Identifying Resource Efficiency Indicator Mechanisms for the HA

By
C4S at TRL Limited

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TRL
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For Further Details Please Contact:

Dr Jacquie Berry
TRL Limited
Tel: +44 (0) 1344 700080
Email: jberry@trl.co.uk
1 Executive Summary

This report builds on from previous work conducted for this initiative and seeking to establish new resource efficiency indicator(s) to be applied to the Highways Agency’s construction and maintenance activities. Should suitable indicators and methods of measurement be identified and demonstrated in this and the remaining year of the work programme, then the new measures may replace the current “Area Performance Indicator 15: Recycling and Reuse” within the HA’s Area Performance Indicator Handbook.

Previous work conducted specifically on this initiative is summarised in two past reports:

- Review of Resource Efficiency Metrics and Indicators for the Highways Agency (February 2009).

The first report summarised the requirement for a ‘mass balance’ approach to be pursued. The second report identified the different ways of capturing information on resource efficiency in the form of indicators.

This third report aims to find a way of balancing mass flows in and out of Agency schemes, using the existing ways in which the HA and its contractors collect material and waste data, and then expressing the information which is collected in a useful way, as indicators. Indicators can then be used over time for benchmarking and for measuring progress towards internal and external targets for the efficient use of materials. Where possible, input has been sought from parties who currently collect data for the HA, either internally or externally as contractors. This input was sought to establish the usefulness of the data collection methods already in use for this new purpose, since one of the underlying aspirations for this work was not to create further data collection demands for the Agency and its contractors but to use methods which already exist, or are envisaged to be implemented in the near future. Review work undertaken elsewhere under the HA BRO3 Sustainable Construction and Maintenance work programme also proved to be informative for this task, particularly:

- The review of HA and Service Provider data collection methods undertaken in Task Element 5 of the 2007/08 programme (May 2008).
- A briefing paper which considered possible linkages and synergies between the HA’s Carbon Accounting Framework, SWMP templates and EnvIS, undertaken in Task Element 2 of this year’s programme (October 2008).

This review concludes with a number of recommendations as to the most feasible indicators and possible mechanisms by which they can be measured. The next step will be to finalise development of the methods and to demonstrate their use on two HA projects which have been identified.
2 Introduction & Scope of this Report

The forthcoming requirements which will be sought of the HA in terms of resource efficiency and its commitment to achieving the targets are well established. The key targets for improving resource efficiency come in the form of BERR’s Strategy for Sustainable Construction and the cross-governmental Targets for Sustainable Operations on the Government Estate. These two documents translate national legislation into a form which is applicable to the HA. Site waste management plans (SWMPs) provide the reporting framework by which compliance to these targets can be demonstrated. The Strategy for Sustainable Construction sets a 50% reduction of construction, demolition and excavation waste to landfill by 2012, relative to 2008 levels. Sustainable Operations on the Government Estate sets targets to reduce the amount of waste generated overall, stipulating a 5% reduction by 2010 and a 25% reduction by 2020, both relative to 2004/05 levels. Robustly measured resource efficiency indicators should assist demonstration of progress towards these targets, by capturing the necessary project level data which can then be aggregated together. The HA’s commitment to achieving greater resource efficiency is stated in the Sustainable Development Plan and Vision, the Environment Strategic Plan Creating a Balance with Nature and the Sustainable Development Action Plan 2007-2008.

2.1 Principal findings from the review of resource flow analysis approaches

The report Understanding Resource Use and Waste Generation within the Network: A Mass Balance Approach yielded the following conclusions which had specific implications for developing the new methodology and indicators. Under each point it is stated where each issue has been interpreted in subsequent research:

- Resource Flow Analysis (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.

  The research team has been conscious only to explore existing methods of data collection with contractors, with a view to not creating any extra burdens on their time.

- 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.

  The review of resource efficiency indicators determined indicators which measured material use in isolation, waste in isolation and others which coupled waste or service output to the initial outlay of materials. To achieve extra awareness amongst contractors of linking waste to resource use, it is recommended to use one of the coupled indicators.
• 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.

The view is not to create a static, post-evaluation procedure but to have dynamic indicator(s) that are periodically measured throughout a project. Re-measurement of the indicator(s) would coincide with updates to other data collection methods. Once the established indicators have been used with a variety of projects (varying in type and size), benchmark levels of resource efficiency will be established. Benchmarks will therefore give an idea of what can be achieved in terms of resource efficiency at the design stage of projects.

• It is clear that existing RFA methodologies have mainly be 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.

‘Top down’ accounting applied at high and medium levels is not an approach which has been encountered in the HA’s data collection methods and is not likely to be much use on a project by project basis. It is therefore proposed to follow a ‘bottom up’ methodology which gives the most possible resolution to material flows.

• 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.

