



Sustainable Construction, Maintenance and Operations

Understanding Resource Use and Waste Generation within the Network: A Mass Balance Approach

By

C4S at TRL Limited and Halcrow

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Executive Summary

The construction industry is the UK's largest consumer of natural resources, using over 400 million tonnes of material per annum, some 13% of all raw materials used by the whole UK economy (BERR, 2007). The sector generates around 120 million tonnes of waste per year, which is more than one-third of the UK's waste arisings, of which only half is reused or recycled.

It is in this context that the Government has set a number of targets to improve the efficiency of the sector, in the framework of overall sustainable development aims. The HA has set itself the objectives of reducing resource use and waste arisings, although clear targets can only be set once the current pattern of resource use is better understood and benchmarked.

This document is subdivided into two parts and constitutes the first and second deliverable of Task TE4 within the BRO3 programme. The aim of the task is the delivery and validation of a workable resource flow methodology that would enable the HA to quantify the amount of materials used and waste generated under the delivery of its statutory duty through the Agency's contractors.

This document first reviews the existing available methodologies for analysing flow of resources in a system and how they have been used in policy making. The main conclusion of this review is that LCI/LCA, hybrid LCI or a Bulk Material (or Material System) Analysis provide useful elements for the development of an approach to assess resource efficiency at a project or area maintenance level using existing reported data.

The report then considers the current contractual arrangements in the delivery of construction, maintenance and operation of the network, focusing specifically on how materials are procured and how data can be accessed. A brief review of available HA tools and other construction stakeholders' tools is also undertaken and includes the upcoming obligations under the new Site Waste Management Plans; a full review of the tools is however being undertaken in parallel under Task TE5 and further work is required to understand how the new SWMP will be applying to the HA contracts.

The main conclusion of the first part of the report is that a methodology for resource efficiency accounting can conceptually be developed, but that it will require to be based on existing reporting methods and obligations as much as possible to obtain buy in from the contractors.

Part II of the report outlines the building blocks and an illustration of a pragmatic methodology proposed for the assessment of the resource flow and other resource efficiency indicators. The methodology is to be trialled and validated with two live demonstration projects.

The Highways Agency (HA) does not have, to date, a measure of how much materials are used and how much waste is generated in its operations and its cost to HA: although some mechanisms are in place, sufficient data is not available. Hence it is difficult for the HA to plan effectively waste and emissions minimisation and resource efficiency maximisation. However, Government targets and the overall need for reducing the impacts of the Agency's operations on the environment require a clear understanding of the current situation and potential for improvements.

1 Introduction

The construction industry is the UK's largest consumer of natural resources, using over 400 million tonnes of material per annum, some 13% of all raw materials used by the whole UK economy (BERR, 2007). It generates around 120 million tonnes of construction, demolition and excavation waste per year (Figure 1), which is more than one-third of the UK's waste arisings and is equivalent to 30% of the resources coming into the sector.

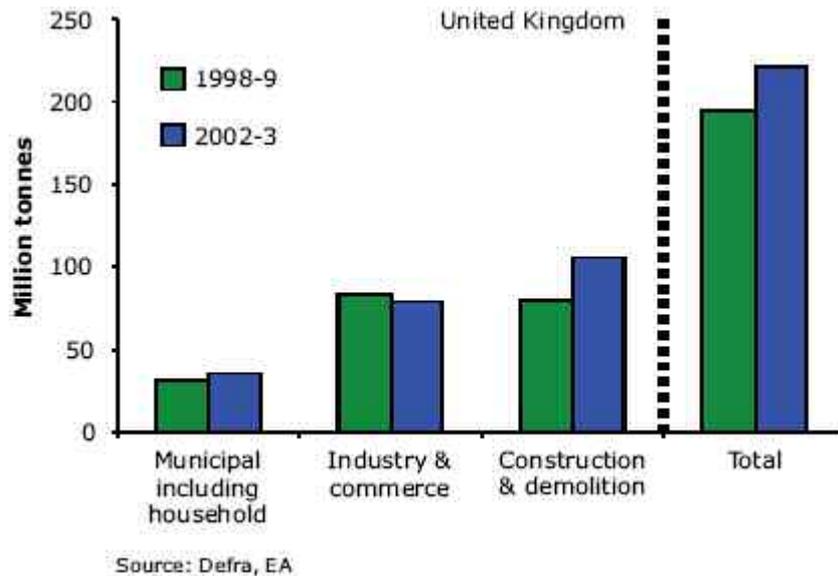


Figure 1: The waste arisings in the UK (1998-9 and 2002-3)

Only half of the waste generated is reused or recycled (primarily aggregates and metals), with the remainder being sent to landfill or similar disposal sites every year (WRAP, 2007a). It is clear that this not only equates to an incredible waste of resources and has significant impacts on the environment, but represents also a very significant cost to the whole supply chain, from clients to subcontractors.

It is in this context that resource efficiency principles have been driven both at regulatory and strategic levels and at procurement and industry level. The Waste Strategy for England 2007 (DEFRA, 2007) includes consideration of the target of halving the amount of waste from the construction industry going to landfill by 2012. The draft Sustainable Construction Strategy (BERR, 2007) dedicates a whole chapter to waste and materials, explaining what the Government is already doing and introducing the following targets:

- By 2012 a 50% reduction of construction, demolition and excavation waste to landfill compared to 2005, in line with the Waste Strategy;
- By 2015, zero net waste, at construction site level (see below in section 7.4);
- By 2020, zero waste to landfill.

Both documents are also aligned with other documents on resource efficiency, such as the Sustainable Procurement Action Plan (HM Government, 2007) and the latest Sustainable Development Strategy (DEFRA 2005).

These strategies have influenced a move towards resource efficiency with specific actions targeted at the Construction industry, in particular from Constructing

Excellence with a Lean Construction Programme and Key Performance Indicators; to the funding of a specific programme of research on resource efficiency in construction administered by the Waste and Resources Action Programme (WRAP).

In the Highways Agency Environment Strategic Plan (Highways Agency 2008), the HA identified the need to:

- Identify where waste is being generated;
- Establish benchmarks for the quantity of waste produced in trunk road management; and
- Conserve existing resources and reduce quantities of waste.

This has evolved in the recent Sustainable Development Action Plan (2007), which includes the action of developing a waste, resource use and recycling strategy for maintenance and construction operations seeking to establish a benchmark for future target setting.

The Highways Agency (HA) does not have, to date, a measure of how much materials are used and how much waste is generated in its operations and its cost to HA: although some mechanisms are in place, sufficient data is not available. Hence it is difficult for the HA to plan effectively waste and emissions minimisation and resource efficiency maximisation. However, Government targets and the overall need for reducing the impacts of the Agency's operations on the environment require a clear understanding of the current situation and potential for improvements.

2 Summary of the work to be carried out within Task TE4

Under the Being a Responsible Owner BRO3 programme, this research task aims at defining and validating a resource efficiency methodology, based on existing working practices and data collection tools, which can be used by the HA and its supply chain. Employing the validated method will help the HA and its stakeholders to understand how much material and waste is used and generated by the construction and maintenance work undertaken for and on behalf of the Agency, for benchmarking and policy making purposes within the HA's established mechanisms.

The work was subdivided into three elements:

- A review of existing methods and tools to analyse the flow of resources within a complex system and a review of how the Highways Agency procures, monitors and delivers its statutory duties;
- The conceptual development of a methodology for the use of resource flow techniques within the Highways Agency "system"; and
- Validation of the model using two demonstration projects identified with the help of the Steering Committee.

More details on the sub-tasks are available within the proposal developed by the Research Consortium and provided in Appendix A for reference.

3 Aims of this document

This document aims at providing the HA and its stakeholder with an overview of the different resource flow analysis tools available. It also considers in parallel the mechanisms of the HA (and its supply chain) operations and the current available HA tools which cover the area of environmental sustainability and, more specifically, resource use. This is a working paper to be used for a discussion with the TE4 Steering committee to identify two demonstration projects which is to be selected (and further developed to the specific needs of the HA) as this task progresses.

The document is structured as follows:

PART I

- An introduction to resource flow analysis and an analysis of the common methodologies used;
- How resource flow analysis is currently being used to drive the evidence-based policy making;
- A summary of the working mechanisms of the HA procurement and delivery
- A brief overview of the tools already available within the HA; and
- A set of conclusions and options for application of resource flow analysis within the HA operations;

PART II

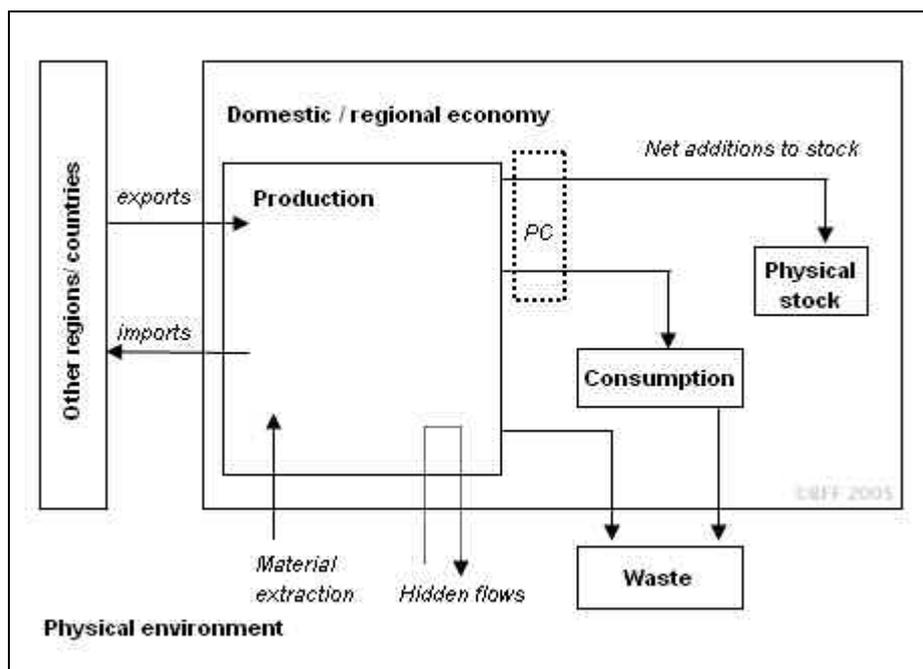
- A suggested, draft methodology to be validated with the two demonstration projects.

