SuRF
SUSTAINABLE REMEDIATION FORUM UK

sponsored by the

Homes & Communities Agency

A Framework for Assessing the Sustainability of Soil and Groundwater Remediation

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MARCH 2010

CONTAMINATED LAND: APPLICATIONS IN REAL ENVIRONMENTS

CL:AIRE

Sponsored by the

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A Framework for Assessing the Sustainability of Soil and Groundwater Remediation

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Foreword

We welcome the publication of the UK Sustainable Remediation Forum's (SuRF-UK) "A Framework for assessing the sustainability of soil and groundwater remediation". This framework represents a valuable addition to best practice guidance available in the UK on risk management of land contamination. It sets out, for the first time, the essential link between the principles of sustainable development and the criteria (environmental, social and economic) for selecting optimum land use design with sustainable remediation strategies and treatments.

The SuRF-UK Steering Group has successfully engaged with a wide range of stakeholders across a broad range of organisations working in contaminated land and brownfield management. Through its series of open forums and consultations it has ensured that a wide number of parties have had a chance to engage with, and contribute to, the development of this framework. The resulting framework highlights the importance of considering sustainability issues associated with remediation right from the outset of a project and identifies opportunities for considering sustainability at a number of key points in a site's (re)development or risk management process. We encourage inclusion of sustainability issues in planning development strategies, project planning, design of remediation strategies, options appraisal, implementation and verification.

The application of this sustainability framework will realise a number of benefits for users including for example:

- Contributing to sustainable development at a number of levels including regional development plans, development of site master plans and site specific remediation strategies;
- Demonstrable commitment to sustainable development and sustainable remediation;
- Effective management of risks to human health and the environment due to land contamination;
- Maximising the value delivered by remediation by optimising the cost benefit ratio;
- Better Regulation and cost savings by demonstrating the need not to implement unnecessary or unsustainable remediation measures; and
- Positively demonstrating corporate and environmental social responsibility and managing public relations.

Further phases of work are planned to (i) develop the indicators for sustainable remediation and (ii) demonstrate the application of this framework via a series of worked examples.

In the meantime, this framework will be of value by informing the decision making process where remediation measures are required in dealing with historic or new contamination under all relevant regulatory regimes in England, Scotland, Wales and Northern Ireland and we, therefore, commend it to you.

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[1] SAGTA: Soil and Groundwater Technology Association (http://www.sagta.org.uk/). This is a not-for-profit association of member organisations drawn from UK companies representing many major land holding sectors. Its members actively address challenges associated with the ownership and management of both contaminated operational land and brownfield development sites. Building on more than a decade of experience, SAGTA is the authoritative voice of contaminated land from a land holder's perspective.

Table of contents

Foreword i

Acknowledgements iii

Table of contents iv

List of figures v

List of tables vi

Executive summary 1

1 Introduction 2

1.1 Why adopt sustainable remediation? 2

1.2 Purpose and objectives of the document 2

1.3 Target audience 3

1.4 Report structure 3

1.5 Overview of sustainable development 4

1.6 Role of remediation within sustainable development 5

2 Legislative and regulatory context in the UK 7

2.1 Planning regime 7

2.2 Contaminated land regime 8

2.3 Environmental Liabilities Directive 8

2.4 Proposed Soil Framework Directive 9

2.5 Other duties on the environment agencies to consider sustainable development 9

2.6 Technical guidance on land and groundwater remediation 9

3 The SuRF-UK framework for sustainable remediation 12

3.1 Introduction and definition of sustainable remediation 12

3.2 Key principles of sustainable remediation 12

3.3 The structure of the SuRF-UK framework 13

3.4 The use of the framework in different remediation scenarios 14

3.4.1 Local planning 15

3.4.2 Land changing use 16

3.4.3 Land continuing in current use 16

3.4.4 Land restoration to ‘soft’ end-uses 17

3.4.5 Remediation implementation only 17

3.5 Influence of decisions at different project stages on sustainability 17

4 Applying the SuRF-UK framework 19

4.1 A complementary approach to sustainable management of land contamination 19

4.2 Using SuRF-UK across project lifecycle and land-cycle 20

4.3 A tiered approach to assessing sustainable remediation 21
4.4 Involving stakeholders 25
4.5 Setting the boundaries for a sustainability assessment 27
4.6 Sustainability indicators for remediation 28
4.7 Methods for assessing sustainable remediation 29
4.8 Sensitivity analysis 31
4.9 Incorporating sustainability considerations in a tiered risk assessment 31
5 Recording decisions 32
6 Interactions of SuRF-UK with other sustainable remediation initiatives 34
6.1 SURF 34
6.2 NICOLE 34
6.3 SuRF-Australia 35
6.4 USEPA Green Remediation 35
7 References 36
8 Glossary 40

Appendix A: Local (Town and Country) planning scenarios 44
Appendix B: Brownfield land redevelopment 45
Appendix C: Remediation of operational land (no change of use) 47
Appendix D: Land restoration schemes 48
Appendix E: Remediation implementation only 49
Appendix F: Some techniques used in sustainability assessments 50
Appendix G: Pros and cons of scoring, weighting and ranking sustainability criteria 53

List of figures

Figure 1.1: Sustainable development is a balance between environmental, social and economic factors. 4
Figure 1.2: The property lifecycle concept. 5
Figure 2.1: SuRF-UK sustainable remediation assessment is aligned to the CLR11 framework, with quotes relating to sustainability (adapted from EA & DEFRA, 2004). 10
Figure 3.1: The SuRF-UK Framework. 14
Figure 3.2: Use of the SuRF-UK framework for different remediation scenarios. 15
Figure 3.3: Illustrative effect of decisions made at different stages on overall sustainability of brownfield regeneration 18
Figure 4.1: Tiered approach to assessing the sustainability of remediation. 22
Figure 5.1: Recording decisions where no net-benefit accrues ('unsustainable'). 33

Figure A1: How the SuRF-UK Framework applies to local planning as Stage A1 only. 44
Figure B1: How the SuRF-UK Framework applies to brownfield redevelopment, covering Stages A1 and A2. 45
Figure B2: How the SuRF-UK Framework applies to brownfield redevelopment, covering both Stages A2 and B. 46
Figure C1: How the SuRF-UK Framework applies to the remediation of operational land, covering both Stages A and B. 47
Figure D1: How the SuRF-UK Framework applies to land restoration schemes, covering both Stages A and B. 48
Figure E1: How the SuRF-UK Framework applies to remediation implementation, being effectively Stage B only. 49

List of tables

Table 2.1: Planning and contaminated land legislation in parts of the UK.................................. 7
Table 4.1: Summary of site-specific SuRF-UK assessment points aligned to the procedure for managing land contamination (CLR11). 19
Table 4.2: Other sustainability considerations related to land contamination management and the project lifecycle. 20
Table 4.3: Overarching categories of indicators for sustainability assessment of remediation options. 28
Table 4.4: Selected decision support techniques with relevance to sustainable remediation assessments. 30

Executive summary

This document presents the first phase of work by the UK Sustainable Remediation Forum (SuRF-UK), which is a framework for assessing the sustainability of soil and groundwater remediation, and for incorporating sustainable development criteria in land contamination management strategies. It helps assessors to identify the optimum land and/or groundwater remediation strategy and/or technique.

