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Leakage Methodology Review Project

Providing Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation

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EXECUTIVE SUMMARY

The economic level of leakage (ELL) is the point at which the cost of further leakage reduction is just equal to the additional benefit gained. It relies on two key relationships:

- The costs of the various activities for controlling leakage e.g. finding and repairing leaks, and how they vary with the level of leakage
- The impact that different leakage levels have on the costs of delivering water to customers (treatment and pumping costs) and the timing of planned new supply, treatment and demand management (including water efficiency) schemes

Water companies regularly review their ELL calculations and submit them to the Water Services Regulation Authority (Ofwat) who use these assessments at price reviews to set leakage targets for at least a five-year period. The ELL is also a fully integrated part of companies' Water Resource Plans (WRPs).

It has become increasingly recognised in recent years that if leakage levels are to fully reflect the preferences of society, the costs and benefits that are included in ELL calculations should include not just those that are borne directly by water companies (known as 'private' costs) but also the 'external' costs and benefits that arise as a result of the environmental and social impacts of leakage control activities and leakage itself. These include, for example, the environmental benefits of reduced abstraction levels resulting from a reduction in leakage, and the social costs of traffic disruption arising from leak repair and mains renewal activities. The appropriate inclusion of both private and external costs and benefits ensures that leakage targets are set at a level that is optimal for customers and broader society.

Since the last periodic review of prices in 2004 (PR04) Ofwat have identified the inclusion of external costs and benefits as an area of the ELL calculation that can be improved. In April 2007 a steering group of Ofwat, the Environment Agency (EA), Defra, CCWater and Water UK commissioned RPS Water Services to provide 'best practice' guidance for the evaluation of the external costs and benefits of leakage and how these should be incorporated in an ELL calculation. Guidance was also required for the measurement of carbon emissions associated with different leakage levels and leakage control activities. The objective of the study was to provide practical guidance on the evaluation of external costs and benefits for water companies to use in their ELL calculations for PR09.

The consultant's report is presented in two parts:

Part 1 (Main Report) presents an overview of the research project and its key findings, and provides an introduction to the recommended methodologies described in the detailed guidance.

Part 2 (Guidance) is a self-contained, step-by-step framework for assessing the environmental, social and carbon impacts of leakage and leakage control activities and shows how these can be integrated into an ELL calculation.

Given the time available for the study, the Guidance builds on, rather than replaces existing assessment approaches in this area; collates these into a single source; and, where possible, recommends best practice. The aim has been to develop guidance that can be used by all water companies for PR09 and that will help to ensure a consistent and transparent approach across the industry.

CONTENTS

GLOSSARY

AIC, Average Incremental Cost	As AISC but only private costs included
AISC, Average Incremental & Social Cost	The net present value of the whole-life costs of a supply, demand management or leakage control intervention divided by the net present value of the volumetric yield (or leakage savings)
ALC, Active Leakage Control	The proactive detection and repair of leaks in water distribution networks
AZNP, Average Zone Night Pressure	The average hydraulic pressure (available head) across a network at the time of minimum night flow
Background leakage	The aggregation of undetectable leaks and seepage in a network (related to asset characteristics and unrelated to effort). (see also PML)
Carbon accounting	Is the general term used to describe the accounting undertaken to measure the amount of carbon dioxide equivalent given-off, sequestered or the amount of carbon that has been prevented from being released into the atmosphere.
Carbon Dioxide / CO_2	The greenhouse gas, the concentration of which is most affected by human activities which include the burning of fossil fuel. CO_2 also serves as the reference to compare all other Greenhouse Gases (GHGs). Sometimes referred to in short as simply 'carbon' in literature although this should not be confused with carbon (C).
Carbon equivalent / CO_{2eq}	Measure used to compare the emissions of the different greenhouse gases based upon relating their global warming potential to that of carbon dioxide.
Carbon externalities	The range of impacts (positive or negative) associated with emissions or savings of CO_2 within the atmosphere. Impacts can be social, economic or environmental.
Carbon footprint	A representation of the effect human activities have on the climate in terms of the total amount of greenhouse gases produced (measured in units of carbon dioxide). Carbon footprints can be calculated on many scales, from individual personal footprints, through to footprints of development projects and organizations. Development project footprints include both construction and operational phases.
Carbon impacts (leakage management-related	The fuel and embedded carbon effects of leakage management activities e.g. leak repairs,

	replacement pipes and fittings
Carbon impacts (leakage related)	The effects on fuel use and greenhouse gas emissions resulting from changes in pumping and treatment following a change in leakage level
Carbon management	A strategy for organisations who wish to manage and reduce their carbon emissions while growing profitably. Such a strategy provides a view of how carbon impacts the organisation by identifying the risks and opportunities associated with climate change.
Carbon related impacts	Both the leakage and leakage management related impacts of carbon on activities associated with leakage and leakage management.
Carbon valuation	Refers to the methods by which carbon is valued so it can be included in cost-benefit assessments; examples include the Social Cost of Carbon (SCC) and Shadow Price of Carbon (SPC).
Climate change	Refers to the variation in the Earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes may come from processes internal to the Earth, be driven by external forces or, most recently, be caused by human activities.
ELL, Economic Level of Leakage	The point at which the cost of reducing leakage is equal to the benefit gained from further leakage reductions
Embodied carbon	The amount of carbon and /or carbon dioxide released as a result of the extraction, processing and manufacturing of materials. Exact definitions vary by application and sometimes include transport of materials throughout the various stages.
Emissions factor	The relationship between the amount of pollution produced and the amount of raw material processed or burned. For road traffic it is the relationship between the amount of pollution produced and the number of vehicle miles travelled. By using the emission factor of a pollutant and specific data regarding quantities of materials used by a given source, it is possible to compute emissions for the source. This approach is often used in preparing an emissions inventory.
Environmental impacts	The effects on, for example, angling, bird watching, biodiversity etc. resulting from changes in abstraction from rivers, groundwater and reservoir following a change in leakage level

Excess leakage	The difference between a given level of leakage and Background Leakage.
External costs and benefits of leakage	The costs not borne directly by a water company and attributable to the environmental, social and carbon impacts of leakage and leakage control activities
Leakage externalities	The leakage-related and leakage management-related environmental, social and carbon emission impacts resulting from changes in leakage level and leakage control activities
Greenhouse gases (GHGs)	Any gas that absorbs infrared radiation (heat) in the atmosphere. Greenhouse gases include water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxides, halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs) and hydrofluorocarbons (HFCs).
Headroom	The difference between supply (water available for use, WAFU) and demand (consumption plus leakage).
Intervention policies	A collective term for leakage management activities including active leakage control, pressure management and leakage-driven asset renewal
LCP, Least Cost Planning	The activity that arrives at the minimum whole-life cost of supply, demand management and leakage management interventions over a planning period to achieve a balance between supply and demand at a given level of reliability
LI, Leakage Index	A function of the average zone night pressure in a network and which provides a means of estimating the savings in leakage through pressure management
LRELL, long-run ELL	The ELL that results from an LCP study whereby leakage is considered alongside supply and demand management activities to meet a long run supply-demand balance. In surplus zones with no supply-demand imbalance the LRELL may equal the SRELL.
Marginal Unit Cost	The variable operating cost (excluding fixed overheads) required to deliver a unit saving in leakage or unit of water into supply
MNF, Minimum Night Flow	The minimum hourly flow at night (determined by rolling 4 x 15-minute night flow values)
NRR, Natural rate of rise in leakage	The rate at which leakage would increase in a network with no leakage management interventions
PML, Policy Minimum Leakage	The lowest level of leakage that can be achieved through intensive active leakage control using

	conventional methods and reasonable effort (see also Background Leakage)
Private (costs and benefits)	Costs and benefits borne directly by water companies
SELL, Socially Efficient Level of Leakage	The optimal level of leakage that results from the inclusion of both private and external costs and benefits
Shadow Price of Carbon (SPC)	The government preferred method of incorporating carbon emissions in cost-benefit analysis and impact assessments. The SPC captures the damage costs of climate change caused by each additional tonne of greenhouse gas emitted, which is converted into CO_2eq for ease of comparison. It is different to the Social Cost of Carbon (SCC) as it takes more account of uncertainty, is based on a stabilisation trajectory and is in line with the marginal abatement costs of reaching the stabilisation goal.
Social Cost of Carbon (SCC)	The social cost of carbon (SCC) measures the full cost today of an incremental unit of carbon (or equivalent amount of other greenhouse gases) emitted now, summing the full cost of the damage it imposes over the whole of its time in the atmosphere. It measures the scale of the externality which needs to be incorporated into decisions on policy and investment options in government. The SCC matters because it signals what society should, in theory, be willing to pay now to avoid the future damage caused by incremental carbon emissions. However, in all Government documents and policy appraisals this has now been replaced by the Shadow Price of Carbon (SPC).
Social impacts	The effects on, for example, pedestrian and traffic flow rates, interruptions to supply etc. resulting from leakage management activities
SRELL, short-run ELL	An ELL based only on the balance between leakage management costs and the short-run marginal cost of water, excluding all future capital investment that may be required to meet supply-demand shortfalls
Transition	The change in leakage from one level to another
WSP, Water Service Provider	All ''Water-only' and ''Water and Sewerage' companies and other licensed water suppliers in England and Wales

1. INTRODUCTION

1.1 BACKGROUND

In 2002 The Tripartite Group (OFWAT, the Environment Agency and Defra) commissioned research into future approaches to leakage target setting for water companies in England and Wales. The resulting Tripartite Report (2002) set out a broad framework of analysis for ELL determination set firmly within the wider perspective of least cost planning, introduced many key concepts required in the modelling process, including an overview of environmental and social cost valuation, and provided a number of relevant ground rules for best practice methods of data collection and analysis.

The Tripartite Report has provided the industry with a good basis on which to base further research and development of ELL-related methodologies. However, since 2002, the continuing drought in the south and east of England has highlighted customer concern at leakage levels at a time when consumers are subject to restrictions on their water use. Furthermore, there has been increasing political and social pressure on the water industry to take fuller account of the range of social, environmental and carbon-related externalities arising as a result of its activities.

These concerns were clearly demonstrated in the House of Lords Science and Technology Committee report on Water Management, which called for a move towards a 'sustainable level of leakage'. Similarly, the Consumer Council for Water outlined a 'need to review the basis of leakage targets in water scarce areas'

During 2006, having undertaken a review of leakage management practice and target setting, OFWAT identified a number of areas which would, in the light of new information and better data, benefit from a more detailed review. Following consultation with stakeholders, three key research projects were identified:

1. Alternatives to ELL as a basis for target setting
2. Best practice guidance for the inclusion of externalities in the leakage calculation
3. Review of methodologies for assessing per capita consumption

Research in each of these areas was concurrently undertaken by contractors during 2007. This report presents the findings from the second of these studies.

1.2 CONTEXT

An externality is any positive or negative impact arising from an activity that is not normally considered in the decision of the agent (in this case the Water Service Provider) undertaking the activity. Such impacts impose a cost or benefit to third parties but not to the WSP. Externalities arise when positive impacts (or the avoidance of negative impacts) have a value but there is no obvious market price (or cost) which reflects third parties' willingness to pay. An unregulated WSP would therefore have no financial incentive to weigh such impacts in their decision.

If externalities are not appropriately accounted for in the decision making process, decisions that are optimal from the WSP's point of view may not be socially efficient; while net private benefits are maximised, net social benefits may be lower or even negative.

Leakage-related environmental externalities arise if the associated increase in abstraction impacts on the ecological attributes of a river, which both affects biodiversity and reduces opportunities for recreational users of the river. Alternatively, a social externality occurs when the detection and repair of leaks generates disturbance or nuisance in terms of noise or road traffic disruption.

It is clear that, in leakage as in many other areas of water service provision, a gap exists between social objectives and those of water service providers (WSPs). In recent years, water industry regulators have aimed to close this gap by requiring that WSPs assess the monetary value of associated external costs and benefits, and include these alongside their conventional capital and operating expenditures.

In particular, OFWAT has stated that, for PR09, it expects WSPs to justify their investment programmes using cost-benefit analysis (CBA), where monetary costs and benefits include the full range of environmental, social and carbon-related impacts. WSPs are expected to carry out their CBA at a range of appraisal levels. WSPs must demonstrate that their top-level strategic plan is cost-beneficial and consistent with customers' preferences / willingness to pay. However, since not all projects within a programme may be cost-beneficial, 'bottom-up' appraisals at a more disaggregated level are required for the justification of individual projects and sub-programmes[1].

It is evident that many, if not all, Water Service Providers (WSPs) made some attempt to include social and environmental externalities in their PR04 leakage submissions and have improved these in subsequent reviews. However, limitations of data and the absence of detailed guidance on appropriate valuation methods may in some instances have resulted in inadequate or inappropriate valuation of external costs and benefits, particularly with respect to carbon-related impacts.

If, for example, social and carbon-related costs of leakage reduction activity are understated (or, alternatively, the environmental benefits of leakage reduction are overstated), the resulting ELL assessment will tend to be 'too low' (i.e. lower than is socially optimal), and the cost of attaining it may not be supported by a top-level preference survey / willingness-to-pay assessment. Conversely, if the environmental benefits of leakage reduction are understated, the ELL assessment will be higher than is socially optimal. In this case, top-level willingness-to-pay surveys may indicate customers' preferences for greater leakage reduction expenditure and/or environmental improvements in the form of flow alleviation schemes.

In recent years, methodologies for valuing external costs and benefits have become both better grounded in economic theory and more accepted by non-specialists. Well-defined methodologies now exist for assessing the social cost of nuisance and disruption. Key benefit valuation approaches include revealed preference techniques (such as, for example, hedonic pricing, travel cost and averting behaviour methods), where willingness-to-pay for an external benefit is determined using related or proxy markets; stated preference techniques (including, for example, choice modelling and contingent valuation), where willingness-to-pay (or willingness-to-accept) is elicited using carefully constructed customer surveys; and benefits transfer, where benefit valuations derived from an existing revealed or stated preference study are 'borrowed' and appropriately adjusted. A detailed review of these approaches, together with examples of their practical application, can be found in UKWIR (2007a).

Many but not all of the available techniques are appropriate for use in either project-level (bottom-up) or programme level (top-level) assessments of benefits. WSPs are increasingly making use of top-level stated preference surveys, which, if well designed and carefully analysed, can be used to inform the prioritisation of an overall investment programme. The

[1] In cases where WSPs experience the 'paradox' whereby a large programme is justified in absolute terms using the bottom-up approach, but is not supported by a top-down analysis of customers' willingness-to-pay, OFWAT expects WSPs to appropriately prioritise and phase programmes over the 25 year planning horizon.

strengths and weaknesses of alternative techniques, however, must be appropriately considered in light of available timescales and resources, the number, nature and size of the projects or schemes (and associated benefits[2]) being evaluated, the extent to which they are part of a larger programme of water service improvements, and the degree of schemes' substitutability in terms of their contribution to customers' welfare. Although essentially non-prescriptive, OFWAT's guidance for PR09 has made clear that WSPs should develop an appropriate mix of methods to fulfil and reconcile both top-level and bottom-up approaches.

While methodological refinements are on-going, many benefits assessment techniques remain relatively 'young' and are associated with a number of methodological and practical issues. However, since publication of the Tripartite Report in 2002, fresh academic research and on-going implementation of assessment techniques have generated a number of improvements in the way in which leakage-contingent externalities can be valued and included within the ELL modelling process.

While environmental valuation methodologies have undergone continuing refinement, the inclusion of carbon valuation within mainstream analyses is a comparatively recent development. However, a number of methodological approaches for the monitoring, quantification, reporting and accounting of carbon emissions have been developed and are now internationally recognised. Methodologies for the valuation of carbon have emerged from work completed by academic sources and the Intergovernmental Panel on Climate Change, with more recent reviews and development of social cost methodologies arising from The Stern Review being spearheaded by Defra and HM Treasury. However, there remain areas of significant debate and large uncertainties associated with attaching costs to climate change and emissions of greenhouse gases.

1.3 OBJECTIVES

The objectives of the study were:

(i) To provide guidance for WSPs on how to:

- include environmental and social costs and benefits in an ELL calculation;
- measure the carbon emissions of differing leakage levels and of different leakage activities and how this measurement may be used when considering scheme prioritisation for water resources planning.

(ii) To provide a final report which:

- includes advice on what external costs and benefits to include when completing an ELL analysis and how to do so;
- includes key data sources that can be used by WSPs;
- provide practical guidance that the water companies can use immediately for PR09 water resource planning

1.4 SCOPE

The principal tasks of the project have been to:

- review the guidance for including environmental and social costs and benefits in a ELL calculation as set out in Tripartite Report;

[2] For example, revealed preference techniques cannot be used to assess the benefits arising from non-use.

- review how WSPs made use of the guidance at PR04 and subsequent revisions, identifying examples of best practice that are still relevant;
- audit and identify WSP practice in the area of leakage-related carbon accounting. This comprised a survey of all water companies in England and Wales;
- identify the leakage contingent external costs and benefits for inclusion in the ELL calculation;
- identify material sources of carbon emissions in the leakage management and control process, suggest appropriate methodologies for quantifying and valuing these emissions, and identify how to take account of emissions associated with different levels of leakage when making decisions on balancing the supply and demand for water;
- identify and be guided by authoritative sources of policy and data in the area of environmental and social cost and carbon emissions;
- identify a best practice and practical approach for WSPs to include externalities in their ELL analyses including an assessment of carbon emissions;
- test recommendations for change with a range of companies;
- identify weaknesses and uncertainties in the recommended techniques and practical guidance on how these should be addressed when completing an ELL analysis.

1.5 REPORTING STRUCTURE

The report is presented in two parts. Part 1 (this report) presents an overview of the research project and its key findings, and provides an introduction and methodological background to the practical guidance document, which is contained in Part 2.

The structure of this report is as follows: Section 2 provides a brief overview and discussion of the ELL calculation and how this is theoretically affected by the inclusion of related externality assessments. Section 3 presents a classification and checklist of relevant externalities for consideration in ELL determination. Section 4 reviews existing sources of guidance on the assessment and inclusion of externalities in the ELL calculation, and Section 5 presents key results of the survey of best practice approaches within the industry. Section 6 provides an overview of the guidance methodology, and Section 7 presents key conclusions and recommendations arising from the study. The outcomes arising from the trialling and testing of the methodology by two WSPs are presented in Annex 2 [forthcoming].

2. ELL AND THE LEAST COST PLAN

2.1 INTRODUCTION

To ensure that external cost ~ leakage relationships can be properly integrated within the ELL calculation, this Section provides a review of the ELL modelling approaches currently in use by WSPs. However, it is outside of the scope of this report to update ELL modelling practice and developments since the Tripartite Report (2002).

There are two complementary approaches to the determination of ELL:

The marginal cost of water approach

In this approach, the ELL is the level of leakage at which the marginal cost of leakage control equals the marginal cost of water (MCOW).

