viable.

**Investment:** Depending on the option considered, the infrastructure costs for East Dunbartonshire alone were shown to range from £1 million to £4.2 million. This included the construction of the facility, wharves, licensing etc.

**Cost benefit analyses:** The study showed that the transport of WEEE by waterway to Twechar, using mainly the Forth and Clyde canal, was competitive with road haulage, in particular from Glasgow and East Dunbartonshire (Bishopbriggs) sites. This competitiveness continued for haulage to sites further away, in West Dunbartonshire, Renfrewshire and Inverclyde, but decreasingly so. The main benefit of canal haulage was shown to be the greater quantities of material which could be hauled on barges compared to road vehicles.

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**Table 4.2 Examples of modal shift of waste from road to canal in Scotland**

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Encore Aggregates – transfer to C&amp;DW and recycled aggregates</strong></td>
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</tr>
<tr>
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</tr>
</tbody>
</table>

---

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Ensuring that data were translated correctly from the source data (SWMBA).

Comparing the SWMBA data to LAWAs.

Comparing SEPA transfer station data to the data once it has been through the above process.

As part of the National Waste Strategy SEPA requires each local authority to produce a LAWA, which describes annual waste arisings. From these reports SEPA produces an annual Waste Data Digest that summarises the findings (SEPA, 2003b). It has been assumed that the Waste Data Digest accurately summarises the LAWA reports and has therefore been used for the data validation work described in this report for waste arisings. The exceptions to this involve Household and Commercial waste, where the data have been taken directly from the LAWA reports instead of the Digest. The LAWAs contain total arisings figures, whilst the Digest has this waste stream split into the categories ‘recycling’ and ‘disposal’. For the validation of the data for these two waste streams, the total waste arisings for each LA have been taken to be the figures contained in Table D1 of the LAWA report - for 2000/01 and 2001/02 (SEPA, 2001 & 2003a).

The base year for data collection was 1998. Where SWMBA data were not available for 1998 data for waste arisings was validated against years after 1998. Similarly there is no LAWA data for 1998. The first LAWA reports were not produced until 2000/2001. Validation of data from later years has taken into account growth rates of waste arisings. The estimated growth in arisings has been estimated at 2% each year with the exception of special and industrial waste (at 1%) (SEPA, 2003c).

Data available for validation were presented in different formats. SWMBA data are presented by calendar years (1998, 1999) while the LAWAs are prepared by financial years (2001/02). For the purposes of comparison of data sets in this study financial years were allocated to the earlier year. For example LAWA data for 2001/02 were counted as representing data for 2001.

Waste transfer station data provided by SEPA were also used to verify the data. The data describe the tonnage and type of waste transported by quarter. SEPA provided figures for 2002. Each company return classifies the waste by the European Waste Catalogue. Each classification was allocated one of the categories used in this study e.g. industrial. The data set provided by SEPA was incomplete, with no data available for some quarters. Annual figures were therefore calculated based on the data provided. For example if data for two quarters were provided, the average was calculated, and then multiplied by four to give an annual figure. The data were sorted by WSA and total figures for each waste stream calculated. These were compared to the data originally transcribed from SWMBA.

4.4.1.1 Data gaps

Areas where there are data gaps which have limited the validation of the waste arisings and import and export data include:

- Total commercial waste arisings from sources other than local authorities for the following WSAs; North East, Fife, Lothian and Borders, Ayr and Galloway, Clyde Valley and Argyll and Bute.

- There is a lack of data on non local authority industrial and commercial waste arisings, which has been identified by SEPA as an area for future improvement.

- Special waste arisings can vary in years of large remediation projects. The incorporation of one-off events into waste predictions distorts future waste arisings.

- Import and export data figures.

4.4.1.2 Accuracy of validation

Validation of the study data was only as good as the data available for Scotland. Historically, waste arisings data for Scotland has been limited, and as a result this limits the data validation process. In recent years SEPA has requested that local authorities record waste arisings in the form of LAWAs. This has provided the main source of validation for the study data. The one limitation of the LAWA data is that SEPA has yet to implement a consistent data collection methodology across the local authorities; therefore it is possible that the LAWA data may contain inaccuracies that are yet to be addressed.

As local authorities are the predominant collectors of household waste, verification of household waste arisings data has been possible against the LAWA data. However, local authorities only collect a proportion of commercial and industrial waste and therefore validation of these waste streams was limited. Commercial and industrial waste producers keep records, but the data are not available in a format that enables calculation of total waste arisings. This is an area SEPA will be addressing, but for the purposes of this study commercial and industrial waste arisings in Scotland were estimated using statistics or secondary sources.

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1 Note that ‘arisings’ refers to waste produced regardless of the management option.
This report has used the SWMBA summary table for further data validation. These data were used in work on Scotland’s Footprint (Chambers et al., 2004). The SWMBA data highlighted errors in waste arisings data and the years they correspond to, particularly for construction and demolition waste (C&DW).

The SEPA waste transfer station data helped to provide information on the industrial and special waste data that were missing from the LAWA reports. However, the data set was incomplete, thus some companies will be missing, and some quarters returns were missing. While averages were used to calculate annual tonnages for missing quarters, missing data sets mean there will be errors in the total waste arisings estimated.

### 4.4.2 Waste transport lengths

Data on transport lengths were obtained from the results of a questionnaire survey and the SEPA transfer station data.

#### 4.4.2.1 Questionnaire survey results

Average transport lengths were calculated based on the results from the telephone questionnaire. The results are indicative given the limited number of respondents. Some of the responding companies transport waste up to 350 miles. This affects average transport lengths; therefore Table 4.3 shows average transport lengths both excluding and including distance of 200 miles or more. The table shows the number of companies which transport waste more than 200 miles, and they are a minority.

Table 4.3 shows the number of respondents for each waste type. It should be noted, that while respondents identified which WSA they travelled within, they did not always know distances.

#### Construction & Demolition Waste

- A previous study on C&DW transportation has been included, this adds 48 samples to the C&DW transport lengths.
- Only six respondents ever moved this type of waste further than 100 miles, which reflects the high cost for long distance haulage.
- Eleven respondents (19%) occasionally moved waste more than 50 miles and less than 100 miles.
- The remainder of respondents, 41 (71%) never moved their waste more than 40 miles.
- The maximum distance for the movement of non-hazardous waste was 60 miles (one respondent), due to the rural nature of the area.

#### Special waste

The limited disposal and treatment options for special waste are reflected in the results as this was the waste stream that most commonly moved across WSAs. In several instances these were transported to England for treatment/disposal, hence the large maximum distance of up to 350 miles for special waste.

#### 4.4.2.2 SEPA transfer station data results

While the questionnaire provided data on some waste movements in Scotland, the responses were limited. Additional information on waste movements across Scotland was obtained from data provided by SEPA.

The total average transport lengths were calculated using the SEPA transfer station data and questionnaire. The averages are given below. These averages are based on miles travelled not tonne miles travelled as presented in Chapter 5.

### Table 4.3 Transport lengths

<table>
<thead>
<tr>
<th>Waste type</th>
<th>No. of respondents</th>
<th>Average* typical distance (including distance &gt;200miles)</th>
<th>No. of respondents travelling &gt; 200 miles</th>
<th>Average* typical distance (excluding distance &gt;200 mile)</th>
<th>Maximum distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>26</td>
<td>76</td>
<td>1</td>
<td>33</td>
<td>230</td>
</tr>
<tr>
<td>Commercial</td>
<td>23</td>
<td>69</td>
<td>1</td>
<td>40</td>
<td>250</td>
</tr>
<tr>
<td>Industrial</td>
<td>20</td>
<td>102</td>
<td>1</td>
<td>26</td>
<td>250</td>
</tr>
<tr>
<td>Construction and demolition</td>
<td>58</td>
<td>100</td>
<td>2</td>
<td>16</td>
<td>300</td>
</tr>
<tr>
<td>Special</td>
<td>11</td>
<td>100</td>
<td>2</td>
<td>30</td>
<td>350</td>
</tr>
</tbody>
</table>

*Not all companies gave information on transport lengths.

*Not weighted averages.
converted into percentages for application to the SEPA transfer station data. Special Waste was not a category in the data collated for the Scotland’s Footprint study. Therefore the figure from the most recent Waste Data Digest produced by SEPA (SEPA, 2003b), that 1.2% of all waste going to landfill is Special Waste was applied. Therefore the amount of Special Waste going to landfill could be calculated based on the landfill figures generated. These calculations are shown in Table 4.5. It should be noted that this is an estimate, as in some cases the figure in Table 4.5 exceeds the waste arisings for Special Waste.

<table>
<thead>
<tr>
<th>WSA</th>
<th>Minimum transport length</th>
<th>Maximum transport length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>550</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>245</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>360</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>300</td>
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<tr>
<td>6</td>
<td>5</td>
<td>172</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>635</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
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</tr>
<tr>
<td>9</td>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>664</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>123</td>
</tr>
</tbody>
</table>

### Table 4.4 Distribution of transport lengths by WSA

In each WSA, often there was a balance between the validated total waste arisings and the volume of waste for which information was available on waste movements. Any balance was given the average transport length for that waste type.

Distribution of transport lengths for each WSA is shown in Table 4.4.

#### 4.4.2.3 SEPA matrix imports and exports

The SEPA transfer station data were used to create a matrix of imports and exports between each WSA, and was used to validate the study import and export data.

#### 4.4.3 Waste management destinations

The SEPA transfer station data does not specify waste management destinations (e.g. landfill, recycling) for the waste arisings. Data are presented only by council area. When the data were obtained it was noted that some of the missing SEPA data was data that went to either another transfer station or to disposal. While it is impossible to know the waste management destination based on the SEPA transfer data alone, estimates can be made based on data available from the Scotland’s Footprint study (Chambers et al., 2004).

The breakdown of waste management destinations obtained from the Scotland’s Footprint study was

<table>
<thead>
<tr>
<th>WSA</th>
<th>Landfill exc. Special Waste</th>
<th>Total incl. Special Waste (at 1.2%)</th>
<th>Special Waste to landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29,229</td>
<td>29,584</td>
<td>355</td>
</tr>
<tr>
<td>2</td>
<td>24,923</td>
<td>25,226</td>
<td>303</td>
</tr>
<tr>
<td>3</td>
<td>236,319</td>
<td>239,190</td>
<td>2,870</td>
</tr>
<tr>
<td>4</td>
<td>1,014,659</td>
<td>1,026,983</td>
<td>12,324</td>
</tr>
<tr>
<td>5</td>
<td>676,955</td>
<td>685,177</td>
<td>8,222</td>
</tr>
<tr>
<td>6</td>
<td>645,414</td>
<td>653,253</td>
<td>7,839</td>
</tr>
<tr>
<td>7</td>
<td>1,120,655</td>
<td>1,134,266</td>
<td>13,611</td>
</tr>
<tr>
<td>8</td>
<td>842,920</td>
<td>853,158</td>
<td>10,238</td>
</tr>
<tr>
<td>9</td>
<td>3,469,331</td>
<td>3,511,469</td>
<td>42,138</td>
</tr>
<tr>
<td>10</td>
<td>92,310</td>
<td>93,431</td>
<td>1,121</td>
</tr>
</tbody>
</table>

The SEPA Waste Digest (SEPA, 2003b) also states that approximately 30% of special waste goes to England for treatment and recovery. Therefore, any special waste in Scotland that has gone to England is presumed to have gone for treatment and recovery, as opposed to landfill or other destination.

#### 4.4.4 Handling costs

Data on handling costs were obtained through the phone questionnaire survey.

23% of the companies consulted provided some information on waste movement and transfer costs. All costs, with the exception of one, were for road-to-road transfer and vary widely.

The questionnaire respondents were reluctant to divulge transfer costs because of the commercially sensitive nature of the information. Several respondents were unaware of transfer costs, and did not record information in this way.

The majority of respondents were from the central belt of Scotland, incorporating predominately Glasgow and Clyde Valley, and Edinburgh, Lothian and Borders. There
were no responses from the Islands or Highlands of Scotland, therefore the data extrapolation below could be presumed to be prices for transfer stations near highly populated regions.

Extrapolating accurate costs is difficult; however, the best estimate of road haulage costs is shown in Table 4.6. While based on a small sample these data give an indication of the impact of distance travelled and waste type on the costs of road haulage. C&DW which generally travels only a short distance has low transport costs at £1-£2.50 per tonne. In contrast Special Waste can cost more than £1000/tonne. This reflects the limited number of landfill sites that will accept Special Waste and that fact that more specialist waste transport may be required.

**Table 4.6 Handling costs for waste transport by road haulage**

<table>
<thead>
<tr>
<th>Waste type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>C&amp;D waste</td>
<td>£1-2.50/t</td>
</tr>
<tr>
<td>Clean inert waste</td>
<td>£5-7/t</td>
</tr>
<tr>
<td>Mixed/household/commercial waste</td>
<td>£17-27/t</td>
</tr>
<tr>
<td>Mixed/household waste requiring treatment</td>
<td>£39-50/t</td>
</tr>
<tr>
<td>prior to disposal</td>
<td></td>
</tr>
<tr>
<td>Industrial waste (non-inert)</td>
<td>&gt;£50/t</td>
</tr>
<tr>
<td>Drums of industrial waste</td>
<td>£100/drum</td>
</tr>
<tr>
<td>Special waste</td>
<td>&gt;£1000/t</td>
</tr>
</tbody>
</table>

The additional handling stages for the transfer of waste by rail (compared with road haulage) are summarised as follows. Note that these additional handling stages are required due to the need for containerised waste storage. This would not always need to be the case, for example with respect to C&DW, where the appropriate design of rail sidings and access could negate the requirement for special containers:

**Taking waste to the train:**
- Transfer of container loaded with waste onto a truck.
- Transfer of the container from truck to train.

**Taking waste from the train:**
- Offloading the full container onto a truck.
- Offloading the container from the truck.