Assessment of sustainable remediation is defined by SuRF-UK as 'the practice of demonstrating, in terms of **environmental**, **economic** and **social** indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process'. The SuRF-UK framework recognises two main site management stages where sustainable remediation decision-making can be applied:

1. The project/plan design stage when some of the most influential decisions about the remediation solution can be embedded into a wider sustainable project design as part of a strategy across a portfolio of sites or a site-specific masterplan; and
2. The point of remediation options appraisal, selection and implementation when the decision is about selecting the optimum remedial strategy or technique.

Sustainable remediation considerations may also be an important consideration for local planning.

This document is the first to provide an authoritative framework for assessing the sustainability of soil and groundwater remediation in the UK. While legislation and good practice guidance have encouraged remediation to contribute to sustainable development goals, no formal and authoritative framework has previously been published to guide such an assessment. This document, which was drafted by a team comprising regulators, industry, consultants and CL:AIRE, provides assessors with a means to undertake a sustainability assessment of soil and groundwater remediation, and to ensure that the remediation industry can directly and measurably contribute toward sustainable development goals.

The framework described in this document complements existing UK best practice guidance, such as the '*Model Procedures for the Management of Land Contamination'* (CLR11), but is sufficiently generic to be applied elsewhere and under different regulatory systems. SuRF-UK believes that its publication and use will lead to more sustainable remediation practice in the UK and elsewhere.

1 Introduction

1.1 Why adopt sustainable remediation?

Soil and groundwater remediation, although designed to remedy contamination and reduce risks to human health and/or the environment, also has the potential to cause environmental, economic and social impacts. If poorly selected, designed and implemented remediation activities may cause greater impact than the contamination that they seek to address. The best solution is remediation that eliminates and/or controls unacceptable risks in a safe and timely manner, and which maximises the overall environmental, social and economic benefits of the remediation work. We call this sustainable remediation, and define the process of assessing sustainable remediation as 'the practice of demonstrating, in terms of **environmental**, **economic** and **social** indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process'. Adopting sustainable remediation has the following benefits:

- Maximising the value delivered by remediation works, by optimising the overall benefit to cost ratio;
- Cost savings through avoidance of unnecessary or unsustainable remediation;
- Effective management of risks to human health and the environment associated with soil and/or water contamination;
- Minimising the impact of remediation works on the environment and surrounding communities;
- Demonstrable commitment to sustainable development in remediation works;
- Positive impact on reputation and public relations, by demonstrating corporate environmental and social responsibility;
- Improving the robustness of remediation decision making; and
- Contributing to sustainable development, which now forms a cornerstone of many government and corporate policies.

1.2 Purpose and objectives of the document

This document presents a framework for managing soil and groundwater contamination in a manner compatible with sustainable development principles. It has been developed by the UK Sustainable Remediation Forum (SuRF-UK) to help assessors take account of relevant sustainable development criteria in selecting the optimum land-use design, determining remedial objectives for contaminated land and groundwater, and in selecting a remediation strategy and technique.

SuRF-UK was established in 2007, under the co-ordination of CL:AIRE, to "develop a framework to embed balanced decision-making in the selection of a remediation strategy to address land contamination, as an integral part of sustainable development", and the framework presented is the output of the first phase of work. During SuRF-UK's open forum meetings and consultations it became clear that there were a wide range of views and expectations of sustainable remediation, from a strategic framework to a technology-specific accreditation scheme. This document sets out SuRF-UK's recommendations on where sustainability issues should be considered in land contamination risk management decisions.

The SuRF-UK framework has been prepared for use in the UK, including within the planning and contaminated land systems within England, Wales, Scotland and Northern

Ireland. The framework also embodies the UK Government's recommended approach to the assessment and management of land contamination, set out in the '*Model Procedures for the Management of Land Contamination*' (CLR11, Environment Agency & DEFRA, 2004). The framework identifies two fundamental stages at which sustainability can be considered: Firstly within the plan/project design stage and, secondly, remediation implementation. Invariably, more sustainable decisions can be made the earlier in the process remediation is considered. Understanding sustainability requires some form of assessment to be carried out. In its simplest form, a sustainability assessment should require only limited additional effort. The framework is flexible so that it can be applied to various remediation decision-making scenarios within a property lifecycle and for different sizes of project or site. Because of this inherent flexibility, it is considered that the framework can also be applied to remediation decision-making within regulatory systems beyond the UK.

This document has been developed by SuRF-UK under the co-ordination of CL:AIRE and with funding from the Homes and Communities Agency (HCA). It has been subject to wide remediation industry and regulator consultation. The framework presented is intended to be a voluntary initiative, but one that has regulator support. It is hoped that publication and use of this framework will lead to more sustainable soil and groundwater remediation in the UK and elsewhere. The framework does not make recommendations on the sustainability of any specific remediation technologies or approaches, but rather provides a framework for assessors to identify the optimum solution on a site-by-site basis.

This document is the first product of an on-going initiative co-ordinated by CL:AIRE that will involve further research and development of guidance on sustainable remediation.

1.3 Target audience

The intended audience for this document includes anyone involved with, or affected by, the selection, design, implementation, and monitoring and verification of soil and groundwater remediation strategies or schemes. This will typically include site-owners and their consultants, remediation contractors, town planners, architects and urban designers, environmental regulators, and other interested parties, including site neighbours and local residents.

The document describes anyone who is involved in the process of evaluating the sustainability of remediation options as an 'assessor'.