For the short run ELL (SR ELL), the MCOW is based on current variable system operating costs (production and distribution) largely made up of energy and chemicals.

For the long run ELL (LR ELL), the MCOW is based on variable system operating costs plus the capital and operating costs of any future supply and demand options required over the planning period. Usually, however, only the costs associated with the next supply scheme are considered in order to assess whether a change in ELL is required. For this reason, the marginal cost of water approach is often used as an interim approach between successive price reviews (and least cost plans).

The LCP approach

In this approach, the ELL is set within the context of achieving a balance between water supply and demand. The Least Cost Plan (LCP) is the vehicle by which Water Service Providers (WSPs) determine the optimal mix of interventions necessary to ensure the long-term balance between supply and demand for specified design headroom. More details of the LCP methodology may be found in the EBSD[3] guidelines (the Environment Agency, 2002). By minimising the present value of whole-life costs over the planning period, the LCP produces the least cost mix of supply, demand and leakage management interventions from a basket of options:

Supply schemes:	additional resource(s), bulk transfer, etc
Demand management:	water efficiency, metering, etc
Leakage control:	ALC, pressure management, asset renewal

Schemes may be selected on the basis of Average Incremental Social Costs (AISCs) or using optimisation techniques such as linear programming or genetic algorithm (GA) methods.

One of the outputs of the LCP will be the profile of leakage over time, consistent with minimising the total cost of the supply – demand balance, the minimum of which will be the LR ELL . The LCP approach is commonly regarded as best practice for deriving the LR ELL.

For water resource zones (WRZs) with adequate headroom over the whole planning period, and therefore where no additional investment is required for additional capacity:

LR ELL = SR ELL.

[3] The Economics of Balancing Supply and Demand

For WRZs where headroom falls below the design level at some point over the planning period, and therefore where additional capacity is required:

$$\text{LR ELL} \leq \text{SR ELL}$$

where the difference depends on the cost of further leakage control below SR ELL relative to the cost of other supply or demand management options for adding capacity.

Notwithstanding the above, some WSPs use the SR ELL as the leakage component in the base demand forecast used in the LCP, since it is the *maximum* level of leakage to which WSPs should aspire in the absence of a supply - demand - headroom imbalance.

ELL values can be expected to vary over time depending on, for example:

- Improvements in the efficiency of leakage control practice and new technology;
- Changes in the marginal cost of water as a result of
  - increased use of the more expensive sources, as demand increases
  - changes in cost of water efficiency measures
  - relative increases in energy costs over time;
- The refinement of methods for valuing externalities.

2.2 INCLUSION OF EXTERNALITIES

2.2.1 Consideration of externalities in the LCP

There is likely to be a range of externalities associated with implementation of each of the supply, demand management and leakage control options considered in the LCP. Each option may have external costs and benefits that, when appropriately weighed and considered within the LCP (in terms of average incremental social cost), may affect the socially optimal combination of options over the planning period.

Because the external costs associated with one option or activity may be represented as the external benefit of another, care must be taken to avoid double counting. For example, deferral of the environmental and social costs arising from the development of a new resource is sometimes described as an external benefit of leakage reduction. Inclusion within the LCP of these externalities both as a cost of the new resource and as a benefit of leakage reduction amounts to double counting. In this case the external costs, along with associated capital costs, are directly related to implementation of the resource rather than to leakage reduction, and should therefore be included in the resource's AISC assessment.

Guidance on valuation of the externalities arising from implementation of non-leakage related options considered in the LCP is outside the scope of this study.

2.2.2 Leakage and leakage management externalities

External costs associated with leakage management arise directly from the *activities* of leakage control (i.e. leak detection and repair, pressure management and asset renewal). These include, for example, a range of social disruption impacts and associated carbon emissions. Guidance on assessment and valuation of these externalities (termed throughout the report as leakage management externalities) is provided in this report.

There are a number of external benefits associated with leakage management which also require consideration. These arise as a direct *effect* of leakage control activity, rather than from the activity itself. In the SR ELL calculation, these benefits are reflected in the environmental and carbon-related improvements associated with decreased abstraction, treatment and distribution, the value of which can be added to the marginal operating cost of water. This report provides guidance on assessment and valuation of these benefits (termed as leakage-related externalities) for use in the SR ELL calculation.

For zones in deficit over the planning period, however, any environmental benefits arising from reduced abstraction (through either implementation of further leakage reduction below the SR ELL, or other demand management alternatives) are unlikely to materialise. In this context, therefore, the external costs of leakage are not relevant.

2.2.3 Socially efficient leakage levels

The inclusion of leakage and leakage management externalities produces a short run leakage assessment that may be regarded as the socially efficient level of leakage (termed throughout this report as the short run SELL). When externalities associated with implementation of the broader array of demand management and supply options are included alongside the relevant capital and operating costs in the LCP (reflected in associated AISCs), the resulting policy mix may also be regarded as socially efficient. The leakage component of this policy mix is termed as the long run SELL.

The process map in Figure 2.1 illustrates the key components of the LCP discussed in this Section, and defines the specific areas of guidance included within the scope of this project.

2.3 LEAKAGE ~ COST MODELLING

Regardless of whether ELLs are calculated using the marginal cost of water approach or the LCP approach, there is a need to establish the relationships between leakage control costs and leakage for each of the 3 principal leakage management options: Active leakage control (ALC), pressure management and asset renewal.

The Tripartite Report focuses its review of cost ~ leakage modelling on ALC. A summary of this review is provided below.

2.3.1 Active Leakage Control

Conventional wisdom indicates that the cost of ALC increases disproportionately as leakage is reduced and that there is a level of leakage at which further reduction in leakage through ALC is not practicable. In the Tripartite Report the term 'Policy Minimum Leakage' (PML) was developed to describe this lower limit. The term 'Background Leakage' is also used however, and is often confused with PML. Background Leakage can be defined as the aggregate of small leaks from fittings and joints in a system that cannot be individually detected; related to the physical characteristics of the network infrastructure and to pressure. Background leakage is therefore a physical lower limit whereas PML is a practical lower level dependent on effort. The 'exit level' of leakage following intensive ALC in district meter areas is often used to establish PML.[4]

The term 'excess leakage (L_E) can be used to define the difference between current leakage and background leakage (See Figure 2.2).

[4] The exit level of leakage is the level of leakage at which detection teams move on from leak detection in one DMA to begin in another

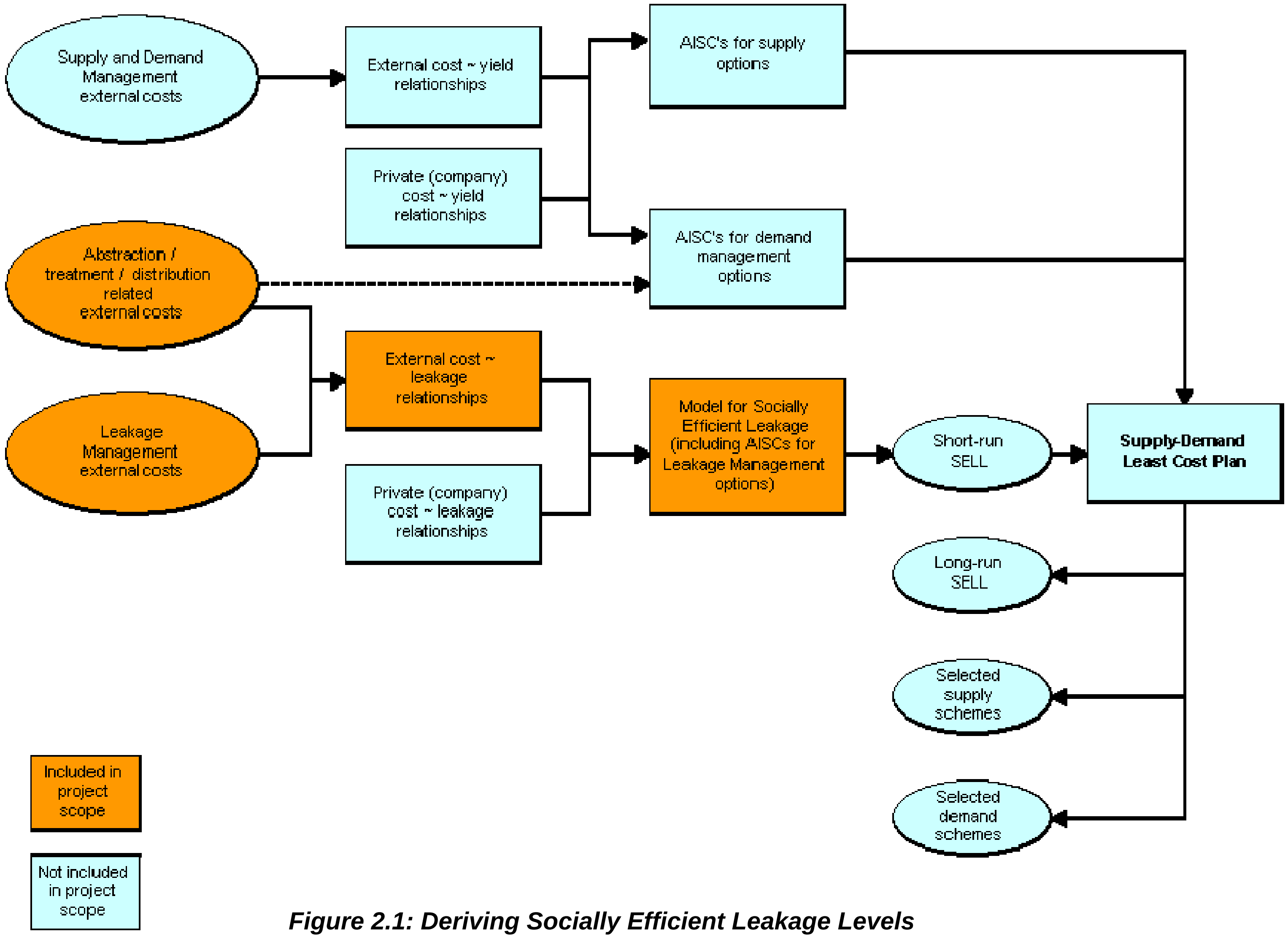


Figure 2.1: Deriving Socially Efficient Leakage Levels

The Tripartite Report summarises the various approaches for modelling ALC cost ~ leakage relationships and categorises them into Method A and Method B:

A. The costs of transition from one leakage level to another and the costs of maintaining a given leakage level are modelled separately

B. Transition and Maintenance are modelled in a single function and a parameter known as the 'natural rate of rise in leakage (NRR)[5]' is included

Models using Method A are ideally based on the collection of annual costs from WSP job management systems from which the annual 'steady state' costs and 'transitional' costs are abstracted. The variable elements of the 'steady state' costs are used to establish the non-linear relationship between ALC and leakage by fitting to one of a number of different functional forms e.g. log, power, hyperbola, to give:

$$\text{Detection Cost, £ per property (or km) per yr} = f\,[\,L_E\,]$$

Transition cost ~ leakage relationships are similarly developed.

In the absence of observed data, Method A 'steady state' models can also be developed using theoretical relationships between leak numbers, average flow rates and changes in leak run times for different intervention levels e.g. BABE

Models using Method B are based on regression analysis of observed marginal unit costs derived from WSP costs and leakage savings for a range of leakage levels; savings calculations include NRR. The relationship between the marginal unit cost of active leakage control and leakage is then usually described by the power function:

$$\text{MUC (e.g. p / m}^3\text{)} = a \,.\, L_E^{\ b}$$

Where a and b are coefficients, the 'b' coefficient being negative and thus giving $MUC = \infty$ when $L_E = 0$

In practice, Method B marginal unit cost functions are usually developed for the detection and detected repair elements of ALC separately. Reported repairs are usually not considered and are regarded as non-varying with leakage level.

The total annual detection and detected repair cost of either moving from one level of leakage to another or maintaining a given level of leakage is calculated from the integral of the marginal unit cost functions. This gives costs in a form that are then compatible with Method A (£ per property or km per year).

Both approaches are in common use across the industry and although there are differences in approach, the overriding requirement is that the relationships should adequately predict the current ALC expenditure at current levels of leakage.

The EBSD Guidelines (The Environment Agency, 2002) discuss a number of methods for the selection of options and for arriving at the LCP: AISCs or direct optimisation of solutions based on linear programming or other methods. In all cases it is usual to consider Total Annual Costs and for ALC these can be calculated year on year, for a given leakage profile using either Method A or Method B.

[5] NRR is the increase in leakage that would occur over a year if repairs to leaks were not carried out. It therefore represents the leakage that needs to be overcome in order to maintain a given leakage level. The NRR is related to asset condition and other factors.

2.3.2 Pressure Management

The principal benefits of pressure management (PM) are:

- Reductions in leakage
- Reduction in consumption
- Reductions in burst frequency
- Improvements and consistency of service to customers

While the reduction in consumption should be sustainable, because of the natural rate of rise in leakage over time there is some uncertainty as to whether the leakage reduction benefits of PM are sustainable in the longer term, or whether PM should be regarded purely as a means of 'buying time' until ALC and / or asset renewal is required.

The link between leakage and network pressure is well established and attempts have been made over several years to relate leakage and pressure through what is known as the Leakage Index (LI) equation. There are several functional forms for LI one example of which is the power law:

$$LI = AZNP^{N1}$$

Where AZNP = average zone night pressure (m), N1 is an exponent dependent on asset characteristics (N1 = 1.118 is a typical average).

In a system where pressure is reduced from $AZNP_{old}$ to $AZNP_{new}$, the new minimum night flow can be predicted by calculating the LI for the AZNP before and after:

$$MNF_{new} = MNF_{old} \,.\, LI_{new}/LI_{old}$$

By rearranging, the resulting saving in MNF can be calculated as:

$$\text{Saving in night flow} = MNF_{old} \,[\, 1 - (AZNP_{new} / AZNP_{old})^{N1} \,]$$

Calculation of the equivalent daily savings depends on the diurnal variation in pressure at the average zone point and requires the estimation of what is known as the Hour Day Factor, HDF. A constant AZP pressure for example will give an HDF of 24hrs. A typical industry value is 22 hrs resulting from the fact that night pressures are higher than daytime pressures. Advanced pressure control (APC), such as closed-loop flow modulation, is now being added by many WSPs to existing fixed-outlet PRVs in order to further reduce night time pressures and obtain virtually flat diurnal pressure profiles, in order to maximise leakage savings.

By taking excess pressure out of the system and producing a 'calmer' network, the main benefits of PM emanate from reduced leak flow rates and reduced leak breakout rates. These result in reductions in:

- Background Leakage
- Natural Rates of Rise in leakage (NRR)
- Flow rate of detectable leaks
- Numbers of reported leaks

The social costs and benefits attributable to the introduction of pressure management include:

- Traffic and pedestrian disruption associated with the installation of new PRVs (this is unlikely to be significant in the case of retro-fit APC devices)

- Risk of unplanned low pressure possibly leading to loss of supply to some customers
- Reductions in the frequency of detected and reported leaks and burst mains.

There are well-established methods for determining pressure management cost ~ leakage relationships for a region and these will involve detailed investigations to establish the potential for new pressure managed areas (installation of fixed-outlet prv's with or without APC) or retro-fit of APC onto existing prvs, together with an analysis of their net costs and potential savings. Some companies have undertaken such studies using their libraries of network models or using GIS property elevation data and pressure thematics.

Net costs relate to the capital and annual maintenance costs of the scheme (including all relevant externality costs and benefits associated with, for example, reduced numbers of low pressure complaints) less the ALC cost savings (including all relevant externality costs and benefits) arising from a reduction in the leak breakout rate.

Volume savings arise from the reduction in current leakage levels and NRR plus any reductions in customer consumption.

All costs and savings attributable to each scheme are then estimated from which the scheme AISC values are established. Schemes are then ranked by AISC and a relationship developed between cumulative costs and the cumulative leakage savings achieved. These relationships are then used as part of the SR ELL calculation and/or directly in the development of the LCP.

2.3.3 Asset Renewal

Leakage-driven asset renewal is increasingly being considered by WSPs as a cost effective leakage management option in some parts of their networks where DMAs are proving to be non-responsive to ALC as a result of high Background Leakage and high NRR. Although mains renewal has often been considered to be the most cost effective asset renewal policy for leakage reduction, some investigations have shown that comm. pipe and customer supply pipe renewal may be more cost efficient.

A considerable area of uncertainty is the net return (or effectiveness) of renewal in terms of leakage reduction and work is currently underway nationally to improve the robustness of these estimates. The net reduction in leakage achieved by renewing a particular length of main will not be 100% of the leakage associated with that main since disruption effects and increases in pressure are likely to give rise to increases in leakage elsewhere.

The establishment of a cost ~ leakage relationship for asset renewal is similar to that for pressure management. For a given renewal policy e.g. mains plus comm. pipes, target mains are identified in each DMA and the capital cost of renewal is calculated depending on surface type, technique, diameter etc.. For the target assets, the leak breakout rates, current leakage and NRR are also estimated together with an estimate of the effectiveness factor. The AISC is then computed for each DMA for each alternative renewal policy.

Net costs relate to the capital costs of the scheme (including all relevant externality costs and benefits associated with, for example, reduced supply interruptions and discolouration problems) less the ALC cost savings (including all associated externality costs and benefits) arising from a reduction in the leak breakout rate.

Leakage savings arise from the reduction in current leakage levels and NRR multiplied by the effectiveness factor.

Schemes are then ranked by AISC and a relationship developed between cumulative costs and the cumulative leakage savings achieved. These relationships can then be used as part of the SR ELL calculation and/or directly in the development of the LCP alongside ALC and PM.

2.3.4 Integration of externalities

External costs need to be included in the various approaches for quantifying SR ELL using a marginal cost of water approach or in the calculation of AISCs for use in the LCP. In order for the externality valuation methodologies in this Guidance to be compatible with these alternatives, a recommendation is included in the Guidance that functional relationships be established for each of the leakage management interventions as follows:

Leakage Management Policy	Function Required
Active Leakage Control (ALC)	Mains, communication and customer supply pipe leak repairs per unit saving in leakage (m^3) at a range of leakage levels
Repair Reported Leaks	Mains, communication and customer supply pipe leak repairs per unit saving in leakage (m^3) at a range of leakage levels
Pressure Management (PM)	Metre reduction in pressure per unit saving in leakage (m^3) at a range of leakage levels
Asset Renewal (AR)	Linear metre of renewal (e.g. of mains) per unit saving in leakage (m^3) at a range of leakage levels

Table 2.1 Required leakage management functions

Leakage management externalities are then evaluated per leak, per metre pressure reduction or per linear metre of renewal (as appropriate), from which the marginal social unit cost ~ leakage relationships can be developed as follows:

ALC for a range of leakage levels:

Leak repairs per m^3 saved
x
Marginal social cost per leak repair
=
Marginal social cost of ALC per m^3

PM for a range of leakage levels:

Metres reduction in pressure per m^3 saved
x
Marginal social cost per reduction in pressure
=
Marginal social cost of PM per m^3

AR for a range of leakage levels:

Lin. metres renewal per m^3 saved
x
Marginal social cost per lin. metre of renewal
=

Marginal social cost of AR per m^3

These can then be used either directly in the SR ELL calculation process or aggregated with private costs and converted to AISCs for use in the LCP.