Consultation resulted in a best estimate of £2/t being used to assess the cost of each of the waste handling stages described above for rail haulage. Thus the cost of these additional stages for rail haulage is £8/t. The cost of transporting by rail is £12/t for a distance of approximately 40 miles. A conclusion from the consultation was that the only way rail can compete financially against the single transfer costs of road-to-road haulage, is over long distances, where for example the cost of hauling 20 tonnes of waste from northern Scotland to Edinburgh may be approximately £400. This equates to a cost of £20/t which begins to make the cost more comparable with road transportation.

No handling costs of transfers from canal to rail or canal to road were obtained during the survey.

**4.4.5 Lorry loads**

Data on the number of lorry loads were obtained from the phone questionnaire survey.

Acquiring information on the number of lorry loads shifted within different waste transport areas, proved difficult for the following reasons:
- Records by respondents were usually in tonnages not lorry loads.
- Lorry sizes vary and compaction rates are different, resulting in a high variation in the actual waste moved.

Lorries move different waste streams, which again means there is a variation of tonnages moved around. For example, a lorry of household waste would vary from a lorry of cardboard boxes and so forth. So while respondents knew tonnages, it is hard to extrapolate that to lorry loads of waste on the road.

A total of 18 responses on lorry loads were received, whereas 39 respondents were able to provide volumes of waste moved. To widen the data set available for modelling, this section will discuss both lorry loads and tonnes of waste moved.

The range of lorry loads per day varied widely depending on the size of the company. Some companies moved only one lorry per fortnight, while others moved up to 150 per day. A total of 2,048 lorry movements were recorded from the 18 respondents. The majority of lorry movements were in Glasgow and the Clyde Valley and Edinburgh, Lothian and Borders. Lorry movements were also recorded in small numbers for all remaining WSAs, with the exception of Argyll and Bute and Orkney and Shetlands. A summary of the average results is listed in Table 4.7.

Waste haulage organisations must submit a quarterly return to SEPA detailing waste movements and quantities. The average lorry load determined during the questionnaire was applied to the SEPA transfer station data described in Section 4.4.2.2.
The number of lorry loads was calculated based on validated total arisings for each WSA. Assuming an average lorry weight of 20 tonnes, the estimated number of lorry loads for each WSA is shown in Table 4.8.

Table 4.7 Average lorry movements and tonnages

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of lorry load per company</td>
<td>114</td>
</tr>
<tr>
<td>Average tonnage per lorry load</td>
<td>16.4</td>
</tr>
<tr>
<td>Average tonnage of household waste moved per week</td>
<td>1,727</td>
</tr>
<tr>
<td>Average tonnage of commercial waste moved per week</td>
<td>1,343</td>
</tr>
<tr>
<td>Average tonnage of C&amp;D waste moved per week</td>
<td>2,448</td>
</tr>
<tr>
<td>Average tonnage of industrial waste moved per week</td>
<td>4,000</td>
</tr>
<tr>
<td>Average tonnage of special waste moved per week</td>
<td>88.5</td>
</tr>
</tbody>
</table>

The respondent was a haulage company and so there was no perceived need to change.

Transfer stations are too remote.

It would be the waste processor that influenced change not the waste transporters.

Not viable.

There is no rail in the borders.

Respondents that were not aware of alternatives provided some of the following reasons for their response:

- Logistics are prohibitive and there are too many hazards if changing waste transportation modes.
- They don’t move waste often.
- Only small amounts of waste are moved.
- It would cause more problems than it would be worth.
- It would only be viable if transporting waste over long distances, e.g. to England.

One respondent from the Islands was aware of alternatives and would consider changing to alternatives if SEPA shut any of the landfills, as this would force waste to be transported to the mainland.

The respondent who transported and transferred waste by rail was an advocate of alternative waste transport options. He believed rail was a viable option for long distances. Travel in the Central Belt by rail, could not compete with road costs (due to handling costs of rail), but transport from northern Scotland to southern Scotland would be possible. He had also investigated inland shipping, but costs were high as was the tidal range which meant that logistically waste could only be transported at certain times of the day. He also discussed canal belts, but highlighted that the two main canal belts covered the narrowest parts of Scotland and would be more serviceable by road. Ships would not travel fast enough and there is the issue of back loads, as ships are expensive to run. He had investigated using Highland Canals, but the canals were too shallow for the purpose envisaged.
5 Waste transport modelling

This chapter describes the waste transport cost model that was developed to examine the potential for modal transfer in Scotland. The chapter includes a comparative discussion of cost modelling versus Life Cycle Analysis (LCA).

5.1 Model description

Cost models were created for road, rail, canals, and coastal shipping. The main difference between road and the other models is the impact of economies of scale. The initial costs of a waste transport operation by road are far lower than by rail or water, although the average cost per tonne mile could be substantially higher when there are large waste volumes and/or longer lengths of haul.

There are many combinations possible for the transport models, which can change costs dramatically. Continuous checks were carried out with industry representatives to ensure that most of the important cost elements were included, the scenarios were feasible, and the models represented typical operations. Road transport has the most complete of the cost models represented here, as there was information available to build a comprehensive model including externalities. The external costs included in the road model were those relating to congestion.

In the case of rail and waterways, there was less information available and external costs could not be considered. This means that the cost model would show rail and waterways to be slightly cheaper than they actually are, and more attractive than road transport. This has a limited impact on the results presented in Chapter 6, as even with this cost advantage, the amounts shifted to these other modes are in most cases not significant.

The emissions to air from all three modes were calculated by the modelling. However, no monetary value was assigned to the emissions. Many appraisals in the UK do measure some environmental effects (i.e. emissions), but fail to provide monetary valuations for them. For example, the Guidance on the Methodology for Multi-Modal Studies presents most costs used in the appraisal process under the ‘Economic Efficiency Table’, but this does not include monetary valuations for the environment. Additionally, monetary valuations for most environmental externalities are difficult to assess and there is little agreement between environmental economists on their value. For all these reasons, they were not included in the cost functions for the different modes.

The transport scenarios only consider the final movements delivering waste to landfill sites from transfer stations and other locations. This is in effect the last leg of the journey to final destinations. Movements from source to transfer stations are outside the scope of the model. The model assumes that the existing landfill sites have sufficient capacity in the cycle 2002-2020 to cope with future waste volumes. Data on landfill capacity was not available for this study.

The road model considers a mix of fixed and variable costs, using factor costs across all modes. For many origin-destination (O-D) pairs, the volumes were very small and did not justify the operation of one dedicated vehicle for a whole year. For this reason, all the fixed costs for road transport were transformed into a cost per mile, considering the average mileage that an average truck did in one year. This contrasts with the rail and waterways modes, in which the fixed costs were not averaged over distance. This means that the full effect of the economies of scale was considered in their case. This may constrain the waste volumes transported by rail and waterways to only those flows that are very high or have a long length of haul, because they would have to bear the whole costs of expensive transport infrastructure. In order to test the impact of this assumption, a sensitivity analysis was carried where all the fixed costs for rail and waterways were reduced by 50%. This showed little effect on the overall volumes transferred from road to other modes (less than 0.5%).

For road transport, the costs for the operator, time costs, and other users’ costs such as congestion and extra operating costs were estimated using figures from Transport Economics Note 10 (DfT, 2001) and speed and flow relationships from the SATURN manual (Vliet and Hall, 2002). Congestion costs were estimated considering the delay to other vehicles and the impact it had on their vehicle operating costs and time costs. This calculation employed the average traffic levels for each road type in Scotland. Emissions for \( PM_{10}, NO_x \) and \( CO_2 \) were also calculated. As costs were estimated per year, care was taken to use projections for the perceived costs of fuel in the future. All costs were obtained for 1998 prices, which is the base used by the Transport Economics Note published by the DfT, but were later updated to 2003 prices.

The rail model was based on data obtained from SWARMMS (2002) and from Thrall Europe (2000). This involves fixed and variable costs for the rolling stock, costs for accessing the infrastructure, loading and unloading vehicles, employment, and mobility costs. There are very high initial costs as rolling stock and loading equipment are very expensive, so it is necessary to load a substantial number of tonnes to make it cost effectively. A road journey is also added to the costs to and from railway freight transfer stations.

All the information for the inland waterways model was obtained from Milton and Huge (2003). Their report
looked at the specific transport of waste along canals for different scenarios. The model employed the costs for the most typical scenario using standard vessels and waste containers, although this was not the cheapest option examined in their study. Average values were obtained for handling (in pounds per tonne) and for waterborne components (pounds per tonne per mile).

The costs for the coastal shipping model were provided by the private operator KD Marine, and would be representative for a typical waste transport operation. The costs components correspond to loading and unloading, vessel operations, use of ports, and road transport to and from port facilities.

5.2 Transfer of waste volumes to other modes

Once the costs functions for the base case scenario (all road) were built, the next stage was to focus on the volumes of waste that could be transferred to other modes.

The key components that influence the feasibility of waste transfer to other modes are:

- Access to appropriate infrastructure.
- Volume of waste to be transported.
- Haul distance.

As such the first stage of identifying waste streams that could be transported to other modes was to identify the O-D pairs that had access to the necessary infrastructure. These identified O-D pairs were then sorted in descending order according to the waste volume transported and the haul length. This approach was used because waste streams with the greatest volumes and haul lengths, and with access to the appropriate infrastructure are more likely to be transferred to alternative modes cost effectively as railways and waterways are more competitive at longer distances.

Once this process was complete the transport costs of the modes were estimated using the models just described. In most cases, only those O-D pairs with large waste volumes and long lengths of haul could transfer waste to other modes economically. The costs of the new mode were compared with road transport, and the volumes were only transferred if the costs were lower in the new mode.

5.3 The effects of waste consolidation and longer distances

In order to compare the effects of distance and large volumes of waste, the model was run assuming an O-D pair with 100,000 and 200,000 tonnes of waste. The roads are assumed as dual-carriage way with typical traffic levels in Scotland. The costs for railways and canals were added to the additional costs of road distance to and from the inter-modal stations.

The consolidation of loads can reduce substantially the costs per tonne mile for railways. In the case of railways, the breakeven point is reduced from just over 60 miles to 40 miles when the annual volume of waste increases from 100,000 to 200,000 tonnes. Note, however, that canals hardly change at all when the volumes increase, as the fixed costs per tonne remain. In this model, canals only show economies of scale with respect to distance, but not with respect to freight volumes. In reality, water transport costs would be lower with large volumes thanks to economies of scale. However, it was not always possible to disaggregate the information on fixed costs obtained for this mode. A more representative model could be built with more detailed data.

Road transport exhibits the same costs per tonne mile regardless of the volumes carried. This is because all the fixed costs for roads such as capital and annual labour wages were converted into distance related (variable) costs per mile. This method represents the transport costs more accurately for those flows with small volumes. For example, a flow of just 50 tonnes of waste per year would have been allocated all the labour costs for one driver at £20,000 per year. Instead the £20,000 was divided by the average mileage done in a year providing a cost per mile. This conversion of fixed costs into variable costs was used for all the flows in the sample.

The costs of water transport show similar behaviour to those for road: the costs per tonne mile remain the same regardless of the volumes transported, although in contrast with road they do decline with distance. This is because all fixed costs are estimated as an average per tonne, as not enough information was available to build detailed cost functions for all the corridors involved in the model.

5.4 Data provided and additional calculations

Waste volumes

The sources of data for waste volumes and total transport distances by road are discussed in Chapter 4, while forecasts for waste recycling and growth rates for 2010 and 2020 were obtained from the National Waste Plan (SEPA, 2003c). The volumes are available by specific O-D pairs (usually based on districts), each one listing the Waste Strategy Areas to which they belong and the waste types. Each waste amount was also assigned a road distance from the stated origin to a final landfill site.

Taking the base year and the forecasts, waste volumes for each individual year between 2002 and 2020 were
obtained by interpolation assuming linear growth. This provided the total waste volumes to be transported every year for the cycles 2002-2010 and 2002-2020. The volumes of waste that are effectively transported are the forecast volumes minus the targets for recycling. These are also the volumes that were finally used in the models in this exercise. Therefore the model effectively takes the best case scenario where all recycling targets are achieved and therefore the transport of this waste does not need to be considered.

**Distances by mode**

Suitable road distances for each O-D pair were calculated from the waste transfer station data provided by SEPA. The road distances were broken down into different road types, as type attracts different operating costs. The transport modes available for each individual O-D pair were identified and a suitable distance to landfill was allocated for rail and waterways models. This ensured that only O-D pairs that had access to other modes could waste be transferred from road to rail or waterways. No changes to the transport infrastructure were carried out in the model, meaning that the lengths of haul for each mode remain the same throughout the cycle 2002-2020 for all modes.

Most waste currently is being transported by road, although there are some small movements using maritime transport in Scotland. At the time of estimating the costs of the base case scenario (all transported by road), only the road length of the journey was estimated when other modes such as coastal shipping were being used as well. This has a very small impact on the aggregated costs, as the volumes and costs of this additional mode are unlikely to be significant. Table 5.1 summarises the main data sources.

### Table 5.1 Main data sources for the models

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>Transport Economics Note (DfT, 2001b), SATURN 10 manual (Van Vliet, D and Hall, M, 2002), FORGE database (DfT, 2003b)</td>
</tr>
<tr>
<td>Waste volumes and distances</td>
<td>SEPA (see Chapter 4)</td>
</tr>
<tr>
<td>Emissions</td>
<td>EU Studies (Rhys-Tyler et al., 2001), Jorgensen and Sorensen (1997)</td>
</tr>
</tbody>
</table>

---

### 5.5 Life Cycle Analysis (LCA) and modelling

This section reviews the potential contribution and/or role of waste management LCA modelling to this study.

This study was described in the Scoping Study as follows (Winter et al., 2001):

> ‘The project is designed to approach the movement of waste in the same way that integrated transport approaches the transport of people’

As such, the project combines decision making approaches and tools from the fields of waste management and transport planning. Specifically, the two fields have traditionally employed different models to support decision making, namely:

- Transport: Cost Benefit Analysis (COBA) or cost modelling.
- Waste: LCA.