1.4 Report structure

The report is structured as follows:

- **Chapter 1:** Overview and introduction to sustainable development and remediation;
- **Chapter 2:** Legislative and regulatory context in the UK, setting out when sustainable remediation assessment may be applied in regulatory processes;
- **Chapter 3:** The SuRF-UK framework for assessing sustainability of soil and groundwater remediation – what the framework looks like;
- **Chapter 4:** Applying the SuRF-UK framework. How to assess sustainability of remediation options;
- **Chapter 5:** Recording decisions. Describes the importance of ensuring the process, assumptions and decisions are documented;

- **Chapter 6:** Brief overview of other international sustainable remediation initiatives;
- **References** and **Glossary**; and
- **Appendices:** Giving examples of sustainable remediation assessments to illustrate the text in main document.

1.5 Overview of sustainable development

Sustainable remediation forms one part of a much broader sustainable development agenda. A definition of sustainable development was produced by the World Commission on Environment and Development (1987), commonly known as 'the Brundtland Commission'. They defined sustainable development in 'the Brundtland Report' as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" and it is this definition that is adopted within this framework document. This definition forms the basis for much of the UK Government's policy on sustainable development (Her Majesty's Government *et al*., 2005). It is commonly interpreted as those actions that, taking account of environmental, social and economic factors, optimise the overall benefit (Figure 1.1).

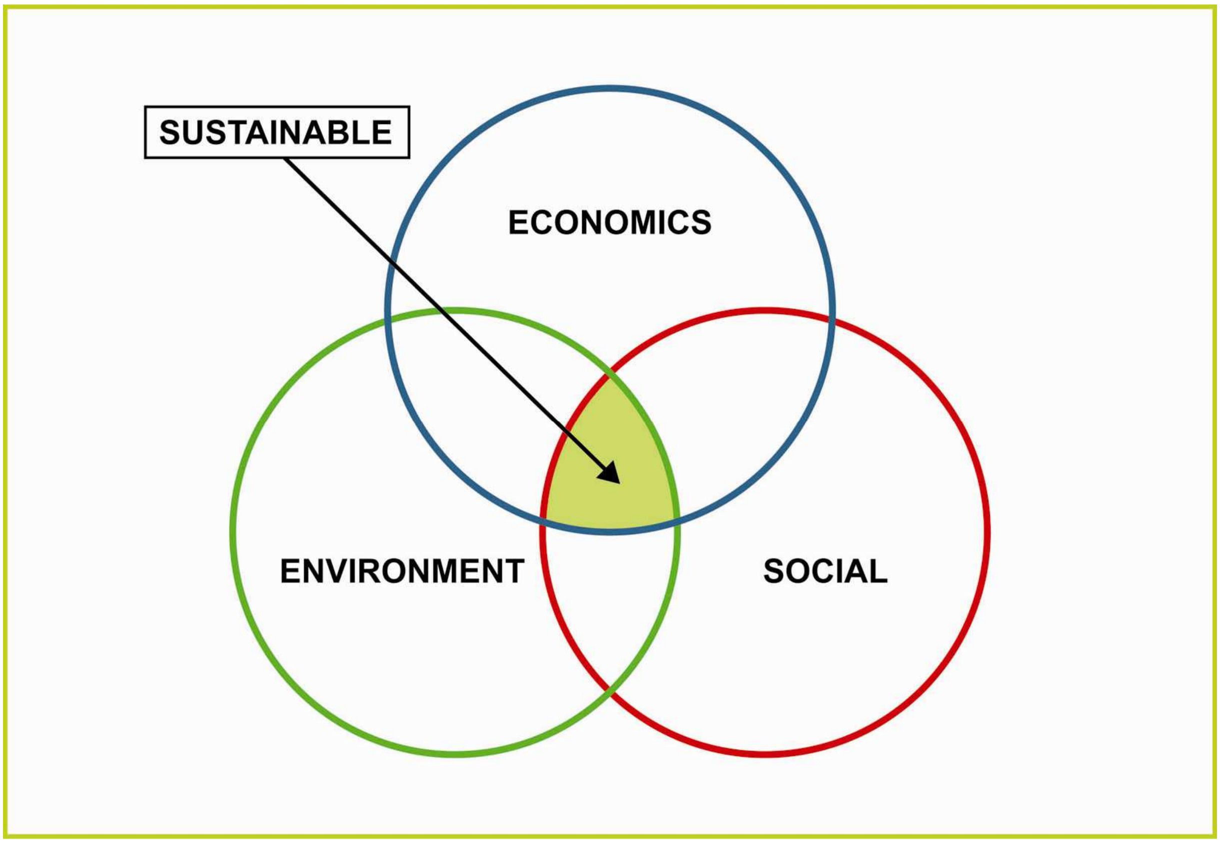

Figure 1.1: Sustainable development is a balance between environmental, social and economic factors.

Sustainable development appraisals are commonly undertaken for large and extensive (in both spatial and temporal scale) developments. Remediation activities are often just one component of a wider redevelopment or land-management project, but one that is commonly overlooked during initial planning and sustainable development appraisals. SuRF-UK believes that consideration of remediation issues in wider sustainable development appraisals will result in projects that are 'better by design'. The framework is based on current practice regarding sustainability assessments (i.e. after the principles set out in the Brundtland report), however more recent approaches, such as assessment and protection of ecosystem goods and services, and consideration of environmental capacity and resilience provide complementary concepts that may need to be considered.

1.6 Role of remediation within sustainable development

The three elements of sustainable development (environment, society and economy) can be considered when assessing the likely impacts and benefits of undertaking any scheme, including remediation. Remediation is defined here in its broadest sense as actions to assess potentially contaminated sites, or break a source-pathway-receptor linkage and thereby manage risks associated with the presence of contaminants in the environment. It includes voluntary remediation schemes and those that may be regulated under the Town and Country Planning system, the contaminated land regime (Part IIa of Environmental Protection Act 1990), Water Resources Act 1991 and Anti-Pollution Works Regulations 1999, the PPC regime, the Environmental Damage Regulations 2009, or other relevant regulations.

The overall significance of soil and groundwater remediation to the sustainability of a scheme can vary depending on its relative contribution to a project. The earliest influence on the property lifecycle (Figure 1.2) considered in this framework is regional spatial planning, as influenced by Planning Policy Guidance (PPG) and the newer Planning Policy Statement (PPS) (see section 2.1). At this stage remediation-related considerations are only one small component of a spatial strategy for a region. For example, demographics, flood-risk and transport are also factors. Consequently, the impact of sustainable remediation decisions may have a relatively minor impact on the sustainability of a scheme. At this stage it must be recognised that on occasions decisions will be made that appear to be non-optimum with regard to remediation because other factors are more influential in optimising the overall (environmental, social and economic) benefits of a scheme. The framework allows reconsideration of overarching project principles and objectives through a feedback loop in instances where non-optimum remediation would result.