It has been established that the scope of this initiative is to measure resource efficiency and not to equate environmental impacts to resource flows. If significant data gaps exist when the methodology is trialled with demonstration projects in 2009/10 then there may be a requirement to revisit ‘top down’ methods of data collection to fill the gaps and thereby create a hybrid methodology.
2.2 Principal findings from the review of resource efficiency indicators

The report a Review of Resource Efficiency Metrics and Indicators for the Highways Agency arrived at the conclusions below. Under each is a summary of the implications for subsequent research:

- The system should consider only the activities which the HA has direct influence over i.e. material inputs and outputs to and from highway construction and maintenance sites.
- Mass balance is the fundamental principle on which many resource efficiency metrics/ indicators are based.

The methodology chosen should balance material flows into and out of highway construction sites in order to be most applicable to the HA, if indicators are to focus on resource efficiency in construction.

- A consideration as to which material flows are included within the system needs to be made:
  - Flows into the system consist of materials, non-renewable energy sources and water;
  - Flows out consist of waste (including waste water) and emissions; and
  - The addition of ‘stock’ balances the system.

A comprehensive mass balance would consider each of the flows above but it is possible to isolate some of the flows to concentrate on initially. For example the corresponding input and output flows of materials and waste can be isolated from non-renewable energy and emissions, water and waste water.

- The review of existing metrics and indicators which have been developed by a variety of organisations in the construction sector and beyond discovered indicators which fell into three main categories, these were:
  - Indicators which were mainly concerned with measuring the amount of material going into a system in isolation;
  - Indicators which were mainly concerned with measuring the amount of waste coming out of a system in isolation; and
  - Indicators which coupled material input to waste or useful service output, thereby creating a simple measure of resource efficiency.

Which indicators are pursued depends to some extent on the perspective of resource efficiency which is to be followed. If the perspective being taken was to measure resource efficiency in procurement, then the indicator chosen might be concerned with the quantity or proportion of recycled materials procured for incorporation into highway schemes. If the perspective was resource efficiency in waste management then the measure might be the proportion of waste going to reuse or recycling.
Alternatively, the perspective taken might be resource efficiency across HA schemes in construction which would consider material wastage as a proportion of materials coming into the scheme or in relation to addition to stock. A suite of indicators might be chosen to combine more than one perspective.

- There are a variety of different types of construction projects which need to be included within the scope: roads, bridges, tunnels and associated works; and maintenance projects: re-surfacing, minor and major maintenance.

Ideally the indicators chosen should be applicable to all types of project within the HA’s jurisdiction.

- There is also a wide range of project sizes which could be included: macro (organisational level), intermediate (individual business sectors and/or projects) and minor (individual processes).

The indicators will be developed for use mainly at the intermediate and micro levels, which is the current level at which API 15 is aimed at.

The points above can be summarised into a number of objectives to consider whilst developing a new indicator for resource efficiency in the HA, these are as follows:

- The new mechanism should be derived from existing HA data collection methods;
- In considering possible new indicator(s), the different perspectives of resource efficiency which can be taken should be considered;
- There are also different temporal aspects to indicator measurement; a consideration of whether new indicator(s) should be used to undertake continual evaluation or post project evaluation should be made;
- A ‘bottom up’ methodology is most appropriate for initial development;
- The indicator(s) should ideally apply to all HA project types;
- An indicator which measures resource efficiency and is concerned primarily with material and waste flows is the first priority; and
- Balancing material and waste flows across projects is appropriate for indicators which measure resource efficiency in construction.

2.3 The Current Area Performance Indicator 15: Recycling and Reuse

It is a possibility that the new indicator(s) which are developed may replace the existing Area Performance Indicator 15, which measures recycling and reuse in network activities. It is therefore important to consider how the current indicator works and its advantages - and shortcomings - to be taken forward and addressed in developing new indicator(s).
At present, API 15 works via subjective assessment of the levels of recycling and reuse achieved in 19 waste categories on a monthly basis. Monthly performance is then aggregated up to calculate a rolling twelve month performance.

The advantages of the current method include the level of segregation in the waste flows before aggregation, which allows information on particular materials to be considered, and the rolling nature of the reporting period which allows for continual monitoring.

The disadvantages of the current method include the subjective nature of reporting and the arbitrary allocation of scoring between different materials, which is independent of the quantities of waste produced. This may be addressed by establishing clear rules for reporting and weighting (which could be based on quantity produced and relative ‘impact’ of the waste stream. A further disadvantage is the low reported take up of the methodology by contractors; this may be addressed in future mechanisms by embedding it within existing data collection methods as proposed.