PART I: REVIEW OF RESOURCE FLOW ANALYSIS METHODS AND HIGHWAYS AGENCY EXISTING MONITORING TOOLS

4 Introduction to Resource Flow Analysis or Material Flow Analysis

The expression Material Flow Analysis (MFA) or Resource Flow Analysis (RFA) describes a number of methods and tools that provide an account of the amount of resources entering a production system (from national economies to sectors to single products supply chain) and the resulting products, to understand the efficiency of the resource use within the system and/or the impacts on the environment. A representation of a typical MFA/RFA is shown in 2.

Figure 2: The generic structure of a Resource Flow Analysis



PC = Total physical consumption, where certain materials and products are perishable within a year (such as food) and their byproducts are returned to the environment in the form of waste, while the remaining consumption concerns goods and materials likely to remain within the economy for longer periods (such as buildings). Source: Griffiths & Lewis 2004.

Most often, MFA / RFA methods are governed by the principle of conservation of mass, i.e. provide a balance between resources in – materials in most cases, but also energy and water in some cases - and products out – added value materials but also in some cases, releases to the environment, i.e. waste, waste effluents, emissions to air. The only method where this balance does not apply, because of the complexity and the level of details of the systems studied, is Life Cycle Assessment (see below in section 4.6).

A solution for today's environmental problems requires a sound understanding of the physical metabolism of societies – resource extraction, transformation and waste release. Establishing a robust evidence base about the material movements through the human activities is therefore of key importance for tackling environmental problems in a preventive policy approach, as highlighted in the sustainable development strategy of the government (DEFRA, 2005). Hence, MFA approaches are at the heart of environmental decision-making.

Environmental problems are generally related to resource use patterns in two different ways – in the level of resource use and the impact per unit of mass flow. In the MFA literature, therefore, two general strategies for tackling environmental problems have emerged in the policy context of MFA - dematerialisation and detoxification. Dematerialisation focuses on the reduction of the environmental impacts through cutting down the total amount of physical flows (therefore often targeting physical flows of high volume). The latter concentrates on reducing the impact per unit of physical flow. Most MFA methodologies have no in-built capacities to address environmental impacts; they can only prioritise physical flows according to their weight and achieve detoxification only indirectly through dematerialisation

(Wiedmann, 2006). There are, however, some techniques which have been devised to address this, as described in the remainder of this section.

RFA/MFA are used as policy instruments, for benchmarking or performance monitoring, at various levels, to establish how well a system uses the resources and/or what are the impacts of the system on the environment. The systems analysed – and therefore the levels of policy - can be:

- entire economies at national or regional level – the boundaries of the systems being geographical boundaries –; or
- entire industrial sectors, covering the supply chain up and down as defined within the methodology; or
- Single products, again with boundaries covering the supply chain as defined by the single project.

Typical examples for the three categories include:

- Studies such as Scotland resource flow analysis (BBF, 2004) and London's City limits (BBF, 2002), both of which have been used as benchmarking of the consumption patterns of the two areas; and the Total Material Requirement (TMR) indicator, which is published by the ONS in the UK National Accounts "Blue book" (ONS, 2007);
- Studies covering the construction (Smith *et al.*, 2002), motor industry (Elghali *et al.*, 2004), publishing (Sturges *et al.*, 2005) and textile industries (Allwood *et al.*, 2006); and
- Life Cycle Analysis studies of products that are contributing at European level to the Integrated Product Policy (EC, 2001)

The RFA/MFA family comprises of various methodologies, including established account tools governed by internationally recognised codes and standards, such as ISO standards on Life Cycle Assessment (ISO 2006). They have been established as policy instruments in a number of European Countries, and have consequently become a tool used at European level to generate comparable statistics of resource efficiency amongst the member countries (EC 2008).

The following subsections include a summary review of the existing RFA/MFA methods, with particular focus on relevance to waste and construction industry.

4.1 Resource Flow Analysis review – the sources

This review summarises studies commissioned by DEFRA from 2005 under the Sustainable Consumption and Production programme of research, namely:

- *Sustainable Consumption and Production - Development of an Evidence Base*. DEFRA Project Ref.: SCP001, by Wiedmann *et al.* (2006): a report providing the most recent review of RFA methodologies;
- *Methods review to support the PAS process for the calculation of the greenhouse gas emissions embodied in good and services*, DEFRA Project Ref.: EV2074, by Minx *et al.* (2008): a recent report including a review of three specific RFA techniques for carbon footprinting.

The review has also informed the short-listing of methodologies proposed within this paper which would be tested against the reality of the existing highways

maintenance projects and practices to identify the most suitable methodology to be taken forward.

4.2 Available MFA methodologies

The most recent review of MFA methodology has been carried out during 2005-06 by the Stockholm Environmental Institute and the Policy Studies Institute on behalf of DEFRA (Wiedmann *et al.*, 2006) (Figure 3), Sustainable Consumption and Production unit. The methodologies identified as being the most relevant to the issue of sustainable consumption and production, under which resource efficiency can be seated, and reviewed in the DEFRA project are represented in the figure below. This paper summarises the review of those methods which are of most interest for the task, i.e. the methods listed under the "General Resource Flow Analysis Methods" and "Specific Hybrid Methodologies".

Figure 3: Main MFA methodologies, from Wiedmann *et al.* (2006)

Category	Methods included	Representation in Report
General Resource Flow Analysis Methods	<ul style="list-style-type: none"> Economy-wide Material Flow Analysis Biffaward Bulk Material Flow Analysis Physical Input-Output Analysis/ NAMEA/ Environmental Input-Output Analysis Substance Flow Analysis Lifecycle Inventories 	Individual discussion; detailed assessment
Specific Methods with direct sustainability reference	<ul style="list-style-type: none"> Ecological Footprinting Environmental Space 	Joint discussion; general assessment
Specific Hybrid Methodologies	<ul style="list-style-type: none"> Waste IO Hybrid LCA Environmental Input-Output LCA 	Joint discussion; general assessment
UK resource flow models	<ul style="list-style-type: none"> Stockholm Environment Institute - REAP Cambridge Econometrics - REEIO Best Foot Forward – Stepwise University of Surrey – Regional Material Flow Accounting Model 	Joint discussion; general assessment

Key: NAMEA= National Accounting Matrix including Environmental Accounts, an environmental accounting framework developed by Statistics Netherlands at the end of the 1980s. It consists of a conventional national accounting matrix extended with environmental accounts in physical units.

IO= Input Output; LCA = Life Cycle Analysis; REAP = Resources and Energy Analysis Programme; REEIO = Regional Environment-Economic Input Output model

The methodologies are mainly analysing the "physical society-nature exchange/relationship from a socio-economic perspective usually with the aim to learn where the physical flows come from, how they transmit through the socio-economic system and where they end up, with the ultimate goal of devising policy measures for intervention" (Wiedmann *et al.*, 2006), i.e. they consider how materials flow within a system without considering the effects on the environment. There is however another, complementary, approach that takes the starting point of the impacts on the environment; methodologies that can be ascribed to this second approach include Environmental Impact Assessment and Impact Potential Approaches (often included within full Life Cycle Analyses).

The results of the overall review, with specific information on waste issues, is summarised in the following sections.

4.3 Economy-wide Material Flow Analysis (EMFA)

Standardised in 2001 by Eurostat, the EMFA aims to measure systematically the overall physical size of a country's societal metabolism, in tonnes, for a given reporting period (usually a particular year) within clearly defined geographical boundaries. This includes all physical flows out of and into the natural environment as well as the physical size of imports and exports; the internal economy is treated as a black box. EMFA has typically been applied at national or regional level to provide aggregate indicators such as the Domestic Materials Consumption, which is part of the UK 20 Sustainable Development indicators.

This methodology is widely used by OECD countries and in the UK aggregate data, and indicators, are available from the ONS, although at the moment no data is included on waste sent to landfill.

This methodology has a very high level of aggregation of data and is therefore not suitable for the benchmarking of the HA operations.

4.4 Bulk Material or Material System Analysis

The most known example of this type of assessment is the Biffaward founded series of 50 Mass Balance projects developed between 1997 and 2003, which covered flows of materials within regions (Scotland, Northern Ireland, South East) or industries (motor industry, construction industry) or single materials flows within the UK economy (used tyres, aluminium, textiles etc.). The methodology, although based on Linstead and Ekins, 2001 and with further guidance from Forum for the Future, was purposely left open and it has been applied with great flexibility by the different studies. All studies however are based on the principle of mass balance.

Because of the remit of the funding mechanism (the Landfill Tax Credit Scheme), the studies give relevance to the emissions to soil, water and air, hence including waste. A full codification/classification system for waste was however not available/not devised during the programme, and therefore any further application of the methodology would require a review of this specific subject.

Some components of this methodology have some relevance to the benchmarking exercise, although again the method uses a top down approach and aggregate data, due to the large size of the systems under consideration.

4.5 Analysis of Material Flows by Sector: NAMEAs¹, Generalised Input-Output Models, and Physical Input-Output Analysis

Input-output models describe the economic activities of a sector for a certain period in a matrix format. They allow the study of a full supply chain and clearly link consumption to production. I-O models can be combined with NAMEA type sectoral environmental accounts data (see UN, 2003) to model the pathways of physical flows through the economic network from entry to release.

There are two types of input-output tables:

¹ National Accounting Matrix including Environmental Accounts

- (1) Monetary input-output tables (MIOT);
- (2) Physical Input-Output Tables (PIOT).

They can both be used to perform environmental input-output analysis (EIOA) and have a generic structure shown in Figure 4.