Figure 1.2: The property lifecycle concept.

At a site-specific level, such as a brownfield redevelopment, the remediation process becomes more significant in the overall project sustainability, and during the remediation of operational land (i.e. where there is no change of use proposed) the sustainability of the remediation defines the project sustainability.

Some organisations may manage a portfolio of sites or other assets, some of which may need risk management action. In this case sustainable remediation considerations may be an important component of strategic planning to form a robust and defensible assessment of which sites should be considered earlier than others. In addition sustainable remediation can assist with other issues of corporate governance.

2 Legislative and regulatory context in the UK

Two principal regulatory regimes apply to land contamination - the planning regime and the contaminated land regime, as set out for each country in Table 2.1.

Table 2.1: Planning and contaminated land legislation in parts of the UK.

Country	Planning legislation	Contaminated land legislation
England	• Town and Country Planning Act 1990 (as amended) • Planning and Compulsory Purchase Act 2004	• Environmental Protection Act 1990, Part IIa • The Contaminated Land (England) Regulations 2000 (SI 2000, No 227) • The Contaminated Land (England) Regulations 2006 (SI 2006, No 1380)
Wales	• Town and Country Planning Act 1990 (as amended) • Planning and Compulsory Purchase Act 2004	• Environmental Protection Act 1990, Part IIa • The Contaminated Land (Wales) Regulations 2001 (Welsh SI 2001, No 2197) • The Contaminated Land (Wales) Regulations 2006 (Welsh SI 2006, No 2989)
Scotland	• Town and Country Planning (Scotland) Act 1997 (as amended) • Planning and Compulsory Purchase Act 2004	• Environmental Protection Act 1990, Part IIa • The Contaminated Land (Scotland) Regulations 2000 (Scottish SI 2000, No 178) • The Contaminated Land (Scotland) Regulations 2005 (Scottish SI 2005, No 658)
Northern Ireland	• Planning (Northern Ireland) Order 1991	• Waste and Contaminated Land (Northern Ireland) Order 1997, Part 3 • The Contaminated Land (Northern Ireland) Regulations (DRAFT)

The UK approach to the management of historic land and groundwater contamination is founded on a risk-based 'suitable-for-use' philosophy. Under both sets of legislation remediation requirements should remove unacceptable risks to human health and the environment, and should contribute to broader sustainable development goals. The key legislation that supports or drives a sustainable approach to remediation of land and groundwater in the UK is summarised in section 2.1.

2.1 Planning regime

Planning Policy Statements 1 (PPS1) '*Delivering Sustainable Development*' and 23 (PPS23) '*Planning and Pollution Control'* apply in England and cover requirements for sustainable development and dealing with contamination through the planning system. Other planning policy guidance exists that may be relevant, including PPS9 '*Biodiversity and Geological Conservation*', PPG14 '*Development on Unstable Land*' and PPS25 '*Development and Flood Risk*'.

PPS1 provides statutory guidance for the Town and Country Planning process and states that "sustainable development is the core principle underpinning [land-use] planning" and that "planning should … promote sustainable patterns of … development" (ODPM, 2005a). In addition, PPS1 states that:

- Development plan policies should take account of environmental issues such as land contamination;
- Development plan policies should aim to promote the prudent use of natural resources by supporting "housing at higher densities on previously developed land, rather than at lower densities on greenfield sites"; and
- In preparing development plans, planning authorities should "seek actively to bring vacant and underused previously developed land and buildings back into beneficial use".

PPS23, Annex 2, on the "development of land affected by contamination" (in England) states that consideration of "... contamination issues can help in locating development that is less sensitive to contamination on areas where the contaminated state of land is … more difficult to address" and that planning authorities should "take into account issues of sustainability … which might arise from the contamination" (ODPM, 2004). Regional Spatial Strategies (RSS's) and Local Development Framework (LDF) or Local Development Document (LDD) have a positive role to play in steering development onto appropriate previously developed land, some of which may be affected by contamination, and to protect greenfield land from avoidable development. LDF's / LDD's should include policies and proposals for dealing with contamination to ensure land is suitable for the proposed development or use.

In Wales, sustainable development principles are embedded in the planning system through Planning Policy Wales (WA, 2002), which responds to the duty imposed on Welsh Ministers to promote sustainable development under the Government of Wales Act 2006. Similar principles are enshrined in Scotland by the Planning Policy Scotland (The Scottish Government, 2008) and in Northern Ireland by the Regional Development Strategy and Planning Policy Statement 1 (PPS1) 'General Principles Policy Publications: A Planning Strategy for Rural Northern Ireland' both published by the Department of the Environment (NI) in 1998.

2.2 Contaminated land regime

The contaminated land regimes (Table 2.1) require local authorities to identify and determine contaminated land in their areas. Remediation Notices must be served by local authorities (or the environment agencies for Special Sites) on the appropriate persons who are responsible for the contaminated land. The legislation requires that remediation specified by a regulatory body in a Remediation Notice should meet the 'test for reasonableness', which include an assessment of the costs and benefits for the current use of the land.

2.3 Environmental Liabilities Directive

The EU Environmental Liabilities Directive (CEC, 2004) and the transposing Environmental Damage (Prevention and Remediation) Regulations 2009 require that new environmental damage (derogation of natural resource or services) caused by certain activities is fully remediated by way of a combination of primary, complementary and compensatory remediation. The criteria for evaluating remediation options include many of the factors that contribute to sustainable development including cost, social and cultural concerns, safety, environmental performance, timescales to complete remediation etc.

The framework described in this document may be helpful in determining the best options for (and combinations of) primary, complementary and compensatory remediation.

2.4 Proposed Soil Framework Directive

Although currently caught up in high level discussions, it is likely that there will be a EU Soil Framework Directive (SFD), whose objective to provide a framework that will require each EU Member State to decide how best to protect and use soil in their territory. It may require Member States to identify areas at risk of soil degradation (in its widest sense) and to take measures to address those risks. Addressing risks associated with land contamination currently forms a large part of the proposed SFD. All previous drafts have included text that required that protection and use of land must be considered in a sustainable way, including risks from contaminated land.

2.5 Other duties on the environment agencies to consider sustainable development

Section 4 of the Environment Act 1995 places a “principal aim and objective” on the Environment Agency (EA) to “contribute to the goal of achieving sustainable development” in undertaking its activities. Similarly, Section 32 of the Environment Act 1995 places a duty on the Scottish Environment Protection Agency (SEPA) to “have regard to social and economic needs in exercising its [environmental] functions”.