2.4 IMPACTS OF INCLUDING EXTERNALITIES IN THE ELL CALCULATION

2.4.1 Leakage management externalities

The social disruption and carbon-related externalities arising from leakage management activity will tend to increase as the intensity of the activity increases, i.e. as leakage levels are reduced[6]. As with the conventional financial costs of active leakage control, given the diminishing returns arising from increasing ALC intensity, total external costs are expected to increase at an increasing rate as leakage levels are reduced. This produces a marginal external cost relationship not dis-similar in shape to the conventional marginal cost of active leakage control. Both marginal relationships are illustrated in Figure 2.2.

Whether total or marginal, private (conventional) and external cost ~ leakage relationships may be vertically summed to produce a social cost ~ leakage relationship for active leakage control. Summation of private and external marginal cost relationships is illustrated in Figure 2.2 by the 'marginal social cost of leakage control' curve.

2.4.2 Leakage-related externalities

The environmental and carbon-related externalities arising from the effects of leakage reduction (i.e., the external benefits of active leakage control) are more directly associated with the reductions in abstraction, treatment and distribution that may result[7]. These may be viewed as the external costs of leakage and, as with conventional operating costs, their total value will increase as leakage increases.

Depending on ecological (flow / water level) conditions and related valuation assumptions used, the total external cost of leakage may increase either linearly or non-linearly with leakage. Marginal external costs may, therefore, either increase or remain constant as leakage levels increase.

Figure 2.2 illustrates a case where the marginal external costs of leakage increase with increasing leakage levels. Figure 2.2 also illustrates the conventional (private) marginal cost of leakage (measured by the marginal operating cost of the water lost) and which, typically, is constant for all leakage levels.

Summation of the two cost relationships provides an assessment of the social cost of leakage (i.e. the social benefit of leakage control). Figure 2.2 illustrates the resulting marginal social cost ~ leakage relationship given non-constant marginal external costs.

2.4.3 Derivation of SELL

The derivation of the socially efficient leakage level may be determined by considering either total leakage-related costs, or marginal leakage-related costs. When total cost relationships are used, the SELL is determined by minimising the sum of all total leakage management and leakage-related costs, both private and external. Alternatively, the SELL is found by equating the marginal social cost of leakage management with the marginal social cost of

[6] It will be seen in Section 3 that there may be a number of direct benefits of increasing leakage management activity, arising from the averted costs associated with reported bursts and their subsequent repair. These should be 'netted' out from the direct external costs of leakage control activity.
[7] Principally only in surplus zones.

leakage (i.e. the marginal social benefit of leakage control). This approach is illustrated in Figure 2.2

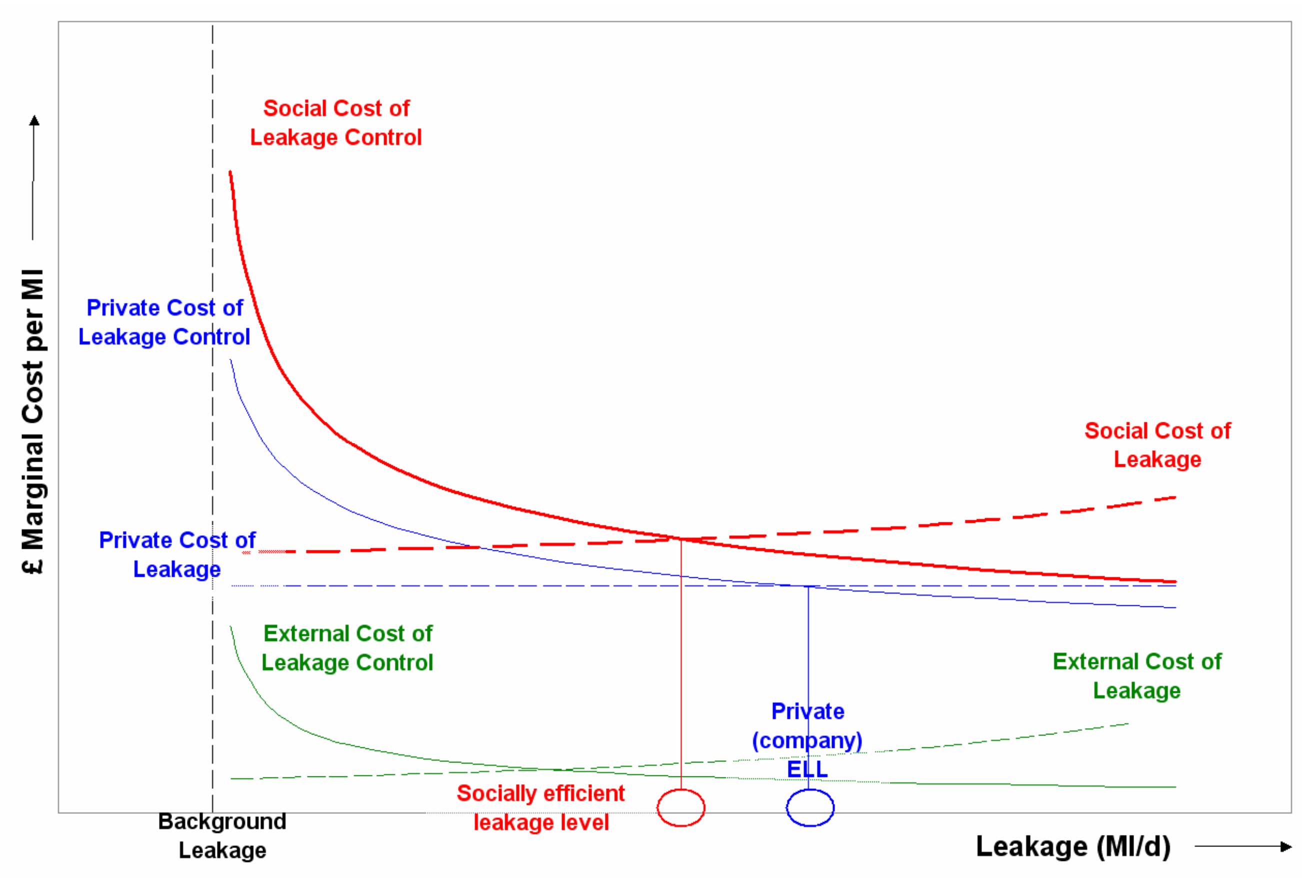


Figure 2.2: Derivation of socially efficient leakage levels (surplus zones)

In Figure 2.2, the net effect of including both leakage management and leakage-related externalities produces, in this example, a reduction in the ELL from the privately optimal solution, which considers only those financial costs incurred by and benefits accruing to the WSP, to the socially efficient leakage level (SELL), which equates the full social cost of undertaking an additional increment of leakage control with the full social benefit.

If the external costs of leakage control exceed the external benefits, the SELL will be higher than the private ELL. In general, the size and direction of changes in a zone's ELL as a result of including external costs and benefits are likely to be influenced by two key zonal characteristics. These are (i) network density (i.e. number of properties per km of mains) and (ii) environmental sensitivity of the relevant catchment(s). Figure 2.3 provides a simple framework for assessing the potential change in ELL in any zone, based on the relatively magnitudes of these factors. The arrows in Figure 2.3 indicate the likely directional impact on ELL, while the relative lengths of the arrows indicate the potential magnitudes of changes. It is evident from Figure 2.3 that there are certain circumstances where external costs and benefits may offset one another, producing only a small overall impact on ELL.

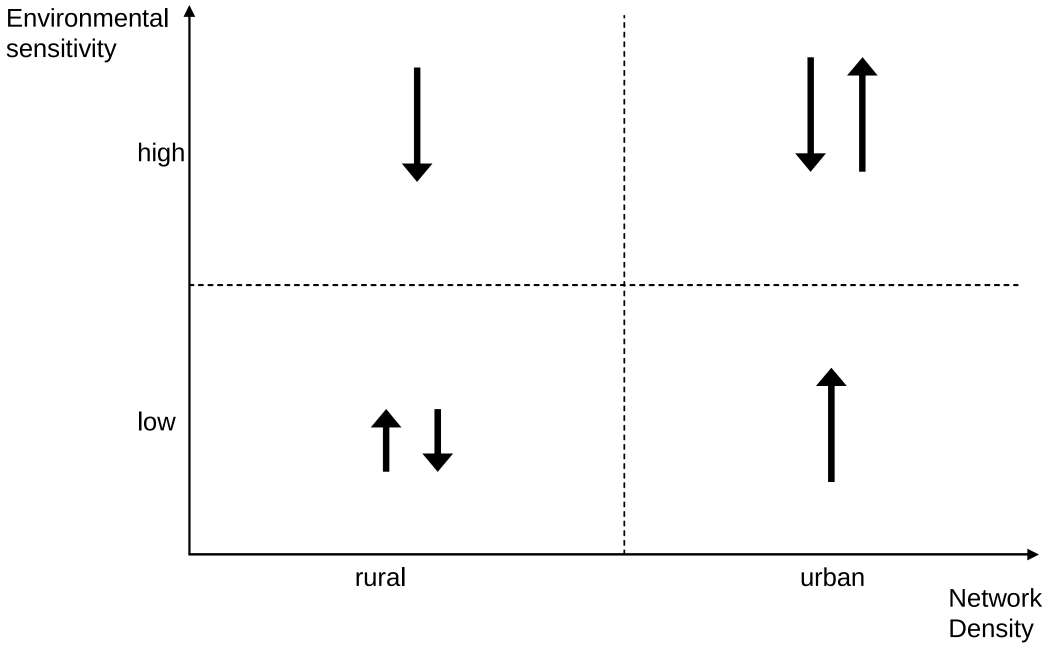


Figure 2.3: Potential impacts on ELL of including externalities

3. CLASSIFICATION OF EXTERNALITIES

3.1 LEAKAGE RELATED EXTERNALITIES

Table 3.1 provides a classification of the set of leakage-related externalities. These may be viewed either as the external costs of leakage, or as the benefits of leakage control. Leakage-related externalities derive from any changes in abstraction, treatment and distribution that result from changes in leakage levels, and can be sub-divided into environmental and carbon-related impacts.

3.1.1 Environmental impacts

Environmental impacts primarily derive from leakage-related changes in abstraction from rivers, groundwater or reservoirs. Changes in abstraction will impact on the flow / water levels of these resources and these, in turn, may generate costs or benefits to users of the resource, through their potential impact on a range of activities.

Activities potentially affected by flow / water level changes include, amongst others, angling, walking, bird watching, boating, commercial aquaculture, commercial navigation, and agricultural use, such as wild fowling or reed cutting. Other abstractors besides the WSP may also be affected by water level ' flow changes, and there may be a number of more indirect impacts on local archaeology and landscape appearance (heritage), and local property prices and urban regeneration (amenity).

The final category of environmental impacts arising from leakage-related flow / water level changes is described as 'biodiversity and non-use'. This category also includes 'indirect use' value, which refers to the ecological functions of a resource as, for example, a breeding habitat. Option values are often described as indirect use values, since these reflect the desire of individuals to guarantee the availability of a resource for their future use.

Non-use values reflect the value people place on improvements in or protection of the ecological quality of a resource where there is no intention of directly using or consuming that resource. Non-use also includes bequest value (the value of knowing that future generations will benefit from the resource) and existence value (the value of knowing that the resource exists, independent from its use).

3.1.2 Carbon-related impacts

The direct carbon-related impacts arising from changes in leakage levels derive from the associated changes in abstraction, treatment and distribution. These changes affect the quantity of carbon emitted from pumping and related fuel use, and greenhouse gas emissions arising from water treatment.

While there may also arise from changes in water resource users' activities a number of indirect carbon-related impacts (related to, for example, changes in travelling patterns and associated impacts on fuel consumption) these are not considered in this guidance.

Activity	Externality	Potential impacts			
		Carbon	Environmental		
			River	Reservoir	Wetland
Abstraction (from river, reservoir, ground water)	Pumping energy / fuel use	✓			
	Angling		✓	✓	
	Informal recreation (walking, bird watching, picnicking etc)		✓	✓	✓
	In-stream recreation (boating, bathing etc)		✓	✓	
	Biodiversity, indirect use and non-use (existence, option, bequest values, etc)		✓	✓	✓
	Commercial fisheries		✓	✓	
	Commercial navigation		✓		
	Other [8]		✓	✓	✓
Treatment	Fuel use from treatment plant	✓			
	GHG emissions from water treatment	✓			
	GHG emissions from water treatment waste disposal	✓			
Distribution	Pumping energy / fuel use	✓			

Table 3.1 Leakage-related externalities

[8] Includes agricultural use, other abstractors, heritage (archaeology and landscape) and amenity (property prices and regeneration)

Activity	Externality	Potential impacts	
		Carbon	Social
Leak detection	Transportation energy / fuel use	✓	
Detected leak repair	Road traffic delays / disruption and diversions	✓	✓
	Pedestrian diversions		✓
	Commercial and domestic disruption / disamenity due to excavation		✓
	Noise impact of street works		✓
	Transportation energy/fuel use	✓	
	Work site energy / fuel use	✓	
	Embedded materials	✓	
Asset renewal	Road traffic delays / disruption and diversions	✓	✓
	Pedestrian diversions		✓
	Commercial and domestic disruption / disamenity due to excavation		✓
	Noise impact of street works		✓
	Transportation energy / fuel use	✓	
	Work site energy / fuel use	✓	
	Embedded materials	✓	
	Avoided costs of discolouration		✓
Reported (unplanned) leak repair	Road traffic delays / disruptions and diversions	✓	✓
	Pedestrian diversions		✓
	Commercial and domestic disruption / disamenity due to excavation		✓
	Noise impact of street works		✓
	Transportation energy / fuel use	✓	
	Work site energy/fuel use	✓	
	Embedded materials	✓	
Reported mains burst events (externalities are potential benefits attributable to asset renewal and pressure management)	Commercial and domestic cost of flooding		✓
	Cost of unplanned interruptions to supply / pressure reduction		✓
	Transportation energy / fuel use	✓	
	Work site energy/fuel use	✓	
	Sewer flooding (water only companies)		✓
Pressure management	Road traffic delays / disruptions and diversions		✓
	Cost of unplanned interruptions to supply / pressure reduction		✓
Transportation of potable water to sites where supply has been disrupted	Extraordinary fuel use	✓	

Table 3.2 Leakage Management Externalities

3.2 LEAKAGE MANAGEMENT EXTERNALITIES

Table 3.2 provides a classification of the set of leakage management externalities. These relate to the external impacts arising directly from the implementation of leakage management activities.

3.2.1 Classification of leakage management activities

The various leakage management methods employed by a WSP are referred to hereinafter as Intervention Policies and within the scope of this project these are limited to:

- Active Leakage Control (ALC): detection and repair of leaks from water mains and service pipes

- Repair of Reported Leaks (passive leakage control): repair of 'visible' leaks reported to a WSP by members of the public and others. Although related to ALC, these interventions are considered separately since they would be carried out regardless of whether ALC is practiced or not. There is anecdotal evidence which indicates that as ALC intensity increases the number of reported leaks decreases i.e. more leaks are detected and repaired before they have 'grown' to a size at which that are visible. However, this relationship is not well proven and it is assumed in this guidance that the average number of reported leaks is largely unchanged from year to year.

- Pressure Management: the control of pressure, for example through the installation of pressure control valves, in order to minimise diurnal pressure variation and remove excess pressure from the network without prejudicing service standards.

- Asset Renewal: the replacement or structural rehabilitation of water mains and/or service pipes[9]

3.2.2 Social impacts

The social externalities associated with leakage management activities potentially include:

- Pedestrian and traffic disruption
- Planned and unplanned low pressure events and interruptions to supply
- Noise pollution
- Visual disamenity

These impacts are likely to increase as the intensity of leakage management increases. Thus for all intervention policies, the social costs associated with the above externalities are likely to increase as leakage is reduced.

However, asset renewal and pressure management interventions tend to reduce leak breakout rates. As well as the direct external costs arising from these interventions in affected DMA's, therefore, there will also be a range of offsetting external benefits arising from a reduction in leak detection and repair. Offsetting external benefits may also arise from any reduction in the frequency of burst mains arising from asset renewal and pressure management. These benefits derive from the reduction in external impacts arising from both mains bursts and their subsequent (unplanned) repair.

These interrelated impacts are summarised in Table 3.3.

[9] Asset replacement or rehabilitation may be driven by factors other than leakage e.g. water quality or other serviceability issues but only leakage-driven asset renewal is considered here.

Intervention / Event	Carbon and Social Costs	Carbon and Social Benefits
Leak detection	Externalities are all COSTS associated with Active Leakage Control	Externalities are all BENEFITS associated with Asset Renewal and Pressure Management
Detected leak repair		
Reported leak repair	Externalities are all COSTS associated with Passive Leakage Control	
Burst main		

Table 3.3 Interrelated Carbon and Social Costs and Benefits

3.2.3 Carbon emissions

For the purposes of this report consideration has been given to the estimation of greenhouse gas emissions from the leakage management techniques employed by a WSP. Essentially such emissions are associated with the following areas:

- Fuel use (transportation) – associated with finding leaks, repairing leaks and any disruption associated with the latter. Such activities directly consume fossil fuels and emit carbon to the atmosphere.
- Worksites – activities on worksites that consume fuel. Such activities also directly consume fossil fuels and emit carbon to the atmosphere.
- Materials – new pipes and fittings require the consumption of materials. An estimated factor of emissions embedded within such materials has been included in the Guidance.

4. REVIEW OF EXISTING GUIDANCE AND DATA SOURCES

4.1 ENVIRONMENTAL AND SOCIAL EXTERNALITIES

4.1.1 Background

The Tripartite Report (Defra, the Environment Agency and Ofwat, 2002) offered a best practice approach to leakage target setting, set within the context of a least cost plan. The Tripartite Report's guidance for including environmental and social impacts within the ELL calculation was a synthesis of earlier guidance commissioned by the Environment Agency / NRA during the late 1990's. Particular reference is made in the report to the RPA (1998) guidance for valuing environmental impacts, and to the NERA (1998) guidance for assessing social impacts. Carbon-related impacts were not considered.

The Tripartite Report methodology is based on the principle of monetary valuation. Financial valuation methods allow inclusion of relevant externalities on a like-for-like basis with private financial costs for the purpose of cost-benefit analysis. The monetary valuation of externalities is consistent with guidance from OFWAT in 2007 on how it expects WSPs to approach their business plans for PR09.