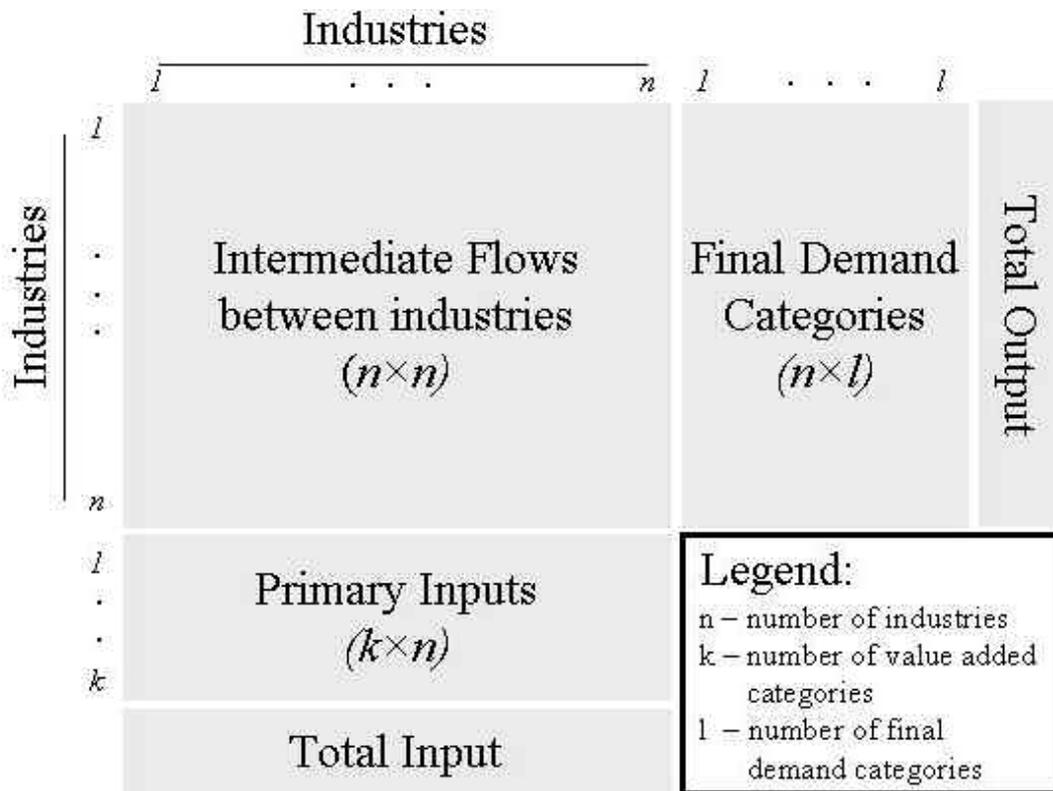


Figure 4 Representation of I-O tables (Wiedmann, 2006)

MIOTs are restricted to the flows of goods and services within the economy. The n different industries use a selection of the k different primary inputs such as labour and capital and combine them in their production processes with intermediate goods and services (as well as imports from the rest of the world). This is recorded in the first n columns of the input-output matrix adding up to total inputs. The goods and services produced by the industries are then sold either to other producing sectors as intermediates or to the l different final demand categories, where they are either consumed by households or governments, added to the fixed capital stock or exported to the rest of the world. This is recorded in the first n rows of the input-output matrix. By definition of mass balance, for each sector the total input must equal the total outputs (Wiedmann, 2006).

Physical input-output tables work in the same way, although they also account for all the physical exchange with the natural environment – all measured in tons (instead of money): the first n columns of the PIOT matrix give the total material inputs taken up by each industry. The industries sell or release these goods as intermediates to the other sectors or as final products to the different final demand entities such as households or the government, as well as adding to the stock and exporting. The environment figures amongst the “demand” entities as pollution and wastes are created and released into it. It can be said that PIOTs are the only analytical tool which allows fully tracing the material transformation processes from raw material to

goods to wastes and residuals, however this has not currently being exploited (Wiedmann, 2006).

From the methodological point of view, the main advantages and relevance of Input-Output tables and analysis are:

- Ability to describe the full supply chain of a product and the flow of resources – and associated wastes - within a sector;
- Ability to take a lifecycle view at sector level, which can be relevant for policy making; and
- Flexibility that allows integration with other approaches – typically, to cover data gaps in Life Cycle Inventories.

EIOA is largely dependent on the data provided by National Statistical Offices because of the large amount of resources that are needed for the compilation of input-output and sectoral NAMEA type environmental account data. Unfortunately, PIOT are not available for the UK and MIOT are published only every five years, while a precursor of input-output tables, called supply and use tables (SUT) is published bi-annually – although there are some issues with data availability and consistency of accounting. NAMEA are instead published twice a year, although they miss out important impacts such as waste, water, land-use, toxic chemicals and transport.

It is felt that this methodology can have some use for the TE4 task, although it is recognised that data availability and the level of aggregation are major obstacles for its application.

4.6 Life Cycle Inventory analysis (LCI)

Life Cycle Assessment (LCA) is a methodological tool used to assess the environmental impacts of a product, process or service. The tool assesses the use of 'inputs' such as raw materials, resources, energy, and 'outputs' such as emissions to water, air, by products and wastes. The assessment of inputs and outputs to the environment forms the basis of the assessment of environmental effects of the product or process. In this way LCA adopts a life cycle (often referred to as cradle to grave) approach.

A full life cycle approach ensures that the assessment is holistic and will include all phases of a product's life cycle from raw material production, transport, processing, distribution, use and to disposal.

LCA can be used to assess a range of environmental categories such as global warming impacts, pollutants, land use, depletion of ozone layer and minerals, human-toxicological pollutants etc.

The LCA methodology can be applied to products or service such as comparing the environmental impacts of reusable nappies versus disposal nappies, or comparing the environmental burdens of different packaging options such as glass versus plastic. It is also used by industry in product development and marketing and has been the basis for several EU policies such as the European Integrated Product Policy (IPP) (Com (2003) (302) and the new Thematic Strategies on Waste Prevention and Recycling (Com (2005) (666)). LCA can also be used to identify which processes in the life cycle of a product or process are more environmentally damaging (Europa website [site on LCA Tools, services and data http://lca.jrc.ec.europa.eu/lcainfohub/introduction.vm](http://lca.jrc.ec.europa.eu/lcainfohub/introduction.vm)).

Limitations to the use of LCA include; it cannot address local impacts as differences in sensitivity within regions are not captured in the LCA study; the LCA tool regards all environmental and economic processes as linear; LCA tools only focus on environmental aspects of products and not economic, social or other characteristics; LCA is considered to be science-based but in fact it relies on a number of technical assumptions and value choices; and finally the availability of data is also a limitation with data often being obsolete, unavailable or unknown. (Life Cycle Assessment: An Operational Guide to the ISO Standards, Final Report 2001. J B Guinee Final Editor) <http://www.leidenuniv.nl/cml/ssp/projects/lca2/part1.pdf>

Life cycle inventory analysis (LCI) is one of four stages of Life Cycle Analysis (LCA). LCA is a standardised methodology that identifies and compares physical flows and associated environmental impacts of a product or system through all stages of its lifecycle from resource extraction to end-of-life (sometimes known as “cradle to grave”). LCA is typically broken down into four stages (Figure 5):

1. Goal definition and scoping – this stage sets the boundary for the study and establishes the functional unit, therefore allowing different options for the product/system to be compared on a ‘level playing field’;
2. Life Cycle Inventory (LCI) analysis – here data is collected which informs life-cycles of the different options to be analysed. Data on resource use, energy use, water use, transport, waste etc. is compiled into an inventory. The inventory also includes outputs, such as emissions to air, water and land.
3. Impact assessment – the benefits/burdens of the life cycles are realised, often with the aid of specialist LCA software. The results can be expressed in terms of different environmental impact categories such as Climate Change, Acidification, Eutrophication, Summer Smog etc.
4. Interpretation – presentation of the results of the study in the appropriate format.

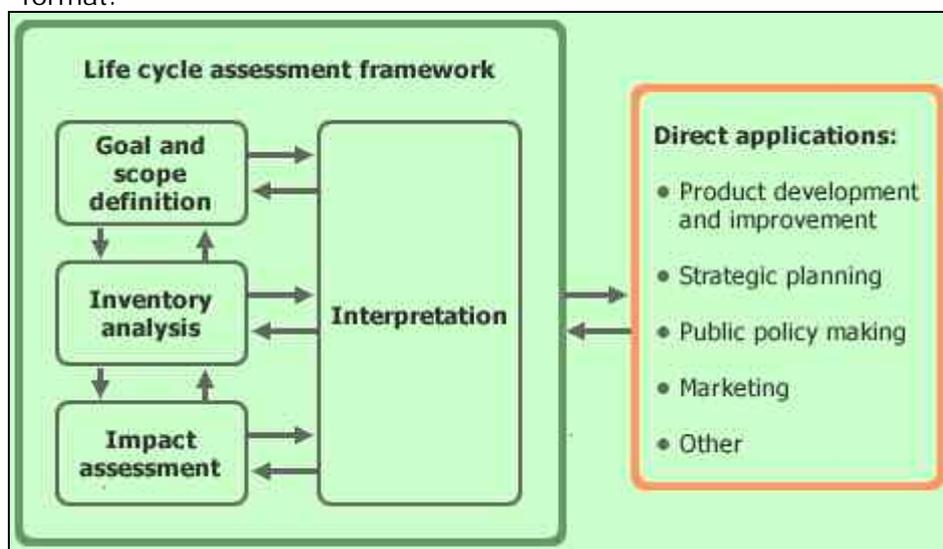


Figure 5 Life Cycle Assessment Phases (UniS 2008)

LCI specifically deals with modelling the “system” (i.e. those activities under study) and gathering data used to compile the information for each part of the system modelled. Life cycle inventories concentrate on quantifying the use of raw materials and energy as well as the associated releases to air, water and land. LCI is the basis for LCA; the link is bridged when the emissions of the LCI are equated into impact categories via ‘characterisation factors’. Characterisation factors assess the potential of any given chemical species to cause an environmental impact; an example would

be Global Warming Potential (GWP) which is used to assess the contribution of gases (e.g. CO₂ and CH₄) to climate change.

LCI methodology is standardised within the ISO14041 series. The main challenges of the methodology are the definition of boundaries and the data collection, more specifically it is quite arbitrary how far up the supply chain is included within a system, thus making comparisons of two Life Cycle Assessments not feasible.

LCA does not include a requirement for mass balance, because of the complexity of the system considered. Furthermore, the LCI/LCA methodologies suffer from truncation problems, which inevitably exist in traditional [process] LCI methodologies since it is necessary to exclude and include some processes when the system boundary is set. An example would be where impacts associated with the use of capital equipment are not included within the system under analysis to streamline the study, but they obviously exist and need to be accounted for somewhere. Finally, the LCI/LCA methods approach the system under study considering the chain of inputs and processes, often represented as a flow diagram – this approach is however substituted with a matrix approach for hybrid systems (see below 4.8).

LCI/LCA methodologies have the advantage of being a bottom-up approach, where data needed for the analysis are collected directly for the specific system under consideration, as opposed to top down approaches that rely on aggregate data that are not directly collected. LCI/LCAs for road construction and maintenance have been undertaken (e.g. Stripple, 2001). However, it is clear that there are problems with considering a full balance of resource flows because of the complexity of the system, and that mainstream literature (e.g. Minx 2008) suggests an integration of this approach with a top-down methodology. This is to ensure that, whatever the choice of boundaries, the data is sufficiently complete.

The bottom-up approach of this methodology and its standardisation are the most desirable characteristics that should be taken forward within the definition of a methodology for resource flow analysis within highways maintenance contracts. See also section 4.8.