Section 39 of the Environment Act 1995 requires each of the environment agencies to take account of the likely costs and benefits in deciding whether and how to exercise its statutory powers (e.g. by serving a notice to require remediation under the Anti-pollution Works Regulations 1999).

2.6 Technical guidance on land and groundwater remediation

Overarching technical guidance on managing risks at sites affected by land contamination is provided in ‘Contaminated Land Report 11: Model procedures for the management of land contamination’ (CLR11, EA & DEFRA, 2004). CLR11 makes reference to the need for sustainable remediation (Figure 2.1). The SuRF-UK framework for assessing sustainable remediation has been designed to fit within, and complement, the phased approach to risk assessment and management described in CLR11. Key assessment points align with CLR11 ‘risk assessment’, ‘options appraisal’ and ‘implementation’ stages as described in Chapter 4. In addition, the SuRF-UK framework provides a means of taking sustainability into account when comparing different land uses for brownfield land, based on the wider impacts and benefits of their risk management requirements.

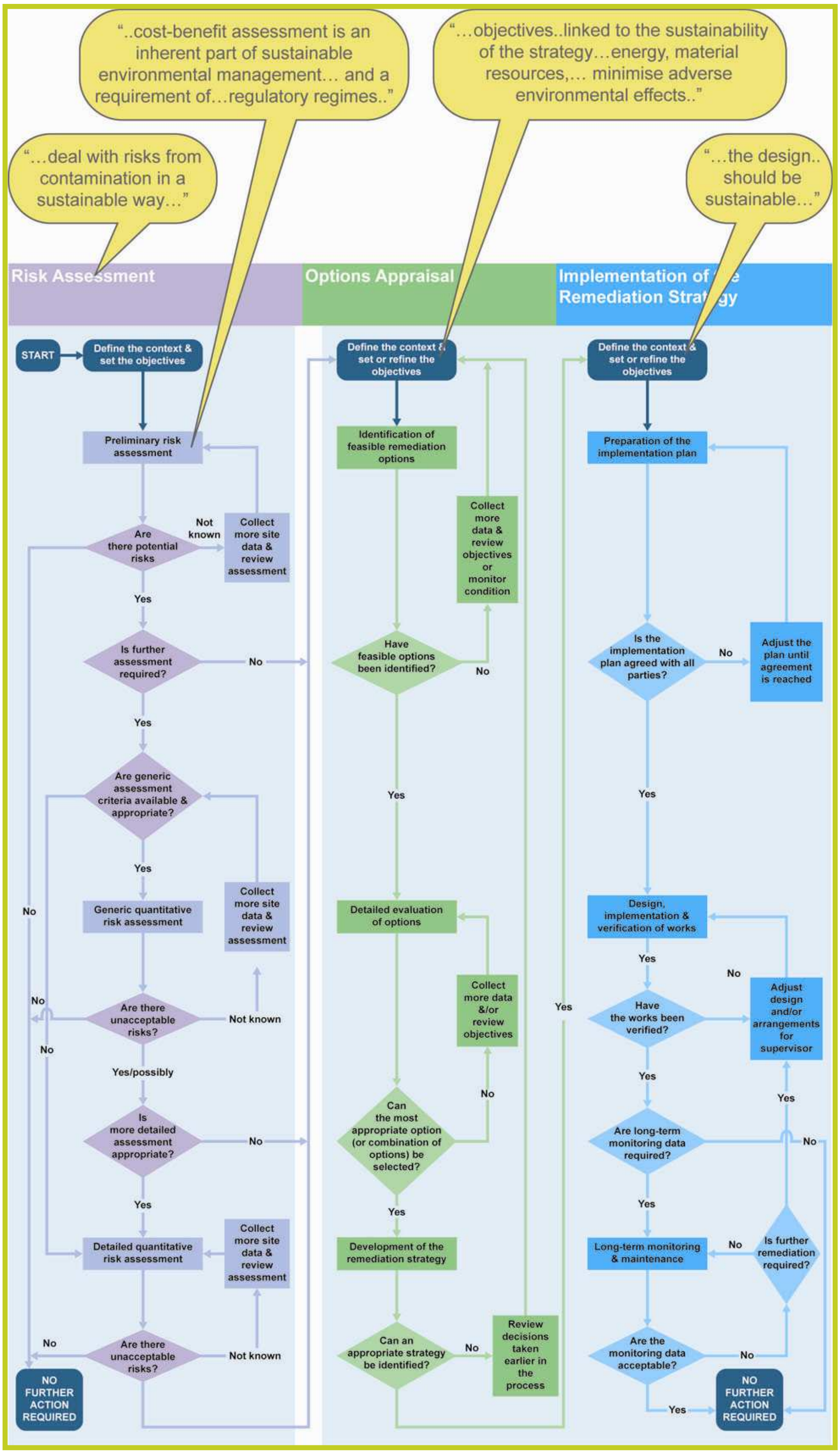

Figure 2.1: SuRF-UK sustainable remediation assessment is aligned to the CLR11 framework, with quotes relating to sustainability (adapted from EA & DEFRA, 2004).

The SuRF-UK framework also extends into wider considerations not explicitly considered in CLR11 that relate to integration of remediation with non-risk based aspects of project design. These include, for example, whether efficiencies can be gained by integrating remediation with wider sustainable development intentions, such as:

- Site masterplanning and urban design to minimise the need for remediation;
- Construction and remediation processes for waste minimisation purposes;
- Integration of a remediation scheme with renewable energy, such as ground source heating and cooling, or biomass production; and
- Integrating remediation work with provision of sustainable drainage and flood protection measures.

These are not intended to be prescriptive examples, but rather to illustrate the wide scope of possibilities that might be made available by taking a more holistic project design approach.

The EA's guidance on assessing risks to the water environment from land contamination (EA, 2006a) describes a framework that seeks to establish risk-based remedial goals that are achievable, reasonable, and which takes into account the relative costs and resources needed to meet those goals and the environmental benefits provided. These principles sit within overarching policies on protection and remediation of contaminated sites and the water environment (DoE-NI, 2006; EA, 2006b; Scottish Executive, 2006; SEPA, 1997, Welsh Local Government Association *et al*., 2006).