2.4 Aims and scope of this report

The aim of this report is to explore how resource efficiency indicators in the HA can be feasibly measured. The scope of indicators is largely defined by the points above, determined from the previous reports on this initiative. The review will consider three indicators, each of which considers resource efficiency from a different perspective (in procurement, during construction and in waste management). A recent meeting of waste champions from MACs decided that the following two indicators would be useful:

- Percentage of recycled materials used in construction per £ spent on material.
- Percentage of total waste diverted from landfill and other disposal options.

The first is an example of measuring resource efficiency in procurement, the second measures resource efficiency in waste management. In addition, it is proposed to look at an indicator which measures resource efficiency across a construction system:

- Waste as a proportion of material input (in terms of mass or monetary value).

This third proposed indicator is an amalgamation of one which features in CIRIA’s Club 10 suite of indicators (CIRIA, 2004) and one which features in the WRAP SWMP template (WRAP, 2008a).
3 Data Collection Mechanisms

Existing data collection mechanisms were explored to determine their suitability for measuring resource efficiency. A previous review of HA and Service Provider data collection methods undertaken in Task Element 5 assisted in reducing the list of data collection methods initially from the wide range which are available. Those omitted from the review at this stage, on the basis that they did not capture data on material use, waste or addition of stock to the network, were as follows:

- Highways Agency Drainage Management System (HADDMS);
- Highways Agency Geo-technical Database Management System (HAGDMS);
- Environmental Management and Reporting System (EMaRS);
- Scoping Tool for Environmental Assessment; and
- Structures Management Information System (SMIS).

This left the following to consider in more detail:

- Environmental Information System (EnvIS) - designed to capture material use and waste data;
- HA Carbon Accounting Framework - collects material use and waste data; and
- Highways Agency Pavement Management System (HAPMS) - records addition to the network as stock.

Further sources of information which were identified as potentially useful were:

- Site Waste Management Plans (SWMPs) - waste data; and
- Bills of quantities - material use data.

Each of the five mechanisms were explored in more detail with the help of a MAC (A One in Area 14) and major scheme contractors (Arup for the M1), in house TRL experts and/or HA representatives.
3.1 Environmental Information System (EnvIS)

EnvIS is a relatively recently implemented data collection method (IAN 84/07, July 2007) in the HA which records information in relation to environmental assets located within the highways estate and surrounding areas and management of those assets. Amongst a number of objectives, EnvIS aims to assist in the review and reporting of environmental performance of both the HA and Service Providers.

3.1.1 Data records relevant to resource efficiency reporting within EnvIS

EnvIS has the capability to record information on both waste production and material resource use. Material resources are defined as solid materials that are used in construction, maintenance and operation. Within EnvIS, water and energy are not considered to be material resources. EnvIS has the capability to record point sources of licensed (>20m3/day) and unlicensed water abstractions but not the actual quantities consumed. Energy use or the pre-cursor fuel use is not recorded in any form.

Material resources and waste is one of seven environmental topics which EnvIS is designed to record, alongside landscape, nature conservation and ecology, water, cultural heritage, air quality and noise. Environmental information recorded through EnvIS’ extensive template system are displayed in the HA Geographical Information System (HAGIS). Waste quantity would be recorded alongside one of twenty European Waste Catalogue (EWC) codes and its destination.

The system also has the capability to record whether material derives from a re-used, recycled or primary source, and whether it comes from supplier, recycling centre, other site or on-site. EnvIS collects a detailed description of the material and the material class (system categories material as primary, recycled, and reused). The quantity (in tonnes) and the origin of the materials are recorded. Material categories which are permitted for entry into the system are as follows:

- Aggregates
- Asphalt
- Batteries
- Bricks
- Bulbs
- Concrete
- Earthworks other than aggregates
- Environmental barriers: other
- Environmental barriers: timber
- Fencing: other
- Fencing: timber
- Ferrous metal
- Gritting sand & salt
- Lanterns
- Non-ferrous metal
- Other (specify)
- Paint
- Plastic
- Road restraint systems: ferrous metal
- Road restraint systems: other
- Timber
- Topsoil
Waste and material resources data are required to be submitted annually to EnvIS at the beginning of the financial year. This submission will include planned records for the forthcoming financial year and actual records from the previous financial year, thereby providing a medium to compare and reconcile estimates with actual figures.

Overall responsibility for ensuring compliance with EnvIS lies with:

- The HA Project Team Leader and Environment Coordinator (in the course of the Environmental Impact Assessment (EIA) and Environmental Planning and Design);
- The Environmental Manager (in the course of Construction); and
- HA Area Teams and the Area Environmental Manager (in the course of Maintenance and Operation).

Submissions made by service providers are checked and uploaded to EnvIS by the HA Information Directorate.

3.1.2 Update on EnvIS

Contact with a representative from Arup, a BRO3 Steering Group member (Pers. Comm. 2009a), has provided an update on the current status of EnvIS. At present EnvIS is not live so data has only been collected from Maintenance Area Contractors through the ITT (invitation to tender) process and also through the CHAMP (cultural heritage) project. Neither of these initiatives was required to submit any waste or material use information so none currently resides within EnvIS.