4.7 Substance Flow Analysis

Substance Flow Analysis (SFA) is mainly used to trace the flows of a single or a group of (chemically defined) substances between the economy and the environment within a predefined system – usually a geographic region (Wiedmann, 2006). Typically, this analysis has been applied for hazardous, low volume but potentially high environmental impact substances, such as lead, chromium or heavy metals. The methodology involves not only considering the human sphere but the environment as well to identify where the substances accumulate. The main disadvantage of this methodology is that there is no standardised definition of human activities, while the definition of substances is clearly defined based on their chemical nature.

This methodology has a clear, more limited area of applicability than other methodologies and it is therefore not further considered for the TE4 task.

4.8 Environmental input-output life cycle inventories and other hybrid IO- LCI methodologies

The EIOLCI (or EIOLCA if a full Life Cycle Assessment is undertaken) are hybrid methodologies structured like a normal EIOAs. However, instead of being based on very aggregate data, they show a high level of disaggregation (down to products)

and also include more comprehensive environmental data (resource input as well as waste and pollution output). In this form EIOLCIs consider all economy-wide interdependencies and solve the truncation problems of LCI methodologies, providing cheap and fast data. Limitations include dependency on publication of I-O data (published by the Office of National Statistics in the UK), which is not usually very timely and is likely to be older than the data gathered through LCI, and restricted to a reporting year, which means that end of life issues – disposal, recycling - are not considered. The consequence of this latter consideration is that the EIOLCI can be classified as a “cradle to gate” approach (Minx, 2008) rather than “cradle to grave” approach. The methodology is a top-down approach.

Some of these and other limitations of EIOLCI have been addressed by a family of RFA methods called Hybrid LCI approaches, Table 1 (Minx 2008). An example of a hybrid LCI approach would be ‘tiered hybrid analysis’, which adds the process-based impacts of the use and disposal phases to IO data which informs the remainder of the life-cycle. Other hybrid approaches includes ‘IO-based’ hybrid analysis and ‘integrated’ hybrid analysis (Minx, 2008). All three are bottom up approaches, which consider as starting point the LCI methodology, therefore look for process specific data either through direct survey or published information, and then cover the remainder of the system using I-O data, thus reducing the truncation error of the LCI methods.

This type of approach is currently being discussed as the basis for the Publicly Available Specification (PAS) 2050 “Measuring the embodied greenhouse gas emissions in products and services” (Minx 2008). A hybrid life cycle inventory has also been used in Australia (Treloar *et al.*, 2000 & 2004) to compare different roads during their lifecycle.

Hybrid LCI approaches still suffer from data availability problems and require careful consideration at the interface between LCI and I-O tables – with a solution being compiling LCI data into a matrix rather than a flow diagram. This particular method has been used in Japan for studying the flow of waste throughout the economy or associated with a specific commodity (Wiedmann, 2006). Furthermore, good LCA software tools such as SIMAPro have embedded this approach (Minx, 2008).

This methodology appears to be a favourite because of the ability of joining a bottom-up approach with the completeness of a mass balance. It is however recognised that there are not many examples of this approach being applied in the UK and that it might be quite a complicated approach for the systems likely to be considered within this Task.

Life Cycle Methodology	Strengths	Weaknesses
Input-Output LCI	Covers all emissions (environmental interventions) from upstream processes in the supply chain taking place directly or indirectly for the production of an arbitrary final demand/ functional unit	High level aggregation, which does not easily allow for a product or brand specific analysis and leads to a generic aggregation error Does not fully cover the whole life cycle of a product
Hybrid LCA	Streamlines the process data collection and seeks to optimise data quality in a transparent procedure Hybrid approaches are all aimed at achieving best quality and highest level of comparability in estimates with the least effort.	Integrated HLCA analysis in some cases can be resource and time intensive The quality of a HLCA analysis will partially depend on the quality, timeliness and detail of the available environmental account and input output data

Table 1 Summary of Input-Output and Hybrid LCAs (Minx 2008)

4.9 Conclusion of this section

- A few methods have a robust and standardised methodology, internationally recognised, while for a few this is lacking, often to provide flexibility to the research.
- Data availability is an issue to all the methods, with many tools depending on data being published by the Government; on the other end of the spec, process-based, bottom-up approaches enable the gathering of data but suffer from truncation errors.
- At this stage it is possible to conclude that some of the methods reviewed are extremely complicated and potentially “unwieldy” with respect to the problem at hand, as they deal mainly with larger entities than the systems likely to be analysed in this Task. For example, in dealing with country-wide or sector-wide data sets, the necessary ‘granularity’ is not provided to analyse the impacts a single local network management scheme (LNMS) scheme
- For these reasons, of the methodologies analysed, the Bulk Material or Material System Analysis, LCI and hybrid approaches seem to provide elements the most suitable for the development of a pragmatic methodology applicable to the HA system, as they provide the most flexibility and allow for a bottom up approach. This is further discussed in Part II of this document.

5 How RFA has been used for policy making

RFA has been widely used in Europe and beyond to guide policy making, with countries such as Germany, Japan, Italy, the Netherlands, Belgium, Czech Republic, Austria, Latvia having formally established quantitative reduction or resource productivity targets in their sustainable development strategies, based on MFA methodologies, particularly EMFA. Many countries have well established environmental accounting supported by PIOT tables, while at the other end of the scale, bottom up approaches such as Life Cycle Assessment and Inventories have

been used to develop eco-labelling and guide consumers' choice. Given this successful application of RFA approaches to policy making worldwide, one of the aims of this task is to find an appropriate combination of techniques to aid the HA's own policy / decision making for a Strategic Road Network (SRN).

In the UK, a 2001 report from the Performance and Innovation Unit (now Strategy Unit), within the overall move towards sustainability, can be traced amongst the drivers for the recent DEFRA investment in research on available RFA methodologies, under the Sustainable Consumption and Production programme. Outside the Government, NGOs, environmental bodies and environmental consultancies have used the methodologies and generated landmark programmes of research, tools and documents such as the Mass Balance movement (Biffaward under the Landfill Tax Credit Scheme, 1997 to 2005) and ecological footprinting (imported from the continent and developed as a tool by Best Foot Forward amongst others and at the basis of the WWF annual/bi-annual "Living Planet" report). At the time of writing, RFA methodologies are informing the development (and the debate) of the Publicly Available Specification PAS2050 on Carbon Footprinting.

In general, the usefulness of Resource Flow Analysis is well recognised in literature, although it is clear that those studies require considerable efforts in data collection that only Government or large institutions could afford, providing data are available at the right level of disaggregation. However, the very recent UK debate on green house gases accounting, or carbon footprinting, has proposed that a hybrid LCI approach should be used to cater for the needs of different sized organisations and projects and to provide a unique method to approach the carbon reporting obligations.

In analogy with the above and from the review summarised in section 4, it is believed therefore that the mass balance, LCI and hybrid LCI methodologies provide elements to build the conceptual methodology for undertaking a resource flow study of the HA operations. The following sections consider issues of relevance to the implementation of such methodologies, in particular from a data collection point of view; the development of a methodology is addressed later on the basis of previous experience in the development of LCI -type tools and mass balance studies.

6 A summary of the working mechanisms of the HA procurement and delivery

The Highway Agency delivers its commitments to the network in a number of different ways. Network is currently split into 15 areas across England and the maintenance and operation of the network is contracted out to Network Managing Agents (private companies with a 30 year lease on the network). New build work (widening, structures, junction improvements etc) is contracted through a number of different routes, DBFOs, ECI and D&B being most common. There are also a number of different communications contracts dealing with the increasing development of communications initiatives (AMS etc). However, this section provides an appreciation of the current operating mechanisms by which the HA delivers its statutory duties; i.e. how the maintenance and construction of the network is subcontracted to Maintaining Agents, how major schemes are procured and delivered etc., to identify those contractual arrangements most likely to facilitate the application of resource flow analysis. This represents our understanding of the procurement mechanisms based on a review of documents available from the Agency and other sources and from the brief survey undertaken for the SWMP

scoping study (Greenwood *et al.*, 2007). The input of the Steering Committee is welcomed on this specific issue to guide the selection of the project which will be used to validate the conceptual methodology drafted in Part II of this document. In the following, the focus is on the way the input of materials is controlled or accounted for, while for waste, the findings on SWMP of Greenwood *et al.*(2007) are relevant as well as the results of the first year of operation of EnVIS.

- In the past five years, the Highways Agency has relatively recently launched a Model Contract Document for Early Contractor Involvement, which is used for major contracts. This aims at obtaining a better control of budget and estimates of costs. ECI contracts encourage transparency and open book working, where the contractor and the client have access to data on material use and costs associated with the delivery of the work. This would mean that some degree of transparency in partnering working, including access to materials cost and input or usage, should be in place. The work is procured in ECI is usually consist of supply chain of sub contractors, lead by main contractors, who are involved in preparing target costs for Derived Price Scheme projects and also Framework Schemes within ECI contracts. This target cost usually involves material procurement, waste management and any recycling activities on site and off site. Suppliers produce informal Site Waste Management Plans and submit them to the main contractor with all related information on materials used, purchased and dispatched from the site in the form of waste, including the waste transfer notes. In recent months within EnVIS has been used to populate EnVIS with relevant site information. The only waste that is not recorded and communicated to the main contractor is about light fittings and safety barriers etc.
- Whilst the ECI approach is generally followed for major contracts, 'Design and Build' type contracts are often still a viable alternative, particularly in relation to smaller contracts.
- Maintenance of nine out of 14 maintenance areas of the network is procured under MAC contracts. A single access point might therefore be available if a geographical area is chosen as system under study. Furthermore, with the new SWMP regulations, it is likely that the MAC agent will be responsible for the SWMP plans. However, Greenwood *et al.* (2007) found that the supply chain is responsible for the procurement of materials. It is therefore likely that only transparency and partnering within the supply chain would enable access to these data.
- Area Nine and Ten contract has been established under Construction Management (CM), a framework arrangement allowing the Agency to directly appoint specialist trade contractors and suppliers, including suppliers of materials. Suppliers have been involved in measuring performance and driving out wastage (HA 2005a): it would therefore appear that under these circumstances the MAC might have the type of partnership required for enabling data access.
- Under DBFO, the private sector, over the 30-year life of the contract, assumes responsibility for the operation and maintenance of a length of existing road (where appropriate) and the detailed design and construction of specified improvement schemes and their subsequent operation and maintenance (HA, 2005b). It is in the interest of the DBFO contractor to achieve resource efficiency and again it is expected that supply chain relationships would be the main factor affecting data availability.