The techniques that are identified for assessing the sustainability of different remedial strategies and technologies also draw on existing published guidance, including EA research and development reports on assessing the costs and benefits of land remediation (EA, 1999a), groundwater remediation (EA, 1999b, 2000a, 2001), and the wider environmental benefits of remediation (EA, 2000b). The SuRF-UK framework, therefore, draws on existing methods with the aim to develop a robust and streamlined framework for assessing sustainable remediation that is compliant with legislative requirements, complementary to current UK good practice (namely CLR11), practicable to implement, and will achieve industry-wide acceptance including, critically, the relevant regulatory authorities.

3 The SuRF-UK framework for sustainable remediation

3.1 Introduction and definition of sustainable remediation

The SuRF-UK framework has been developed to complement existing good practice guidance (e.g. Planning Policy Statements and CLR11) and to be suitable for use under the range of regulatory regimes in the UK. It is sufficiently generic for use in other situations where assessment of sustainability (or simply costs and benefits) associated with remediation is required. Although drafted for a UK regulatory frame, it may have application in a wider European or international context.

The process of identifying sustainable remediation is defined by SuRF-UK as "**the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process**."

'Sustainable remediation' is a term adopted internationally (SURF, 2009) and encompasses sustainable approaches to the investigation, assessment and management (including institutional controls) of potentially contaminated land and groundwater.

Sustainability assessments frequently incorporate subjective views of the affected stakeholders. Sustainability criteria and indicators can be used to help encourage a consistent approach to sustainability assessment, and to aid decision-making. These criteria and indicators may be applied in a range of techniques, models or other tools used in the assessment process as an aid to decision-making. It is important that these aids are used to support and not to provide the decision. Ultimately the assessors make the decision, not the sustainability tool.

3.2 Key principles of sustainable remediation

SuRF-UK identified a number of key principles that are associated with sustainable remediation, and which should be considered by practitioners in the design, implementation and reporting of sustainable remediation schemes. The balancing of environmental, social and economic costs and benefits in identifying the optimum remediation solution needs to be carried out while complying with the key principles. The key principles are:

- Principle 1: **Protection of human health and the wider environment.** Remediation [site-specific risk management] should remove unacceptable risks to human health and protect the wider environment now and in the future for the agreed land-use, and give due consideration to the costs, benefits, effectiveness, durability and technical feasibility of available options.

- Principle 2: **Safe working practices.** Remediation works should be safe for all workers and for local communities, and should minimise impacts on the environment.

- Principle 3: **Consistent, clear and reproducible evidence-based decision-making.** Sustainable risk-based remediation decisions are made having regard to environmental, social and economic factors, and consider both current and likely future implications. Such sustainable and risk-based remediation solutions maximise the potential benefits achieved[2]. Where benefits and impacts are aggregated or traded in some way this process should be explained and a clear rationale provided.

- **Principle 4: Record keeping and transparent reporting.** Remediation decisions, including the assumptions and supporting data used to reach them, should be documented in a clear and easily understood format in order to demonstrate to interested parties that a sustainable (or otherwise) solution has been adopted.

- **Principle 5: Good governance and stakeholder involvement.** Remediation decisions should be made having regard to the views of stakeholders and following a clear process within which they can participate.

- **Principle 6: Sound science.** Decisions should be made on the basis of sound science, relevant and accurate data, and clearly explained assumptions, uncertainties and professional judgment. This will ensure that decisions are based upon the best available information and are justifiable and reproducible.

3.3 The structure of the SuRF-UK framework

The SuRF-UK framework recognises two fundamental stages at which sustainability can be considered: Stage A) plan/project design and Stage B) remediation implementation (Figure 3.1). The framework also recognises a clear break-point between the Stage A 'design' phase and Stage B 'remediation selection and implementation' phase. The opportunity to revisit the decision once the design milestone has passed is often limited.

Within Stage A (project design) there is an opportunity (Task A) to embed a sustainable remediation strategy into the wider project/plan design[3]. This stage is considered a relatively flexible stage, permitting several design iterations in an effort to integrate the optimum remediation strategy into the wider project (Milestone A).

Invariably completion of Stage A delivers an agreed and final project design or plan. Once the broader project frame is established the main influence that can be achieved by a sustainable remediation assessment is to identify the optimum remediation that will facilitate delivery of the project design or plan[4].

Conceptually, within any scale of site (local plan, industrial mega-site or small site) or any type of project (brownfield redevelopment, operational site remediation) the same framework rules govern the approach:

- There is a starting point at which the project design or plan layout is under consideration. Task A involves inclusion of the requirements and implications for remediation into broader site masterplanning, and subsequently the development of a remediation strategy for a site. These are together called Stage A. In certain situation (e.g. brownfield regeneration) both aspects are important and the framework refers to Stages A1 and A2 to distinguish them. In others (e.g.

[2] In certain projects it is recognised that non-optimum remediation decisions may be made because other factors are more influential in optimising the benefit from a wider development scheme. Considering regulatory implications and recording why such a decision was taken should be a minimum requirement for any decision making process.

[3] This stage is where the 'core aspects' of a project are set (as described in EA, 2000b).

[4] These are the 'non-core aspects' of a project (as referenced in EA, 2000b).

remediation of an operational site) only Stage A2 is relevant. Regardless of the site-specific detail, the outcome of Stage A is a final project/plan design.

- At the completion of Milestone A there is typically a point of limited return (the break-point). This occurs because, for example, contracts, regulatory agreements, conditions of a permit or a planning consent are finalised. In contractual terms, the break-point often is the point of signing a contract, irrespective of the form of agreement under consideration. For some projects it may also be the point at which remediation practitioners first become involved, although earlier involvement is often beneficial and is encouraged.

- After this point, the project design is set and the only relevant task (Task B) is to select the most sustainable remediation option. The final milestone (Milestone B) is a completed remedial options appraisal, which results in selection of a preferred remediation solution that can be implemented and subsequently verified.