This study has employed cost modelling, as set out in earlier in this chapter. However, the recognition of the key role played by LCA in waste management decision making has resulted in the identification of a need for a review of the two methodologies in the context of this study, with the following objectives:

- To review the cost modelling.
- To highlight how the cost modelling carried out for this study might compliment LCA work carried out for waste planning in Scotland.
- To discuss ways in which the cost modelling results from this study might be compared to LCA results.

The modelling comprises the following elements:

- Cost models for a range of scenarios (including baseline) for road, rail, canals, and coastal shipping – including external costs associated with congestion for road.
- Emissions of CO₂, NOₓ, and PM10 for all scenarios.

### 5.5.1 LCA and waste management

LCA is an established method of measuring the environmental flows or burdens associated with a product or service ‘from cradle to grave’ in order to enable the comparison of alternative options. Environmental flows include the consumption of raw materials and energy, emissions to air and water and the production of wastes. LCA systematically examines and quantifies the flows
resulting from a product or service and assesses the potential impacts that these have on the environment for the whole of the life cycle. The structure of a product or service LCA is shown in Figure 5.1.

In recent years, LCA models have been developed to assess the environmental flows or burdens associated with integrated waste management systems. A product or service LCA considers the Life Cycle of the product from raw material extraction, through manufacture distribution, use and final disposal (the ‘cradle-to-grave’ approach). A waste LCA also employs a ‘cradle-to-grave’ approach, however, the cradle is the point at which the material becomes waste (according to Directive 75/442/EC (OJEU, 1975) an item becomes waste when the holder discards or is required to discard it). A waste LCA is illustrated in Figure 5.2. A Waste Management LCA aims to optimise the design, planning and management of an Integrated Waste Management System, including infrastructure (MRF, EfW, landfills etc) and collection and transportation.

As such, the system will comprise a range of ‘front-end’ flows or burdens, for example, energy consumption and emissions from transport, but will also include ‘internal’ flows and burdens, for example, embodied energy in materials and products and associated energy savings from recycling.

There are two LCA Models in current use in the UK, the Environment Agency/SEPA/Ecobilan WISARD Model and the Proctor and Gamble IWM2.

5.5.1.1 WISARD – Environment Agency/SEPA/Ecobilan

The Environment Agency began a life cycle program for waste management in 1994. In 1999, WISARD (Waste-Integrated Systems Assessment for Recovery and Disposal) was launched. The tool includes the data on waste management operations and processes compiled under the Agency’s programme, as well as background data on raw materials, energy and other processes in life cycle from Ecobalance UK’s proprietary life cycle database, DEAM (Data for Environmental Analysis and Management). A wide range of LCA studies using the WISARD program have been carried out throughout the UK. The most consistent and coordinated use of WISARD has been in the development of the Scottish Waste Strategy and Area Waste Management Plans by SEPA, where the WISARD modeling has been carried out by the SEPA Waste Strategy Area Coordinators as an integral part of the BPEO Process.

5.5.1.2 IWM2 – Proctor and Gamble.

Integrated Solid Waste Management – A Lifecycle Inventory was published in 1995 (McDougall et al., 2001). This consisted of a book and an LCA spreadsheet model (IWM-1), which enabled the modelling of the overall environmental impacts and financial costs of municipal waste management. A second edition of the book was published in 2001 with an upgraded version of the model, IWM-2. IWM-2 is designed to be an ‘entry level’ LCA model for solid waste and appropriate to users starting to apply lifecycle thinking to waste systems.

Figure 5.1 Structure of a product or service LCA

Figure 5.2 LCA for waste management
The model is the only other waste management LCA Model to have received significant use in the UK and had been considered a ‘rival’ to WISARD.

However, the authors have recently stated that they do not intend to carry out any further development work on the model (McDougall et al., 2001).

5.5.2 The use of WISARD in waste planning and BPEO assessment in Scotland

The use of the WISARD LCA has been at the heart of the BPEO process throughout the preparation of the AWPs, which were subsequently amalgamated into the National Waste Plan in 2003 (SEPA, 2003c). The BPEO process is:

- Step 1 - Establish the Baseline.
- Step 2 - Options Generation and Profiling.
- Step 3 - Options Assessment.
- Step 4 - BPEO selection.

The Options Assessment phase includes the following elements:

- consider the environmental impacts of each option;
- consider the financial and economic implications of each option;
- determine if relevant targets (e.g. the Landfill Directive diversion targets) will be met;
- comparison of options with the current situation.

WISARD was used in the preparation of all of the Area Waste Plans to quantify the environmental burdens associated with each option, as part of the assessment of environmental impacts.

The National Waste Plan described the WISARD process as follows:

‘This is the first time such a quantitative technique has been applied to strategic waste planning in Scotland. While it has undoubted benefits, it must be emphasised that WISARD compacts which are readily quantifiable. Other issues, such as biodiversity, soil quality, visual amenity and natural and cultural heritage inputs, cannot be assessed by WISARD. These, non-quantifiable impacts were assessed separately by individual Waste Strategy Area Groups in choosing their BPEO.’ (SEPA, 2003c)

In other words, LCA quantifies the environmental burdens, in terms of resources, energy and emissions from the system, but it does not measure the environmental impact of these burdens.

The EA is currently carrying out an extensive LCA research programme which will produce a new version of the WISARD LCA software and a number of projects are underway. The launch of ‘WISARD II’ is due to take place by the end of 2004. This will include guidance on the use of Impact Assessment in LCA to local authorities, development and enhancement of the WISARD software, data development and refinement for WISARD e.g. home composting LCA, financial data on the performance of waste management systems. Additional data sets will also be added (EA, pers. comm., 2004), these are set out in Table 5.2.

The improvements to WISARD II should have a number of impacts of relevance to the BITOW modeling:

- Guidance on the use of Impact Assessment in LCA – this has the potential to bring LCA ‘closer’ in decision making terms to the cost modeling carried out for BITOW.
- The financial data on the performance of waste management systems.

5.5.3 LCA and waste transport

The collection and transportation of waste are processes which should be taken into consideration when making a LCA of waste management. Emission from road transport can represent a large part of the emissions from the ‘front-end’ waste collection and transport system. However, research has indicated that changes to transportation distances of waste by road had a limited influence on the overall LCA results in terms of energy demand and emissions of CO₂, SO₂ and NOₓ (ECDGJRC, 2004).

While the energy use and emissions from collection and transport are a significant part of the ‘front-end’ elements of the LCA system, these play a relatively minor role when compared with the embodied energy associated with materials and products and with related recycling and energy recovery associated with these materials and products.

One potential exception to this is the transport of small quantities of waste materials in cars. For example, a waste management system whose recycling component is based solely on bring banks and recycling centers rather than kerbside collection. Research carried out in the UK has shown that the waste management system can be sensitive to the types of system chosen for collection of recyclable materials (Leach et al., 1997).
5.5.3.1 Cost modelling

As set out above, this study employs cost modelling, which has been described as follows (ECDGJRC, 2004):

‘CBA attempts to quantify the total costs and total benefits of a given policy option in order to determine whether the policy is worth pursuing’

In terms of costs, the study modelling included both ‘internal’ costs (i.e. the financial costs of waste transport), and some ‘external’ costs (e.g. congestion), expressed as a monetary value. In addition, the total volume of selected emissions to air were calculated. An example of how these data were presented is shown in Table 5.3.

<table>
<thead>
<tr>
<th>Vehicles and transport</th>
<th>Containers</th>
<th>Sacks</th>
<th>Collection routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCV fleet</td>
<td>120 wheeled bin</td>
<td>Refuse sack (paper)</td>
<td>Residual</td>
</tr>
<tr>
<td>4x2 skip unit fleet</td>
<td>140 wheeled bin</td>
<td>Refuse sack (plastic)</td>
<td>Collection/RCV</td>
</tr>
<tr>
<td>8x4 vacuum tanker</td>
<td>240 wheeled bin</td>
<td>Refuse sack (bio-plastic)</td>
<td>Kerbside sort</td>
</tr>
<tr>
<td>Fleet</td>
<td>330 wheeled bin</td>
<td></td>
<td>Collection/RCV</td>
</tr>
<tr>
<td>Artic tanker fleet</td>
<td>1100l wheeled bin</td>
<td></td>
<td>Recyclable</td>
</tr>
<tr>
<td>Artic fleet</td>
<td>551 kerbside box (with lid)</td>
<td></td>
<td>Collection/LCV</td>
</tr>
<tr>
<td>8x4 rear end loader fleet</td>
<td>551 kerbside box (without lid)</td>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>LCV</td>
<td>1350l oilbank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car petrol fleet</td>
<td>4m3 recycling bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car diesel fleet</td>
<td>14yd3 recycling bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x4 FEL. fleet</td>
<td>Container 30yd3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4x2 skip unit</td>
<td>Recycling bank 2.5m3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x4 FEL</td>
<td>Skip 12 yd3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x4 roll-on-off</td>
<td>8x4 rear-end loader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x4 roll-on-off fleet</td>
<td>Artic fleet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inland waterway</td>
<td>Intermodal containers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is much discussion and no universal agreement amongst environmental economists on the costs assigned to environmental impacts.

5.5.3.2 Case study: inland waterways and the transport of waste (Ecobalance UK, 2000).

This study was a comparative review of the environmental impacts of different transport options for the transport of wastes in London, and therefore combined decision making tools from both waste planning and transport planning, employing both Cost Modelling and LCA.

The analysis was of a range of scenarios which modelled both road and waterways transport of the wastes and the sensitivity of the analysis to the distance of the waste collection operations from the river. The study carried out a limited LCA focussing on the Greenhouse Gases, Atmospheric acidification, Ozone depletion and Non-renewable resource depletion. An example of how these data were presented is shown in Table 5.4.

5.5.4 Discussion

The range of advantages and disadvantages associated with the LCA and cost modelling methodologies, both individually and when used in ‘parallel’ are discussed below.

**WISARD LCA:**

- Presents the analysis and data in a form which is compatible with the analysis of waste scenarios set out in the Scottish Area Waste Plans.
Table 5.4 Emissions data from inland waterways and the transport of waste (g/km)

<table>
<thead>
<tr>
<th>Emissions</th>
<th>NO&lt;sub&gt;x&lt;/sub&gt;</th>
<th>PM&lt;sub&gt;10&lt;/sub&gt;</th>
<th>CO</th>
<th>SO&lt;sub&gt;2&lt;/sub&gt;</th>
<th>Benzene</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGV (urban)</td>
<td>8.97</td>
<td>0.3</td>
<td>5.25</td>
<td>0.3934</td>
<td>0.00844</td>
<td>0.51</td>
</tr>
<tr>
<td>HGV (motorway)</td>
<td>7.33</td>
<td>0.14</td>
<td>1.57</td>
<td>0.33</td>
<td>0.00355</td>
<td>0.09</td>
</tr>
<tr>
<td>Tug</td>
<td>509.15</td>
<td>0.79</td>
<td>86.193</td>
<td>0.57</td>
<td>NQ</td>
<td>NQ</td>
</tr>
<tr>
<td>Rail</td>
<td>120</td>
<td>2.86</td>
<td>6.8</td>
<td>5.95</td>
<td>NQ</td>
<td>NQ</td>
</tr>
</tbody>
</table>


- Allows analysis of the environmental impacts of infrastructure associated with the scenarios such as transfer stations, materials recovery facilities, containers, barges etc. Economies of scale associated with waterways transport could lead to a smaller number of larger facilities, which may reduce the overall environmental impact of the facilities – only the application of the LCA methodology to the scenarios will allow the overall ‘system’ impacts to be quantified.

- Cannot currently analyse the financial/economic performance of the waste management options.

Cost modelling:
- Cost modelling is the ‘norm’ for transport modelling which presents the analysis and data in a form, which is compatible with other transport costs assessments.
- Provides estimates of emissions.
- Presents the outputs of the modelling in monetary values, allowing ‘like with like’ comparison in terms of financial/economic performance.
- No industry agreement on what monetary values should be assigned to environmental impacts.

Combination of WISARD LCA and Cost modelling:
- Analysis of the emissions associated with the different transport options using both methodologies would provide a useful cross-check of the results.
- The disadvantage of this is, of course, increased costs.

As a programme which integrates the fields of waste management and transport/logistics the BITOW project has the option of employing decision making approaches and tools from either or both fields. The review of the modelling options set out above indicates that the use of Cost Modelling provides a range of advantages relative to LCA. Recent research has demonstrated techniques for integrating the outputs of Cost Modelling and LCA, and it is recommended that any further work should explore the options for applying and integrating both Cost Modelling and LCA to support decision making for integrated waste transport in Scotland.
6 Future scenarios for modal shift of waste

6.1 Introduction

This chapter compares different scenarios for the transport of waste in Scotland, in particular the possibility of transferring waste from road to other modes. The costs for each mode were first estimated for three different cycles: the base year 2002 for which there were validated figures available, the years 2002-2010 and 2002-2020. The scenarios involved the transfer of waste from road to rail, and waterways (canals and coastal shipping).

6.2 Results from the scenarios

Seven different scenarios were modelled including the base case as follows:

1 Base case scenario: all transported by road.

2 Transfer to rail. As 1 but transferring waste to the rail mode when economic savings possible.

3 Transfer to waterways. As 1 but transferring waste to the waterways mode economic savings possible.

4 Maximum transfer to rail and waterways in WSA 10. As 1 but focusing on modal transfers only in WSA 10.

5 Supersites – all transported by road. Moving all the waste to 4 Supersites. This has the effect of increasing the distance travelled by most of the waste flows.

6 Supersites – transfers to rail. As 5 but transferring volumes to rail when economic savings possible.

7 Supersites – transfers to waterways. As 5 but transferring volumes to the waterways mode when economic savings possible.

The following sections describe the results from the model for each of above scenarios.

6.2.1 Base case scenarios: all waste transported by road

The total amount of waste transported by road annually would increase from 15.6 Mt in 2002 up to 19.2 Mt in 2020. Table 6.1 shows the totals obtained by summing all the years across the cycle 2002-2010. The total volume of waste transported is 145.9 Mt and 326.4 Mt for the cycle 2002-2020. C&DW (see the breakdown in Table 6.2 and Table 6.3) has the highest share of transported volumes, at 149.3 Mt or 45% of the total for the cycle 2002-2020. In the same cycle, WSA 10 produces the largest share of the waste transported, a volume of 120.9 Mt or 37% of the total.