Further information, gathered during this TE4 Task, is included in Appendix A.

7 A brief overview of the tools already available within the HA

This section considers briefly some of the tools used (or to be used) by the Agency's supply chain either because of contractual requirements or because of legislative requirements the Highways Agency. This review is kept to a minimum as an entire task of this research programme is dedicated to the review of the tools available within Task Element 5 (TE5) Sustainable, Construction, Maintenance and Operation – Performance and Reporting Tools" available end March 2008. It also considers tools completed and already available or under development by other organisations, with a specific attention to tools freely available and widely recognised.

7.1 EnvIS

The HA Environmental Information System (EnvIS), launched in July 2007 as an IAN (84/07) provides information on the HA environmental assets and the management of these assets. Information is submitted by Service Providers at either specified milestones, quarterly or annually, depending on the type of environmental information to be submitted. EnvIS, a mandatory requirement, applies to all new build and maintenance and operation contracts and Service Providers.

The HA Environmental Information System (EnvIS) contains a waste module, where contractors and service providers have started, from April 2007, to record information on waste and material resource use. Information collected in EnvIS is used to assist the HA in monitoring the amount of recycling in its operations and set targets for future projects to demonstrate that it is meeting its objectives of maximising recycling and minimising waste in its construction, maintenance and operation activities.

The information is captured at the Planning & Design, Construction and Maintenance & Operation stages, so that there is a continuous record of material use and waste production and the reasons for any changes can be recorded. The waste section in particular was designed to be compatible with the information required for Site Waste Management Plans, so as to minimise the extra information that has to be collected. Therefore, the categories available for recording the management of waste are the same as the ones set out in the DTI guidance on Site Waste Management Plans (DTI, 2004):

- Re-used on site
- Re-used off site
- Recycled for use on-site
- Recycled for use off-site
- Sent to recycling facility
- Sent to WML exempt site
- Disposal to landfill

In addition to the capture of waste information, EnvIS additionally requires Service Providers to submit information relating to material resources. The information submitted by Service providers includes material origin (primary, secondary etc) and type (timber, plastic etc).

The waste module is strictly related with a material section, as both together are needed to capture resource use within the HA's operations (Greenwood *et al.*, 2007).

This tool would therefore be fundamental for the understanding of the resource flow within HA operations and it is intended that the mass balance approach to be proposed would analyse the information arising from EnvIS and help in developing a benchmark and future targets setting.

7.2 Area Performance Indicator

Area Performance Indicator (API) Handbook details the measurement system developed by the Area Maintenance Community for the delivery of the HA's Managing Agent and Managing Agent Contractor contracts.

The API handbook is broken down into a number of lower level indicators. One of these indicators strictly related to waste which is API 15 – 'Recycling and Reuse'. The purpose of API 15 is to promote the recycling and reuse of materials used or in arising from all network activities. This represents a subjective assessment based on evidence, of the percentage recycling and/or reuse of materials in 19 identified categories, using a points system (Greenwood *et al.*, 2007).

From the resource use point of view, there are some indicators which have some indirect relevance as they imply some form of continuous monitoring of work progress, and therefore, expectedly, resource use. For example, indicators are used to measure and identify defects to be repaired (and how quickly they were repaired, API 2), intervention on street lights (API 12), cost of discrete schemes (API 6 and API 7). Many of the above indicators are based on a defined scoring system, with scoring being calculated by the contractors on the basis of monitored data, which is therefore available. It is however clear that some more manipulation might be needed to achieve the information required for the resource use balance (see Greenwood *et al.*, 2007 about API 15 and SWMP compatibility and the role of EnvIS as a bridging tool between the two).

7.3 Regulatory requirements on waste

7.3.1 Duty of Care

The Duty of Care requires that waste cannot be moved without Waste Transfer Notes or, if hazardous, Hazardous Waste Consignment Notes. The documents contain details of the waste transferred: types, using the List of Waste Regulations six digits codes, details on origin and on disposal. Producers of waste are obliged to keep the documents for at least two years and only registered carriers can be used.

Through an analysis of the above documents it is therefore possible to understand the amount of waste produced and removed within a specific site.

7.3.2 Site Waste Management Plans (SWMP)

From 6th of April 2008, SWMPs becomes a regulatory requirement for projects above £300,000 in net value. The new regulations have been consulted upon during 2007 and have been published mid February 2008. Work is under way within the Research Community to understand the implications of the requirements on the Highways Agency working. Previous work (Greenwood *et al.*, 2007) has however shown that many representatives of the supply chain were aware of the plans and gearing up to if not already implementing SWMPs in their operations. It should be noted that routine maintenance operations such as gully cleaning, litter removal, and landscape management including grass cutting, coppicing etc, i.e. not involving the

maintenance of a structure, do not fall within the scope of the regulations and a SWMP for these activities is not required.

7.4 SWMP tools

SWMPs as assessment and monitoring tools provide a great deal of information on the forecasted and actual waste arisings, and are very useful for a resource balance study. A few general SWMP tools and templates are available from various organisations, including WRAP, BRE's SMARTWaste Plan, Construction Resources and Waste Platform and EnviroWise's SWMP Builder tool, Figure 6 (DEFRA 2008).

The WRAP SWMP templates have been developed by C4S specifically for civil engineering applications. The SWMP templates are available at the link: http://www.wrap.org.uk/construction/construction_waste_minimisation_and_management/swmp_form.html. Furthermore, the HA is developing templates suitable for highways maintenance operations.

	BRE (incl. support services)	CRWP	EnviroWise	WRAP (incl. NHBC/WRAP)
Awareness of SWMPs and their mechanisms	●		●	●
Practical/worked examples of SWMPs	●		●	●
Paper based/static templates	●		●	●
Interactive templates - Generic	●	●	●	●
Interactive templates - Housing	●			●
Interactive templates – Other construction	●			●
Waste reuse and recycling options	●			●

Figure 6 Matrix of SWMP specific tools and support services (DEFRA 2008)

7.4.1 WRAP tools

The Waste and Resources Action Programme is funded by DEFRA and the devolved administrations and has, amongst others, the remit of driving resource efficiency in construction. Alongside a very successful programme which has delivered considerable improvements in the amount of recycled aggregates currently used in the UK for construction applications, it is delivering research on waste minimisation and management and use of recycled materials throughout the spectrum of construction products and throughout the supply chain. Although working mainly with the building industry, civil engineering applications have been considered and incorporated in a number of tools. Two of them are considered for their relevance and potential familiarity to the HA supply chain.

7.4.1.1 Recycled Content toolkit and Quick Wins

The Recycled Content toolkit allows the designers and specifiers to forecast and monitor the recycled content of their construction project. It also provides guidance

on how to improve this value, e.g. to show innovation, best practice or to meet resource efficiency targets set by the client, through the identification of Quick Wins, i.e. materials which are already available with recycled content at no additional cost and meeting the same performance specifications. The tool is available from WRAP at the link <http://rctoolkit.wrap.org.uk/>.

The relevance of this tool to the resource flow is mainly for potential improvements purposes (medium-long term developments of the RFA methodology) and to show a system of on-line data recording based on Bills of Quantities. It is also an introduction to the forthcoming tool, described below.

7.4.1.2 WRAP net waste method

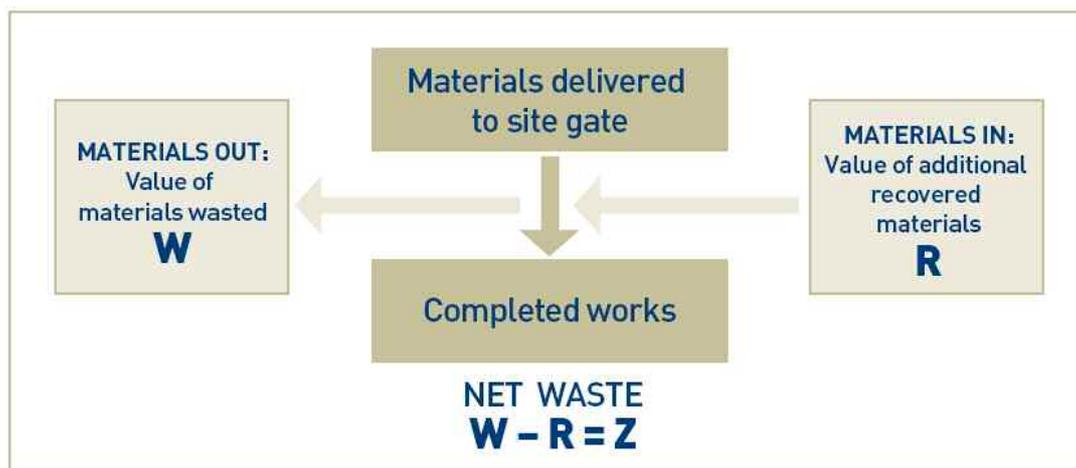
Waste neutrality is promoted by the Government's Waste Strategy and draft Sustainable Construction Strategy, and fits with the industry's own priorities. The Strategic Forum for Construction has adopted the target of halving waste to landfill by 2012, and the Major Contractors' Group has committed to measuring what can be achieved.

The Net Waste Method, being developed by WRAP as a standard metric for measuring progress towards 'waste neutrality', has been created in conjunction with key industry players. A number of construction contractors, including Carillon, Skanska and Balfour Beattie have also partnered up with WRAP for demonstrating how this principle can be used in practice. An online tool, which includes elements of waste assessment, compatible with requirements for SWMP, waste minimisation and recycled content accounting, is to be delivered in Spring 2008.

More information on the methodology is available from WRAP at this link: http://www.wrap.org.uk/construction/the_net_waste.html and from WRAP (2007b). However, in simple terms, WRAP has applied a resource flow approach of sort to account for "entering" materials with recycled content and waste produced by the operations, with the aim of reaching a balance between the recycled content brought in and the wastage generated, i.e. 'waste neutrality'. A representation of the method is given in Figure 7.

More details on the methodological background of the tool are not known at the time of writing; however, it is clear that WRAP is proposing this as the metric that should be universally adopted to measure the progress towards waste neutrality proposed within the Waste Strategy 2007 and the draft Sustainable Construction Strategy. Of note is that the metric is based on monetary value rather than mass measurements. This is a pragmatic approach, which has the obvious advantage of making the cost of waste management more "real" and clearly understood throughout the supply chain, thus ensuring buy in. At the same time, potential disadvantages could be, from a mass flow point of view, inherent inconsistency in accounting the movement of materials for projects in different locations throughout the country (cost/valued might depend strongly on transport costs, and therefore availability of facilities) and linking weakly to the impacts of resource use on the environment (through for example disposal costs – very high for hazardous materials - and Aggregates Levy). This upcoming tool will need however careful consideration for future alignment of the Highways Agency with potential requirements set by the Government.