Amongst the developers of EnvIS it is realised that some changes will have to be introduced to make it compatible with the SWMP regulations. It is intended to do this once the system is live and receiving waste data. Discussions with the developers of EnvIS in Arup have revealed that it could play a key role in helping the HA to report on resource efficiency and sections can be re-developed in a way that would facilitate this. There is the potential for the project team to work with EnvIS developers during the 2009/10 programme to ensure that the three initiatives (EnvIS, SWMPs and this Task Element of BRO3 are aligned).

3.2 HA Carbon Accounting Framework

Although not its primary objective, the HA Carbon Accounting Framework (introduced in IAN 114/08) records data on both material use and waste. Both sets of data are required as intermediates on route to calculating carbon emissions from activities under the HA’s jurisdiction, which include:

- Internal operations
- Network consumption
- Major projects
- Managing agent contractors (MACs)
- Tolling stations
3.2.1 Data records relevant to resource efficiency reporting within the HA Carbon Accounting Framework

Each of the operations above has a separate spreadsheet workbook which is designed to facilitate data collection; material use (as purchases during the reporting period) and waste removal are each recorded on a separate worksheet of a standard format. The material use and waste removal spreadsheets are two in a set of five which accept data inputs, the others being energy, transport, and renewables and recycling. Material use data recording is very segregated, as it is necessary for embodied carbon calculations. Quantities consumed can be entered against a number of categories including cements, metals, miscellaneous, mortars, plastics and quarry sourced materials, timber, ready-mixed concrete, windows and office equipment. A portion of the data entry sheet is presented in Figure 3.1.

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of Material</th>
<th>Unit</th>
<th>Total Material Purchased</th>
<th>Unit conversion: density</th>
<th>Embodied CO2 per tonne material</th>
<th>Quantity (tonnes)</th>
<th>Total Distance from Supplier to Site (km)</th>
<th>Pre-determined Mode of Transportation</th>
<th>Embodied CO2 (tonnes)</th>
<th>Transportation of Material (tCO2)</th>
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<td>Quarry Sourced Material</td>
<td>Gravel aggregate</td>
<td>Tonnes</td>
<td>90</td>
<td>2.8 tonnes/m³</td>
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<td>92</td>
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<td>0.72</td>
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<tr>
<td></td>
<td>Recycled aggregate</td>
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</tr>
<tr>
<td></td>
<td>Blocks</td>
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<td>2.4 tonnes/1000 litres</td>
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<td>0</td>
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<td>Road</td>
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<td>Stone drainage pipings</td>
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<tr>
<td></td>
<td>Slate</td>
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<td>0.00</td>
<td>2.7 tonnes/m³</td>
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<td>Road</td>
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<td></td>
<td><strong>396.5</strong></td>
<td><strong>10.48</strong></td>
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<th>T/O/t</th>
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<th>Embodied CO2 (tonnes)</th>
<th>Transportation of Material (tCO2)</th>
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<td>Particle board</td>
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<td>1.08 kg/m³</td>
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<td>0</td>
<td>0</td>
<td>Road</td>
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<td>1.5 m³</td>
<td>1.08 kg/m³</td>
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<td><strong>2.93</strong></td>
<td><strong>2.27</strong></td>
<td></td>
<td><strong>3.03</strong></td>
<td><strong>19400.00</strong></td>
</tr>
</tbody>
</table>

**Figure 3.1. Example material inputs into the Carbon Accounting Framework**

Waste data is also fairly well segregated and it is entered against three categories; office waste for general disposal, office waste which is recycled and construction waste. The construction waste category is further sub-divided by European Waste Classification (EWC Code) or into the categories of inert waste, inert waste that can be used as aggregate and hazardous waste where the EWC code is unknown. The construction waste input sheet is shown in Figure 3.2 and the sheet which captures recycled content in Figure 3.3.
3.2.2 Update on the Carbon Accounting Framework

There is presently some on-going work elsewhere in the BRO3 initiative to synchronise the requirements of the waste removal spreadsheet of the framework with requirements which are met as part of SWMPs (Section 3.4). Considerations made in other elements of the BRO3 programme have come up with the following recommendations, which will help to synchronise these two data collection mechanisms:

- Add a column to the Site Waste Management Plan Template to record the distance which waste is transported from site to reprocessing or disposal.
- Require the Site Waste Management Plan Template to be updated quarterly to match the reporting period of the Carbon Accounting Framework.
If these recommendations are implemented it will have some consequences for using either or both of these data collection mechanisms for the basis of a resource efficiency calculation.