There are three methods for deriving monetary valuations for external benefits and costs: *revealed preference* techniques (such as hedonic pricing and avertive expenditures) use information in markets related to the non-market good or service to impute an economic value; *stated preference* techniques (such as choice modelling and contingent valuation) are designed to elicit customers' economic valuations for non-market goods through the use of hypothetical market scenarios which are developed using questionnaires; and *benefits transfer* methods 'borrow' information from existing revealed and stated preference studies and apply it in a new context. A detailed review of the techniques together with examples of their practical implementation for water industry investment appraisal can be found in UKWIR (2007a) and Vivid Economics (2007).

Limitations and issues arise in relation to each of the valuation methods currently available:

- Revealed preference methods rely on observation of actual behaviour in a related or proxy market for the benefit being valued. The method cannot be applied to investment options or impacts where no related market exists, and a key failure of the technique in this respect relates to the valuation of non-use, which is a central component of many environmental benefits.

- Unbiased valuations derived from stated preference methods require carefully designed surveys that both fully inform customers of relevant impacts and appropriately reflect attributes that are relevant to them. This can be difficult for certain types of environmental benefits, particularly when these are incorporated into programme-level benefits surveys, where the level of detail required to appropriately describe the choice set is high, and the information presented to the customer can lead to a 'cognitive overload'.

- The successful application of benefits transfer methods relies on the availability of existing studies which themselves must be robust, and which should relate to sites and scenarios with similar characteristics. The transfer of benefit functions which link willingness-to-pay (WTP) to explanatory variables is considered, when available, to be more reliable than the simple or adjusted transfer of average WTP estimates (although the costs of applying such a function may exceed the benefits in terms of the accuracy improvements gained).

Notwithstanding their well-documented limitations, a key strength of the benefits transfer method is its practicability. The desk-based nature of the approach enables a comparatively rapid assessment of the relative magnitudes of a wide range of environmental impacts. It offers a practical solution in cases where an immediate valuation is required and, where the magnitude of the benefit is expected to be relatively small, it can reduce the need for a large number of often costly site-specific studies. Benefits transfer methods are also particularly useful in global contexts (such as, for example, the widespread use a single transfer value for the cost of carbon) where the benefits of improvements are both spatially uniform and non-substitutable.

4.1.2 The 'Benefits Assessment Guidance'

Due to the large number of projects and disparate environmental impacts involved, in 2003 the Environment Agency utilised the benefits transfer approach for assessing the environmental and social costs and benefits of all non-mandatory schemes in the PR04 environmental investment programme. For this purpose it developed the Benefits Assessment Guidance (BAG). The BAG provides a desk-based approach for the monetary valuation of project-level (i.e. bottom-up) environmental and social benefits and costs. It was also utilised by a number of WSPs both in their PR04 submissions and in subsequent reviews.

The BAG is divided into a number of parts, each comprising detailed guidance on valuation of the impacts of specific types of (i) water quality and (ii) water resource schemes affecting, for example, rivers and groundwater (Part 2), and reservoirs, lakes and broads (Part 3). Part 5 of the BAG deals with assessment of the social costs arising from construction and operating activities ('work related impacts'). For quantitative valuation of traffic-related impacts, Part 5 of the guidance draws on NERA guidance (1998), which offers particularly relevant guidance for the valuation of traffic disruption arising from both leakage and leakage management activity. However, the BAG assessments of the unit cost of delays are based the now outdated study by Newberry (1992). More recent assessments for average hourly traffic flows on different road types are available from the Department for Transport, as are up-to-date assessments of the financial value of time lost through traffic disruption (Department for Transport, February 2007).

Part 5 also includes a limited discussion of the assessment of minor interruptions to water supply, excavations at domestic properties, and noise from plant operations, but no guidance is offered on the financial valuation of these impacts. An outline methodology for assessing carbon-related impacts is also presented in Part 5.

BAG offers a 'progressive' assessment approach that involves first the assessment of impacts in qualitative terms, then, where impacts are considered to be more significant, proceeds to quantitative assessment and, finally, to financial valuation. Due to a lack of appropriate source studies, the BAG approach does not employ the transfer of benefit functions but rather involves the unadjusted or adjusted transfer of benefit values.

4.1.3 Issues with the BAG

Limitations of the BAG approach have been well documented in recent years. A full discussion of these can be found in Willis (2004), UKWIR (2007a) and Vivid Economics (2007). Many of the criticisms relate less to the water resources valuation sections, but rather to the water quality and bathing waters aspects of the methodology, which have tended to be more problematic.

The most relevant criticism of BAG has focused on the potential problems arising from independent valuation and summation (IVS). IVS is a potential problem in many project or scheme-level valuation studies, regardless of the valuation method employed. It is argued that the valuation studies identified in the BAG for benefits transfer are based on the assessment and evaluation by consumers of individual schemes, in isolation from all other potential improvements in water service. When such valuations are summed across an entire programme of water service improvements, therefore, it is possible that the programme-level benefits will be overstated, with the result that the resulting ELL is 'too low'. The extent of the overstatement is related to the degree of substitutability between competing projects within the programme. Since many environmental resources can be regarded as at least partial substitutes, as increasing environmental improvements are made, the value of further incremental improvements falls.

This issue is closely related to the appropriate consideration in benefits valuation studies of customers' overall household budget constraints, which can significantly reduce consumers' WTP for any single improvement when it is set within the wider context both of other water service improvements and additional household expenditures making a claim on limited budgets.

To the extent that separate components of a WSPs proposed overall investment programme may be at least partially substitutable, the problem of IVS is potentially an issue when the BAG approach is used[10]. Similarly, customers' budget constraints are likely to affect their willingess-to-pay for any component of an overall programme when weighed against the full range of schemes being proposed. It should be noted, however, that several of the studies recommended by the BAG for benefits transfer attempt to take at least some account of income constraints and the IVS problem by embedding WTP assessments within the context of regional environmental (eg low flow alleviation) programmes.

For example, benefit valuations from the Mimram study (Jacobs Gibb, 2002) are recommended as the default values for benefits transfer to other low flow sites. The Mimram study involved deriving valuations for a specific flow alleviation project within the context of an overall, regional-level low flow alleviation programme, thus it explicitly addressed the IVS issue with respect to substitute flow alleviation schemes. The study first elicited WTP for low flow alleviation at all 30 worst affected rivers in the Thames region, thus an indicative budget constraint was generated before WTP for an individual river (the Mimram) was then elicited.

The Mimram study also attempts to address a number of other key issues arising in benefits valuation studies by developing a series of mean WTP estimates for both use and non-use value, and for four different distance bands away from the site. The development of distance-decay relationships provides important insights into the relationship between distance and use and non-use values, since the relevant population over which WTP assessments are aggregated, particularly those relating to non-use, can significantly affect a total benefits valuation (see, for example, Bateman *et al* (2000)).

Through the use of GIS modelling, distance-decay, along with relevant socioeconomic data, has increasingly been incorporated into benefit functions such that individuals have a predicted valuation based on distance from the site, income, household composition and other known explanatory factors. However, while information on distance-decay relationships appropriate for individual sites is becoming increasingly refined, there is still relatively little evidence available on how these relationships are affected by the simultaneous consideration of an entire programme of environmental improvements.

[10] Although the extent to which environmental improvements are directly substitutable for improvements in other water service areas, (such as, for example, drinking water quality improvements and a reduction in domestic sewage flooding risk) is not entirely clear.

4.1.4 Top-level willingness-to-pay studies

For PR04, Yorkshire Water undertook a top-level stated preference study, using choice modelling, to assist with the determination of its optimal investment plan (see Willis, Scarpa and Acutt (2005), or UKWIR (2007a) for an overview of the method). In light of the growing regulatory expectation that WSPs should be able to justify their top-level investment programme as cost beneficial, an increasing number of WSPs have begun to undertake programme-level WTP assessments similar to the method developed by Yorkshire Water.

The approach involves the definition of a number of top-level service areas relating, for example, to sewage flooding into properties, pollution incidents, leakage, and the ecological quality of rivers. Survey respondents are presented with random combinations of choices for the level of each service factor, with each combination being associated with a price change relative to current water and sewage bills. The choices made by respondents reveal their preferences in terms of willingness-to-pay (implicit prices) for different service level combinations.

The key advantage of this approach is that it allows the modelling and quantification of service factor tradeoffs, so that resulting WTP estimates for a particular service factor are conditional upon customer preferences for all other service factors. The resulting WTP assessments may be used either to inform the selection and prioritisation of investment alternatives or to weight, in line with customer preferences, the level of planned investment for each service area, such that a given cost constraint is not exceeded.

There are a number of practical issues associated with top-level preference surveys of this type, however, and these relate particularly to the valuation of environmental impacts. They centre on the ability of top-level surveys to provide sufficient information on environmental impacts (without inducing 'cognitive overload') to enable respondents to make appropriate comparisons between tangible service factors (such as reduced supply interruptions) and more intangible environmental benefits relating, for example, to river flow alleviation. The challenge is thus to provide adequate information on, for example, the incidence of low flows and problems they cause alongside all the other water service problems so that individuals can fully perceive and understand them.

Arguably, top-level surveys cannot at present adequately address these issues, particularly in the current climate of flooding. The issue may become a more significant problem for the Water Framework Directive when the number of schemes and associated environmental impacts is likely to significantly increase.

A further, related difficulty with the top-level approach arises from the need for environmental benefits valuations that relate to specific zones and/or abstraction sources. These are required for use in leakage modelling at the zonal level, and where environmental impacts may differ significantly from site to site, problems may arise in determining the appropriate weighting of top-level environmental benefit values across individual zones / sites.

4.1.5 The way forward

While choice modelling approaches appear to be very well suited to the top-level valuation of a wide range of water service improvements, it is also evident that they may not, at present, be able to appropriately reflect the economic values of more complex environmental impacts arising from, for example, low flow alleviation, particularly at the zone-level which is required for leakage modelling. Notwithstanding its limitations, the BAG approach is considered by the Environment Agency to be, at present, the best available and most practical means for valuing the benefits associated with these types of water resource schemes.

In the light of these issues, the guidance presented in this report for valuing the environmental benefits of leakage reduction involves the reconciliation (adjustment, or calibration) of economic values derived from bottom-up application of the BAG approach with the WTP assessments derived from top-level preference surveys, assuming the latter are both available and appropriately defined in relation to flow alleviation issues.

This approach is designed to satisfy the regulatory requirement that WSPs' investment programmes should be supported by customers' overall WTP, such that required tradeoffs are undertaken in line with customers' identified priorities. At the same time, the approach permits more detailed consideration of environmental impacts at the project- and zone-level, and resulting assessments can be used as a basis for defining appropriate zonal weights which reflect more detailed characteristics of environmental impacts such as location and severity. This approach is similar to (and consistent with) the 'two stage' approach to benefits valuation, recommended in UKWIR (2007b) in relation to the valuation of the benefits of sewer flooding alleviation.

Criticisms of the bottom-up approach relating to weak budget constraints and IVS are addressed through the reconciliation of valuations with top-level survey results where these problems are significantly reduced.

The guidance provided for valuation of the social impacts of leakage reduction activity also builds on the BAG approach for assessing works related impacts (Part 5), but offers significantly more detail with respect to developing the social cost ~ leakage relationship, and employs up-to-date valuations for the unit costs of delays and related disruptions.

Over the longer term, well-designed stated preference surveys aimed at establishing WTP for low flow alleviation schemes within a specific zone or region, set within the context of household budget constraints and wider environmental improvements, are likely to offer a superior alternative to benefits transfer. Should WSPs have available benefit valuations derived from previous surveys of this type, it is recommended that these are used in place of transferred benefit values.

While providing considerable insight into relative priorities at the programme-level, the application of top-level surveys aimed at eliciting consumers' preferences and WTP for leakage schemes within the context of other water service programmes should not be regarded by WSPs as a substitute for the development of a detailed quantitative ELL model.

4.2 CARBON-RELATED EXTERNALITIES

There is a wide and expanding body of literature relating to the assessment of carbon emissions. Although there is not one standard methodology for carbon footprinting there are a number of common elements which require inclusion, often being subdivided into those issues related to construction (construction traffic, equipment, embodied carbon), and those related to operational issues (energy and fuel consumption, traffic emissions and waste disposal). An assessment specific to the water industry requires the footprinting process to be broken down within its main areas of activity, leakage and leakage management and by social and environmental costs. Within this section the key documents relating to these areas are summarised. They are listed under the section to which they relate most, but are cross referenced where necessary. Although emissions also arise from the treatment of waste water, this is outside the remit of this project and therefore is not discussed.

Pressure on the measurement and control of greenhouse gas emissions is likely to increase in the future across all areas of the economy including the water sector. In late 2006 early 2007 there were a number of key developments that set out the potential political agenda related to carbon going forward.

Following on from the comprehensive Stern Report on the economic effects of climate change (2006) which advocates strong action now to avoid the worst effects of climate change, the Draft Climate Change Bill (March 2007) has been published. This is intended to act as a catalyst to individuals to invest in low carbon technologies with time horizons extending beyond the current 2012 Kyoto Protocol limits. The main elements of the Bill include making the current objective to reduce CO_2 by 60% by 2050 a legal requirement, with a 26-32% reduction by 2020 and the setting of five year carbon emission budgets / allowances. Key elements of the Draft Bill are currently undergoing consultation, however the overall intent of the policy and therefore future government direction is clear. It is likely that the water sector will face restrictions on greenhouse gas emissions as part of this policy although the levels and precise mechanisms to be employed are still under development.

Another regulatory tool with the potential to impact on the water sector through the imposition of restrictions on carbon is the carbon reduction commitments, which at the time of writing was in its consultation stage. Announced in the 2007 Energy White Paper, the Carbon Reduction Commitment (CRC) proposes a mandatory cap and trade scheme applying to large non energy intensive organisations in both the public and private sectors that are below the threshold for the EUETS or Climate Change Agreements (CCAs). The Climate Change Bill would enact the Commitment. This policy instrument would establish an emissions cap and carbon price for the carbon dioxide emissions associated with electricity and fuel use in the whole of the water industry. At such a time that this system is introduced WSPs should ensure that double counting within calculations such as set out in this document does not arise.

The UKWIR Workbook for Quantifying Greenhouse Gas Emissions (2005) relates to the assessment of emissions during the production and supply of clean water. It attempts to produce a standardised approach for estimating GHG emissions from individual water companies, the UKWIR report offers a spreadsheet model which has been agreed through industry consultation. The workbook covers a number of activity areas in relation to the production and management of drinking and waste water. As such, these methodologies also provide guidance on the assessment of greenhouse gas emissions from leakage including: drinking water treatment and pumping, and administrative activities.

The review of the WSPs completed as part of this study indicated that a number of the WSPs had or were using this guidance in relation to the assessment of greenhouse gas emissions. Not wishing to create layers of additional carbon accountancy as part of this work the proposed methodology for the estimation of emissions associated with leakage draws heavily on this methodology. In a number of cases, however, the methodology has been adapted to incorporated the latest guidance on greenhouse gas emissions related to fuel such as provided by DEFRA (2006, 2007) (see below).

The emissions associated with leakage management activities can be divided into three distinct elements:

- Fuel consumption transport
- Fuel consumption worksites
- Emissions embedded in materials.

The assessment of emissions from fuel consumption for simplicity draws upon the DEFRA publications on Reporting Guidelines for UK Businesses (2006) and complementary annexes of conversion factors (June 2007). The DEFRA Reporting Guidelines (2006) provide voluntary guidelines for businesses to report on their environmental performance and provides support for the measurement of GHGs in the form of conversion factors, published in annexes which are updated separately as more refined methodologies become available. Conversion factors to reach units of CO_2 are provided in the annexes for: fuel types, exports and imports of Combined Heat and Power, electricity by year, typical industrial processes, process emissions, and road/rail/air/haulage transport emissions. Such information was used as a tool when compiling the guidance contained in this document.

Emissions associated with disruption and diversions associated with worksites have been estimated drawing upon information contained in the Department for Transport WebTag assessment notes and the Design Manual for Roads and Bridges assessment techniques. The approach extracts information related to typical roads and estimates the impacts on fuel consumptions from speed reductions, congestion, and diversions based on road types and assumed vehicle flow rates.

In relation to emissions from worksites there are comprehensive lists of equipment commonly used within construction (DEFRA, 2005c) intended for established fields which require such information e.g. noise assessments, however, there is a lack of comprehensive guidance on the calculation of greenhouse gas emissions from construction activities. Drawing on data provided about construction equipment a bespoke method has been developed to estimate the fuel consumption from indicative construction sites in order to provide the simple metrics contained in this guidance.

During the repair and replacement of pipe-work new piping is installed that also brings with it a measure of emissions. Making assumptions related to the type of material embedded emissions have been estimated for PVC and ductile iron drawing on lifecycle carbon data in CES Edupack, 2006.

Having estimated the emissions of greenhouse gas the final step is to monetise these emissions in order to incorporate them into the ELL calculations. There is an abundance of literature on the social cost of carbon and historically, estimates of its worth vary widely. As opposed to discussing the potential sources of carbon prices (e.g. trading schemes, futures markets, other proxies etc.) and the pros and cons of such methods a summary of the sources used for this study have been provided.

In August 2007 Defra issued interim guidance on adopting the concept of the Shadow Price of Carbon (SPC) which replaces *all* guidance on using the previous social cost of carbon (SCC) valuation method. The SPC differs from the SCC fundamentally in that it takes more account of uncertainty, is based on the stabilisation trajectory and is in line with the marginal abatement costs of reaching the stabilisation goal. Using this methodology, in the year 2000, in year 2000 prices, the SPC is £19 per tonne CO_2e which rises over time for two reasons:

1. to account for observed (and assumed) inflation; and
2. to rise by 2% per year due to the rising damage costs from higher greenhouse gas concentrations.

The SPC for a policy beginning in 2007 is £25.4/tCO_2 in (which has been increased from the 2000 price by use of both the 2% per annum increase and HMT's GDP deflator to account for observed inflation over this time). To obtain figures after 2007, prices rise by 2% per annum to provide £26/tCO_2 in 2008, rising to £33/tCO_2 in 2020 and £49/tCO_2 by 2040.

Companies are advised to detail specifically which year their policy starts in, and which year it is appraised in as this will affect the SPC schedule used within calculations.

5 INDUSTRY SURVEY

A key element of the study was a requirement to undertake a survey of all 23 water companies in England and Wales. The survey, supported by the literature review, provided the basis for development of the guidance methodology.

5.1 SURVEY OBJECTIVES

The survey's aims were:

for valuation of environmental and social externalities,

i. to audit/review the nature and extent of water companies' usage of the Tripartite Report and/or other guidance on including environmental and social externalities in their ELL determination for PR04 and subsequent revisions;

ii. to identify weaknesses and strengths in the practical application of the Tripartite Report guidance on including environmental and social externalities;

iii. to identify best practice examples of inclusion by water companies of environmental and social externalities in PR04;

for carbon accounting,

iv. to review the nature and extent of water companies' leakage-related carbon accounting in PR04 and subsequent revisions;

v. to identify best practice examples of leakage-related carbon accounting in PR04;

vi. to identify the existing range and quality of data available to (or collected by) water companies for undertaking a carbon accounting exercise.