Figure 7 Representation of the Net Waste method (WRAP 2007b).



W is the cost of wastage (value of materials not incorporated in the construction works¹) [Materials Out];
R is the value of additional recovered materials² incorporated in the construction works or in off-site applications [Materials In]; and
Z is the NET WASTE, which contractors would aim to reduce towards zero for waste neutrality.

7.5 Summary of the review of the current tools and conclusion

- The HA is implementing a number of tools that already impose some resource monitoring requirements on the operations of its supply chain.
- The development of a resource balance method and its application are considered a useful and necessary benchmarking exercise for the operations of the HA' supply chain. This needs to take into account the existing data collected under the HA requirements: it would appear that EnvIS contains most of the data required for the analysis of the resource flow within the HA operations.
- There are some advantages in providing a dynamic feature to this balance, and this will need to take into account and integrate existing/ forthcoming tools and requirements; however, no more tools will be developed, but rather a method of analysis of data already collected.

8 Conclusions of Part I

Part II of this document will provide a more detailed description of the methodology proposed for the accounting of the resource flow within the HA operations. However, the following conclusions can be drawn from this working paper:

- RFA is a powerful policy tool for understanding resource use and driving resource efficiency, however, there is a need for ensuring any new proposed methodology limits the burden imposed onto the supply chain. This will be done by ensuring the approach uses existing data gathering tools such as EnvIS, SWMP, etc.
- There are clear economic advantages to the supply chain in linking up their resource use with their wastage, particularly through waste (resource use) minimisation – the analysis could come up with an indicator that shows this.
- RFA has mostly been applied as a static, post-analysis tool considering resource use over a past period of time only, therefore leaving little space for improvement – i.e. through lessons learnt. It might be that more engagement from the supply chain could be obtained through providing them with immediate feedback. It is recognised that this feature could be included only in the medium-long term to limit the burden on the supply chain and at the

same time that any methodology devised should be flexible enough to include this.

- It is clear that existing RFA methodologies have mainly been applied to high and medium levels (e.g. economies of nations and regions; supply chain of sectors) with data collected from central offices (i.e. the Office for National Statistics). Considerable effort and resources are needed to collect the data, which cannot be disaggregated to the level required from this brief.
- A bottom-up approach, which would prescribe the collection of data from the system under consideration (i.e. the specific project or area managed), as Life Cycle Assessment methods, seems more appropriate, although again data collection is likely to require a significant effort. However, the principle of mass balance should be added to the LCA method or a Bulk Materials Analysis should be taken into consideration.
- Furthermore, consideration should be given to the current methodological debate on carbon footprinting, where the development of a Publicly Available Specification is bringing to the fore hybrid methodologies that would help in covering data gaps and reducing the effort required. It is believed that a hybrid methodology would also be conceptually suitable for the task of accounting resource use and waste arisings.
- Attention should be paid to current tool developments within other areas of policy making and guidance, particularly from DEFRA and WRAP, and liaison with their initiatives should be sought to avoid duplication of efforts and exploit current initiatives the supply chain might already have signed up to.
- From the 2007 review of the Site Waste Management Plans issue (Greenwood *et al.*, 2007) and other contracts, it is clear that different contractual arrangements appear to offer good opportunities or, conversely, barriers to the establishment of a RFA methodology or tool. On the other hand, it would appear that EnvIS is applicable whatever the contractual arrangements.
- The two projects to be used for the validation should as much as possible demonstrate the full potential of the proposed methodology; however, future trialling and ongoing discussion with representatives of projects procured under less favourable contractual circumstances should be sought.
- The conceptual development of the methodology is presented in Part II of this document; it will however require liaison with the Steering Group for advice and reality checking and it is likely to evolve with the application of the approach to the two real projects.

PART II: CONCEPTUAL DEVELOPMENT OF A DRAFT RESOURCE FLOW ANALYSIS METHODOLOGY FOR THE HIGHWAYS AGENCY OPERATIONS

9 Introduction to Part II

Part II of this document extends the conclusions of Part I into the development of a draft methodology to be applied for understanding the balance and efficiency of resource use within highways maintenance projects. This methodology is developed as a “concept” as it is likely to require adjustments during the validation exercise to be undertaken as final sub-task of this Task TE4.

From the analysis undertaken in Part I of this document, the following points are further developed:

- This sub-task will develop an approach or method based on existing measuring and monitoring tools, with limited burden on the supply chain. Specifically, it is recognised that EnvIS and SWMP will be likely to supply the most relevant information;

- Bulk Material Analysis, LCI and hybrid LCI approaches have been identified as methodologies providing useful elements for the approach under development. This approach, kept as pragmatic and simple as possible, is developed in this section; and
- A proposed aim of the analysis of resource flow within highways maintenance operations could be to achieve an indicator of resource efficiency for benchmarking and target settings. This is briefly discussed within this document but will however require further discussion and definition with the stakeholders.

10 Definition of the system proposed for analysis

It would appear that there are at least two different systems that can be analysed within highways maintenance contracts, with the boundaries being spatial or temporal – these systems could be seen as a rough categorisation of types of work undertaken during highways maintenance:

- Work undertaken within a maintenance contract (Area Maintenance or DBFO) during a fixed period of time, e.g. one year or longer– this would include routine maintenance alongside any sizeable interventions, e.g. resurfacing schemes;
- A defined piece of work within a maintenance area, from start to finish, or a phase within a major scheme.

It is believed that the methodology should be applicable to both systems, providing it is clearly defined what the system analysed is. Boundaries would be linked to materials and waste bought during the defined period or for the defined piece of work. The contractual terms and data recording practices are likely to have an influence on / help in this definition of the system for the purpose of the analysis.

It would be useful if the demonstration projects could be chosen to represent one of each system. It is appreciated that the results of the analysis would not be (and do not intend to be) necessarily representative of the overall resource flow within highways maintenance contracts but rather representative of the feasibility of the analysis for a potential benchmarking and targets setting exercise in the future.

A further consideration should be made about how far in the supply chain the resource efficiency should be pushed to: the current Carbon Trust document on Carbon Footprinting (Carbon Trust, 2007) proposes a basic “system” where only the processes under direct control are accounted for and a more complex “system” which takes into account the processes used by the supply chain (e.g. how the materials bought in are produced).

11 Elements necessary for developing a suitable methodology

The following are the proposed building block of the methodology; a draft step by step approach is presented later in section 12.

- The resource flow within the system should be as much as possible fully accounted for and (mass) balanced, i.e.:
 - (Material) resources entering the system can only become addition to stock (i.e. incorporated into roads) or exit as waste. The procurement and use of materials is documented as a minimum within Bill of Quantities and accounting systems used by specifiers and (sub) contractors;

- Materials generated within the system (e.g. waste from verge maintenance; material taken up for resurfacing etc.) can either be reused/recycled within the system or disposed of somehow (internally, if stored for future use, or externally if destined to reuse/recycling elsewhere or disposed of). The accountancy of this flow and the waste flow in general should be possible with the Site Waste Management Plans coming into force or already voluntarily applied and with the EnvIS system;
- Mass quantities rather than monetary values should be adopted as the latter are likely to be confidential information and would vary depending on contractual arrangement and local circumstances; the team will need to produce a reference sheet of mass conversion factors for items bought mainly in numbers (e.g. lampposts, light bulbs) or lengths (e.g. barriers) or areas/volumes;
- A bottom-up approach is to be followed with data collected from the supply chain through the reporting mechanisms already in place – EnvIS, SWMP, regulatory waste returns and any other tools which the TE5 task will highlight – or through existing internal accounting systems if made accessible;
- A flowchart approach, as used by most of the LCI practitioners, will be adopted first for simplicity of communication; however, a table/matrix approach will be explored and applied to ensure the material balancing is achieved;
- A decision is to be made as to how far in the supply chain the resource flow should be considered: it is suggested that at least the first tier of material suppliers should be considered, to understand, for example, how much recycled content is in manufactured items bought in. This would link with the current discussion (and potential targets imposed from government) on “buying recycled” and zero net waste. It is clear that this liaison with material suppliers is likely to be a weak link in the data collection mainly due to the potential high number of suppliers and distance within the supply chain (i.e.: not always a direct link between main point of data collection and material provider);
- Data gaps are to be plugged using as much as possible data from publicly available literature, e.g. technical data sheets, WRAP Quick Wins guides (Aggregain, 2008), on specific products; if not available, use would be made of available UK LCI/LCA publications on generic products and then, as last resort, international LCI/LCAs, including databases of software such as SIMAPro or GaBi which contain I-O data. This hierarchy of information sources is proposed to ensure that the methodology is easily reproducible;
- The opportunity for applying nationally recognised classification systems should be explored for adoption to ensure repeatability/reproducibility and solve any potential confidentiality issues:
 - products/materials bought in/used should be identified using the Combined Nomenclature, which is a 8 digit trade classification system, used by the European Union for statistical and tariff purposes, uniquely identifying products and materials; suppliers would know what their products/materials code is or the team will establish a matrix to create correspondence between products and Combined Nomenclature code for future use;

- Wastes should be classified using the current 6 digit system adopted in Waste Transfer Notes.
- A discussion should be held about the indicators that the analysis should produce – these indicators can be decided later in the project as they would require relatively simple analysis of data gathered for the balance.

12 Draft indicative step by step methodology

The following is an indicative draft step by step illustration (Figure 8) of how it is envisaged that the methodology should be applied. This will be refined during the validation exercise but it is described here in a simplified manner to clarify the process to be followed. It is important that the team collecting the information has some experience of data collection and management and that guidance is provided at key stages such as conversions and final balancing stages. An appropriate review process should be established not only on the data collected but also on the overall process.