These waste volumes are transported an average distance of 21 tonne-miles, and there is a total of 6,856 million tonne-miles for the cycle 2002-2020. The longest length of haul corresponds to special and clinical waste (34 miles), while the C&DW has the shortest distance (15 miles).

Note that the transport costs per tonne decrease from £1.59 for the year 2002 to £1.18 for the cycle 2002-2020. This appears odd as the larger volumes of waste would cause higher external costs of congestion, producing higher transport costs. This reduction can be explained by the fact that the model discounts all future costs by an annual 3.5% to consider the value of money at different times. This means that one pound of transport costs in 2020 is equivalent to just 54 pence in 2002, because one pound consumed in the present is valued more highly than one in the future.

The transport costs obtained from the model are very close to other figures available in the literature. The Society of Operations Engineers (2004) estimates transport costs for a 34 tonne (GVW) truck at 0.043 pounds per tonne-mile, assuming a 20 tonne payload. This is close to the estimates provided by the model. Note that the costs per mile displayed in Table 6.1 include the outbound and return trip costs and are 0.076 pounds per tonne-mile. The external costs of transport are a small part of the total costs, being 1% of the total road costs in 2002 increasing to 6% in 2020.

More detailed results are presented in Table 6.2 to Table 6.5.

Table 6.1 Characteristics of the base case scenario for each time period: all transported by road

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative tonnage</td>
<td>15,570,005</td>
<td>145,888,739</td>
<td>326,374,809</td>
</tr>
<tr>
<td>Cumulative tonne-miles</td>
<td>326,449,677</td>
<td>3,064,338,073</td>
<td>6,856,535,654</td>
</tr>
<tr>
<td>Average length of haul (miles)</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Average cost per tonne (£)</td>
<td>1.59</td>
<td>1.39</td>
<td>1.18</td>
</tr>
<tr>
<td>Average cost per tonne mile (£)</td>
<td>0.076</td>
<td>0.066</td>
<td>0.056</td>
</tr>
<tr>
<td>Cumulative total road transport costs (£)</td>
<td>24,732,260</td>
<td>202,961,042</td>
<td>386,387,520</td>
</tr>
</tbody>
</table>

All costs in 2003 prices.
### Table 6.2 Base case – all road transport – cycle 2002 – 2020: cumulative total tonnage

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>398,938</td>
<td>80,119</td>
<td>213,879</td>
<td>315,593</td>
<td>32,260</td>
<td>1,040,789</td>
</tr>
<tr>
<td>2</td>
<td>231,229</td>
<td>55,091</td>
<td>285,164</td>
<td>140,763</td>
<td>4,774</td>
<td>717,021</td>
</tr>
<tr>
<td>3</td>
<td>1,573,442</td>
<td>838,913</td>
<td>3,017,955</td>
<td>9,854,990</td>
<td>7,383,273</td>
<td>34,256,242</td>
</tr>
<tr>
<td>4</td>
<td>3,415,687</td>
<td>2,965,644</td>
<td>11,358,868</td>
<td>3,415,687</td>
<td>2,965,644</td>
<td>34,256,242</td>
</tr>
<tr>
<td>5</td>
<td>2,912,045</td>
<td>1,183,083</td>
<td>17,584,845</td>
<td>7,383,273</td>
<td>17,584,845</td>
<td>34,256,242</td>
</tr>
<tr>
<td>6</td>
<td>2,427,631</td>
<td>1,514,913</td>
<td>7,865,664</td>
<td>2,965,644</td>
<td>7,865,664</td>
<td>34,256,242</td>
</tr>
<tr>
<td>7</td>
<td>3,203,866</td>
<td>3,340,645</td>
<td>5,631,903</td>
<td>19,082,728</td>
<td>5,631,903</td>
<td>34,256,242</td>
</tr>
<tr>
<td>8</td>
<td>4,331,950</td>
<td>2,965,644</td>
<td>11,358,868</td>
<td>9,854,990</td>
<td>11,358,868</td>
<td>34,256,242</td>
</tr>
<tr>
<td>9</td>
<td>2,912,045</td>
<td>1,183,083</td>
<td>17,584,845</td>
<td>7,383,273</td>
<td>17,584,845</td>
<td>34,256,242</td>
</tr>
<tr>
<td>10</td>
<td>2,427,631</td>
<td>1,514,913</td>
<td>7,865,664</td>
<td>2,965,644</td>
<td>7,865,664</td>
<td>34,256,242</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>326,374,809</strong></td>
</tr>
</tbody>
</table>

### Table 6.3 Base case – all road transport – cycle 2002 – 2020: cumulative total tonne-miles

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,769,358</td>
<td>2,150,294</td>
<td>2,727,349</td>
<td>26,008,946</td>
<td>282,542</td>
<td>33,938,488</td>
</tr>
<tr>
<td>2</td>
<td>9,637,730</td>
<td>2,996,950</td>
<td>4,277,460</td>
<td>4,183,003</td>
<td>1,879,790</td>
<td>21,270,594</td>
</tr>
<tr>
<td>3</td>
<td>45,755,771</td>
<td>49,088,778</td>
<td>45,429,020</td>
<td>36,906,072</td>
<td>1,879,790</td>
<td>301,991,431</td>
</tr>
<tr>
<td>4</td>
<td>46,503,751</td>
<td>70,422,977</td>
<td>181,221,765</td>
<td>314,582,615</td>
<td>4,277,460</td>
<td>914,722,193</td>
</tr>
<tr>
<td>5</td>
<td>44,131,166</td>
<td>49,483,807</td>
<td>263,851,891</td>
<td>118,452,169</td>
<td>4,277,460</td>
<td>518,678,383</td>
</tr>
<tr>
<td>6</td>
<td>50,202,107</td>
<td>81,586,223</td>
<td>117,066,164</td>
<td>114,817,829</td>
<td>17,102,440</td>
<td>380,774,767</td>
</tr>
<tr>
<td>7</td>
<td>66,851,503</td>
<td>171,996,570</td>
<td>94,284,212</td>
<td>578,277,433</td>
<td>10,517,140</td>
<td>921,926,858</td>
</tr>
<tr>
<td>8</td>
<td>48,648,069</td>
<td>69,456,558</td>
<td>349,201,135</td>
<td>312,228,677</td>
<td>198,027,502</td>
<td>977,561,941</td>
</tr>
<tr>
<td>9</td>
<td>98,219,103</td>
<td>256,401,463</td>
<td>211,138,479</td>
<td>84,769,314</td>
<td>4,399,153</td>
<td>654,927,512</td>
</tr>
<tr>
<td>10</td>
<td>285,736,142</td>
<td>239,607,467</td>
<td>999,544,668</td>
<td>282,053,645</td>
<td>371,971,959</td>
<td>2,178,913,881</td>
</tr>
<tr>
<td>11</td>
<td>19,549,635</td>
<td>21,440,972</td>
<td>12,018,295</td>
<td>21,702,319</td>
<td>49,930</td>
<td>74,761,151</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>6,856,535,654</strong></td>
</tr>
</tbody>
</table>

### Table 6.4 Base case – all road transport – cycle 2002 – 2020: total transport costs in pounds (in 2003 prices)

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>186,065</td>
<td>139,415</td>
<td>180,200</td>
<td>1,612,432</td>
<td>18,677</td>
<td>2,136,789</td>
</tr>
<tr>
<td>2</td>
<td>617,602</td>
<td>192,836</td>
<td>281,433</td>
<td>2,727,349</td>
<td>272,428</td>
<td>11,421</td>
</tr>
<tr>
<td>3</td>
<td>2,960,258</td>
<td>3,103,946</td>
<td>2,987,850</td>
<td>2,375,491</td>
<td>121,286</td>
<td>11,548,831</td>
</tr>
<tr>
<td>4</td>
<td>2,595,801</td>
<td>3,915,848</td>
<td>10,141,756</td>
<td>17,050,085</td>
<td>17,050,085</td>
<td>51,443,503</td>
</tr>
<tr>
<td>5</td>
<td>2,502,964</td>
<td>2,778,727</td>
<td>14,756,835</td>
<td>6,483,355</td>
<td>2,412,382</td>
<td>28,934,281</td>
</tr>
<tr>
<td>6</td>
<td>2,908,120</td>
<td>4,584,777</td>
<td>6,542,167</td>
<td>6,417,962</td>
<td>942,649</td>
<td>21,395,675</td>
</tr>
<tr>
<td>7</td>
<td>3,890,163</td>
<td>9,664,589</td>
<td>5,276,077</td>
<td>3,421,172</td>
<td>594,442</td>
<td>51,846,443</td>
</tr>
<tr>
<td>8</td>
<td>2,613,637</td>
<td>3,857,444</td>
<td>19,406,529</td>
<td>17,450,038</td>
<td>11,038,094</td>
<td>54,385,741</td>
</tr>
<tr>
<td>9</td>
<td>5,768,711</td>
<td>14,438,293</td>
<td>11,799,085</td>
<td>4,752,027</td>
<td>247,234</td>
<td>37,005,350</td>
</tr>
<tr>
<td>10</td>
<td>16,349,443</td>
<td>13,370,976</td>
<td>55,702,867</td>
<td>15,714,651</td>
<td>20,938,940</td>
<td>122,076,877</td>
</tr>
<tr>
<td>11</td>
<td>1,128,495</td>
<td>1,204,995</td>
<td>672,631</td>
<td>1,229,352</td>
<td>2,836</td>
<td>4,238,309</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>386,387,520</strong></td>
</tr>
</tbody>
</table>

57
Table 6.6 Characteristics of the waste transported by rail for all cycles

<table>
<thead>
<tr>
<th>Year range</th>
<th>Cumulative tonnes</th>
<th>Percentage of total waste</th>
<th>Tonne-miles by rail</th>
<th>Length of rail haul (miles)</th>
<th>Average cost per tonne (£)</th>
<th>Average cost per tonne mile (£)</th>
<th>Total rail transport costs (£)</th>
<th>Costs saved over road (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>235,237</td>
<td>1.5%</td>
<td>9,070,732</td>
<td>39</td>
<td>3.01</td>
<td>0.078</td>
<td>708,139</td>
<td>172,146</td>
</tr>
<tr>
<td>2002-2010</td>
<td>3,055,800</td>
<td>2.1%</td>
<td>136,651,444</td>
<td>45</td>
<td>3.03</td>
<td>0.068</td>
<td>9,255,155</td>
<td>1,779,367</td>
</tr>
<tr>
<td>2002-2020</td>
<td>7,657,755</td>
<td>2.3%</td>
<td>366,560,560</td>
<td>48</td>
<td>2.56</td>
<td>0.053</td>
<td>19,601,721</td>
<td>4,725,161</td>
</tr>
</tbody>
</table>

Table 6.5 Base case – all road transport – cycle 2002 – 2020: length of haul in miles

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Weighted average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>27</td>
<td>13</td>
<td>82</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>54</td>
<td>15</td>
<td>30</td>
<td>37</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>29</td>
<td>59</td>
<td>15</td>
<td>30</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>24</td>
<td>16</td>
<td>32</td>
<td>45</td>
<td>27</td>
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<td>5</td>
<td>15</td>
<td>42</td>
<td>15</td>
<td>16</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>54</td>
<td>15</td>
<td>27</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>51</td>
<td>17</td>
<td>30</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>25</td>
<td>14</td>
<td>27</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>25</td>
<td>53</td>
<td>15</td>
<td>28</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>15</td>
<td>16</td>
<td>19</td>
<td>44</td>
<td>18</td>
</tr>
<tr>
<td>11</td>
<td>29</td>
<td>53</td>
<td>14</td>
<td>74</td>
<td>10</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>30</td>
<td>15</td>
<td>26</td>
<td>34</td>
<td>21</td>
</tr>
</tbody>
</table>

6.2.2 Rail scenario

Very small volumes could be transferred to from road to rail economically. Table 6.6 shows the totals obtained by summing all the years across the cycle 2002-2010. In the case of the 2002-2020 cycle only 7.6 Mt or 2.3% of the total tonnage can be transported more economically by rail. For all cycles analysed, the potential amounts to transfer are all below 3% of the total tonnage.

Most of the waste shifted to rail is made up of commercial waste (96%) coming from waste strategy areas 7 and 9. The remaining waste shifted is made up of special and clinical (4%) from WSA 4. These were the only flows with the right combination of large volumes, longer lengths of haul and access to rail available.

For the year 2002 the average length of haul is 39 miles and this increases slightly to 45 and 55 miles for the cycles 2002-2010 and 2002-2020 respectively. This longer average distance for the rail case in comparison to road is in line with expectations as rail is competitive only at longer distances. In the case of special and clinical waste for example, the length of haul is over 140 miles. The economies of scale with respect to distance can be seen in the transport costs per tonne at £2.56 for rail (2002-2020), which are almost twice the costs of road. When the costs are estimated per unit of distance, rail becomes cheaper at £0.053 per tonne-mile. This lower cost means that £4.7 million are saved over the cycle 2002-2020, although this is just 1% of the total road transport costs over the same period.

There are many other logistic combinations in rail transport that would give different cost estimates. Just changes in one single variable, such as adding more wagons to a locomotive can have a substantial effect on costs over a whole cycle. However, even with these operational changes, the fundamental characteristic that makes rail transport competitive remains valid, which is that it would only be economically viable to move large volumes over longer distances using rail. The large majority of waste flows in Scotland are over short distances and using small volumes so there is a very limited scope for using rail in this scenario.