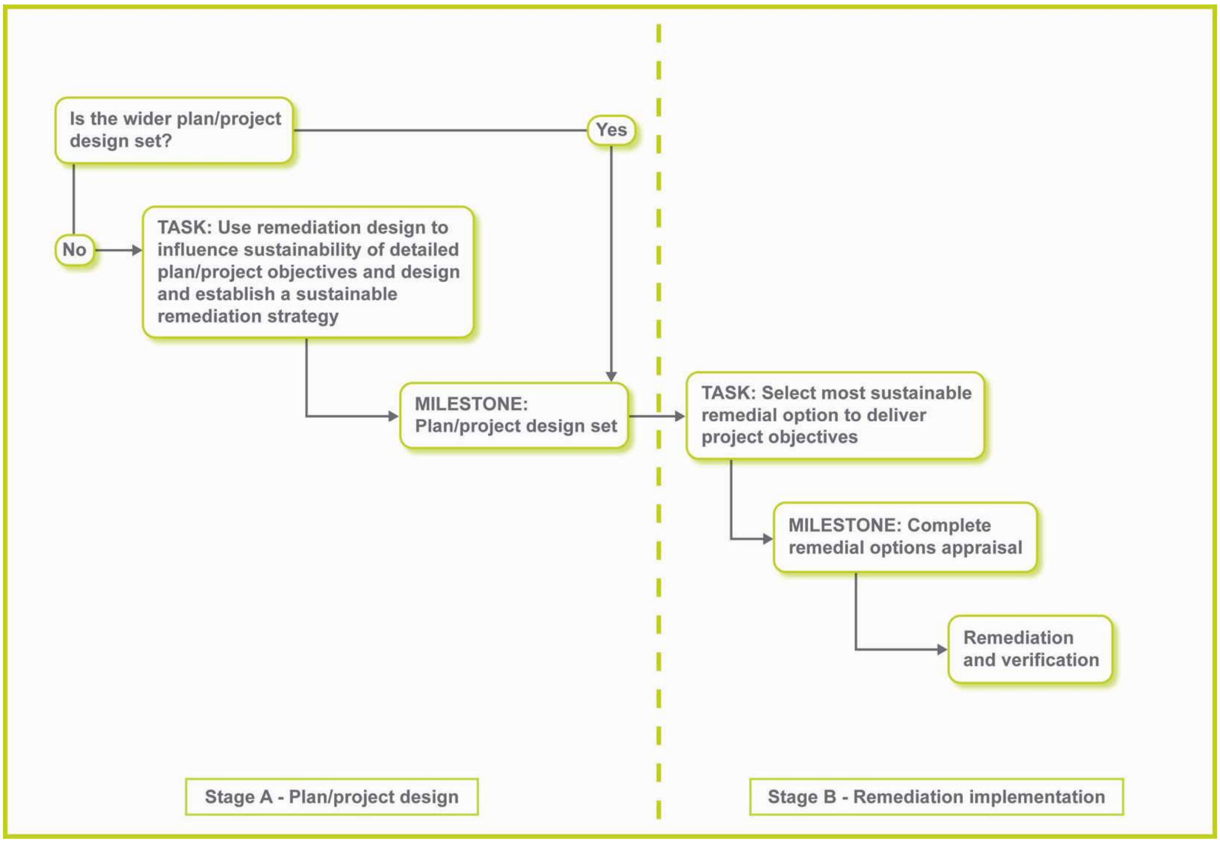

Figure 3.1: The SuRF-UK Framework.

3.4 The use of the framework in different remediation scenarios

The framework is sufficiently flexible that it can be applied to various decision-making scenarios within a project/property lifecycle, and to different sizes of project or site. Figure 3.2 illustrates how it can be applied to different remediation scenarios by using one or both stages of the framework. Further, Stage A can be split into Stages A1 and

A2 within a brownfield land assessment that is taken through design stages, firstly at regional-scale planning, and then at a site-specific level.

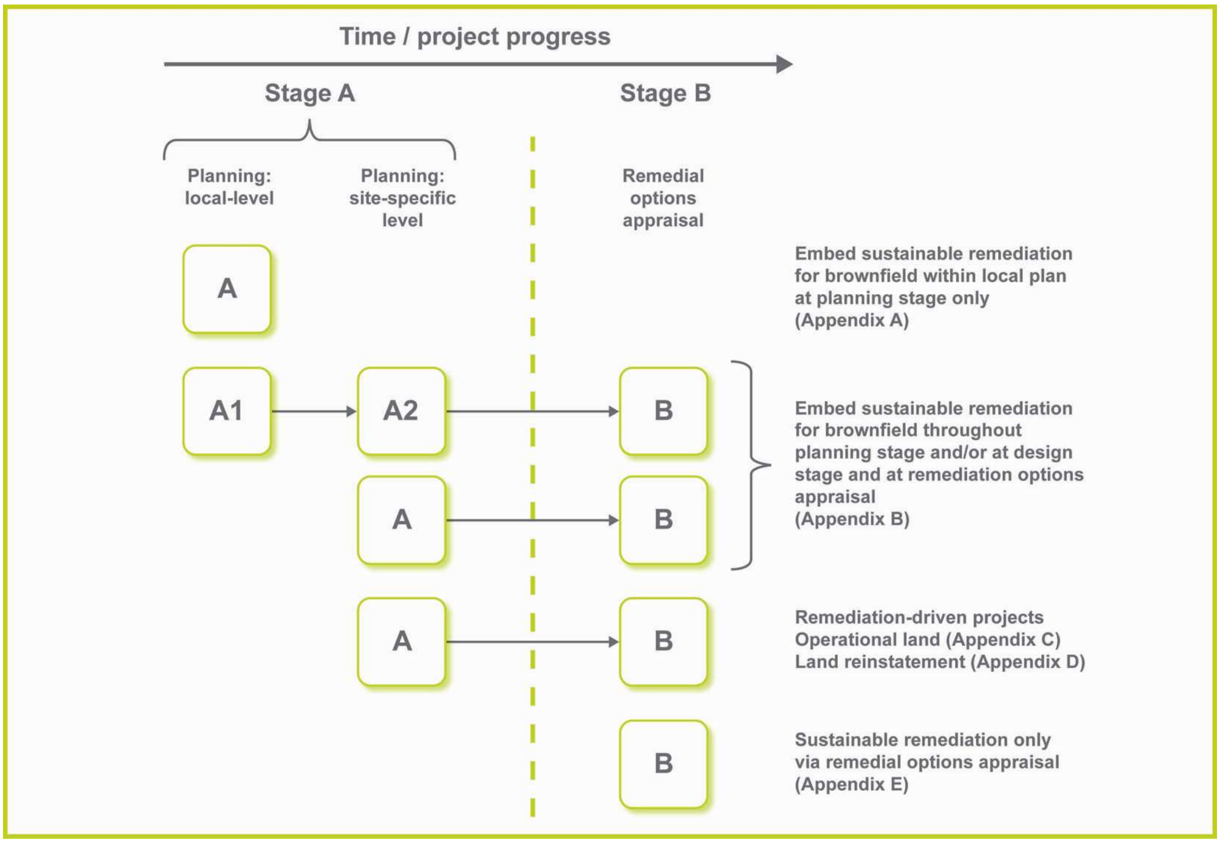

Figure 3.2: Use of the SuRF-UK framework for different remediation scenarios.