3.3 Highways Agency Pavement Management System (HAPMS)

HAPMS is the HA’s asset management system. HAPMS consists of database which records information on the HA network and is updated by HA Service Providers. Each section of the HA’s network is uniquely referenced and information on each is accessed via a map interface. The information stored includes data on construction, a definitive inventory, traffic, accident statistics and condition.

3.3.1 Data records relevant to resource efficiency reporting within HAPMS

Of particular interest to this initiative is the construction and highway inventory data that is held within HAPMS. From the perspective of measuring resource efficiency, this information can potentially provide the amount of material input to a road scheme that has been usefully used and, when added to waste, provides the total for the output side of the mass balance equation for a construction project. In theory HAPMS could provide a record of what remains behind after construction or maintenance activities are complete (stock and additions to). Construction data provide information on highway construction in terms of dimensions (lengths of sections in metres, lane widths, depths in millimetres) and types of material used. What should be listed in the carriageway inventory is specified by the Routine Maintenance Management System (RMMS). The inventory stores information on the locations and non-highway assets including:

- Bollards
- Footways
- Kerbs
- Interceptors
- Lighting
- Manholes
- Road markings
- Signs

To convert this information into material tonnages, which is the form required to conduct the mass balance, it would require a number of assumptions to be made. For example, average densities of commonly used materials would be required to convert the volume of components into a mass; average dimensions would be required to establish the volumes of many components from quantities. These assumptions therefore come with a consequential error margin for the mass balance overall.

Service Providers are responsible for the accuracy of the content held within HAPMS for their Network. The requirement is for Service Providers to ensure that ‘as built’ data is provided in order to ensure that accurate records are kept at all times. However, there is inevitably some delay in updating the databases with current
records; this is probably due to the number of organisations which are involved in this process (see Figure 3.4). Consultations with the HAPMS help desk have revealed that updates to the system after the completion of works can vary from being almost instantaneous to taking a few months. This largely depends on how routine or ‘planned’ the works are; those with the greatest lead in time are the most likely entered promptly into the system. Hence HAPMS may be most suitable for annual reconciliation of figures via a mass balance method, rather than more frequent use.

Figure 3.4 Data flow diagram for HAPMS (from the Network Management Manual) (HAST are the HAPMS support team)

3.3.2 Alternative ways of recording stock added to the network

National Statistics, produced annually by the Office of National Statistics in the form of the Construction Statistics Annual, provided a further potential means of measuring stock added to the highway network. Using data of this type would couple ‘bottom up’ methods of data collection (individual waste stream data) with ‘top down’ aggregated data sources such as those which feature in Figure 3.5, thereby creating a ‘hybrid’ methodology. However, on further investigation, the statistics available on highway schemes of this nature have proved to be too aggregated, since resolution would be required at least on an individual scheme basis.
3.4 Site Waste Management Plans

The requirement to complete Site Waste Management Plans (SWMPs) for construction projects became a formal requirement for projects over £300k in value when the Site Waste Management Plans Regulations (Statutory Instruments 2008 No. 314) came into force. These regulations have been translated into a draft IAN for the HA. The IAN has an accompanying set of templates which facilitate preparation of SWMPs for HA projects.

### 3.4.1 Data records relevant to resource efficiency reporting within the Site Waste Management Plans

SWMPs provide a measure of the quantity of waste which is generated in construction projects, provided that they are over the £300k threshold in terms of value in the agreed tender for work (excluding VAT). SWMPs apply to all aspects of construction work including preparatory work such as site investigation, demolition, advanced groundworks and structural maintenance projects (pavements, bridges, drainage, earthworks, technology facilities etc.) but are not required for routine maintenance operations such as gully cleaning, litter removal, and landscape management including grass cutting, coppicing etc., although the HA may deem that it advantageous to do so in some circumstances to maintain best practice across all waste management activities. Despite the threshold being present, it is envisaged that the majority of the material intensive construction projects will have an SWMP, by nature of the scale of works that the HA commissions. Before construction is commenced, SWMPs are used in a predictive capacity as far as waste quantities go, but as the project proceeds will be updated with ‘actual’ data (a regulated requirement). Hence an accurate picture of waste management undertaken throughout the project will be present in records at the time of completion. Figure 3.6 shows an example of the template which is used to record predicted quantities (and destinations) of waste during a construction project. Figure 3.7 shows an example of the template which is used to capture the actual waste data.
As a minimum, the SWMP Regulations require that the plans are updated every 6 months to record the types and quantities of waste which have been generated.

### 3.4.2 Update on SWMPs for the HA

Recommendations made under the HA Carbon Accounting Framework (section 3.2.2) are also relevant to SWMPs. Sub-contractors from the main contractor may conduct works which fall under the threshold and may not be recorded centrally.
3.5 Bills of quantities

Information is currently being sought from HA representatives on the specific use of Bills of Quantities (BOQ) within the Agency and this section will be updated accordingly when this information is obtained.