If the volumes of waste are transported between the same origin and destinations, the only way to make rail attractive is to consolidate most loads. The scope for consolidation, however, is very limited in this case as most distances are short. Even in the case of longer hauls and bigger loads, consolidation may not be feasible for lack of facilities or logistic problems. There would be many operational problems that have to be studied case by case, although the results of the aggregate model

<table>
<thead>
<tr>
<th>Year range</th>
<th>Cumulative tonnes</th>
<th>Percentage of total waste</th>
<th>Tonne-miles by rail</th>
<th>Length of rail haul (miles)</th>
<th>Average cost per tonne (£)</th>
<th>Average cost per tonne mile (£)</th>
<th>Total rail transport costs (£)</th>
<th>Costs saved over road (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>235,237</td>
<td>1.5%</td>
<td>9,070,732</td>
<td>39</td>
<td>3.01</td>
<td>0.078</td>
<td>708,139</td>
<td>172,146</td>
</tr>
<tr>
<td>2002-2010</td>
<td>3,055,800</td>
<td>2.1%</td>
<td>136,651,444</td>
<td>45</td>
<td>3.03</td>
<td>0.068</td>
<td>9,255,155</td>
<td>1,779,367</td>
</tr>
<tr>
<td>2002-2020</td>
<td>7,657,755</td>
<td>2.3%</td>
<td>366,560,560</td>
<td>48</td>
<td>2.56</td>
<td>0.053</td>
<td>19,601,721</td>
<td>4,725,161</td>
</tr>
</tbody>
</table>

All costs in 2003 prices.
presented here can help to identify the waste strategy areas and waste types with the potential to be transferred to other modes.

Although it is very difficult at this stage to obtain an approximate value of the quantities of waste loads that can be consolidated, it is possible to carry out a sensitivity analysis to assess the economic impact of load consolidation on the volumes transported by rail in this case. The effect of consolidating the waste volumes into bigger loads is, in fact, that the fixed costs are spread over a higher number of tonnes and miles, obtaining lower transport costs per tonne mile.

In summary, for the current O-D flows, there is a very limited scope to shift loads from road to rail transport and the maximum is well below 5% of the total tonnage. This is also an optimistic scenario for rail, as the overall costs of load consolidation or a specific modal penalty for rail were not considered in this assessment and would have reduced the attraction of rail over road transport if they were included in the model.

### 6.2.3 Waterways scenario

All O-D pairs that had access to canals and coastal shipping were considered together in the same model, as the volumes transferred to each mode were very small. Only those O-D volumes with more than 1,000 tonnes per year and which were cheaper to move in the new transport mode were transferred from road to canals and coastal shipping modes. The choice of 1,000 tonnes was a function of the minimum volume required to ensure constant use for the mode. A summary of the results is given in Table 6.7. As in the case of rail, there is a very limited scope to transfer significant volumes, with less than 1% transported by waterways in all the cycles studied, as Table 6.7 shows.

All waste transferred to waterways is made up of industrial waste from WSAs 1, 10 and 11. The length of haul for waterways is more than five times longer than for road (117 miles for the cycle 2002-2020), as waterways like rail are only economical over longer distances. Note that the length of haul decreases from 219 miles in 2002 to 117 in the cycle 2002-2020. This is explained by some O-D flows that become economical to transfer to waterways later in the cycle 2002-2020. These added volumes had a lower average length of haul (82 miles) reducing the overall distance for the whole sample in later years of the cycle.

Given the very low volumes transferred, cost savings from waterways transport are minimal over the whole cycle 2002-2020, amounting to just 0.3% of the total road transport costs. Even increasing consolidating loads would not make significant changes to the volumes shifted to this mode, as in the model used canals show economies of scale with respect to distance but not with respect to volumes. This can be seen with another run of the waterways model where handling costs for canals were halved, which has the same effect as increasing substantially the length of haul for this mode. Handling costs are the largest cost element in canal transport amounting to £10 per tonne, so their reduction to £5 per tonne was likely to have a significant impact in the model. The percentages do increase substantially from 0.3% of the total volume to 0.9% with the cost reduction, although this is still less than 1% of the total waste tonnage. This confirms that at the moment there is little scope for the original transport scenarios to transfer substantial amounts to waterways in a cost effective way.

### 6.2.4 Maximum transfer to rail and water modes in WSA 10

For WSA 10 it was found that 72,931 tonnes would be more economical to be transported by waterways instead of road which is less than 0.1% of the total volume. It was not found economical to transfer any waste onto rail in WSA 10.

### 6.2.5 Supersites scenarios

For this scenario, four Supersites for the all waste disposal were selected (excluding waste recovered). These were chosen to be located across Scotland. This was a theoretical exercise to see the impact of consolidating

---

**Table 6.7 Characteristics of the waste transported by canals and coastal shipping for all cycles**

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative tonnes</td>
<td>2,437</td>
<td>55,889</td>
<td>201,368</td>
</tr>
<tr>
<td>Percentage of total waste</td>
<td>0.02%</td>
<td>0.04%</td>
<td>0.06%</td>
</tr>
<tr>
<td>Cumulative tonne-miles by waterways</td>
<td>533,825</td>
<td>7,712,161</td>
<td>23,463,352</td>
</tr>
<tr>
<td>Average length of haul (miles)</td>
<td>219</td>
<td>138</td>
<td>117</td>
</tr>
<tr>
<td>Average cost per tonne (£)</td>
<td>6.41</td>
<td>5.10</td>
<td>3.77</td>
</tr>
<tr>
<td>Average cost per tonne mile (£)</td>
<td>0.029</td>
<td>0.037</td>
<td>0.032</td>
</tr>
<tr>
<td>Cumulative total water transport costs (£)</td>
<td>15,625</td>
<td>285,112</td>
<td>759,897</td>
</tr>
<tr>
<td>Cumulative costs saved over road (£)</td>
<td>51,669</td>
<td>450,518</td>
<td>997,946</td>
</tr>
</tbody>
</table>

*All costs in 2003 prices.*
waste transfer and therefore landfills were selected at random conferring to the basic specifications below:

- Between Inverness and Aberdeen.
- South of Edinburgh.
- North of Glasgow.
- North of Edinburgh.

Each O-D volume was allocated a suitable distance to the closest Supersite for the different modes considered (road, rail and waterways). The aim of the model is to compare the costs of transport to these Supersites against the original base case scenario, and find out the possibilities for shifting some of the waste volumes to alternative modes.

### 6.2.5.1 Road Supersites scenario

A summary of the results for the road Supersite scenario are presented in Table 6.8. Although the volumes remain the same as in the base case scenario (all road), all destinations have now much longer lengths of haul, with an average of around 69 miles which is an increase of 229% over the original base case scenario by road as shown in Table 6.8 (cycle 2002-2020). The length of haul increases are not uniform across all areas, as some show much higher rises such as WSA 1 with a length of haul of 144 miles (a 323% increase), and WSA 2 with 161 miles (a change of 419%). With the new distances, C&DW, which had the shortest length of haul originally in the base case (15 miles), now has the longest at 85 miles, followed by industrial waste with 68 miles and commercial waste with 52 miles.

The changes in costs with respect to the base case scenarios are also driven by the longer distances. The costs increase to £1.23 Billion over the cycle 2002-2020, which is a change of 230%. This rise corresponds to the percentage change in the average length of haul, and this increase is roughly the same across all the cycles studied (2002, 2002-2010, 2002-2020).

More detailed results are presented in Table 6.9 to Table 6.12.

### 6.2.5.2 Rail Supersites scenario

As the lengths of haul are much longer and in many cases go across WSA boundaries, many more loads can be consolidated when considering Supersites versus current waste management infrastructure. At this stage it is not possible to determine the precise amounts for this consolidation, as this would require detailed information on transport infrastructure and the costs on a case by case basis. For example, two O-D pairs could be located at opposite extremes of the WSA, and the costs for consolidation would be too high. In most cases volumes would be within a reasonable distance when compared with the longer haul required to reach the Supersites.

The results presented in Table 6.13 show a limited scenario where all the volumes within each WSA are consolidated according to waste type. As in the other examples shown in this report this scenario only compares the travel costs from the transfer station to the final landfill site without including consolidation costs. These could be substantial and reduce the attractiveness of rail and waterways.

Note that the road leg of the journey had to be recalculated from the rail inter-modal transfer stations to the Supersites, and in most cases it is longer than the distance estimated for the original scenario without the Supersites. The rail distances were estimated as a proxy to the original road distances for the Supersites road case scenario.

The effects of consolidation and longer hauls have a dramatic effect on the volumes that can be transferred to railways, as shown in Table 6.13. Instead of just 2% of the total volumes moved in the original rail case, in the Supersites scenarios the volumes go up to 259.9 Mt or 80% of the total volume in the cycle 2002-2020. There are no volumes transferred to rail in WSAs 1, 2, and 11. In the remaining WSAs, some categories were more

<table>
<thead>
<tr>
<th>Table 6.8 Characteristics of the waste transported to Supersites by road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Cumulative tonnes</td>
</tr>
<tr>
<td>Percentage of total waste</td>
</tr>
<tr>
<td>Percentage change tonne miles</td>
</tr>
<tr>
<td>Average length of haul (miles)</td>
</tr>
<tr>
<td>Percentage change length of haul</td>
</tr>
<tr>
<td>Average cost per tonne (£)</td>
</tr>
<tr>
<td>Average cost per tonne mile (£)</td>
</tr>
<tr>
<td>Cumulative total road transport costs (£)</td>
</tr>
<tr>
<td>Percentage change of costs over base case (all road)</td>
</tr>
</tbody>
</table>

All costs in 2003 prices.
### Table 6.9 Supersites scenario – all road transport – cycle 2002 – 2020: cumulative total tonnage

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>398,938</td>
<td>80,119</td>
<td>213,879</td>
<td>315,593</td>
<td>32,260</td>
<td>1,040,789</td>
</tr>
<tr>
<td>2</td>
<td>231,229</td>
<td>55,091</td>
<td>285,164</td>
<td>140,763</td>
<td>4,774</td>
<td>717,021</td>
</tr>
<tr>
<td>3</td>
<td>1,573,442</td>
<td>838,913</td>
<td>3,017,955</td>
<td>9,854,990</td>
<td>7,383,273</td>
<td>34,256,242</td>
</tr>
<tr>
<td>4</td>
<td>3,415,687</td>
<td>2,965,644</td>
<td>11,358,868</td>
<td>4,222,916</td>
<td>3,414,834</td>
<td>33,478,080</td>
</tr>
<tr>
<td>5</td>
<td>2,912,045</td>
<td>1,183,083</td>
<td>17,584,845</td>
<td>19,082,728</td>
<td>295,699</td>
<td>31,554,841</td>
</tr>
<tr>
<td>6</td>
<td>2,427,631</td>
<td>1,514,913</td>
<td>7,865,664</td>
<td>14,584,886</td>
<td>8,547,512</td>
<td>120,961,406</td>
</tr>
<tr>
<td>7</td>
<td>3,203,866</td>
<td>3,340,645</td>
<td>5,631,903</td>
<td>19,082,728</td>
<td>4,993</td>
<td>32,076,171</td>
</tr>
<tr>
<td>8</td>
<td>5,857,075</td>
<td>2,770,034</td>
<td>25,070,293</td>
<td>7,383,273</td>
<td>6,186,423</td>
<td>51,549,228</td>
</tr>
<tr>
<td>9</td>
<td>3,943,578</td>
<td>4,847,980</td>
<td>5,631,903</td>
<td>19,082,728</td>
<td>295,699</td>
<td>31,554,841</td>
</tr>
<tr>
<td>10</td>
<td>18,602,000</td>
<td>15,897,761</td>
<td>14,584,886</td>
<td>8,547,512</td>
<td>4,993</td>
<td>120,961,406</td>
</tr>
<tr>
<td>11</td>
<td>672,737</td>
<td>403,134</td>
<td>831,717</td>
<td>19,082,728</td>
<td>295,699</td>
<td>31,554,841</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>326,374,809</td>
</tr>
</tbody>
</table>

The total tonnage is the same as in the base case scenario – all transported by road.

### Table 6.10 Supersites scenario – all road transport – cycle 2002 – 2020: cumulative total tonne-miles

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50,420,452</td>
<td>9,208,472</td>
<td>24,582,170</td>
<td>56,817,175</td>
<td>7,542,454</td>
<td>148,570,723</td>
</tr>
<tr>
<td>2</td>
<td>37,167,545</td>
<td>8,855,279</td>
<td>45,837,009</td>
<td>22,626,120</td>
<td>767,369</td>
<td>115,235,320</td>
</tr>
<tr>
<td>3</td>
<td>145,674,848</td>
<td>80,885,801</td>
<td>297,721,975</td>
<td>109,552,453</td>
<td>2,640,345</td>
<td>636,475,422</td>
</tr>
<tr>
<td>4</td>
<td>214,081,450</td>
<td>156,179,811</td>
<td>1,096,418,452</td>
<td>239,478,398</td>
<td>1,351,153,169</td>
<td>2,295,589,838</td>
</tr>
<tr>
<td>5</td>
<td>114,928,756</td>
<td>88,016,307</td>
<td>1,655,192,774</td>
<td>197,973,603</td>
<td>1,351,153,169</td>
<td>2,295,589,838</td>
</tr>
<tr>
<td>6</td>
<td>237,869,212</td>
<td>150,575,931</td>
<td>756,175,533</td>
<td>368,532,174</td>
<td>2,400,319</td>
<td>1,537,153,169</td>
</tr>
<tr>
<td>7</td>
<td>181,739,551</td>
<td>302,255,368</td>
<td>496,047,397</td>
<td>1,800,539,710</td>
<td>7,067,082</td>
<td>2,787,649,108</td>
</tr>
<tr>
<td>8</td>
<td>74,347,586</td>
<td>112,630,877</td>
<td>2,160,738,555</td>
<td>466,065,507</td>
<td>3,617,144,478</td>
<td>6,180,006,204</td>
</tr>
<tr>
<td>9</td>
<td>241,854,594</td>
<td>477,219,161</td>
<td>1,340,424,433</td>
<td>260,968,356</td>
<td>11,800,422</td>
<td>2,332,316,967</td>
</tr>
<tr>
<td>10</td>
<td>370,870,186</td>
<td>350,456,912</td>
<td>4,724,725,656</td>
<td>409,456,123</td>
<td>324,979,327</td>
<td>6,180,006,204</td>
</tr>
<tr>
<td>11</td>
<td>64,876,481</td>
<td>40,167,420</td>
<td>79,176,240</td>
<td>15,178,168</td>
<td>295,833</td>
<td>199,694,192</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22,496,435,624</td>
</tr>
</tbody>
</table>