The survey questionnaire was divided into two parts. The aim of Part 1 was to derive an overview of WSPs' assessment of externalities for PR04 and subsequent reviews: WSPs were asked to define whether and how (i.e. whether qualitatively or quantitatively) listed externalities were assessed.

Part 2 involved a series of more detailed questions aimed at eliciting from respondents the methods used to derive externality assessments, the difficulties and uncertainties encountered, the approximate magnitudes of externality valuations, and their overall impact on the ELL calculation.

Survey questionnaires were issued to all companies for whom a contact name had been provided; all 10 water & sewerage companies and 10 of the water-only companies offered to participate in the survey. Questionnaires were completed through a mix of telephone interviews and written survey responses. In some cases these were augmented by detailed study reports prepared by various WSP consultants.

5.2 INCLUSION OF EXTERNALITIES BY WSPS

5.2.1 Overview of externalities considered

Of the 20 questionnaires issued, responses were received from 16 companies. Of these, a total of 12 companies considered externalities in their PR04 ELL submissions or subsequent reviews. Externalities have been classified in Section 3 under two broad headings, each with two categories:

- Leakage-related externalities:
  - Environmental impacts resulting from changes in abstraction from rivers, reservoirs and groundwater
  - Carbon emissions associated with abstraction, water treatment and distribution

- Leakage management externalities:
  - Social effects (traffic disruption etc.) associated with various leakage management interventions
  - Carbon emissions associated with leakage management interventions

Figure 5.1 provides an overview of the numbers of WSPs that considered each of the four externality categories.

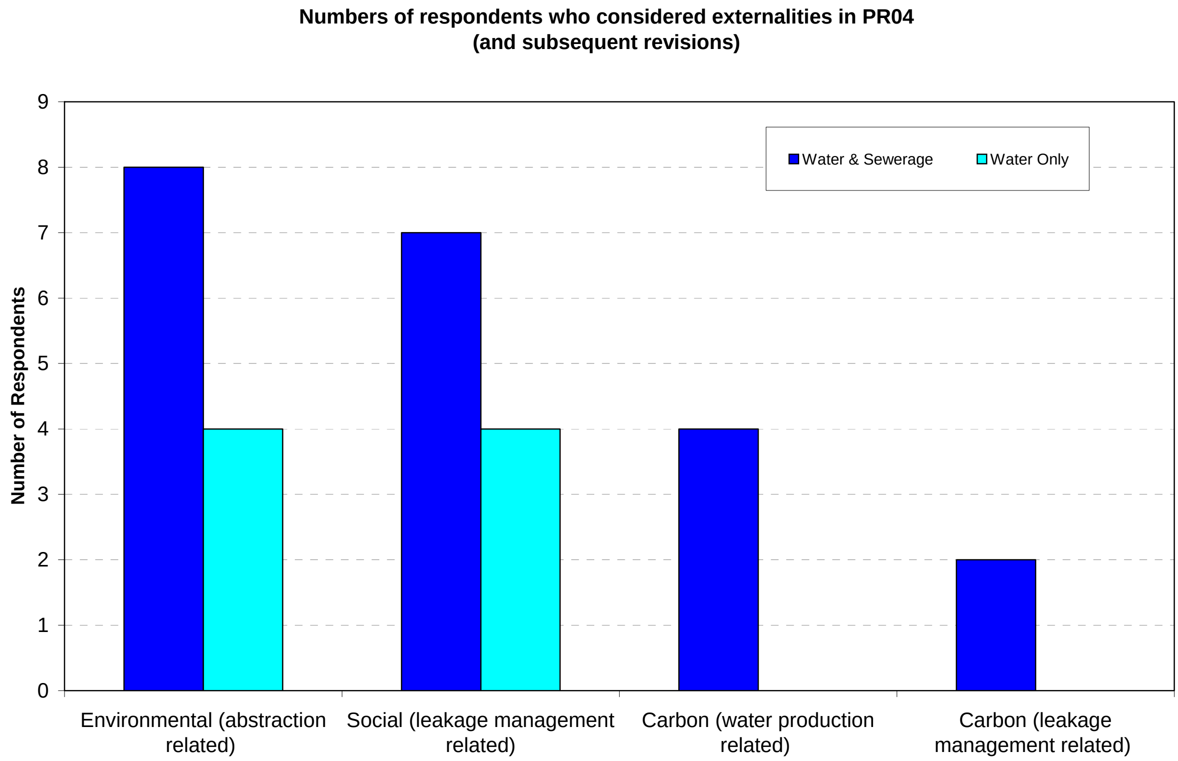


Figure 5.1 Externalities considered by WSPs

Figure 5.1 illustrates that both environmental and social categories were considered by most of the respondents but that carbon impacts have received significantly less attention. General consideration of externalities in the ELL process is dominated water & sewerage companies.

The following Sections provide a more detailed breakdown of the specific externalities considered in each category.

5.2.2 Leakage-related Externalities

Figures 5.2 – 5.4 provide a breakdown of the environment externalities that were considered by WSPs in the context of abstractions from rivers, reservoirs and groundwater (wetland environmental impacts) respectively.

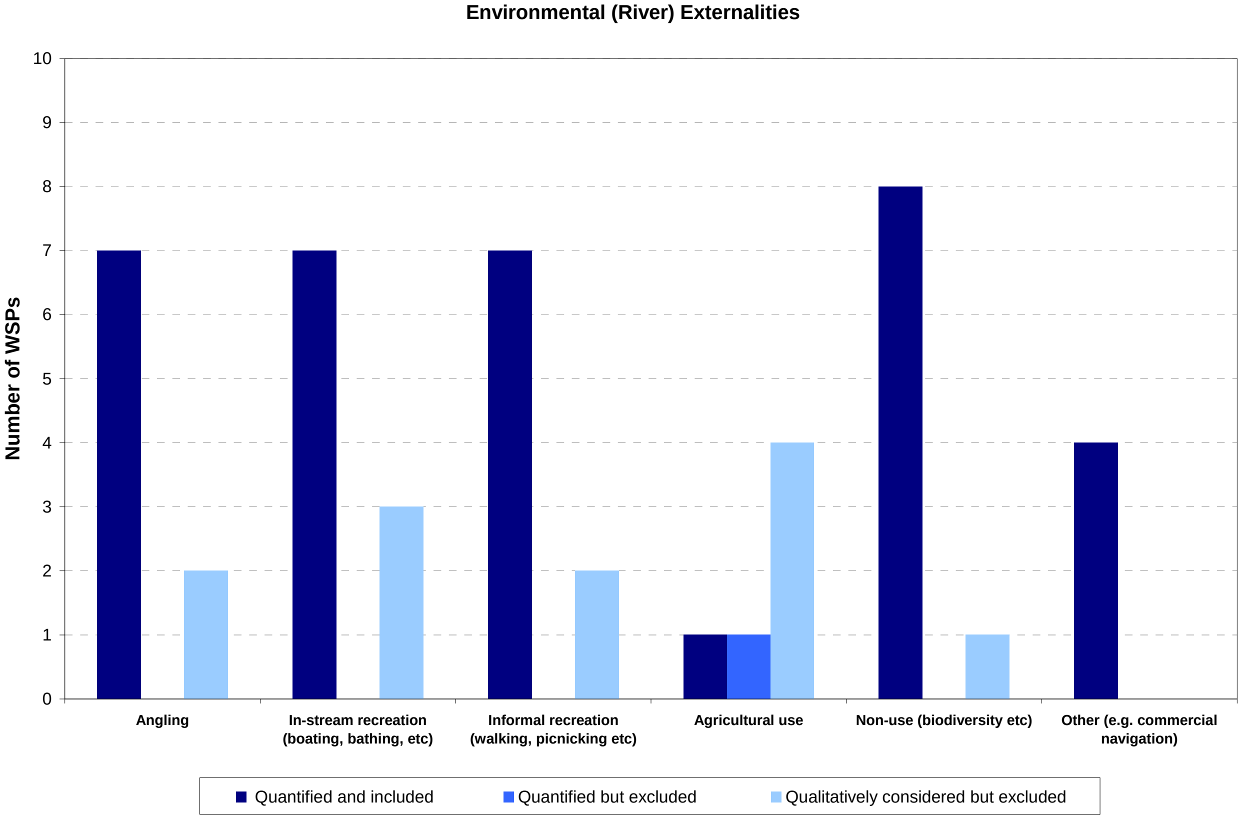


Figure 5.2 Consideration of River Abstraction Externalities

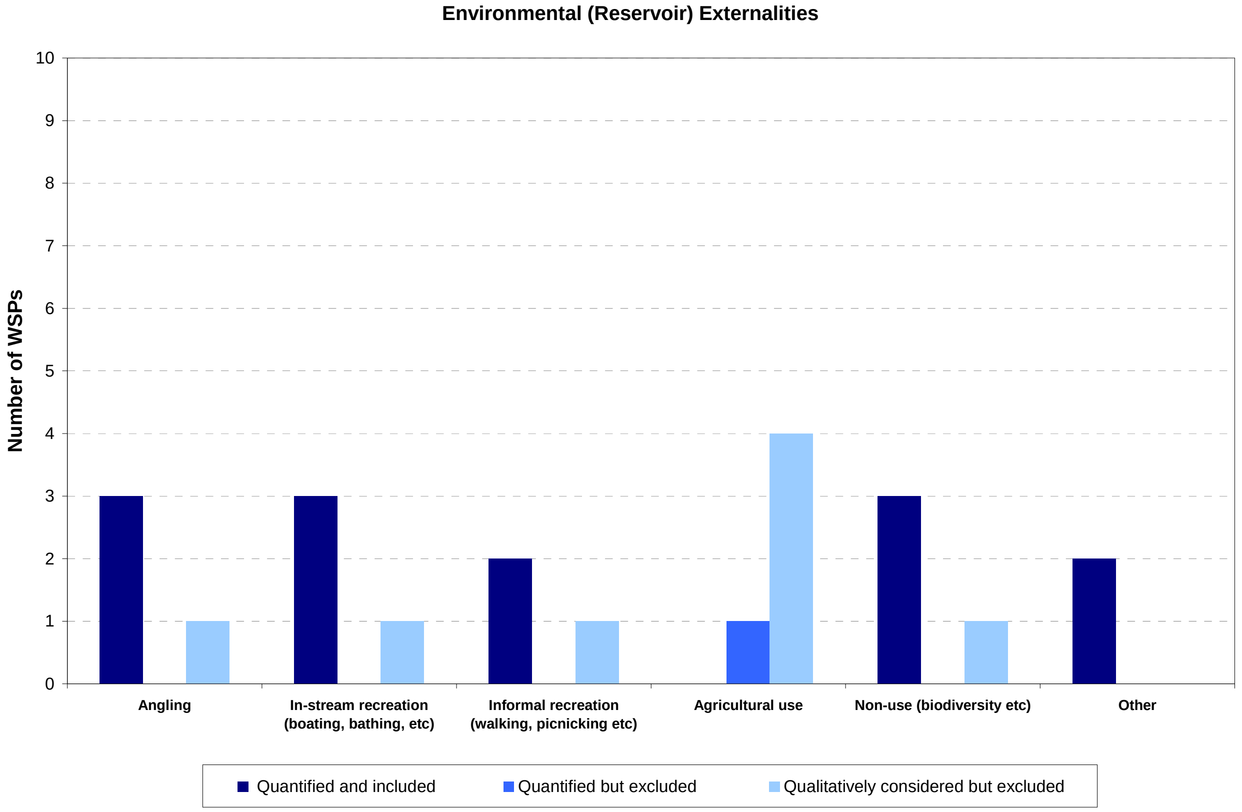


Figure 5.3 Consideration of Reservoir Abstraction Externalities

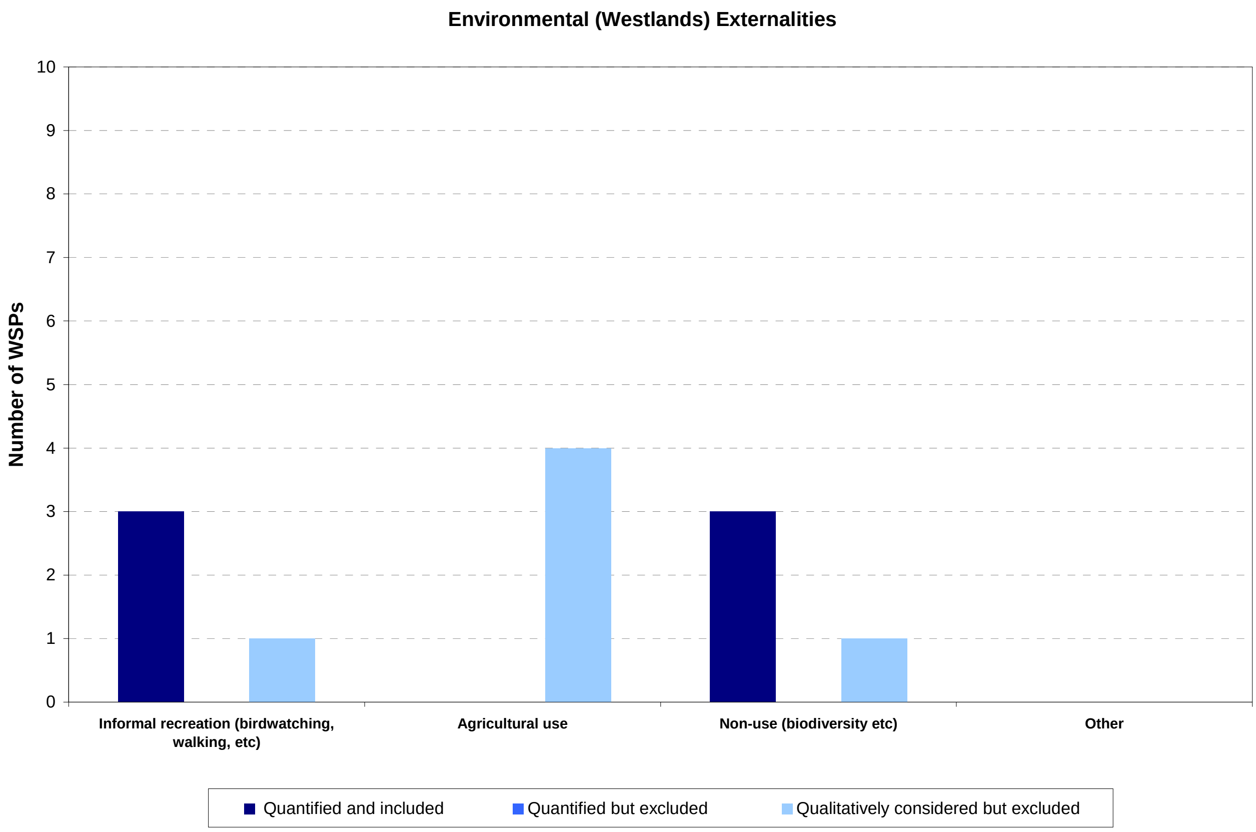


Figure 5.4 Consideration of Groundwater (Wetland) Abstraction Externalities

Figures 5.2 – 5.4 show that the principal focus has been on river abstraction externalities associated with angling and other recreational uses, together with biodiversity and non-use.

Only 4 companies from the survey respondents considered carbon (fuel/energy-related) externalities in the context of water production and distribution, 3 of which included their valuations in the ELL calculation process (Figure 5.5). One of these companies also included valuation of CO_2 emissions from their treatment processes.

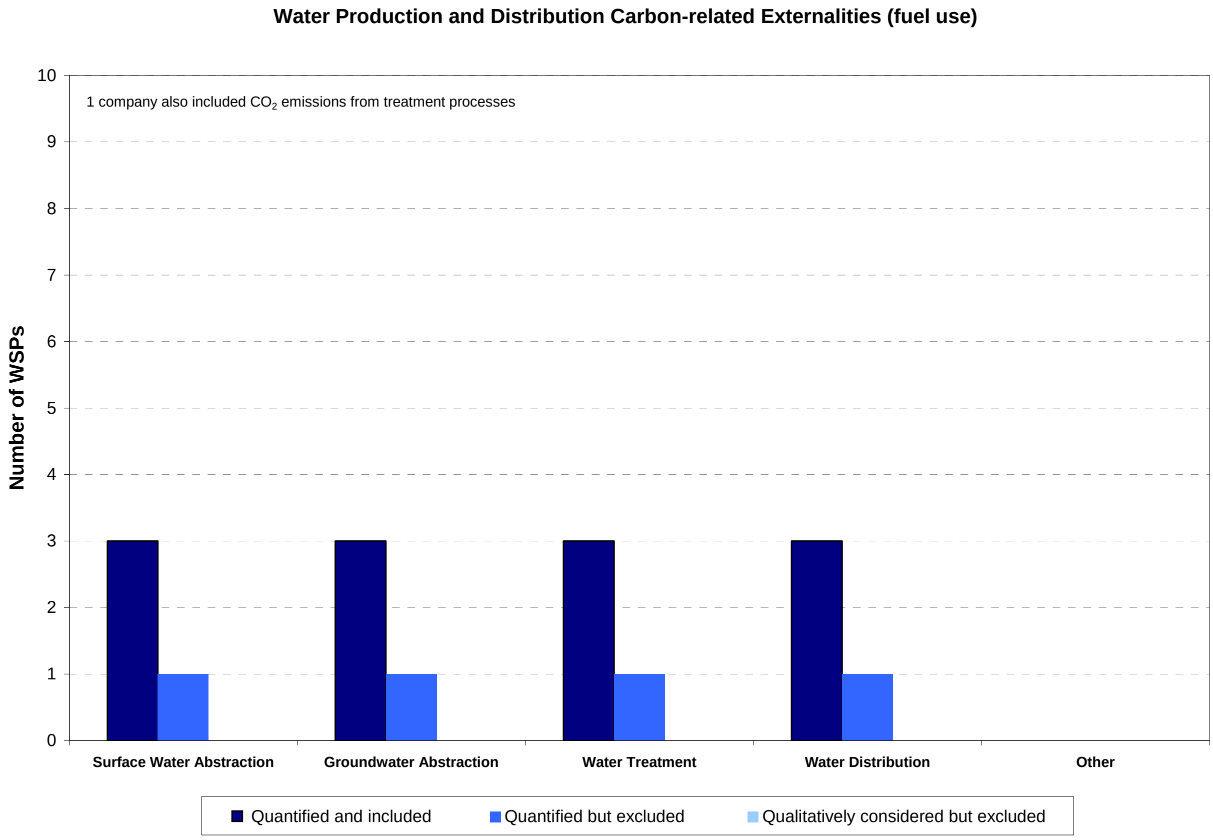


Figure 5.5 Consideration of Leakage-related Carbon Externalities

5.2.3 Leakage Management Externalities

Figure 5.6 provides a breakdown of the social externalities that were considered by companies in the context of leakage management interventions i.e. active leakage control, pressure management and asset renewal.