12.1 Stage 1: Establish the system and prepare the background information

1. Define clearly the system to be analysed: what is it, what period is covered, what materials are likely to be used, who the contact personnel will be, provisional cut off date for data collection
2. Set up a flow diagram/map of the processes to be analysed
3. Set up a connected spreadsheet for pulling data together, differentiating between materials entering, circulating and leaving the system
4. Establish data sources to be used (EnvIS, SWMP, waste returns, accountancy systems etc.) and who will be providing data at which intervals (directly or through existing reporting frameworks)
5. Establish matrix for conversion of items into mass (or retrieve existing one)
6. Set up matrix (or retrieve existing one) for conversion into Combined Nomenclature (CN)
7. Establish a matrix matching products (CN) with waste codes (for wastage of materials in)

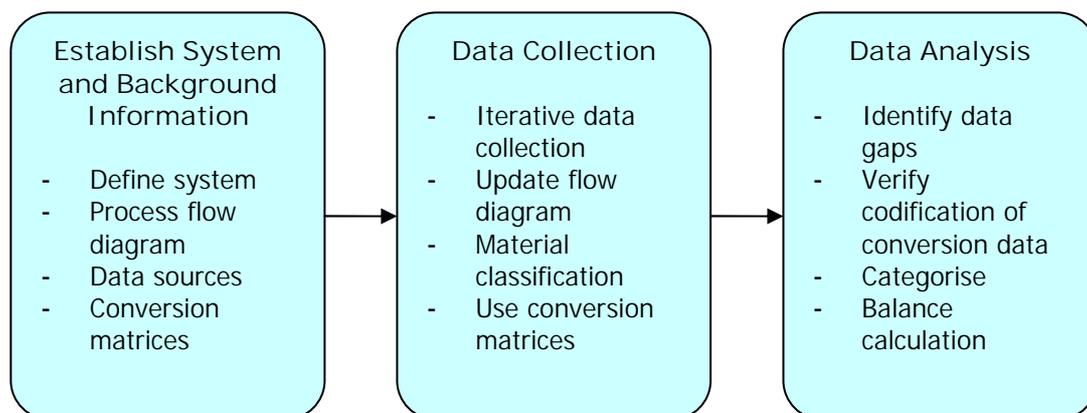


Figure 8 Indicative step-by-step methodology

12.2 Stage 2 (iterative): Data collection

8. Collect data as and when on an iterative basis, depending on the system analysed and the reporting mechanisms/sources of information used.
9. Update flowchart/map as required with new information.
10. Ensure the data include and differentiate amongst materials already in the system (e.g. existing stockpiles of materials), material entering the system, materials added to the "stock" (i.e. incorporated into the works), waste generated, waste reused/recycled internally with or without additional processing, materials/waste stockpiled, waste leaving the site with destination (reuse elsewhere, recycling elsewhere, stockpiling elsewhere, disposal).

NB: waste arising from activities other than construction (e.g. grass cutting, litter) should not be taken into account.

11. Seek information on materials or manufactured products entering the system: technical datasheets, suppliers' information, WRAP or others' guidance, LCIs/LCAs etc. to establish recycled content of materials imported to site, as this contributes to resource efficiency.
12. Record each data source and reference to it to build up a library of references.
13. Convert information into Combined Nomenclature and waste codes as necessary.
14. Convert information into mass using existing matrix or sourcing conversion factors (update conversion matrix as necessary).
15. Compile the data into the flowchart/map and associated spreadsheet.

12.3 Stage 3: Data analysis

16. Review data for gaps and source missing information.
17. Verify codification and conversion of data.
18. Ensure the data is organised or organise and sum up data into the following categories:
 - a. stockpiles of the resource within the unit at the beginning of the period analysed;
 - b. total flux into the system over the accounting period (year(s) or start to finish);
 - c. amount of the resource that is incorporated into the structures or stockpiled for future use;
 - d. amount of resource extracted or produced (typically waste) in the unit during the accounting period;
 - e. amount of resource reused/recycled internally;
 - f. The total flux out of the unit over the accounting period (i.e. waste), subdivided by destination.
19. Undertake the balance calculation using a table showing the different categories listed above so that:
 $a. + b. + e. = c. + f.$
20. Undertake other analyses as requested, see below section 13.

13 Potential issues and opportunities during the validation

- The data collection phase will require using existing reporting mechanisms but it is also likely to require liaison with the supply chain (main contractor at least) due to the recent introduction of systems such as EnvIS and compulsory SWMP. Engagement of the participants to the validation is

therefore required although every effort should be put in ensuring that disruption is limited.

- Although in Part I above a quick analysis of the procurement methods within different contract types has been carried out, there might be fundamental issues or, conversely, better opportunities for accessing information than what has been assumed in developing this methodology. This validation exercise could therefore also be a test on the existing reporting procedures.
- Data collection will be an iterative process and will require the most resources to conduct. Cut-off points should be agreed, depending on the system under analysis, taking into account the delays between works being undertaken and data being reported.
- Care should be taken when plugging data gaps whilst ensuring a traceable method is used; established literature data sources should be used.
- Results might be skewed by elements such as hidden, unreported flows or approximations from data sources. The resource flow might therefore not be fully balanced, although the unbalance should be limited. The results will only be as good as the data provided and collected, therefore the team undertaking the data collection should ensure the procedures followed are clearly documented.

14 Further analysis and benchmarking

The above section describes a basic balancing calculation, which will provide an idea of the amount of materials used and waste generated within the chosen system. It is however clear that the amount and quality of data collected can be further analysed to provide further information, adding value to the exercise. Measures or indicators that can be extracted include:

- Simple ratios of material incorporated vs. material bought in or waste produced vs. material incorporated etc.
- Amount of recycled materials used within the project – either from internal recycling or from import of products/materials with recycled content; this can be normalised vs. the total amount of material incorporated within the structure.

Further indicators might be developed with the incorporation of cost information (e.g. recycled content by value) although this would require additional data collection. Finally, the information collected for this resource mass balance could be integrated with the information collected for a carbon footprinting of highways maintenance operations under the BRO2 programme.

A discussion with the HA stakeholders /Steering Group should be undertaken to establish the indicators to be calculated.

15 Conclusions of Part II

- Part II of this document provides a simple methodology to establish the material flow within highways maintenance operations.
- A pragmatic approach has been chosen to ensure the method is applicable with the data likely to be available from existing reporting.
- A draft, simplified step by step approach has been included to illustrate how the approach would work.

- Alongside a balance of the resource flows, various indicators on resource efficiency can be derived. A decision should be made about exactly which indicators to modify the data collection method if necessary.

16 References

1. Aggregain, 2008. Quick Win Guides accessed 250308 from: http://www.aggregain.org.uk/procurement/quick_wins/index.html
2. Allwood, J.M., Laursen, S.E., Malvido-Rodriguez, C. and Bocken, N.M.P. 2006. *Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom*. A report prepared as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 250308 from: www.massbalance.org/projects
3. BERR 2007. Draft Strategy for Sustainable Construction. A consultation paper July 2007. Department for Business, Enterprise and Regulatory Reform, DEFRA, Communities and Local Government, Strategic Forum for Construction, Department for Culture, Media and Sport. Accessed on 290208 from: <http://www.berr.gov.uk/consultations/page40642.html>
4. BBF 2002. *City Limits – A Resource Flow and Ecological Footprint Analysis of Greater London*. A report prepared by Best Foot Forward Ltd as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 190308 from: www.massbalance.org/projects
5. BBF 2004. *Scotland's Footprint – A Resource Flow and Ecological Footprint Analysis of Scotland*. A report prepared by Best Foot Forward Ltd as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 190308 from: www.massbalance.org/projects
6. Carbon Trust, 2007. *Carbon Footprinting*. Published by The Carbon Trust, accessed 250308 from: <http://www.carbontrust.co.uk/publications>
7. DEFRA 2005. Securing the future. The UK Government sustainable development strategy. DEFRA, London
8. DEFRA 2007. *Waste Strategy for England 2007*. Presented to Parliament by the Secretary of State for Environment, Food and Rural Affairs by Command of Her Majesty May 2007. Accessed on 290208 from: <http://www.defra.gov.uk/environment/waste/strategy/>
9. DEFRA 2008. *Toolkits available to assist production of a SWMP*. Accessed on 010508 from: <http://www.defra.gov.uk/environment/waste/topics/construction/index.htm#swmp>
10. EC 2001. *Green paper on Integrated Product Policy*, adopted by the European Commission. Accessed 250308 from: <http://ec.europa.eu/environment/ipp/>
11. EC 2008. LCA Tools, Services and Data. Accessed 010508 from: <http://lca.jrc.ec.europa.eu/lcainfohub/index.vm>
12. Elghali, L., McColl-Grubb, V., Schiavi, I. and Griffiths, P. 2004. *Sustainable Resource Use in the Motor Industry: a mass balance approach*. A report prepared as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 250308 from: www.massbalance.org/projects
13. Greenwood R., Schiavi I., Hewitt A., Mitchard N., Dolphin J., 2007. *Scoping Study for the Implementation of Site Waste Management Plan, Draft 1*, TRL Unpublished Report UPR 31/03/2007 – HA project reference HTRL 233 (387)
14. Griffiths, P. & Lewis, K. 2004. Development of a Standardised Methodology for Resource Flow Analysis and its Application to Sub-national Regions. Paper delivered at the Clean Air Congress, London

15. Highways Agency 2005a. *Procurement Strategy Review 2005*. Accessed on 290208 from: <http://www.highways.gov.uk/business/1178.aspx>
16. Highways Agency 2005b. *DBFO briefing pack*. Accessed on 290208 from: <http://www.highways.gov.uk/roads/2732.aspx>
17. Highways Agency 2008 *Towards a balance with nature*. Accessed 010508 from: <http://www.highways.gov.uk/aboutus/1982.aspx>
18. HM Government, 2007. UK Government Sustainable Procurement Action Plan - Incorporating the Government response to the report of the Sustainable Procurement Task Force. DEFRA, London. Accessed on 290208 from: <http://www.sustainable-development.gov.uk/publications/pdf/SustainableProcurementActionPlan.pdf>
19. ISO, 2006. International Organization for Standardisation, ISO 14040:2006. Accessed 010508 from: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=37456
20. Linstead, C. & Ekins, P. 2001. *Mass Balance UK - Mapping UK Resource and Material Flows*. Forum for the Future on behalf of the Royal Society for Nature Conservation, London. Accessed on line on 290208 from: <http://www.forumforthefuture.org.uk/files/MassBalanceUK.pdf>
21. Minx, J., Wiedmann, T., Barrett, J. and Suh, S., 2008, *Methods review to support the PAS process for the calculation of the greenhouse gas emissions embodied in good and services*, Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Department for Biobased Products at the University of Minnesota, DEFRA, London, UK.
22. ONS, 2007. *United Kingdom National Accounts The Blue Book 2007*. Annual publication of National Account Statistics. Accessed online on 190308 from: <http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=1143>
23. Smith, R.A., Kersey, J.R and Griffiths, P.J. 2002. The Construction Industry Mass Balance: Resource Use, Wastes and Emissions. A report prepared as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 250308 from: www.massbalance.org/projects
24. Stripple, H. (2001) *Life Cycle Assessment of Road, A pilot study for Inventory Analysis* Second Revised Edition IVL Report B 1210E. Swedish Environmental Research Institute
25. Sturges, M., Brink, J.M. and Freer, E. 2005. *Balanced Reading* A report prepared as part of the Biffaward Programme on Sustainable Resource Use. Accessed on 250308 from: www.massbalance.org/projects
26. Treloar, G.J., Love, P.E.D., Faniran, O.O. and Iyer-Raniga, U. 2000. *A hybrid life cycle assessment method for construction*. Construction Management and Economics 18, 5-9.
27. Treloar, G.J., Love, P.E.D. and Crawford, R.H. 2004. *Hybrid Life-Cycle Inventory for Road Construction and Use*. J. Construction Engineering and Management, January/February 2004, 43-49.
28. UniS (2008) University of Surrey: Life Cycle Assessment Module CD-ROM