### Table 6.11 Supersites scenario – all road transport – cycle 2002 – 2020: cumulative total transport costs in pounds (in 2003 prices)

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,082,702</td>
<td>560,827</td>
<td>1,497,132</td>
<td>3,491,886</td>
<td>463,425</td>
<td>9,095,971</td>
</tr>
<tr>
<td>2</td>
<td>2,315,451</td>
<td>539,090</td>
<td>2,790,454</td>
<td>1,390,726</td>
<td>47,173</td>
<td>7,082,893</td>
</tr>
<tr>
<td>3</td>
<td>9,519,532</td>
<td>5,139,770</td>
<td>18,953,700</td>
<td>7,045,910</td>
<td>171,173</td>
<td>40,830,086</td>
</tr>
<tr>
<td>4</td>
<td>12,377,045</td>
<td>8,700,601</td>
<td>61,516,121</td>
<td>47,002,452</td>
<td>19,687,517</td>
<td>149,283,737</td>
</tr>
<tr>
<td>5</td>
<td>6,581,519</td>
<td>4,919,902</td>
<td>92,812,065</td>
<td>13,408,717</td>
<td>11,067,762</td>
<td>128,789,965</td>
</tr>
<tr>
<td>6</td>
<td>13,912,984</td>
<td>8,448,898</td>
<td>42,428,673</td>
<td>20,884,025</td>
<td>1,356,579</td>
<td>87,031,160</td>
</tr>
<tr>
<td>7</td>
<td>10,617,576</td>
<td>16,952,179</td>
<td>27,820,465</td>
<td>102,013,880</td>
<td>396,568</td>
<td>157,800,666</td>
</tr>
<tr>
<td>8</td>
<td>4,221,660</td>
<td>6,240,989</td>
<td>121,073,495</td>
<td>45,342,411</td>
<td>26,347,100</td>
<td>203,225,655</td>
</tr>
<tr>
<td>9</td>
<td>14,261,926</td>
<td>26,835,731</td>
<td>75,209,489</td>
<td>41,738,939</td>
<td>671,939</td>
<td>131,762,378</td>
</tr>
<tr>
<td>10</td>
<td>21,396,982</td>
<td>19,492,840</td>
<td>264,971,321</td>
<td>23,131,972</td>
<td>18,324,602</td>
<td>347,317,717</td>
</tr>
<tr>
<td>11</td>
<td>3,756,698</td>
<td>2,253,822</td>
<td>4,443,014</td>
<td>860,063</td>
<td>16,788</td>
<td>11,330,384</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,273,550,613</td>
</tr>
</tbody>
</table>

The total tonnage is the same as in the base case scenario – all transported by road.
Table 6.12 Supersites scenario – all road transport – cycle 2002 – 2020: length of haul in miles

<table>
<thead>
<tr>
<th>WSA</th>
<th>Household</th>
<th>Commercial</th>
<th>C&amp;D</th>
<th>Industrial</th>
<th>Special and clinical</th>
<th>Weighted average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>126</td>
<td>115</td>
<td>115</td>
<td>180</td>
<td>234</td>
<td>143</td>
</tr>
<tr>
<td>2</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
</tr>
<tr>
<td>3</td>
<td>93</td>
<td>96</td>
<td>99</td>
<td>89</td>
<td>38</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>63</td>
<td>53</td>
<td>97</td>
<td>84</td>
<td>53</td>
<td>77</td>
</tr>
<tr>
<td>5</td>
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<td>74</td>
<td>94</td>
<td>32</td>
<td>45</td>
<td>69</td>
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<tr>
<td>6</td>
<td>98</td>
<td>99</td>
<td>96</td>
<td>87</td>
<td>14</td>
<td>86</td>
</tr>
<tr>
<td>7</td>
<td>57</td>
<td>90</td>
<td>88</td>
<td>94</td>
<td>24</td>
<td>88</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>41</td>
<td>86</td>
<td>69</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>9</td>
<td>61</td>
<td>98</td>
<td>95</td>
<td>87</td>
<td>68</td>
<td>89</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>22</td>
<td>75</td>
<td>28</td>
<td>38</td>
<td>51</td>
</tr>
<tr>
<td>11</td>
<td>96</td>
<td>100</td>
<td>95</td>
<td>51</td>
<td>59</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>52</td>
<td>85</td>
<td>68</td>
<td>50</td>
<td>69</td>
</tr>
</tbody>
</table>

The length of haul does not change throughout the whole cycle.

Table 6.13 Characteristics of the waste transported by rail to the Supersites – all cycles

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative tonnes</td>
<td>11,218,955</td>
<td>109,548,472</td>
<td>259,982,885</td>
</tr>
<tr>
<td>Percentage of total waste</td>
<td>72%</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Cumulative tonne-miles by rail</td>
<td>747,905,575</td>
<td>7,203,308,391</td>
<td>16,688,307,439</td>
</tr>
<tr>
<td>Average length of rail haul (miles)</td>
<td>67</td>
<td>66</td>
<td>64</td>
</tr>
<tr>
<td>Average cost per tonne (£)</td>
<td>3.19</td>
<td>2.64</td>
<td>2.11</td>
</tr>
<tr>
<td>Average cost per tonne mile (£)</td>
<td>0.048</td>
<td>0.048</td>
<td>0.033</td>
</tr>
<tr>
<td>Cumulative total rail transport costs (£)</td>
<td>69,786,658</td>
<td>289,372,612</td>
<td>547,472,819</td>
</tr>
<tr>
<td>Costs saved over road (£)</td>
<td>33,981,806</td>
<td>298,227,165</td>
<td>607,644,238</td>
</tr>
</tbody>
</table>

All volumes consolidated according to waste type in each WSA. All costs in 2003 prices.

* The rail costs are compared with those for transporting the same consolidated volumes by road.

expensive to move by rail and were not transferred, although these were a small proportion of the total waste. C&DW is the category with the largest volumes transferred (57% of the total volume moved by rail) followed by Industrial waste (23% of the total volume moved by rail). These are also the categories with the highest volumes in the road case scenario. WSA 10 produces the largest volumes moved by rail at 31% of the total transferred.

The average travel distance by rail is 64 tonne-miles over the cycle 2002-2020. This is a similar value to the road scenario which was 69 tonne-miles. The length of haul goes down (67 miles in 2002 to 64 miles in 2002-2020) as flows with higher volumes but shorter distances are transferred from road to rail later on in the cycle. Note that this distance only includes the rail leg of the journey, as the distance by road to access the rail infrastructure is not included in this figure. The transport costs of the road leg of the journey, however, are included in the total cost calculation for rail.

In order to test the effect of including the consolidation costs on the volumes transferred to rail in the case of the Supersites, a cost ‘penalty’ equivalent to 10 miles of extra road transport was added to each of the flows. This only reduced the volumes transferred to rail by 5% in the 2002 cycle to 67% of the total. In other words, the extra costs of consolidation costs do not have a significant effect as the overall saving using rail is substantial.

The cost per tonne mile in the cycle 2002-2020 is £0.033, which is 42% cheaper than road transport. The total cost of rail transport for this case is £547 million, which given the large amounts transferred leads to a substantial 48% saving over the transport of these amounts by road.

6.2.5.3 Waterways Supersites (canals and coastal shipping) scenario

As in the case of railways, the lengths of haul when considering the Supersites are much longer and in many cases go across WSA boundaries, so many more loads can be consolidated. For this reason this model run used the consolidation of all loads according to waste type within each WSA to see if economies of scale can be achieved and waterways can become more attractive in comparison to road transport.
The consolidation and longer hauls to the Supersites have profound effects on the volumes transported as shown in Table 6.14. In the waterways scenario before the Supersites, this mode could not transport more than 1% of the total waste or just 201,368 tonnes for the whole cycle 2002-2020. Now the consolidation manages to increase the volumes to 137 Mt, or 42% of the total for the same period. The growth in volumes also have dramatic effects over time when combined with the consolidation: the volumes for waterways in 2002 are just 1% of the total, but they rise to 42% for the 2002-2020 cycle. Note that during this period, the lengths of haul for all modes are unchanged in the model, so this growth in the waterways is mainly caused by economies of scale caused by rising volumes over time. Although the volumes are lower than for rail, they do indicate that consolidation can also substantially increase the attractiveness of this mode.

In order to test the effect of including the consolidation costs on the volumes moved by water, a cost ‘penalty’ equivalent to moving the loads an additional 15 miles by road was added to each of the consolidated flows. This only reduced the water volumes from 137 Mt (42% of the total) to 98 Mt (30% of total), a reduction of 12%. This indicates that even with the consolidation costs, the economic incentive to transfer significant volumes from road to waterways remains. However, this transfer of volumes is very high and there would be many logistical barriers that would need to be addressed.

The volumes are obtained by carrying out a cost comparison across modes, and do not consider capacity restrictions in the canal network.

An interesting result is that the overall length of haul is reduced from 117 miles in the original waterways case to 79 miles with the Supersites in the cycle 2002-2020. This is contrary to expectations because the overall distances including the road lengths do rise. This is caused by the addition of some flows with shorter lengths of haul that are transferred to waterways and which have cheaper transport costs using waterways. This can also be seen with the growth in volumes over the years: the length of haul decreases from 107 miles in 2002 to just 79 miles in the cycle 2002-2020.

The costs per tonne-mile for waterways are £0.047, which in overall is 18% lower for transporting the same volumes of waste using road transport in the cycle 2002-2020.

6.2.6 Summary of results

The volumes transported by waterways and rail presented for the Supersites scenarios are high in contrast with the tonnages for the first scenarios (without the Supersites). They are, however, also optimistic as the models determined the volumes transferred only by looking at the costs of each mode. In reality, rail is likely to receive far less because the additional flexibility of road has not been built up in the cost model. In addition the costs of consolidation may make rail and waterways expensive when compared with road. Capacity constraints for waterways were not built into the model due to lack of information, and the volumes allocated may exceed capacity.

Table 6.15 to Table 6.17 show the main outputs from the models in terms of volumes and costs for transport. Figure 6.1 illustrates the difference between the cumulative transport costs for all the scenarios. With the current landfill sites, there is very little scope to transport waste to other modes as most volumes are small and the scope for consolidation is limited given the short lengths of haul (21 miles in average). Rail can only receive a maximum of 2.3% of the total tonnage, while the waterways volumes are well below 1%. The main transfers correspond to Commercial (WSA 4 and 7) and Special and Clinical (WSA 9) in the case of transfers to rail. In the case of transfers to waterways, only industrial waste is transferred for WSAs 1, 10 and 11.

In contrast, when the Supersites are introduced the cost model shows a substantial increase in the transfer to other modes. This is mostly due to the effects of consolidating all waste according to waste type within each WSA. The shift to other modes is also encouraged by the longer lengths of haul with an average of 69 miles in the period 2002-2020.

Table 6.14 Characteristics of the waste transported by waterways to the Supersites – all cycles

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative tonnes</td>
<td>238,492</td>
<td>25,387,791</td>
<td>137,433,083</td>
</tr>
<tr>
<td>Percentage of total waste</td>
<td>1%</td>
<td>17%</td>
<td>42%</td>
</tr>
<tr>
<td>Cumulative tonne-miles by rail</td>
<td>25,554,975</td>
<td>2,188,701,944</td>
<td>10,870,829,950</td>
</tr>
<tr>
<td>Average length of water haul (miles)</td>
<td>107</td>
<td>86</td>
<td>79</td>
</tr>
<tr>
<td>Average cost per tonne (£)</td>
<td>8.59</td>
<td>5.54</td>
<td>3.71</td>
</tr>
<tr>
<td>Average cost per tonne mile (£)</td>
<td>0.080</td>
<td>0.064</td>
<td>0.047</td>
</tr>
<tr>
<td>Cumulative total water transport costs (£)</td>
<td>2,049,651</td>
<td>140,685,822</td>
<td>509,832,401</td>
</tr>
<tr>
<td>Costs saved over road (£)</td>
<td>223,611</td>
<td>12,065,338</td>
<td>114,189,705</td>
</tr>
</tbody>
</table>

All costs in 2003 prices.
Table 6.15 Summary of potential modal transfer to rail and waterways for all scenarios

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative total volume (tonnes)</td>
<td>15,570,005</td>
<td>145,888,739</td>
<td>326,374,809</td>
</tr>
</tbody>
</table>

**Percentage transfers to:**

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>1.5%</td>
<td>2.1%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Waterways</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Supersites rail*</td>
<td>72%</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Supersites waterways*</td>
<td>1%</td>
<td>17%</td>
<td>42%</td>
</tr>
</tbody>
</table>

* Revised percentages for the Supersites are presented in Table 6.21.

Table 6.16 Waste strategy areas involved with the transfer to rail and water in cycle 2002-2020

<table>
<thead>
<tr>
<th>Transfers to</th>
<th>Type of waste</th>
<th>WSA</th>
<th>Percentage of total volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail (2.3%)</td>
<td>Commercial</td>
<td>4</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>7</td>
<td>0.8%</td>
</tr>
<tr>
<td></td>
<td>Special and clinical</td>
<td>9</td>
<td>1.4%</td>
</tr>
<tr>
<td>Waterways (0.1%)</td>
<td>Industrial</td>
<td>1</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>10</td>
<td>0.02%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>11</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

Table 6.17 Cumulative transport costs for all cycles

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case (all road)</td>
<td>24,732,260</td>
<td>202,961,042</td>
<td>386,387,520</td>
</tr>
<tr>
<td>Rail* (£)</td>
<td>24,560,114</td>
<td>201,181,675</td>
<td>381,662,359</td>
</tr>
<tr>
<td>% change to base case</td>
<td>-1%</td>
<td>-1%</td>
<td>-2%</td>
</tr>
<tr>
<td>Waterways* (£)</td>
<td>24,680,591</td>
<td>202,510,525</td>
<td>385,389,574</td>
</tr>
<tr>
<td>% change to base case</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Supersites (all road) (£)</td>
<td>79,883,000</td>
<td>661,617,057</td>
<td>1,273,550,613</td>
</tr>
<tr>
<td>Supersites rail* (£)</td>
<td>45,901,195</td>
<td>363,389,893</td>
<td>665,906,374</td>
</tr>
<tr>
<td>% change to Supersites road</td>
<td>-43%</td>
<td>-45%</td>
<td>-48%</td>
</tr>
<tr>
<td>Supersites waterways* (£)</td>
<td>79,659,389</td>
<td>649,551,719</td>
<td>1,159,360,908</td>
</tr>
<tr>
<td>% change to Supersites road</td>
<td>0%</td>
<td>-2%</td>
<td>-9%</td>
</tr>
</tbody>
</table>

* Includes the road transport costs for volumes that were not shifted to rail or waterways. 2003 prices.