This clearly shows that focus has been on valuation of the traffic and (to a lesser degree) pedestrian delays associated with leak repairs and asset renewal. Other externalities such as flood damage, interruptions to supply and low pressure effects have also been considered by a minority of companies but were not included in the ELL calculation process.

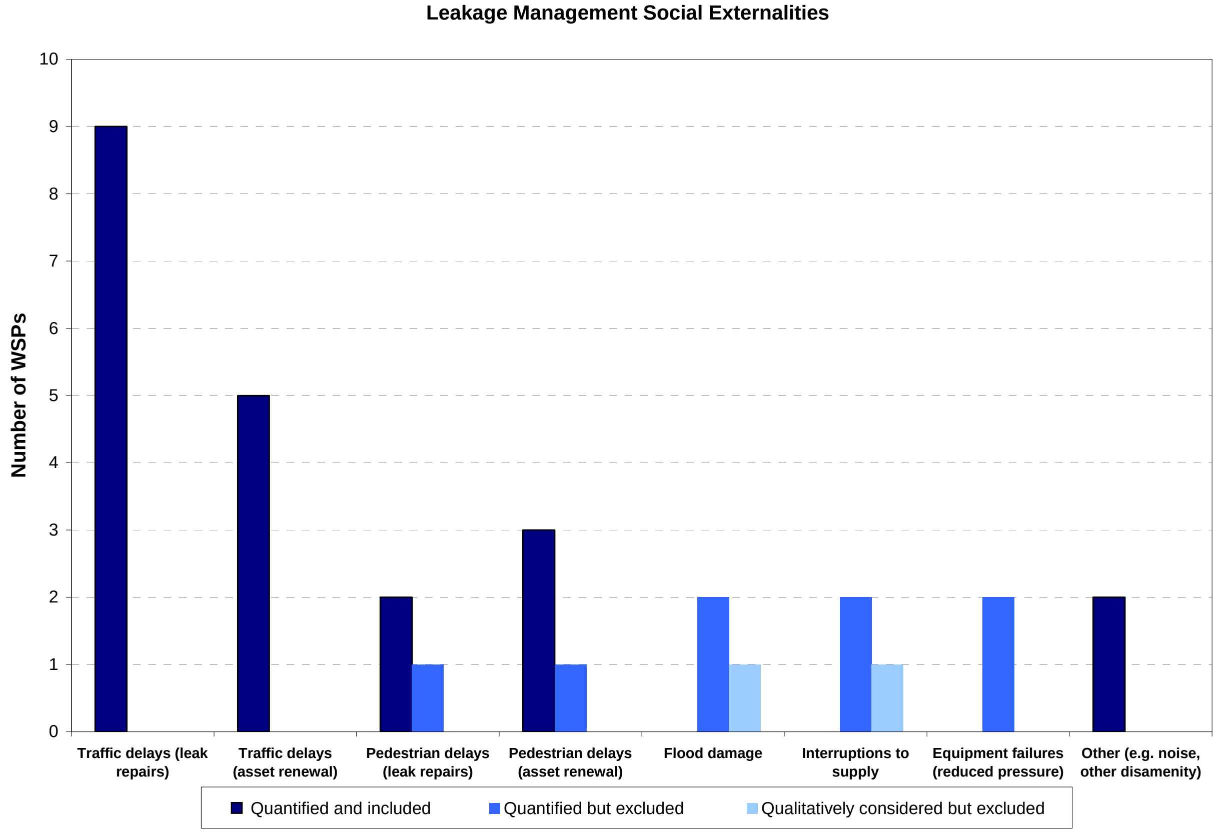


Figure 5.6 Consideration of Leakage Management Social Externalities

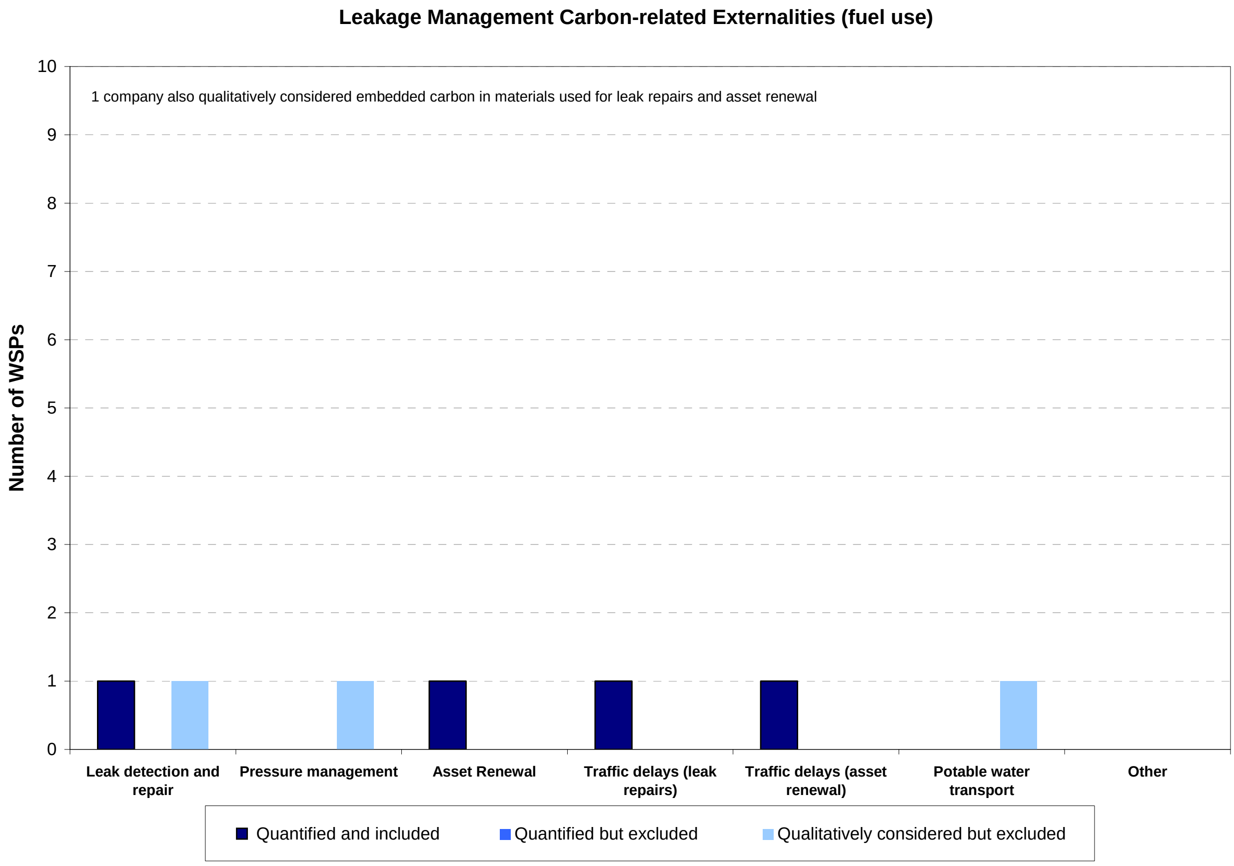


Figure 5.7 Consideration of Leakage Management Carbon Externalities

Only 2 companies from the survey respondents considered carbon (fuel/energy-related) externalities in the context of leakage management and only 1 of these included a valuation in the ELL calculation process. One of these companies also considered the embedded value of carbon in the materials used for leak repairs and asset renewals, but this was not included in ELL calculations.

5.3 EXAMPLES OF GOOD PRACTICE

From analysis of the responses to Part 2 of the questionnaire, it was possible to evaluate the methods used by WSPs to assess externalities in PR04 and subsequent reviews. This evaluation has been used to inform the guidance on existing good practice approaches. The following Sections provide an overview of WSPs' methods for key areas of the assessment process and related discussions designed to highlight areas of good practice.

5.3.1 Environmental externalities

The survey responses suggest a wide range of approaches and assumptions have been used by WSPs with respect to the valuation of leakage-contingent environmental impacts in PR04 and subsequent reviews. The breadth of coverage and level of detail employed was also variable. Resulting valuations tended, with few, zonal level exceptions, either to be relatively low, or to be largely offset by the social costs of leakage control, the net impact on resulting ELL values being in many cases negligible.

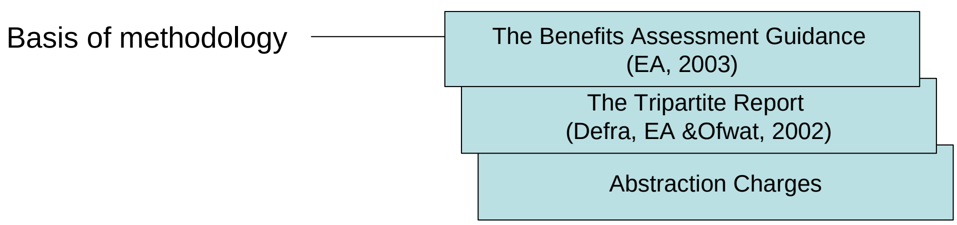
Methodological basis of assessments

Most WSPs who considered leakage-related environmental impacts in their ELL calculation utilised the BAG methodology and associated benefit valuations. This is considered at present to offer the best practice approach for the bottom-up valuation of environmental externalities, and, given the widespread application of the BAG, the resulting environmental valuations will be consistent with those derived for other water resource schemes considered in the least cost plan.

Some WSPs used the BAG guidance in conjunction with the parts of the Tripartite Report that deal with the incremental adjustment of benefits valuations using PHABSIM. Part 2 of this Guidance provides refined recommendations on the application of the PHABSIM adjustment methodology, and these can be considered as best practice.

Some WSPs reported using, in certain circumstances, qualitative trade-off analysis to weigh the relative external impacts against the relevant financial costs. This approach may be regarded as good practice when used to complement financial valuation techniques (as recommended by the BAG), but does not offer a satisfactory substitute for the financial valuation of impacts for which good practice valuation guidance is available.

One respondent used abstraction charges as a proxy for the value of environmental externalities. This approach is not considered to be appropriate because abstraction charges are not intended to 'internalise' the external cost of abstraction, but relate largely to administrative costs: the value of the charges are thought, typically, to be significantly lower than the 'true' marginal environmental cost of abstraction.



Level of analysis

WSPs undertook analyses of geographical areas in a number of different ways. Although two WSPs considered, at least initially, the full range of abstraction sources, most focused on one or several from each zone. Some WSPs focused on the principal abstraction source (or sources) in each zone, while others focused on the most environmentally sensitive site (or sites) in each zone. Two WSPs considered the source from where abstraction was most likely to be reduced given a reduction in leakage.

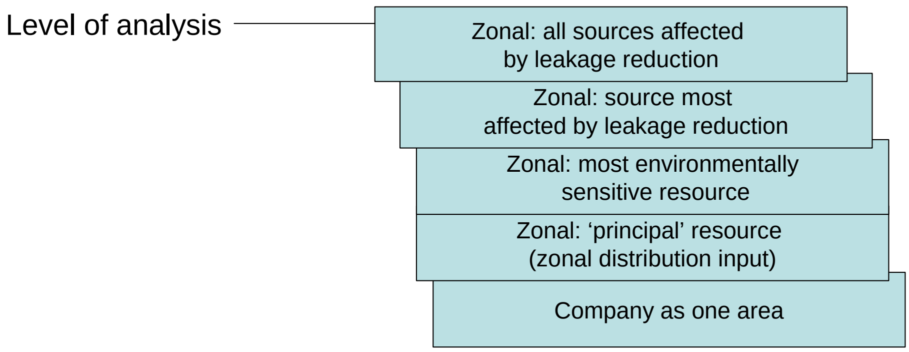
If valuations are derived for one or a small number of abstraction sources, it is important that these are carefully selected and appropriately weighted in the zonal-level marginal environmental cost of leakage assessment. [11]

The analysis should begin by considering all sources of abstraction within a zone. If it is clear that there are a number of sources within a zone where no reduction in abstraction would occur as a result of a reduction in zonal leakage, then these sources may be excluded from further analysis on the basis that although the marginal environmental cost of abstraction may be non-zero, the marginal environmental cost of leakage in these zones is zero.

It is recommended best practice that the environmental impacts of leakage are assessed for all remaining sources within a zone and, where appropriate, valued using the relevant parts of this Guidance. Where there is more than one source remaining, the benefits valuation for each source should be adjusted by the reduction in abstraction expected to occur at that source following a reduction in zonal-level leakage. If this cannot be assessed, then it may be estimated using the source's percentage contribution to zonal distribution input.

Using this approach, the resulting marginal environmental valuations for each source at each level of zonal leakage can be directly summed to provide an appropriately weighted assessment of the zonal-level marginal environmental cost of leakage. In this way, sources where the environmental impacts of abstraction are relatively low (and thus may not even have been quantified) but which make a significant contribution to zonal distribution input are still appropriately weighted in the overall assessment of marginal environmental cost for the zone.

A small number of WSPs treated the region as one area, and applied in their ELL models a single marginal environmental cost assessment for all resource zones across the region. Unless the region comprises a single resource zone, this approach is not considered good practice.



[11] in the same way that 'average zone marginal cost of water' is derived as a weighted average of the operating costs associated with each source, while the 'maximum zone marginal cost of water' is given by the operating costs associated with the most expensive source.

Assessment of beneficiary numbers

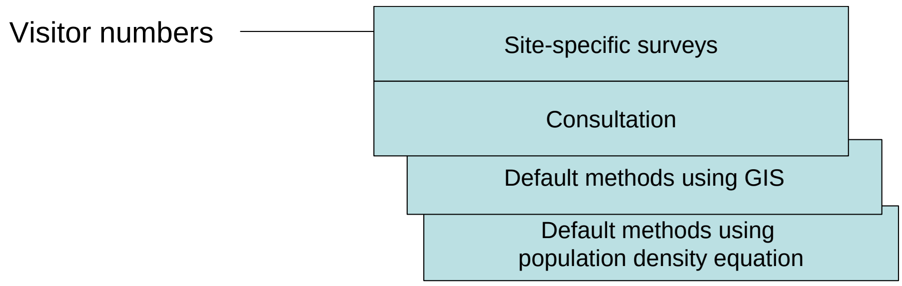
To assess the numbers of beneficiaries likely to be affected by flow / water level improvements at the affected sites, most WSP respondents made use of the default population methods described in the BAG, either by applying GIS to determine actual households within the recommended radius around the site, or by applying a population density equation to the radius. Percentages of the resulting populations likely to benefit from improvements at the site were taken from the BAG.

Most respondents made some effort to adjust the assessments for local circumstances such as coastal areas, large urbanisations, and the number of alternative sites available within the relevant radii.

Some WSPs made use of available site-specific visitor survey data through consultation with local government, environmental groups, associations and clubs. Clearly, if such data is available, consultation is regarded as a more favourable means of deriving site-specific assessments of visitor numbers, since it avoids the need to determine appropriate radii and apply default adjustment factors.

If site-specific data is unavailable, out of date, or cannot be converted to an appropriate format, an alternative good practice means for assessing visitor numbers is through the use of bespoke, well-designed, site-specific surveys (visitor counts).

Clearly, assessments of the beneficiaries relating to the 'non-use' category of benefits cannot be determined through site-specific surveys and, until the results of further research in this area are available, the default methods detailed in the BAG offer, in this case, a good practice way forward.[12]



Source of benefits transfer values

Those WSPs using the BAG also applied the benefits transfer values recommended by the BAG. This is currently considered best practice although, as the number of relevant and robust site-specific water-resource related valuation studies in the UK increases over time, the valuations recommended by the BAG for benefits transfer will need appropriately updating.

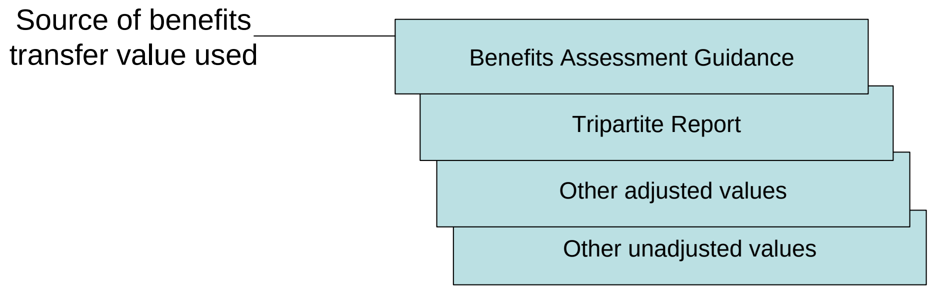
In recent years a number of databases have been developed which purport to offer comprehensive lists of studies available for benefits transfer[13]. While such databases provide a regularly up-dated source of relevant studies for benefits transfer, the selection of appropriate studies and associated valuations from these databases is neither

[12] Appropriate assessment of the non-use category of benefits is currently the subject of considerable debate. For a detailed discussion of key issues, see Jacobs (2006)

[13] For a review of these, see Lantz and Slaney (2005), and for further details of 'EVRI', an international benefits transfer database partly funded by Defra, see McComb (2005).

methodologically straightforward nor considered, at present, to be generally appropriate, particularly if valuations are derived from studies of non-UK sites.

The independent use of such databases by WSPs is not, at present, considered to be desirable in terms of providing valuations that are robust, transparent and comparable across the water industry as a whole.



Adjustment (moderation) of benefits valuations

The survey did not provide a clear picture of the means by which different WSPs adjusted their benefits assessments for specified leakage reductions. Three respondents reported using the PHABSIM adjustment approach, while one WSP reported using a bespoke adjustment methodology.

PHABSIM is a hydrological modelling tool which relates river flow conditions to ecological value. It is recommended in the BAG as an appropriate means of adjusting the benefits valuations transferred from source studies of low flow rivers to target sites that do not have low flow problems. It has since been adopted more generally as a means for adjusting (moderating) benefit valuations derived for 'large' flow changes for the (typically) smaller levels of flow change being considered at the target site.

PHABSIM does this by using a set of equations to calculate, for a specified flow change at the target site, the percentage of the source study benefits valuation that should be applied. This percentage is derived using a set of flow/benefit relationships (for both Q75 and Q98 flows) which estimate the change in environmental value occurring given a change in river flow from current to proposed, where these are expressed as a percentage of natural flows[14].

The principal issues associated with application of the PHABSIM methodology are:

- PHABSIM is designed for adjusting benefits associated with different river flows, and does not relate to adjustment of benefits associated with water level changes on wetlands, reservoirs, lakes or broads. While rivers are likely to be, in most cases, the source that is ultimately affected by leakage changes, the impacts of incremental changes in leakage on water levels for other water bodies must be more qualitatively appraised.