A BOQ estimates the quantity of work to be done in a civil engineering or building contract and includes amount of materials to be used and waste disposal costs. Each item shows the quantity of work involved. The bill is issued to tenderers at the procurement stage of a project, who return it with a price opposite each item. This priced bill of quantities constitutes the tenderer's offer.

3.5.1 Data records relevant to resource efficiency reporting within Bills of Quantities

The quantities of work on a BOQ may be specified in terms of numbers of items, dimension (linear metre, square metre, cubic metre), time (hrs, weeks) or weight. A generic bill of quantity for an infrastructure project is presented in Figure 3.8.

![Figure 3.8 Generic example of a bill of quantities for an infrastructure scheme](image)

Some characteristics of Bills of Quantities make them suitable or unsuitable for resource efficiency calculations and indicators. Firstly, it would be necessary to determine the material components from the non-material components on the bill. Items specified on the basis of price may contain material cost plus the labour cost of installation; hence the two may need to be separated. To do this it may be possible to reduce costs by a certain rate by which it is assumed that material costs have been marked up by (Figure 3.8 demonstrates this marked up rate with the 'materials % of cost' column). Once material costs have been isolated from labour then it should be possible to use Bills of Quantities for procurement focussed resource efficiency calculations.

The use of Bills of Quantities to conduct resource efficiency calculations for construction systems may prove to be a bit more challenging. The units in which
material quantities are specified would have to be aligned to the same that waste is specified in other data collection methods (typically tonnes). Material quantities specified in other units (e.g. number, volume, size) would have to be converted and this may require a wide variety of conversion factors to be used which may complicate the process.

Bills of quantities are a pre-project estimate of work required, hence by the end of the project may contain material data which differs significantly from ‘as built’.

Some contractors undertake final reconciliation between estimates of the BOQ and actual products and services paid for, but we understand this is an internal procedure not always applied and generating potentially commercially sensitive information.
### 3.6 Summary of methods considered

<table>
<thead>
<tr>
<th></th>
<th>EnVI S</th>
<th>Carbon Accounting Framework</th>
<th>HAPMS</th>
<th>SWMPs</th>
<th>Bills of Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Reported</strong></td>
<td>Material inputs Waste</td>
<td>Material inputs Waste</td>
<td>Stock (useful outputs)</td>
<td>Waste</td>
<td>Material inputs</td>
</tr>
<tr>
<td><strong>Operational?</strong></td>
<td>Not fully (esp. not Materials and Waste)</td>
<td>Yes</td>
<td>Yes</td>
<td>Not fully (IAN yet to be issued)</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Reporting Frequency</strong></td>
<td>Annually</td>
<td>Quarterly</td>
<td>No set frequency, but potential delays</td>
<td>Bi-annually (but may be quarterly for the HA)</td>
<td>No set frequency, 1 or 2 versions produced at tendering and contractual stages.</td>
</tr>
<tr>
<td><strong>Units Reported</strong></td>
<td>Unclear</td>
<td>Tonnes</td>
<td>Dimensions (l x w x h)</td>
<td>Tonnes</td>
<td>Various (nr, t, m², m³ etc.)</td>
</tr>
<tr>
<td><strong>Suitable recording structure?</strong></td>
<td>Slightly unclear, but data should easily be extractable.</td>
<td>Yes. A spreadsheet format with fixed cell locations is ideal.</td>
<td>Yes, Extractions in a .csv format possible.</td>
<td>Workable. Spreadsheet format is usable but cell locations are not fixed.</td>
<td>Partially. Records may be kept as written scripts or spreadsheets with no set template.</td>
</tr>
<tr>
<td><strong>Summary Positives</strong></td>
<td>Potentially both materials and waste will be recorded in the same place.</td>
<td>Good detail. Works on many levels. Good format.</td>
<td>The detail of records kept makes it useful.</td>
<td>Good detail. Alignment to Carbon Framework useful.</td>
<td>Provides cost data.</td>
</tr>
<tr>
<td><strong>Summary Negatives</strong></td>
<td>Not yet in use. Annual updates may not be frequent enough.</td>
<td>Time delay of uploads may be problematic. Some approximation s required to make data useful.</td>
<td>£300k threshold may miss some applications.</td>
<td>Combined costs (work + labour) maybe difficult to decipher. Most assumptions would be required with this method to convert units. Predicted not 'actual' use data.</td>
<td></td>
</tr>
</tbody>
</table>
4 Proposed Mechanisms for Calculating Resource Efficiency

4.1 Procurement focussed resource efficiency indicators

Section 2.1 introduced some different perspectives which can be taken to measuring resource efficiency. One of these perspectives was ‘procurement focussed’. A typical indicator which could be used to measure this perspective would be:

- Percentage of recycled materials used in construction per £ spent on material.