29. Wiedmann T, Minx J, Barrett J, Vanner R, Ekins P 2006. *Sustainable Consumption and Production - Development of an Evidence Base*. DEFRA Project Ref.: SCP001 Resource Flows, DEFRA, London, UK.
30. WRAP 2007a. *Achieving good practice Waste Minimisation and Management. Guidance for construction clients, design teams and contractors*. Banbury. Accessed online on 290208 from:
http://www.wrap.org.uk/construction/construction_waste_minimisation_and_management/good_practice_wmm.html .
31. WRAP 2007b. *The Net Waste Method – testing a new standard for measuring waste neutrality*. Banbury. Accessed on line on 290208 from:
http://www.wrap.org.uk/construction/the_net_waste.html .

Appendix A

Summary findings: Procurement and waste services research

The purpose of this section is to review the way materials are purchased and waste is managed and disposed of under three different types of contracts: the Managing Agent Contractor (MAC); Build, Design, Finance and Operate (DBFO); and Early Contractor Involvement (ECI).

The following information was sourced from a desktop study and through telephone interviews with people involved in managing contracts within the Highways Agency and the principal contractors for MAC and DBFO contracts.

Purchasing processes and waste disposal under each contract type.

MAC Contracts

Under MAC contracts materials are purchased through the supply chain- the Highways Agency is not involved in any purchasing, they specify the work to be done and the Principal contractor delivers the work through subcontractors. The Highways Agency appoint suppliers of materials through framework agreements, however it is up to the contractor and its subcontractors to engage who they want.

Under MAC contracts purchasing is very controlled. A material request sheet is signed by two people for all purchases a separate plant request sheet is also used. A Bill of Quantities is used to control spending and a Clark of Works checks all materials purchased against what was specified. When sub-contractors are involved in purchasing materials they use their own procurement teams. AmeyMouchel use a software package called SAP which is a useful tool that tracks all purchasing. With this system, reports can be produced for any period of time, for any job.

The subcontractors are free to use their own suppliers however, sometimes AmeyMouchel will supply a preferred list of suppliers to subcontractors because they have already screened them and know that they can do the job to the specification. Sometimes the Highways Agency will specify to AmeyMouchel when they want a specific subcontractor to be used, but most the time this is not the case.

AmeyMouchel have an open book system with each subcontractor and with the Highways Agency. AmeyMouchel audit the subcontractors under this system and check all purchases through to the delivery ticket level. These checks are made within the first month and then on a quarterly basis. AmeyMouchel only pay subcontractors on a cost basis, so the subcontractors must present all invoices before they can get paid. This means there is a record of all purchases made by the subcontractors and AmeyMouchel can keep track of all materials purchased on each job.

Bill of Quantities are used they are at first fixed and then any changes have to be substantiated and agreed to before they go ahead. The Bill of Quantities is then updated.

(Telephone conversation with Bill Turner of AmeyMouchel – Support Service Manager 14th March, 2008).

In addition to the above information, an email questionnaire was sent to three Highways Agency personnel to obtain more information. There was one response. One important finding from this response was that the Highways Agency recognise the need to get more involved with buying materials through MAC contracts so that they can get savings from Bulk Purchase Agreements with local authorities (Email response from Daniel Cooke, Highways Agency, Procurement for Traffic Operations- Development 14/03/08).

Waste management services

Waste management services are procured by AmeyMouchel and they have a preferred supplier that they use for the majority of work. However, sometime they need to source a local service provider for the removal of contaminated materials. The company they use to do the majority of waste management separates as much waste as possible and have their own recycling plant which helps to minimise waste to landfill.

Subcontractors use their own waste companies, but AmeyMouchel try and encourage them to use their preferred supplier. Specialist companies are also used for the removal and disposal of body parts and animals.

(Telephone conversation with Conversation with Bill Turner of AmeyMouchel – Support Service Manager 14th March, 2008).

DBFO Contacts

The Highways Agency does not get involved in procurement of materials under DBFO contracts. All the purchasing and delivery of services is carried out by the DBFO Principal contractor. The Highways Agency specifies what services the DBFO must carry out under contract, it is then up to the DBFO contractor as to how they go about delivering the specifications.

The Highways Agency is trialling an open book accounting system with the M25 contract. The aim of this trial is to allow the Highways Agency to get a handle of costs and how much the DBFO is spending.

The Highways Agency also sets standards for the DBFO to follow. The standards are called, 'Routine and Winter Service Code' and are currently being updated as they were first written in 1996.

The Highways Agency does not get involved with procuring any waste services, this is up to the DBFO.

(Telephone conversation with Cate Steele from Highways Agency- PFI Policy 13th March, 2008).

Tools that can be used to collect information on purchasing and waste

EnvIs

ENvIS has been designed to be compatible with Site Waste Management Plans to avoid duplicating reporting requirements, in this way the same data will appear in the two systems.

SWMPs

Area 9 has been trialling Site Waste Management Plans (SWMPs) in preparation for the impending legislation. The SWMP will be applied initially to all projects that fall within the scope of the legislation i.e. with a value above £250 000. They will then look at applying SWMP to smaller projects as they believe the SWMP is a useful tool to track waste and encourage waste minimisation (Telephone conversation with Ian Fuller, Special Projects Manager for Area 9 (M5) AmeyMouchel 13/03/08).

Interviews conducted in 2007 for a report carried out by TRL and Halcrow for a scoping study for the implementation of Site Waste Management Plans into Highways Agency operations, found that all MACs were aware of SWMPs and are taking steps to ensure they are ready for the introduction of the new legislation. However, awareness and uptake across

subcontractors is variable, with some being committed and others not. They are also taking steps to ensure their subcontractors are addressing the need to adopt a SWMP.

Areas 1 and 9 are incorporating SWMPs into a section of the construction Environmental Management Plan and Areas 7 is looking to incorporate it into an environmental section within the Health and Safety File. In general, the impression from the other areas is that SWMPs would be utilised on any scheme, whether maintenance or improvement, for which waste was a significant issue (TRL and Halcrow 2007).

For DBFO contracts SWMP plans are not being addressed by Road Management Services (RMS) (the contractor interviewed for the scoping report), and is instead being addressed by the main waste contractors, Ringway is one of them. The larger subcontractors used by DBFOs are already addressing waste and SWMPs proactively (SWMP report TRL and Halcrow 2007).

Under DBFO contractor arrangements adopting SWMPs beyond the minimum requirements of the legislation may be a barrier. It may not be a barrier however, if the subcontractors used by DBFO contractors are implementing SWMP themselves. This was the case with Ringway and it is likely that the larger construction firms will be as well.

Under ECI contracts a waste management plan is required (linked to the Duty of Care) and all future contracts will require a SWMP to be produced.

Findings of the SWMP final report written by TRL and Halcrow 2007 suggests that the preferred method of adopting Highways Agency SWMP requirements into Service Providers business practices would be through including SWMPs into the DMRB Volume 10. This would initially involve the publication of an Interim Advice Note (IAN), aligned with the timescales of SWMP legislation, and then within 12 months the publication of full DMRB advice.

ECI Contracts

A telephone interview was conducted regarding Area 7 with AMSCOTT. AMSCOTT is involved in a number of ECI contracts. ECI is a close relative of D&B, in that it exploits the contractors' unique understanding of the construction processes in order to benefit the design process. The difference is, as the name implies, that ECI involves the contractor far earlier. Under D&B, the contractor is presented with a fixed route and a design that is at least 80% fixed. By the time the contractor comes on board, the scope for its input is limited. With ECI, the contractor joins the team right at the start of the statutory process and is involved with planning, assessing buildability and cost estimating.

The Highways Agency (HA) first adopted ECI in 2001 and it is now its preferred procurement route. It selects contractors not by lowest price bid, as at this stage there is no design to bid for, but by an assessment of the company's track record via its Capability Assessment Toolkit (CAT). The two sides then work together on an open-book basis to develop a target price. The contractor is incentivised/encouraged? To design and construct the scheme within this target price based on a pain/gain share formula. However, where AMScott is involved, two types of ECI contracts exist. They are:

A) Derived Price Schemes

This type of scheme is usually set up for a supply chain of contractors, headed by a main contractor, who is involved in preparing target costs for Derived Price Scheme projects with a value of less than £0.5 million. This target cost usually involves material procurement, waste management and any recycling activities on site and off site. Suppliers produce informal Site Waste Management Plans and submit them to the main contractor with all related information on materials used, purchased and dispatched from the site in the form of waste, including the waste transfer notes. However, in the case of Area 7 they do not use any software to record data on materials, waste etc. However, over the last six months they have begun to populate EnVIS with relevant site information. The only waste that is not recorded and communicated to the main contractor is about light fittings and safety barriers etc.

B) Framework Schemes

This is an arrangement where the terms and conditions (including pricing methodology where possible) are agreed with the supplier(s) of goods and services, which allows for call-offs to be made without the need to go through another formal tendering process. The value of these projects is usually between £0.5 and £500 million. In this case, the main contractor is responsible for developing the bill of quantities, SWMP, schedule for recycling of materials, use of reused and recycled materials. Within the context of Area 7, they do not use any software to record material and waste data. However, over the last six months they have begun to populate EnVIS with the relevant site data.

Summary of contacts

CONTRACT TYPE	AREA/ SCHEME	CONTRACTOR/H IGH WAYS	INTERVIEWEE	DATE
MAC	9	AmeyMouchel	Ian Fuller	13/03/08
MAC	9	AmeyMouchel	Bill Turner	14/03/08
DBFO		Highways Agency	Cate Steele	13/03/08
MAC		Highways Agency	Daniel Cooke (via email)	14/03/08
ECI	7	AMSCOTT	David Gedgney	19/03/08