- The size of the flow change being considered in the source study, though usually 'significant', is not well-defined in terms of translation at the target site.

- Flow/benefit relationships for Q75 flows are linear, implying that the benefit of a flow improvement at relatively low flows is equal to the benefit of an equivalent improvement at relatively high, or near-natural flow conditions. This is unrealistic, since the value that beneficiaries place on successive flow improvements is likely to

[14] A graphical illustration of this method is provided in Part 2 of the BAG (RPA, 2003).

decline, rather than remain constant. While this nonlinearity is appropriately reflected in the Q98 flow/benefit relationship, this relationship is not, typically, relevant for non low flow rivers.

- PHABSIM is typically used to adjust benefits transfer values for the full range of environmental impacts (attributes). It therefore implicitly assumes that changes in river flow produce the same percentage change in the value of each of these, i.e. that all attributes are equally responsive to river flow.

Notwithstanding these issues, PHABSIM at present offers a recognised way of moderating benefit valuations for the relatively small flow changes associated with incremental leakage reduction. Its use is regarded as good practice, although use of alternative adjustment methodologies, if available, may also be regarded as good practice, provided these can be explained and methodologically well justified.

Benefits adjustment method used	PHABSIM
	Other (well defined) adjustment methodologies

5.3.2 Social externalities

Part 1 of the survey, as summarised above in Section 5.2, has shown that in the context of leakage management, the predominant externalities considered by WSPs were traffic and (in some cases) pedestrian disruption associated with leak repairs and asset renewal. As a result, in the few cases where detailed descriptions of methodology have been included in Part 2 of the questionnaire or any follow-up reports, these have been largely restricted to descriptions of traffic disruption associated with leak repairs.

Level of analysis

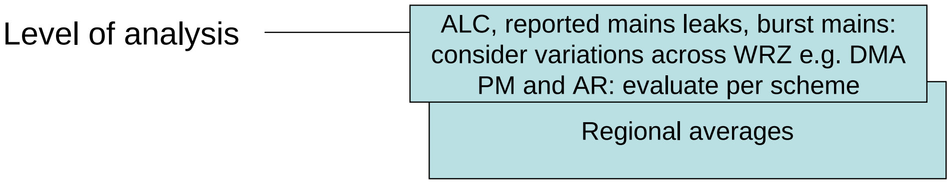
It is recommended that a robust calculation of ELL should include all 3 leakage management policies: active leakage control, pressure management and asset renewal, and therefore 'best practice' evaluation of externalities should include an assessment of the social costs and benefits of each. Furthermore it is important to recognise that the costs associated with one policy may be 'benefits' or savings in another. For example, a proportion of the social costs associated with leak repairs in an ALC policy will become social benefits in an asset renewal policy.

Interventions to be included	ALC, Pressure management, Asset renewal, Repair of reported mains, Burst main events

In addition to traffic disruption, the range of externalities assessed should include the others listed in Table 3.2, even if only qualitatively.

Externalities to be included	Detailed assessment of traffic disruption Qualitative assessment of all others in Table 3.2

The variations in externality costs across a zone should be considered. For ALC, reported mains leak repairs and the impacts of burst mains appraisal should preferably be undertaken at DMA level. For pressure management and asset renewal, carbon and social costs should be evaluated on a per scheme basis per DMA as part of the calculation of AISCs.



Alternative methods that use regional averages are not considered best practice.

Methodological basis of assessment

This commentary is restricted to traffic disruption associated with leak repairs although the general principles also apply to the traffic disruption effects of pressure management and asset renewal.

Where WSPs have quantified traffic disruption, the primary source of guidance for the methodological framework has been the NERA report (NERA, 1998). The principal steps in this approach, which produces a traffic disruption cost per leak, are listed in Table 5.1. WSPs who have undertaken this analysis have all followed this approach but with varying degrees of detail on individual steps; examples of some of these are also given in Table 5.1.

Task		Sources / Methods Employed
I	Assess lengths of road by type	GIS Office of National Statistics
2	Assess traffic flows for each road type	NERA report Average National or Regional Statistics WSP traffic studies
3	Analyse leak repair history by type and location	WSP repair data Only detected leaks considered Local estimates on proportion leak types causing disruption
4	Assess length of works and delay times	Range of disrupted lengths and delay times considered NERA report values for calculating delay
5	Determine value of time lost	Local WSP studies DTR values NERA report values
6	Determine cost per leak	Annual social cost / number of leaks Range of leakage levels

Table 5.1 Evaluation of Traffic Disruption Costs Associated with ALC

Uncertainties are present in each step and best practice methods should be employed to minimise these. Recommended good practice methods / sources are as follows:

	Good Practice
Lengths of road by type	use of GIS
Traffic flows by road type	regional statistics (except where known not to be valid, then local (in-house) traffic studies
Leak repair data	WSP local GIS data on type and location; local data on proportion of types causing disruption
Length of works and delay times	WSP local data; identify lower and upper bounds as well as central value
Cost of time lost	DfT values (TAG[15])
Marginal social cost per leak	Lower and upper bounds and central value; Calculate for reported and detected leaks separately[16]

Although it has not been possible to elicit best practice for other social externalities and leakage management policies from the survey, the Guidance provided in the companion report (Part 2) provides suggestions for evaluating a range of these.

Integration with ELL calculation process

There were few examples of how WSPs had combined the social costs of leakage management options with private costs. Those examples that were provided concentrated largely on ALC and a small number of companies attempted to do this by devising a theoretical relationship between leak numbers and leakage.

In the ALC examples only detected leaks were considered in the calculation, the assumption being that average reported leak numbers are constant across the range of leakage levels.

In one example, the AISC has been quantified for ALC by dividing the annual social cost of detected leak repairs by the PV of the annual savings (natural rate of rise).

5.3.3 Carbon externalities

Due to the very limited number of responses received relating to the analysis of carbon as an externality, it is not possible to make generalisations on many of the responses. However, results have been consolidated and commented on where possible under the relevant headings below.

Methodological basis of assessments

[15] *Value of Time and Operating Costs*, Transport Analysis Guidance (TAG), DfT, Feb 2007
[16] Social cost of reported leaks required as potential benefit attributable to asset renewal

Of the WSPs who considered carbon impacts in their ELL calculation, the methods used to assess the value of energy-related CO_2 emissions, including any simplifying assumptions (question2.2.2) were biased towards applying a published value to MWh/kWh of fuel consumed with two companies citing this method, and one citing a method using fuel consumption from transport. Such approaches are sensible given the uncertainty associated with the various assessment techniques and emissions factors. The approach adopted in this guidance follows a similar approach although specifies values to apply in order to reduce the potential variation uncertainties that could be introduced by the application of different factors in different areas.

Such variation uncertainty is again highlighted when the value applied to carbon/energy is considered. The ranges provided are not comparable due to different units and different scope of application. For example one company included a generic cost per tonne carbon while another company included a carbon cost per kWh energy used drawing on elements such as the climate change levy. A case could be made for the approach adopted under either one of these assessments. For the purposes of this guidance a decision was made to include the social cost of carbon using tonnes of carbon emitted as a metric as opposed to energy use.

Level of analysis

In relation to abstraction, and whether CO_2 was evaluated for the key abstraction source, all significant abstraction sources, or all abstraction sources (question 2.31), only one response was received which stated that all abstraction sources has been assessed. One positive response was also received per category by one respondent (despite ‘all abstraction sources’ being a catch all category) although it was stated that these were planned inclusions in the final water resources plan. One respondent was only undertaking assessments on new schemes which is not altogether a surprising approach to be taken considering the relative youth of carbon assessment field.

A few of the respondents noted that they had drawn upon the UKWIR guidance in the assessment of carbon; this is discussed further below.

Wider work on carbon

Responses were drawn from eight of the eleven responding companies. Again the level of detail appears to be mixed with some companies progressing in the development of their own models. Emerging as potential best practice in terms of approach to leakage emissions is the basis of calculations on UKWIR (2005) NERA (1999).

Some water companies have completed groundwork but are waiting for specific legislation and/or an industry consensus to guide future work. The incorporation of carbon into ELL is only evident in one case for PR04 (for pumping and active leakage control only).

Determination of best practice

Carbon assessment is a relatively new assessment area with water companies, as with many industrial sectors, growing in their understanding as the guidance develops. It is not possible at present to be able to make a confident determination of best practice in the majority of carbon assessment areas, although, some general observations of potential best practice can be made.

Basis of methodology

- Standardised approach consistent and transparent
- Use of consistent emissions and carbon valuation factors
- Possible application of published guidance such as

5.4 KEY ISSUES

Survey respondents were asked to comment on the areas in the externality assessment process that present the greatest difficulty and those subject to the greatest level of uncertainty. The key areas mentioned by at least one respondent are listed below, by category:

***Environmental externalities**:*

- Identifying the impacts of groundwater abstractions
- Identifying the length of an affected river reach
- Objective classification of the affected site's environmental characteristics
- Availability of Q75 and Q98 river flow data
- Selection from the range of available benefits transfer values
- Appropriate exclusion of double counting

Social externalities:

- Traffic disruption valuation
  - Length of road by type
  - Traffic flows
  - Division of repairs occurring on roads versus pavements/footpaths
  - Length of works and duration of delays
  - Cost of time lost
- Valuation of non-traffic externalities
- For ALC: relationship between leak numbers and leakage

Carbon-related externalities for energy / fuel (where undertaken):

- Obtaining contractors data on vehicle movements and assigning these between leakage management and other activities
- Double counting for energy (fuel) use (question 2.26) was identified as being potentially present with relation to the climate change levy and was resolved by removing levy costs from the social cost of carbon
- Inherent uncertainty in the social cost of carbon (-50% to +100%).

Carbon-related externalities for direct (non-energy related) CO_2 (where undertaken):

- Assessment of embedded carbon within assets and associated valuation

- Accounting for sites which were used only during water shortages and were also uncertain how to account for sites where the CO_2 output would vary depending on the weather.

5.5 RELATIVE MAGNITUDE OF EXTERNALITY ASSESSMENTS

WSPs were asked to provide approximate assessments of the relative magnitudes of externality valuations and their related source. Due to the limited quantity of data provided and variations in the magnitudes of these valuations, actual values are not provided in this report.

The 'top three' non-carbon related impacts having the greatest magnitude are listed below:

- biodiversity and non-use
- traffic-related impacts
- angling

Carbon-related impacts are excluded from the above list due to insufficient data. However, preliminary comparisons suggest that carbon emissions associated with water supply may be greater than those associated with leakage management.

Generally, the river environment provided the most significant source of leakage-related environmental externality.

These results provide a potential explanation for the negligible overall impact on ELL that many WSPs reported in their PR04 submissions: the external benefits of leakage reduction (i.e. the environmental costs of leakage) may, to a large extent, have been offset by the external costs of leakage management activity.

5.6 IMPLICATIONS FOR GUIDANCE

The findings of the survey undertaken in this study has provided considerable insight into the analyses undertaken by WSPs for assessing leakage-related externalities in the ELL calculation for PR04 and subsequent reviews. A review of the methods used, particularly those relating to the valuation of environmental and social externalities, provided the basis, in this study, for identifying a good practice approach for use in PR09.

The survey confirmed the view that few WSPs included assessments of carbon-related externalities in their ELL calculation, and a key part of this Report is concerned with the development of a good practice approach.

Despite the limited number of responses within the carbon section of the industry survey, areas where best practice/best identification of issues which could be carried forward to form part of guidance include the removal of the cost of the climate change levy from the social cost of carbon to avoid double counting and the need for a consistent approach to the assessment acknowledging the uncertainty involved.

The survey also identified a number of key issues and areas of difficulty in implementing existing guidance, and this study has attempted to address these.

Finally, the survey identified the categories of externality that are likely to be of greatest magnitude and thus have the greatest impact on WSP's ELL calculation. The guidance offered in this report is focuses in particular on these externalities.

6. OVERVIEW OF GUIDANCE METHODOLOGY

6.1 AIM OF GUIDANCE

The aim of the Guidance is to provide a comprehensive framework for assessing and including leakage-contingent externalities within the ELL calculation. The Guidance builds on, rather than replaces, existing guidance in this area, and collates the range of existing assessment approaches for the different externality components into a single source.

Where both available and appropriate, up-dated data inputs are provided in certain areas and a number of minor refinements to existing processes are recommended, in order to both simplify the assessment process and increase the robustness of resulting assessments.

Application of this Guidance should thus produce valuations for PR09 that offer improved consistency, transparency and comparability across the industry relative to the assessments used in PR04.

6.2 SOURCES OF GUIDANCE

6.2.1 Environmental externalities

To ensure consistency across the different guidance documents offered by industry regulators, the parts of this Guidance that relate to the determination of benefits values for environmental externalities are based primarily on the approaches outlined in the BAG (RPA, 2003). With respect to associated benefits transfer values, the Guidance recommends use of the data sources provided in the BAG.

For the relevant parts of the assessment of environmental impacts, practitioners should refer to the BAG for detailed guidance and appropriate data inputs.

The Guidance presented in this study is subject to the same broad set of methodological issues and limitations as the BAG. Developments of methods to overcome these were outside the scope of this study.

6.2.2 Social externalities

Guidance on the valuation of social externalities presented in this study builds on the BAG (RPA, 2003), which has the earlier NERA guidance (NERA, 1998) at its core. However, updated values for the social cost of traffic delays are used, and the use of up-dated, area-specific traffic flows are recommended.

6.2.3 Carbon externalities

Guidance on the valuation of carbon emissions presented in this study builds upon the following sources of information and guidance:

UKWIR guidance on the assessment of greenhouse gas emissions to provide a consistent approach to the assessment of greenhouse gas emissions associated with leakage.

The 2007 annexes to the guidance from Defra on measuring and reporting greenhouse gas emissions in order to provide up to date assumptions.

Assessment of emissions from traffic should be based on fuel consumptions converted to carbon through the application of factors recommended in the guidance and drawn from the Defra 2007 information.

In order to provide a consistent basis for the assessment of emissions from worksites and repairs a bespoke methodology was developed to estimate the likely magnitude of emissions from typical sites. These utilised data on equipment size published by Defra in 2007 and emissions factors published in 2007 as noted above.

It was intended originally to incorporate a value for carbon which was based on the Defra work on the social cost of carbon which recognised the wide range of carbon values available and the inherent uncertainty associated with these assessment techniques. These values for the social cost of carbon are consistent with the Environment Agency Water Resources Planning Guidelines (April 2007). However, in August 2007, DEFRA published guidance on a new method for valuing carbon, called the Shadow Price of Carbon (SPC). The SPC is conceptually different from the social cost of carbon in previous guidance and is intended to be target-consistent, taking into account DEFRA's best assessment of the costs of abatement. The SPC methodology has been adopted for these guidelines.

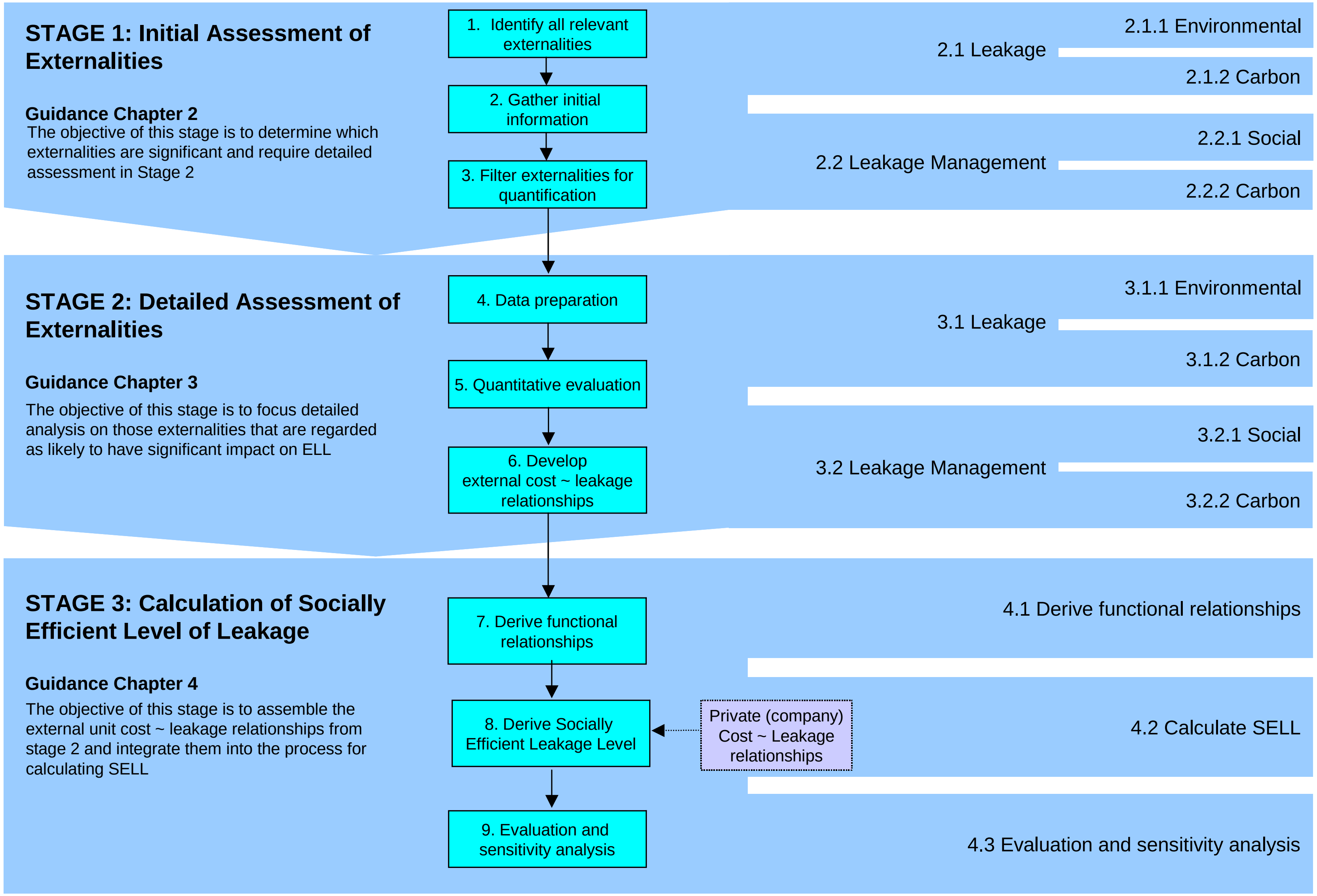


Figure 6.1: Overview Process Map

6.3 STRUCTURE OF GUIDANCE

Figure 6.1 provides an overview of the key processes required for the inclusion of externalities within the ELL. Consistent with the BAG, three distinct stages of the assessment process have been identified:

Stage 1: Initial assessment of externalities

This stage identifies the full range of externalities requiring valuation, and involves their qualitative or simplified quantitative assessment, based on minimal data requirements. Significant externalities are filtered, using objective criteria, for more detailed quantitative assessment at Stage 2.