It is worth noting that while costs reductions are limited when transferring volumes in the original scenario (2% in the railways scenario and 0% for waterways); the situation is very different with the Supersites. When the longer lengths of haul and load consolidation are introduced, the model indicates that substantial volumes transported to the Supersites can be shifted to other modes. According to the model, for the cycle 2002-2020, rail can take 81% of the volumes, leading to a reduction of 52% in the transport costs, while waterways can take 42% of the tonnage with a corresponding reduction in transport costs of 9%. Clearly in a combined transport rail/waterway scenario one or both of these figures would be somewhat lower. The cost savings increase very slowly in the case of rail (47% in 2002 to 52% in 2002-2020) as the percentage of volumes transfer remains more or less constant. In contrast, the volumes moved to waterways increase substantially from 1% in 2002 to 42% in 2002-2020. This is also reflected in the total costs savings obtained with this mode, growing in the same period from 0% to 9%.
6.2.7 Emissions to air for all scenarios

Table 6.18 to Table 6.20 show the total emissions of CO₂, NOₓ, and PM_{10} produced for each of the scenarios. Note that the emissions are estimated for all the journey length, including the road legs to reach inter-modal terminals. In the case of volumes shifted to other modes, their emissions were added to those produced by the tonnages that were still transported by road, giving the total of emissions in each scenario. The emissions for loading and unloading equipment are not considered, which slightly underestimates the emissions for rail and water, making them look more favourable.

The figures indicate that for the original scenarios without the Supersites there are no reductions in emission levels by transferring volumes to rail and water. In fact, in the large majority of cases the emissions are slightly higher (less than 1%) than in the road scenario. Although mile per mile, rail and water have lower emissions than road, the models are producing higher emissions because there is a road leg added to both ends of the rail and water scenarios which increases the overall emission levels for each scenario.

The case is the opposite in the case of the Supersites: rail has almost half the emissions of road in the Supersites because there are substantial volumes transferred to this mode (over 80%) and the lengths of haul are much higher. The reductions in emissions for waterways are less substantial and the environmental benefits not as clear cut as in rail, because in some cases (i.e. PM_{10} in the year 2002) the emissions are even higher.

6.3 Conclusions

The cost model developed for this study has enabled the potential for modal shift of waste transport to be identified at a strategic level. The costing information provided by the model was setup and run to do a comparison between different modes. As such at present it is sufficient to allow a top line comparison of different transport modes for Scotland as whole. However, the data produced should not be used as absolutes for each mode, particularly given some of the assumptions that have made and the quality of some of the data used. The model is not currently accurate and comprehensive enough to start evaluating the effect of marginal changes in one or other of the input variables e.g. changes in fuel costs.

The volumes and cost reductions obtained using rail and waterways from the model, are optimistic as they do not include the logistic barriers to inter-modality, capacity constraints for alternative modes or problems for consolidation. It is likely that in most cases, road would remain the preferred choice for waste transport because of its flexibility and the difficulty in consolidating some volumes, leading to the loss of the cost savings demonstrated by the model. Only when looking at the Supersites scenarios do rail and waterways start having the potential to make up a substantial percentage of total waste transport. The percentages possible are summarised in Table 6.21. Note that the model runs for the Supersites were created assuming full consolidation by waste type within each WSA, although the precise degree of consolidation possible cannot be determined without further detailed analysis of the logistic possibilities and the capacity constraints for rail and waterways. Therefore the percentages of waste volumes transported by rail and waterways presented in Table 6.21 are lower than those calculated by the models. These are considered to be more realistic estimates of the potential modal transfer possible.
Table 6.18 CO₂ (in kg)

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>All road base case</td>
<td>75,083,426</td>
<td>704,797,757</td>
<td>1,577,003,200</td>
</tr>
<tr>
<td>Rail</td>
<td>75,065,563</td>
<td>705,930,431</td>
<td>1,581,209,204</td>
</tr>
<tr>
<td>Water</td>
<td>75,100,714</td>
<td>705,179,880</td>
<td>1,577,945,641</td>
</tr>
<tr>
<td>Supersites road</td>
<td>240,352,901</td>
<td>2,280,671,271</td>
<td>5,174,180,194</td>
</tr>
<tr>
<td>Supersites rail</td>
<td>142,215,045</td>
<td>1,295,741,615</td>
<td>2,753,028,760</td>
</tr>
<tr>
<td>Supersites water</td>
<td>239,055,985</td>
<td>2,135,632,517</td>
<td>4,271,234,318</td>
</tr>
</tbody>
</table>

Table 6.19 NOₓ (in kg)

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>All road base case</td>
<td>907,530</td>
<td>8,518,860</td>
<td>19,061,169</td>
</tr>
<tr>
<td>Rail</td>
<td>907,153</td>
<td>8,530,126</td>
<td>19,105,504</td>
</tr>
<tr>
<td>Water</td>
<td>908,015</td>
<td>8,527,461</td>
<td>19,084,676</td>
</tr>
<tr>
<td>Supersites road</td>
<td>2,905,135</td>
<td>27,566,374</td>
<td>62,540,091</td>
</tr>
<tr>
<td>Supersites rail</td>
<td>1,705,680</td>
<td>15,533,792</td>
<td>32,979,703</td>
</tr>
<tr>
<td>Supersites water</td>
<td>2,902,655</td>
<td>26,943,429</td>
<td>57,239,353</td>
</tr>
</tbody>
</table>

Table 6.20 PM₁₀ (in kg)

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>All road base case</td>
<td>52,232</td>
<td>490,294</td>
<td>1,097,046</td>
</tr>
<tr>
<td>Rail</td>
<td>52,166</td>
<td>490,274</td>
<td>1,097,804</td>
</tr>
<tr>
<td>Water</td>
<td>52,265</td>
<td>490,859</td>
<td>1,098,611</td>
</tr>
<tr>
<td>Supersites road</td>
<td>167,202</td>
<td>1,586,554</td>
<td>3,599,430</td>
</tr>
<tr>
<td>Supersites rail</td>
<td>94,510</td>
<td>858,792</td>
<td>1,816,472</td>
</tr>
<tr>
<td>Supersites water</td>
<td>167,291</td>
<td>1,570,541</td>
<td>3,392,893</td>
</tr>
</tbody>
</table>

Table 6.21 Summary of potential modal transfer – Supersites scenarios only

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2002-2010</th>
<th>2002-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative total tonnage</td>
<td>15,570,005</td>
<td>145,888,739</td>
<td>326,374,809</td>
</tr>
<tr>
<td><strong>Percentage transfers to:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supersites rail</td>
<td>25-40%</td>
<td>25-40%</td>
<td>25-40%</td>
</tr>
<tr>
<td>Supersites waterways</td>
<td>&lt;1%</td>
<td>5%</td>
<td>5-15%</td>
</tr>
</tbody>
</table>

It has not been possible at this stage, to measure the total transport costs taking into account the logistic restrictions as this would require very detailed information on the waste flows. This has to be done in a case by case basis.

Road is the predominant means of transporting waste in Scotland, and for the existing situation there is little scope to transfer significant volumes to other rail, canals and coastal shipping. The additional initial costs for transfer and infrastructure access are too high when considered the average length of haul (21 miles) and the small volumes that most O-D pairs have. Over the cycle 2002-2020, the maximum percentage that can be transferred to rail is just 2.3%, while for waterways (canals and coastal shipping) this percentage is even lower at 0.06%. This is also a conservative estimate, as modal attributes such as the flexibility of road and the traditional preference of shippers for this mode were not considered in this exercise, which mostly focused on costs across modes. The transfers to rail and water do not bring any benefit in terms of reducing emissions, as the lower emissions per mile in these modes are more than offset by the extra emissions caused by transporting the loads by road to the inter-modal stations.

The situation is different in the case of the Supersites scenarios, where substantial volumes can be transferred to rail and waterways. The consolidation of more loads is likely, leading to economies of scale. In the case of the
Supersites it is estimated that rail could take from 25 to 40% of the total tonnage, while it is estimated that the volumes transferred to waterways may range from 5 to 15%. Substantial cost savings can be achieved, and this would be more substantial in the case of rail transport (which can receive a greater volume of waste) than for waterways. In the model with no logistic restrictions, the cost savings over the 2002-2020 cycle were as high as 50% in the case of railways, and 9% for waterways. There is also a clear reduction in emissions for rail in contrast to road. Waterways in contrast, have almost no reduction in emissions when compared to road. These high volumes for rail and waterways, however, may be over-optimistic as in practice there would be many logistic constraints. The model nevertheless indicates the potential to use these modes for longer hauls. To get this level of modal transfer, load consolidation on a large scale would be required, with the use of inter-modal stations or depots. Substantial consolidation of loads is fundamental to make the transfer to non-road modes attractive, and shows that economies of scale can be achieved leading to substantial cost savings.
7 Conclusions and recommendations

7.1 Current position of waste transport in Scotland

Objective: allow interested stakeholders to evaluate the current position of waste transport.

7.1.1 Policy, legislative and planning issues

Policy and legislation at a National, UK and European level is supporting the shift of freight transport from road to alternative modes.

The key transport policy aims in relation to waste transport are:

- Decrease environmental impact.
- Decrease transport distances.
- Investigate alternative transport modes to road.
- Work with the location of facilities in terms of land use planning.
- Deliver an integrated, multi-modal approach.

Waste policy and legislation is driving increasing segregation and recovery of waste steams. This will lead to an increasingly dispersed array of waste transport origins and destinations. The various waste streams require both diverse waste transport arrangements and in addition the markets for the segregated wastes will vary. Policy and legislation will drive up disposal/management costs hence increasing pressure for minimisation and treatment to become more cost effective.

There is a trend towards an increasingly integrated approach towards waste management and its relationship to transport. Planning policy is driving the following:

- Multi modal transport solutions.
- Modal shift away from road transport.
- Achieving economies of scale.
- Integrating land use and transport planning.

The trend in land use planning will take on a more integrated approach to the use of land, hence waste management facilities should increasingly be considered alongside urban development.

From the brief review possible in this study it has been identified that the available guidance on appraisal of waste management and transportation options is not structured to provide a systematic and robust appraisal framework by which the national, regional and local environmental trade-offs can be examined. Further, the appraisal frameworks do not capture the differing environmental characteristics of the alternative transport modes associated with the movement of waste. There are no explicit mechanisms by which the transport implications of the waste strategies are captured and incorporated into the appraisal processes.

7.1.2 Infrastructure restrictions

Currently the majority of waste transport in Scotland is conducted by road freight. Domestic waste accounted for 1.0 Mt of rail freight in 2000, with bulk containerised waste being carried from a refuse transfer station in Edinburgh to a landfill site near Dunbar (MDS Transmodal, 2002).

The design and location of waste management facilities in Scotland generally favour access to the trunk road network. Waste transport by road is only constrained by the network’s capacity. The possibilities to move waste by rail or on inland waterways however, are more limited.

Some of the waste transfer stations located in major towns and cities may be accessible via inland waterways. However, the majority of landfill sites to which waste is sent are not located close to canals or rivers. Waste transport on inland waterways is also constrained by the characteristics and dimensions of the waterways network itself.

Waste transport on the rail network is constrained in similar ways as on the inland waterways. Waste management facilities in Scotland have not been located with consideration for access to the rail network. Therefore transport via these facilities on rail requires an additional road leg and thus additional handling cost and time. Rail presents additional restrictions in terms of loading gauge and speed restrictions. The transport of waste by rail is possibly most constrained by the network capacity. However, the current utilisation of network capacity in Scotland is not uniform with some areas very under utilised. Current infrastructure restrictions do not preclude modal shift.

The Opportunities for Developing Sustainable Freight Facilities in Scotland (MDS Transmodal, 2002) study recommends that a number of strategic freight interchanges should be developed to support modal shift. Significant freight-generating uses should be located as close to the rail network, strategic freight facilities and ports as possible.

Transport policy includes the provision of grants to improve freight facilities. These are driving
improvements in both water and rail infrastructure and removing lorry miles from Scotland’s roads. This should drive twin benefits in terms of waste transport. Firstly congestion on the roads will be reduced and therefore waste transport by road should become more efficient with reduced environmental impacts. Secondly the infrastructure improvements should facilitate the movement of waste onto these modes.

7.1.3 Waste flows
To date, waste transportation by rail is uncommon, but existing rail infrastructure does not limit its use in the future. Waste movement by canal and waterways in general is minimal.

The results of a telephone survey and SEPA transfer station data have shown that the majority of waste in Scotland is transported within one waste strategy area.

The survey results showed that mixed waste and Special Waste were more likely to travel across several WSAs.

Costs of waste transport varied widely from £1/tonne up to £1000s/tonne, due to the widely varying nature of waste materials transported and handled.

The impacts of the Landfill Directive with respect to the classification of landfill sites, means that in Scotland, there are no landfill sites earmarked to manage Special Waste as of July 2004. This will have a significant impact on the current behaviour and costs associated with the haulage of such waste, with material being moved over much longer distances in the future than those recorded in the preparation of this report. The sustainability of a waste management infrastructure which involves there being no local disposal facilities for special waste must be questioned. Further work is required to develop an understanding of the impacts of the closure of landfill sites for special waste. With respect to the collection of waste arising data, future rates of waste arising growth should be monitored as part of the process of informing future policy.