Essentially this is a fairly crude measure of how resource efficiency is pursued in procurement practices, by promoting the purchase of materials from recycled sources above materials which derive from primary resources. The calculation required to measure this indicator would be as follows:

\[
\text{Indicator} = \frac{\text{Quantity of Recycled Materials in Project (t)}}{\text{Total Material Cost in Project (£) × Total Quantity of Materials in Project (t) × 100}}
\]

The indicator calculation would primarily be based on data extracted from bills of quantities, given that this is the only data collection method which includes cost data. The bill of quantities will also specify the types of material, but, as discussed in Section 3.5, the units of quantity data may vary, hence it might be appropriate to obtain material quantity data from another method (e.g. the HA Carbon Accounting Tool). The pathway in Figure 4.1 indicates how it may work. The potential inaccuracies associated with using bills of quantities are all inherent in this method. If material cost is not required in the equation then the HA Carbon Accounting Tool can be used to capture the materials in data instead.

![Figure 4.1 Calculation pathway for a procurement-based indicator](image)

TRL 22
The HA Carbon Accounting Tool also has the added advantage of being aligned to specific quarterly time periods, if this is required for reporting purposes.

Whilst the indicator captures practice which aims to avert resource depletion, there are some potential drawbacks with the method. Promoting a ‘use recycled at all cost’ ethic can prove environmentally disadvantageous when recycled materials have required a high energy input to reprocess (this is a possibility, but not the general case). Also, where materials of relatively low embodied energy are used (e.g. aggregates) transport becomes a significant factor in the overall energy balance of the system. Therefore if recycled materials which have travelled a long distance are used in preference to primary materials which could be sourced more locally, environmental performance of the system may decrease rather than increase.

**4.2 Waste focussed resource efficiency indicators**

Waste focussed indicators are perhaps more straightforward than procurement focussed in terms of the mechanism that they require to operate and the data sources to use. This is partly by virtue of the introduction of mandatory SWMPs for construction projects which record waste quantities and the destination of waste terms of waste management option (reuse on site, reuse off site, recycled on site, recycled off site, sent to landfill etc.).

An example waste focussed indicator would be:

- Percentage of total waste diverted from landfill and other disposal options.

This indicator would be calculated using an equation similar to the one below:

\[
\text{Percentage of total waste diverted} = \frac{\text{Quantity of Waste Materials sent to WM options other than Landfill (t)}}{\text{Total Quantity of Waste Materials Generated in Project (t)}} \times 100
\]

Both of these quantities could be directly obtained from a SWMP. The calculation pathway is summarised in Figure 4.2.

---

**Figure 4.2 Calculation pathway for a waste-based indicator**

A potential drawback of this method would be that in producing a ratio of this type masks how much waste is produced by the project as a whole, which is perhaps the more important measure. Waste minimisation is the preferred option since it precludes the need for waste management in the first place.
4.3 Scheme focussed resource efficiency indicators

Indicators which are based on construction schemes as a whole require material input data as well as waste output data. For given schemes or even areas it is possible to measure indicators such as:

- Waste as a proportion of material input (in terms of mass or monetary value).

A method such as this is advantageous since it measures the HA’s activities which it actually has direct influence over, rather than downstream (waste management) or upstream (procurement) activities to which it can apply policy but perhaps not directly change the practice.

This indicator would be calculated using an equation similar to the one below:

\[
\text{Indicator} = \left( \frac{\text{Quantity of Waste Generated (t)}}{\text{Total Quantity of Materials Procured for Project (t)}} \right) \times 100
\]

The numerator could be changed depending on whether there is a preference to display the information in terms of mass or cost. The most appropriate data source for material input is likely to be the HA Carbon Accounting Tool and waste materials out would be the HA SWMP template, as indicated by the pathway which is displayed in Figure 4.3.

![Figure 4.3 Calculation pathway for a scheme-based indicator](image)
4.4 Possible future enhancements to the methodology

The approaches introduced in 4.1 - 4.3 provide some basic pathways to resource efficiency indicator measurement in the HA. These are practical starting points and in the future extra elements can be added on to create more accurate indicators which display more information.

4.4.1 Balancing mass

If the indicators which are to be developed are used in post-scheme evaluation then an extra level of accuracy may be attained by balancing mass flows. The extra level of accuracy is achieved by insuring that the flows of material into the system equal the flows out (material plus stock gained). Hence material flows are verified against each other. This may be facilitated by using a data collection which captures highway stock added to the network e.g. HAPMS. The data collection pathway displayed in Figure 4.3 could be modified to that which is displayed in Figure 4.4.

Some manipulation of the data obtained from HAPMS would be required to make it suitable for purpose. Highway layer dimensions drawn from HAPMS (length, width and thickness of lanes laid down) could be used to calculate the volume of material placed. The volume could then be turned into a mass which can be added to the mass of waste flows to provide a total for the right hand side of the equation using a density figure for the particular asphalt which is laid (in the region of 2.1 – 2.4 t/m$^3$).