Stage 1 is designed to (i) encourage an initial consideration of the full range of externalities in a consistent manner, (ii) minimise the data inputs associated with assessment of a large number of impacts, (iii) provide an objective means for filtering externalities, and (iv) allow more detailed assessments to focus on those externalities that are likely to be most significant in terms of their impact on the ELL.

Stage 2: Detailed assessment of externalities

The aim of Stage 2 is to produce, where possible, quantitative assessments of significant externalities and to develop a set of relevant cost ~ leakage relationships for inclusion in the ELL calculation. This is achieved through the use of established assessment methodologies, together with the collection and preparation of relevant data inputs.

Stage 3: Calculation of socially efficient leakage levels (SELLs)

This stage focuses on the development of functional cost ~ leakage relationships that may then be used within an established optimisation process, along with the more conventional private costs of leakage and leakage management, to determine leakage levels that are socially efficient.

Stage 3 also involves a sensitivity analysis and evaluation of the impacts of uncertainty. This entails the systematic exclusion of external cost categories, together with consideration of both upper and lower bound limits for individual assessments. A comparison of the resulting ELLs provides some indication of the relative sensitivity of individual impacts and the key sources of uncertainty.

6.4 LEVEL OF DETAIL AND COVERAGE

The Guidance offers a significant level of detail in terms of the number of steps involved at each stage. While appearing at first sight to be complex, the large number of proscribed processes is designed to reduce the potential for 'black holes' in the assessment that may result in misinterpretation and error.

While guidance is provided for all significant leakage-contingent externalities, guidance has not been provided for a small number of impacts listed in the classification of externalities in Section 3. These include, amongst others:

- the benefits of leakage reduction associated with commercial navigation and agricultural use
- the social costs associated with disamenity due to excavations
- the social costs associated with sewer flooding.
- fuel use associated with importing water under extreme events

Guidance on these impacts has not been provided on the basis that either

- there is no existing guidance for valuing these impacts and they are not readily assessed in monetary terms, or
- the impacts are considered to be relatively insignificant, or the impacts are associated with market-related outputs, values for which are readily available in the form of market prices.

6.5 KEY ISSUES

6.5.1 Double counting

With an assessment exercise of this nature, there exists the potential for either exclusion or double counting of relevant impacts. There are three main areas where double counting may occur:

- Impacts are included both as a benefit on one side of the cost-benefit equation and as a cost on the other. For example, for successive leakage reductions, the benefits arising from a reduction in reported leak repairs (if any) may be either netted from the costs of active leakage control, or added to the cost of leakage, but not both. Similarly, the deferral of the environmental and social costs associated with a new resource should not be included in the least cost plan both as an external benefit of leakage reduction and as an external cost of the new resource.

- The value of certain external impacts has been appropriately 'internalised', i.e. is already considered by the WSP in its private decision-making as a result of appropriate transfer payments, taxes or charges intended to reflect the social value of the externality. Even if such transfers do not wholly internalise the externality, assessment and inclusion of the full social value for such externalities amounts produces an element of double counting. Impacts that may to some extent already be internalised within WSPs private decisions are discussed below.

- Externalities for related impacts are double counted because they are not clearly separable. There may be some overlap between categories of impact; the same population may be used for different impacts; or benefits transfer values used may include more than just the specific impact being valued. Examples are provided by non-use and use categories of environmental value, where local populations may visit for informal recreation, or angling, but not both; or where benefit transfer values reflecting both recreation and non-use value are applied only to non-use beneficiaries, and additional values are applied to recreational visitors. These examples will tend to produce externality valuations that are upwardly biased. Although the BAG offers clear guidance on the avoidance of double counting, checks should be undertaken to ensure its absence.

6.5.2 'Internalised' impacts

Impacts are 'internalised' when the social value of the impact is already weighed by the WSP in its private decision-making. This occurs as a result of appropriate transfer payments, taxes or charges which are intended to reflect the social value of the externality.

In relation to the leakage calculation, there are three main categories of externality for which partial internalisation occurs:

- The social cost of domestic disruption due to supply interruptions is at least partially internalised by the Guaranteed Standards Scheme payments to water consumers, plus the additional discretionary compensation offered by most WSPs;

- The Climate Change Levy, designed to reduce carbon emissions, internalises a proportion of the true social cost of carbon;

- The proposed 'lane rental' charge for street works and related activity was intended to reflect to some extent the associated social cost of traffic disruption.

While the values of these transfers, taxes and charges may usefully provide some indication of a minimum bound for the related social cost, given that they typically fail to fully internalise the true social cost of the externality, an assessment of the value of the impact for inclusion in the ELL model is still required.

However, if an element of double counting is to be avoided in such cases, the financial value of the transfer, tax or charge must be 'netted out' from the social cost assessment, since this component is already reflected in the WSPs private financial costs.

It should be noted that abstraction charges are not designed to reflect the true environmental cost of abstraction, but are designed to recover a component of administrative costs.

6.5.3 Dealing with uncertainty

Uncertainty arises from a lack of information or scientific knowledge. Failure to consider uncertainty may result in sub-optimal solutions because the true value of an economic variable differs sharply from its predicted value. It is important that, however managed, uncertainty is dealt with in a consistent and systematic manner.

The scope of this study precluded the detailed development of approaches for dealing with uncertainty. Potentially, confidence assessments based on Monte Carlo analysis of probability distributions for key variables could be developed. However, given the existing difficulties of establishing reliable data inputs, associated probability distributions are likely to be relatively wide.

As a simpler alternative, the Guidance suggests the use of upper-bound, central, and lower-bound values for all key data inputs where there is a significant degree of uncertainty, and the simultaneous development of upper-bound, central, and lower-bound assessments at each stage of the valuation process.

Stage 3 of the Guidance involves a sensitivity analysis and evaluation of the impacts of uncertainty, entailing the systematic exclusion of external cost categories, together with consideration of both upper and lower bound limits for individual assessments. A comparison of the resulting ELLs then provides some indication of the relative sensitivity of individual impacts and the key sources of uncertainty.

Unless there is good justification for taking either the upper- or lower-bound values, it is recommended that the central value should be utilised in the ELL calculation.

6.6 REPORTING AND AUDIT OF ASSESSMENTS

For reporting purposes, there is a need for the findings of the assessment exercise to be well documented, with a clear audit trail provided at each stage. For consistency, the Guidance recommends use of the reporting approach outlined in the BAG, which makes use of an 'Appraisal Summary Table' (AST) for each externality valued.

The ASTs developed in the BAG relate to different water-body types. It is recommended that use of these is extended to include consideration of leakage-related carbon externalities in each zone, and social and carbon-related externalities associated with each of the three leakage management 'schemes' in each water resource zone.

ASTs should be used to record all assumptions made in an assessment as well as the results at each stage. Supplementary spreadsheets should be developed for detailed calculations.

7. SUMMARY AND RECOMMENDATIONS

The Guidance should be considered as a document for immediate use for PR09 but because this is an area for continual development it should not be regarded as a definitive guide.

The proposed Guidance methodologies are recommended for use in "bottom up" programme-level assessment of external costs and benefits associated with leakage and leakage control, principally in the context of the marginal cost of water approach to ELL evaluation.

For consistency, the development / application of similar guidance is required for the assessment of external costs and benefits associated with water resources and demand management schemes as part of a supply demand LCP through which the long run ELL is determined. Some of the methodologies in this guidance may be transferable to these areas.

In addition, and to ensure consistency with recent Ofwat guidance on the use of CBA in strategic business planning and top-level Willingness To Pay studies, this Guidance recommends reconciliation (adjustment) of the economic values derived from "bottom up" valuation e.g. resulting from the use of the BAG, with appropriate WTP assessments. However it is recommended that WTP studies in the context of leakage should not be used as a substitute for quantitative "bottom-up" modelling of ELL.

For application at PR09 the BAG is recommended as the default methodology for the "bottom up" assessment of environmental costs and benefits. The recommended methodology for the assessment of the social impacts of leakage management interventions also builds on the BAG approach. However, it is recognised that over the longer term, appropriate WTP studies may offer superior solutions to benefits transfer. Where WSPs have available appropriate "local" benefit valuations from previous studies these should be used in preference to transferred benefits.

Despite continuing refinement of assessment methodologies and valuations of environmental costs and benefits there is an ongoing need for further research in this area and a need for new valuation studies. The next phase of the Collaborative Research Programme[17] (or its successor) may well be an appropriate vehicle by which these are implemented.

Carbon foot-printing and valuation is in its infancy and has necessitated the development of bespoke methods for some parts of this Guidance. This area continues to be the subject of significant debate and large uncertainties exist in the attachment of costs to climate change and greenhouse gases. There is therefore a need for regular reviews of the Guidance to ensure that it keeps pace with this developing area.

[17] The CRP of River Basin Management Planning Economics is an ongoing programme of stakeholder research aimed at improving assessments of the benefits of meeting the objectives of the Water Framework Directive

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ANNEXES

Annex 1. Survey Questionnaire

WATER SERVICES REGULATION AUTHORITY

Environmental Economics Consultancy:
Leakage Methodology Review Project

Providing Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation

<u>Company Questionnaire:</u>
<u>Inclusion of Externalities in the PR04 ELL Calculation</u>

Company anonymity and confidentiality will be strictly maintained throughout this project

Company……………………………………………………………………

Water Company
Interviewee…………………………………………………………………….

RPS Water
Interviewer…………………………………………………………………..

RPS Water
6 Manaton Court
Manaton Close
Matford Business Park
Exeter
EX2 8PF

PART I. OVERVIEW

1.1 Did your Company consider the following externalities in its ELL calculation for PR04 or in a subsequent update?

a) Environmental (abstraction-related) Yes/No
b) Social (leakage-management related) Yes/No
c) Carbon (both leakage management and abstraction/treatment/distribution related) Yes/No

1.2 If so, please mark from the following list:

'E' those you considered qualitatively, but did not quantify on grounds of size/insignificance.
'U' those you quantified but excluded from the ELL model (due to uncertainty / reliability)
'I' those you both quantified and included in your ELL model.

Please also mark with a **'D'** if you believe that the relevant zone-specific data inputs (eg visitor numbers, flood events, leak locations, energy volumes and charges, vehicle mileage / fuel use, etc) are readily available, or could be readily obtained, *even if you did not utilise this data for your PR04 ELL calculation*

1.2a Environmental externalities (abstraction-related):

	E	U	I	D
Abstraction-related impacts on river flows:				
Angling				
In-stream recreation (boating, bathing, etc)				
Informal recreation (walking, picnicking etc)				
Agricultural use				
Non-use (biodiversity etc)				
Other (please describe)				
Abstraction-related impacts on reservoir levels:				
Angling				
In-stream recreation (boating, bathing, etc)				
Informal recreation (walking, picnicking etc)				
Agricultural use				
Non-use (biodiversity etc)				
Other (please describe)				
Abstraction-related impacts on wetlands:				
Informal recreation (birdwatching, walking etc)				
Agricultural use				
Non-use (biodiversity etc)				
Other (please describe)				

1.2b Social externalities (leakage management-related):

	E	U	I	D
Traffic delays and/or diversions associated with detected leak repair				
Traffic delays and/or diversions associated with unplanned / reported leak repair				
Traffic delays and/or diversions associated with asset renewal				
Pedestrian diversions associated with detected leak repair				
Pedestrian diversions associated with unplanned / reported leak repair				
Pedestrian diversions associated with asset renewal				
Social cost of flood events				
Social cost of unplanned interruptions to supply				
Commercial and domestic equipment and other operational failures arising from reduced pressure				
Other (please describe)				

1.2c Carbon related externalities:

	E	U	I	D
Transportation energy/fuel use related to:				
leak detection				
detected leak repair				
unplanned leak repair				
pressure management				
asset renewal				
traffic disruption/diversion due to detected leak repairs				
traffic disruption/diversion due to unplanned leak repairs				
traffic disruption/diversion due to asset renewal				
extraordinary fuel use: e.g. transporting potable water to sites where supply has been disrupted				
other (please specify)				
Work-site energy/fuel use related to:				
leakage detection				
detected leak repair				
unplanned leak repair				
pressure management				
asset renewal				
other (please specify)				
Abstraction, processing and distribution fuel/energy use:				
fuel use on water treatment fixed plants				
ground water abstraction energy use				
surface water abstraction energy use				
energy use associated with water distribution				
other energy associated with the production, treatment and distribution of clean water (please specify)				
Embedded carbon within the materials used for:				

leak repairs				
asset renewal				
other (please specify)				
Any process emissions of CO_2 from water treatment processes				

1.3 Which guidance documents did you use for your analysis?

1.4 At what level were the externalities calculated?

- company
- resource zone
- operating area
- other

PART II. DETAILED QUESTIONNAIRE

Please answer the relevant sections of this part of the questionnaire.

2A. ENVIRONMENTAL EXTERNALITY ASSESSMENTS (If Yes to Question 1a)

2.1 Please describe briefly the methods used to assess environmental (abstraction-related) externalities, including any simplifying assumptions

2.2 Within each area (company, zone etc) did you evaluate the externalities for:
- o the key (in volume terms) abstraction source
- o the key (in environmental terms) abstraction source
- o all significant (in volume terms) abstraction sources
- o all significant (in environmental terms) abstraction source
- o all abstraction sources

2.3 Were visitor / user numbers derived using
- o default methods from guidance documents or
- o your company's GIS mapping?

2.4 For the following externality categories, please provide, where relevant, the source and value of the per unit (ie household, person, or km etc) 'benefits transfer' values which were used:

- o cost of time lost through traffic-related delays
- o cost of time lost through pedestrian disruption
- o domestic cost of flooding (due to burst events)
- o commercial cost of flooding (due to burst events)
- o cost of failures due to reduced pressure

2.5 Was PHABSIM used in the flow adjustment process? If so,

- o were gauged Q75 and Q98 current and natural flow data readily available?
- o please describe any problems you encountered

2.6 Did you undertake any:
- o original site valuation studies (ie travel cost, contingent valuation etc)
- o more detailed desktop site valuation studies?

If so, please provide details.

2.7 Which areas of your environmental externality assessment and valuation, if any, caused most difficulties? (please outline the difficulties encountered, and how you overcame these)

2.8 Which double-counting issues (if any) did you encounter? How were these resolved?

2.9 Which elements of the analysis were associated with the greatest uncertainty? (Please provide some indication of the sensitivity ranges for key valuations)

2.10 Please rank in descending order, by size, the different components of environmental externality that you (even if only qualitatively) considered

2.11 By how much (in percentage terms) did inclusion of environmental externalities affect your company-level ELL assessment?

2.12 Please indicate the general distribution of assessed environmental externalities across the company.

2B. SOCIAL EXTERNALITY ASSESSMENTS (If Yes to Question 1b)

2.13 Please describe briefly the methods used to derive social (leakage-management-related) externalities, including any simplifying assumptions

2.14 How did you identify the relationship between traffic and/or pedestrian disruption and leakage levels?
o by analysis of historic burst data (incidence, type and location)
o theoretical relationship between leak numbers, incidence and leakage
o other means (please describe)

2.15 For the following externality categories, please provide, where relevant, the source and value of the per unit (ie household, hour, or km etc) 'benefits transfer' values which were used:
- o cost of time lost through traffic-related delays
- o cost of time lost through pedestrian disruption
- o domestic cost of flooding (due to burst events)
- o commercial cost of flooding (due to burst events)
- o cost of failures due to reduced pressure

2.16 Which areas of your social externality assessment, if any, caused most difficulties? (please outline the difficulties encountered, and how you overcame these)

2.17 Which double-counting issues (if any) did you encounter? How were these resolved?

2.18 Which elements of the analysis were associated with the greatest uncertainty? (Please provide some indication of the sensitivity ranges for key valuations)

2.19 Please rank in descending order, by size, the different components of social externality that you (even if only qualitatively) considered

2.20 By how much (in percentage terms) did inclusion of social externalities affect your company-level ELL assessment?

2.21 Please indicate the general distribution of assessed social externalities across zones.

2C. CARBON RELATED EXTERNALITY ASSESSMENTS (If Yes to Question 1c)

Energy (fuel) use

2.22 Please describe briefly the methods used to assess the value of energy-related CO_2 emissions, including any simplifying assumptions. Please include details of the sources of data underpinning calculations

2.23 What £/unit value(s) did you place on energy/fuel related carbon? Please provide the source of these values

2.24 Did you estimate the benefits from the use of alternative fuels e.g LPG or biofuels, instead of fossil fuels. If so, were these included in your CO_2 assessment? If not, why were they excluded?

2.25 Which areas of your analysis, if any, caused most difficulties? (please outline the difficulties encountered and how you overcame these)

2.26 Which double-counting issues (if any) did you encounter? How were these resolved?

2.27 Which elements of your energy-related CO_2 assessment were associated with the greatest uncertainty? (Please provide some indication of the sensitivity ranges for key valuations)

2.28 Please rank in descending order, by size, the different components of energy related CO_2 emissions that you (even if only qualitatively) considered

2.29 By how much (in percentage terms) did inclusion of CO_2 externalities from fuel use affect your company-level ELL assessment?

2.30 Please indicate the general distribution of assessed energy-related CO_2 externalities across zones.

2.31 When considering abstraction sources did you evaluate the CO_2 for:
- o the key abstraction source
- o all significant abstraction sources
- o all abstraction source

Non-energy Emissions

2.32 Please describe briefly the methods used to assess CO_2 for any process emissions or embedded carbon for each of the categories identified in question 1.2c, including any simplifying assumptions

2.33 What £/unit value(s) did you place on direct (non-energy related) CO_2? Please provide the source of these values

2.34 Which areas of the analysis, if any, caused most difficulties? (please outline the difficulties encountered and how you overcame these)

2.35 Which double-counting issues (if any) did you encounter? How were these resolved?

2.36 Which elements of the analysis were associated with the greatest uncertainty? (Please provide some indication of the sensitivity ranges for key valuations)

2.37 Please rank in descending order, by size, the different components of environmental externality that you (even if only qualitatively) considered

2.38 By how much (in percentage terms) did inclusion of CO_2 externalities from direct emissions affect your company-level ELL assessment?

2.39 Please indicate the general distribution of assessed CO_2 externalities from direct emissions across zones.

SUPPLEMENTARY QUESTION

Please answer this question regardless of whether you answered Yes or No to Question 1c.

2.40 While questions above have aimed at exploring the incorporation of carbon within the ELL calculations we are aware that a number of water companies have completed wider work in relation to carbon. Please use this opportunity to:

- describe what you have completed
- provide an overview of data sources and outline methods
- indicate whether you consider there to be any relationship to what you have completed and the incorporation of carbon in ELL calculations (i.e. are there methods that we should consider as best practice for application in relation to this study?)