7.1.4 Data availability
Data in Scotland on waste arisings, transport and costs are poor. A number of assumptions had to be made in the collation of waste transport data for this study. A summary of the data gaps and limitations are given below.

- The LAWA reports used for validation of data in this study do not contain total waste arisings for industrial, commercial and special waste. The Waste Transfer Station data supplied by SEPA provides additional information on industrial and commercial waste, but currently, there is limited data available on total waste arisings for commercial waste streams.
- Commercial waste is collected by a mix of private and public organisations. Information from private collectors is not readily available and therefore the commercial waste data are incomplete.
- Like commercial waste, industrial waste arisings are difficult to validate due to the mixed nature of the waste collection.
- Special waste arisings had to be validated against SWMBA and SEPA transfer station data because LAWA data does not contain information on special waste arisings.
- There is currently no comprehensive data on origin and destination of wastes transported. In this study the data had to be collated from questionnaire responses and analysis of SEPA waste transfer station data which in itself is incomplete.
- Due to incomplete data sets there is no comprehensive data on waste imports and exports across WSAs.

In summary data on waste in Scotland are currently inadequate for both waste planning and strategic planning purposes.

7.2 Potential for modal transfer

Objective - provide guidance on the optimum transport mode based upon:

- Cost of transport and value of waste.
- The characteristics of the waste.
- Energy and fuel consumption.
- Travel time and distance.
- Road congestion.
- Environmental performance.

Without any modal shift of waste transport road transport in Scotland, and related impacts such as congestion and pollution, will increase. Changing practices in terms of the separate collection of waste, the segregation of waste and recycling will add to the transport burden of the industry. It is therefore vital that all opportunities for modal transfer and environmental impact reduction are sought. This requires an integrated approach from the outset.

The cost modelling presented in Chapters 5 and 6 examined the potential to shift waste transport off road. This examined only the movement of residual wastes after recovery from transfer station to landfill site. The potential
modal shift was examined on the basis of costs: i.e. if it was cheaper to transfer by a mode alternative to road.

The economics suggest that only marginal modal shift is feasible with existing waste infrastructure. The outputs from the model have clearly demonstrated that while there is potential for modal shift from road to rail or waterways even this will only be able to deal with a relatively small proportion of the overall waste arisings. Over the cycle 2002–2020, the maximum percentage that can be transferred to rail is just 2.3%, while for waterways (canals and coastal shipping) this percentage is even lower at 0.06%. The transfers to rail and water do not bring any benefit in terms of reducing emissions, as the lower emissions per mile in these modes are more than offset by the extra emissions caused by transporting the loads by road to the inter-modal stations.

While the cost modelling takes into account the externalities of emissions to air and congestion in the case of road, no other environmental externalities were included in the modelling. This is due to the current uncertainty of how environmental impacts should be assigned an economic cost and the lack of data for rail and water. Therefore the full benefits of modal transfer have not been accounted for within this modelling exercise.

Although the modal potential indicated as a proportion is small it should not be discounted. The savings over a base case of all road were in the range of £1 - £4.7 million. While the volumes of waste are relatively small this shows potential for segregated waste streams to be transported by alternative modes rather than looking at mixed waste disposal alone. The movement of segregated waste and waste for recovery has so far been beyond the scope of this study. The added value of some of these segregated waste streams has the potential to shift the economics. The potential for this is shown by the demonstration projects on aggregates that British Waterways have been involved with (see Section 4.3).

It should be noted that the modal transfer figures obtained using rail and waterways from the model, are optimistic. The model does not include external costs for rail and water, the logistic barriers to inter-modality, capacity constraints for alternative modes or problems related to waste consolidation.

Moving from present infrastructure to Supersites dramatically improves the economics of transport by modes other than road. This is consistent with consolidating all waste management facilities at multi treatment centres and gives economies of scale to treatment. When looking at the cumulative cycle of 2002-2020 there is the potential for a shift of 25-40% of the total waste transported by rail, and 5-15% of waste transported by water. In addition the emissions to air are lower than for road only. Two main factors make modal transfer more economic when considering Supersites. Firstly consolidation of loads is more likely when there are fewer destinations for the waste, leading to economies of scale. In addition the transport distances get longer, and therefore rail and waterways become more economic.

While the modal transfer is significant when examining Supersites the total cumulative costs rises by a huge amount. The total cumulative cost for transport in all roads base case was £0.39 billion, this rises to a cumulative cost in all roads Supersite scenario of £1.23 billion.

Potentially moves towards modal shift will be met with reluctance by some members of the freight industry. The phone questionnaire survey (see Chapter 4) to waste haulers in Scotland indicated that while over half the respondents were aware of alternative transport options, less than a third stated they would change transport modes even if it makes financial sense to do so. The results reflect in fact that a substantial proportion of the freight industries currently involved with the movement of waste are road haulers.

### 7.3 Recommendations – future change and next steps

Objective: provide information in a form that can be fed into the planning process, at both the strategic and local level, to inform decisions on integrated transport of waste.

The National Planning Framework (SE, 2004c) states that ‘local authorities will have to work closely together to ensure that facilities are sited in appropriate locations, to identify the most sustainable transport options, and to avoid duplication and achieve economies of scale. Relevant considerations when locating facilities will include the proximity principle and their relationship to the transport network and remaining landfill sites. Modern treatment and transfer centres are contained facilities which can be accommodated on industrial estates. Where possible, they should be located close to the population centres they serve. They should be linked to landfill sites in a ‘hub and spoke’ arrangement, where possible by rail.’

This study has provided a strategic review of the current waste movements in Scotland. The model developed is the basis of a decision making tool which can be used by waste strategists and planners alike to ensure that facilities are located in appropriate locations with consideration given to modal shift.
The following discussion presents the recommendations from the study. Broadly the recommendations fall into two groups. Firstly there are strategic policy recommendations to move towards a successful integrated transport options for waste in Scotland. Secondly there are recommendations to build on and improve the work that has been carried out in this study.

Planning authorities need to consider AWPs and adopt a positive planning approach to the promotion of sustainable waste management by facilitating suitable locations for waste management facilities in locations that reduce the need to transport waste. Working across administrative boundaries and joint working arrangements should help ensure effective strategic planning for the movement of waste and location of waste facilities.

In terms of the planning requirements, there will be a need under the SEA Directive for all options to be examined both in terms of the mix of waste management measures, their location and potentially their scheduling where this may give rise to a qualitative difference in environmental performance. The process of linking the AWPs to the development plans will need to be explicitly explored with assessments of the significant environmental effects taking account of site related impacts, transport impacts and the broader strategic implications associated with resource management.

It is recommended that the guidance that exists for the appraisal of waste projects be revised to explicitly consider the issues explored in this report.

It is also suggested that mechanisms need to be considered by which due weight is given within development plans and development control decisions to the national planning objectives. It is considered that such matters extend beyond the confines of waste planning and go to the heart of delivering sustainable development.

The Supersites were modelled on a theoretical basis only and were not led by any current policy in Scottish government. Therefore while it is not recommended that this is the basis of a waste transport strategy there are lessons to be learnt from these results that could be applied. For instance waste consolidation lead to more potential for modal shift therefore the possibility of having multi treatment facilities for both disposal and recovery could be considered albeit at a substantial cost.

The impacts of waste consolidation on waste transport should be considered.

Achieving waste transport optimisation together with the recycling targets set by the National Waste Plan requires further analysis.

A 'top down' review of all wastes by stream together with proposed sites for waste management should be carried out.

This would be to identify facilities required and locations taking into account self sufficiency and proximity principles: i.e. what facilities are required at Scottish level, what facilities are required at WSA level, what facilities are required at local level. This would need to take into account facilities already in existence and planned.

To take forward the cost model giving greater confidence to future analysis of waste transport options requires and improvement in the waste data. The SEPA waste transfer station data will continue to improve as the system becomes established.

It is recommended that SEPA carry out a dedicated national commercial and industrial waste arisings survey similar to those carried out in England, Wales and Northern Ireland.

This would address the main data gaps with respect to industrial and commercial waste. In addition SEPA need to consider how to capture origin destination data for waste transport in a more efficient manner.

With more development the cost model developed for this study could be a valuable tool in planning for future waste management facilities. The model needs to be developed so that it can be applied to specific studies rather than taking a strategic view of the whole of Scotland. The model while developed to examine the transport from waste transfer station to landfill could be applied to any waste transport scenario including the transport of segregated waste streams.

The cost model has clearly compared options on the basis of economics, which does include some environmental factors such as fuel consumption and emissions to air. However, an integrated appraisal system would also need to take account of full environmental impacts. Therefore in the future a combined approach between cost modelling and the WISARD LCA could be considered.

The BITOW model should be further developed.

It was established based on the views of the project team and the Advisory Group that the sensible next phase of the work would be to develop the model so that it can be used to model specific cases. The steps required are set out in Table 7.1.
<table>
<thead>
<tr>
<th><strong>Step</strong></th>
<th><strong>Requirements</strong></th>
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<tbody>
<tr>
<td>Robust data</td>
<td>For the model to produce robust results the quality of the input data must improve. Essential waste data requirements are:                                                                                     • Origin-destination (O-D) data. This needs to be grid reference level. WSA or LA is not sufficient detail.                                             • Utilisation rates.                                                                                                             • Landfill capacity.                                                                                                               Ideally data would also be available on compaction rates. For both water and rail details would be required on infrastructure capacity.</td>
</tr>
<tr>
<td>Investigate including</td>
<td>There are two options by which this could be achieved:</td>
</tr>
<tr>
<td>externalities for all</td>
<td>1. Integrate cost model and LCA.</td>
</tr>
<tr>
<td>transport modes</td>
<td>2. Include environmental externalities into the model. This would need to address the issue that there is wide discussion on the appropriate costs that should be applied to environmental and social impacts e.g. emissions, congestions costs, accident costs.</td>
</tr>
<tr>
<td>Gather stakeholder support</td>
<td>The model would be refined to enable individual cases to be analysed separately. This would be aimed at identifying routes with appropriate infrastructure and capacity to allow waste transfer or identifying where infrastructure investment could enable modal transfer.</td>
</tr>
<tr>
<td>and obtain funding</td>
<td>• Incorporate improved waste data.</td>
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<td></td>
<td>• Validate assumptions.</td>
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<tr>
<td></td>
<td>• Assess rail and water mode capacity.</td>
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<td></td>
<td>• Consider consolidation of waste streams.</td>
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<tr>
<td>Build user friendly front</td>
<td>• Examine what other similar packages are on the market.</td>
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<tr>
<td>end to model</td>
<td>• Front end software development.</td>
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<tr>
<td></td>
<td>• User friendly.</td>
</tr>
<tr>
<td></td>
<td>• Flexible to allow changes in assumptions.</td>
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<tr>
<td></td>
<td>• Consultation with SEPA and other stakeholders to ensure fit for use.</td>
</tr>
</tbody>
</table>
References


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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AWP</td>
<td>Area Waste Plan</td>
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<tr>
<td>BITOW</td>
<td>Best Integrated Transport Options for Waste</td>
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<td>BMW</td>
<td>Biodegradable Municipal Waste</td>
</tr>
<tr>
<td>BPEO</td>
<td>Best Practicable Environmental Option</td>
</tr>
<tr>
<td>BW</td>
<td>British Waterways</td>
</tr>
<tr>
<td>CHP</td>
<td>combined heat and power</td>
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<tr>
<td>COSLA</td>
<td>the Convention of Scottish Local Authorities</td>
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<tr>
<td>CRP</td>
<td>City Regional Plan</td>
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<tr>
<td>EfW</td>
<td>energy from waste</td>
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<td>LAWA</td>
<td>Local Authority Waste Arisings</td>
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<td>LCA</td>
<td>life cycle analysis</td>
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<td>MCA</td>
<td>multi criteria analysis</td>
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<tr>
<td>MRF</td>
<td>material recycling facility</td>
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<tr>
<td>Mt</td>
<td>million tonnes</td>
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<tr>
<td>Mtpa</td>
<td>million tonnes per annum</td>
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<tr>
<td>MWPF</td>
<td>mixed waste processing facility</td>
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<tr>
<td>NWP</td>
<td>National waste plan</td>
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<tr>
<td>NWS</td>
<td>National waste strategy</td>
</tr>
<tr>
<td>O-D</td>
<td>origin destination</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OJEU</td>
<td>Official Journal of the European Union</td>
</tr>
<tr>
<td>PAN</td>
<td>Planning Advice Note</td>
</tr>
<tr>
<td>PPC</td>
<td>Pollution Prevention and Control</td>
</tr>
<tr>
<td>RdF</td>
<td>refuse derived fuel</td>
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<tr>
<td>SEPA</td>
<td>Scottish Environmental Protection Agency</td>
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<tr>
<td>SE</td>
<td>Scottish Executive</td>
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<tr>
<td>SWMBPA</td>
<td>Scottish Waste Management Baseline Assessment</td>
</tr>
<tr>
<td>WSA</td>
<td>Waste strategy area</td>
</tr>
</tbody>
</table>
Appendix A: Waste strategy areas

WSA 1  Orkney and Shetland
WSA 2  Western Isles
WSA 3  Highland
WSA 4  Moray, City of Aberdeen and Aberdeenshire
WSA 5  City of Dundee, Angus and Perth and Kinross
WSA 6  Stirling, Clackmannanshire and Falkirk
WSA 7  Fife
WSA 8  City of Edinburgh, West Lothian, Midlothian, East Lothian and The Scottish Borders
WSA 9  North Ayrshire, East Ayrshire, South Ayrshire and Dumfries and Galloway
WSA 10 Inverclyde, Renfrewshire, East Renfrewshire, City of Glasgow, South Lanarkshire, North Lanarkshire, East Dunbartonshire and West Dunbartonshire
WSA 11  Argyll and Bute

Source: SEPA, 2000a.