Data manipulations of this kind inevitably require assumptions e.g. when dealing with non-straight sections of the road which do not have a regular ‘cubic’ volume. Also, a mass balance could only be applied to material flows which have corresponding material in and waste out flows. Waste which is generated on scheme, e.g. excavation waste could potentially upset the mass balance equation and would therefore need to be dealt with in an appropriate way.

![Figure 4.4 'Mass balance' data collection pathway](image-url)
Extra levels of accuracy may be gained by using EnvIS for materials in and waste out data, once EnvIS is up and running (see Figure 4.5). The extra accuracy may be gained by the consistency of having a single point of data entry into a system which has all of the required features to measure resource efficiency in the desired manner.

Figure 4.5 ‘Mass balance’ data collection pathway using EnvIS

The level of inaccuracy which may arise due to approximations in any of the methods would need to be evaluated against the potential extra accuracy which is gained by balancing mass.

4.4.2 Additional flows

A decision was taken to concentrate on material and waste flows in the first instance, however, there is also the potential to consider other resource flows in the future, such as water and fuel use. Water may become a more important consideration if water resources become more critical in the future and fuel use with corresponding emissions as outputs would complete the mass balance picture. This may result in a overall resource flow picture which is illustrated in Figure 4.6.

4.4.3 Combinations of indicators

Combinations of indicators can be used to combine different perspectives of resource efficiency e.g. procurement and waste perspectives, as used in WRAP’s Net Waste method (WRAP, 2008b), which combines a measure of the proportion of recycled materials into a system with a measure of material wastage, see Figure 4.7. Combining indicators in a way that is useful to the HA may be a possible future step to take, once the suitable pathways for the calculation of the basic indicators has been established.
4.5 Mechanism of operation

Figures 4.1 to 4.5 indicate the use of macros (displayed as ‘.xls macro’) to extract the data needed from existing data collection methods to be used in resource efficiency calculations. This is appropriate for use with spreadsheets which are used to collect data but is potentially not suitable for data which is recorded in other formats e.g. MS Word documents.
Macros will be used to identify the relevant figures which are required in spreadsheets either by using absolute cell references (for spreadsheets which have fixed cell locations) or by sorting data first and then extracting the data required.

The macros can then copy the data required and paste it to the resource efficiency calculator spreadsheet in specified locations. Calculations will be situated in these specified cells which will be triggered when data is entered. The results of these calculations can be displayed as figures or graphically as required.

4.6 Time perspective and future benchmarking capabilities

Each of the three types of resource efficiency indicators which have been explored: procurement focussed, waste focussed and scheme focussed, are proposed to work on a post-evaluation basis which coincides with the established or proposed reporting intervals of the underlying data collection methods. However, once the established mechanisms have been up and running for a reasonable period (1 or 2 years), and have been tested on a variety projects (major schemes and maintenance projects, large and small), initial benchmarks of resource efficiency can be established based on the levels which have been achieved.

These benchmarks will then provide more scope for a consideration of resource efficiency at the specification, tendering and design stages of projects, depending on their nature. There is therefore scope to make progress towards higher levels of resource efficiency, by changing the targets incrementally over time.
5 Conclusions and future work

A number of data collection methods which the HA uses or requires its contractors to use have been explored. Contractors have shed light on the way that they are used to record the level of material use and waste produced in the schemes and areas which the HA operates. The shortcomings and advantages of each of the methods have been identified. Based on the findings of this exploratory work, a number of feasible pathways by which resource efficiency indicators can be measured have been proposed to measure resource efficiency on a number of different levels and from different perspectives.

5.1 The way forward

Some further information (e.g. on the use of bills of quantities within the HA) is still to be determined. This information should be gathered and added to the information which has been presented in this report.

Of the indicators which have been proposed, any preference which the Steering Group has for the indicator pathways or the perspectives of resource efficiency which can be taken should be obtained. The chosen mechanisms should be developed and then tested with contractors on a number of existing HA schemes. The review has revealed that the most likely means of data collection appear to be the HA Carbon Accounting Framework for materials in data, the HA SWMP framework for waste data and HAPMS for recording added stock. However, methods which are refined and come on stream in the near future may prove to be more suitable for purpose and the situation should therefore be monitored over the next year of the programme.

5.2 Potential demonstration projects for 2009/10 programme

Two schemes has been identified with the assistance of contractors which can be used as demonstration projects during 2009/10. These are:

- The M1 widening scheme, with the assistance of Arup who are the overseeing contractors.
- The M40 J15 bypass scheme, with the assistance of Morrison Construction.

In addition, A One, who are the maintenance area contractors for Area 14 have indicated their willingness to participate and are in the process of identifying suitable schemes.
6 References