These remediation scenarios are briefly described in sections 3.4.1 to 3.4.5 and are supported by further explanation in appendices A to E.

3.4.1 Local planning

In the UK, the Town and Country Planning process develops an RSS followed by a LDF / LDD, the latter of which formally allocates land for different uses (e.g. employment, residential, retail, etc.). Sustainable development is a core principle of this process, indeed it is a statutory requirement that plans contribute to sustainable development.

The RSS and LDF / LDD have a positive role to play in steering development onto appropriate previously developed land, some of which may be affected by contamination, and to protect greenfield land from avoidable development. The LDF / LDD is the most powerful place to improve the sustainability of a site and should include policies and proposals for dealing with remediation requirements as one of the factors that can be considered when developing the preferred mosaic of land-uses and site-specific allocation. This is essentially Stage A of the SuRF-UK framework process (Figure 3.2). Supporting data is presented in Appendix A. It is not linked to Stage B remediation implementation since it is exclusively a decision-making process at a regional planning level and the final milestone is the LDF / LDD.

It is presented in this document to highlight the potential contribution that a sustainable remediation assessment can make in regional spatial planning decisions by considering that contamination may be so great as to effectively preclude the development of some sites for particular sensitive uses.

3.4.2 Land changing use

A parcel of land for development may be subject to two phases of design, firstly at local-scale planning with a land-use determination and then at site-specific level, arguably with a break-point between them, which may be of several years duration. This concept is presented in Figure 3.2 as two stages, Stages A1 and A2, and is supported by Appendix B. However, an alternative, and perhaps more common option, in practice for brownfield land is that the LDF / LDD is set and only the site-specific design issues will be considered. Therefore, only Stage A2 is completed.

Site-specific design examples of sustainability considerations might include:

- Matching land-use with ground conditions (contamination and geotechnical) e.g. locate most vulnerable receptors and land-uses away from most contaminated areas;

- Consider feasibility of locating basement parking within ground conditions that require intervention (e.g. avoid excavating clean soil to create basements while at the same time remediating other soils *in-situ*);

- Location of sustainable drainage systems (SUDS). For example, locate SUDS percolation areas in areas of clean soil to prevent leaching of contaminated materials; and

- Consider the use of vapour barriers to intercept a potential vapour 'pathway' rather than excavating and disposing of large volumes of soil (providing risks to other receptors, such as groundwater, are also appropriately protected, and the barrier is effective for the duration over which a vapour hazard persists).

In terms of any brownfield development scenario, Stage A design commonly links directly to Stage B implementation, with the pre-'break-point' milestone invariably being the granting of detailed planning permission when it is impossible to change the layout of a site without resubmitting a planning application, a lengthy and costly exercise that may not result in success a second time around.

3.4.3 Land continuing in current use

Remediation work on operational land (e.g. where there is no change of use and remediation is part of a liabilities management programme) invariably drives the sustainability of the project, since the remediation work is the project. This scenario is shown as two stages on Figure 3.2 and is supported by Appendix C. In this case establishing a sustainable remediation strategy to embed within the plan/project design and agreeing the overall project design are part of the same milestone.

3.4.4 Land restoration to 'soft' end-uses

Remediation work as part of land restoration projects normally represents one of the main drivers of the sustainability of the project, since the remediation work is a significant part of the project together with non-remediation earthworks.

Unlike brownfield redevelopment the subsequent lifetime impacts of the scheme are commonly less. This scenario is shown as two stages on Figure 3.2 and is supported by Appendix D. Often, establishing a sustainable remediation strategy to embed within the plan/project design and agreeing the overall project design is the same milestone.

3.4.5 Remediation implementation only

In many circumstances, a practitioner does not have an opportunity to influence the design work. They may only be asked to implement a selected remediation strategy, in order to deliver the design requirement. This represents a Stage B framework process as shown on Figure 3.2 and is supported by Appendix E.

At this stage the remediation options appraisal can only seek to influence the technologies or techniques used to achieve risk-based remedial objectives and also optimise the net (environmental, social and economic) benefit provided by the operation of the remediation. The sustainability assessment would generally be undertaken as part of a remediation options appraisal, and reported as part of a Remedial Action Plan (RAP).

3.5 Influence of decisions at different project stages on sustainability

Decisions made at the various stages of a land management project affect the overall sustainability of the project. Figure 3.3 illustrates the potential influence of decisions taken at regional spatial planning, site-specific masterplanning, and site-specific remediation stages for a number of illustrative brownfield regeneration examples. These emphasise the importance of early assessment of remediation on sustainability to deliver a project that is 'better by design'.

In these illustrative examples, Case 1 (red solid line) represents a situation where sustainability has been considered throughout the project, and the optimum option was selected at each stage in the process. By contrast, Case 2 (red solid line then light blue short dashed line) illustrates the same site, for which the same regional spatial planning decisions and remediation technology selection were made, but for which a less than optimum site-specific master-plan was put in place (perhaps it was decided to locate residential properties in the most heavily contaminated part of the site, and light industrial in a clean area, thereby increasing the amount of remediation required, but providing no greater benefit in terms of either amenity or risk management).

Cases 3 and 4 illustrate a different site. In Case 3 (pale green long dashed line) decisions made at regional spatial planning, site-specific masterplanning and remediation technology selection stages are shown to provide sustainability benefits, although these are not as great as in Case 1 (perhaps residential development was allocated on a very contaminated site forcing the need to do extensive remediation to render the site 'suitable for use'). In contrast Case 4 (pale green long dashed line, then dark green long dash then dot line) represents the same site where the same regional and site-specific masterplanning decisions were made, but a very poor remediation technology selection was made, with the result that this single decision resulted in the impacts of the projects being greater than its benefits (i.e. a negative score on the sustainability axis). This might be the situation where a beneficial brownfield redevelopment scheme is adopted, but poor remediation options appraisal results in the selection of ineffective remediation solutions, and numerous attempts at remediation are required to make the site 'suitable for use', which result in high costs, air emission, energy use etc.

The final example, Case 5 (dark blue short dash double dot line), illustrates a situation where a very poor option is selected at regional spatial planning stage, and even though assessment can show net-benefit at both masterplanning and site-specific remediation stages, the overall assessment is negative in terms of sustainability. This might relate to the location of a new waste incinerator in the centre of a residential area, or immediately adjacent to a public water supply abstraction. The remediation associated with making the site fit for its new purpose may be net-beneficial, but the long-term impacts associated with its presence are overwhelmingly negative.

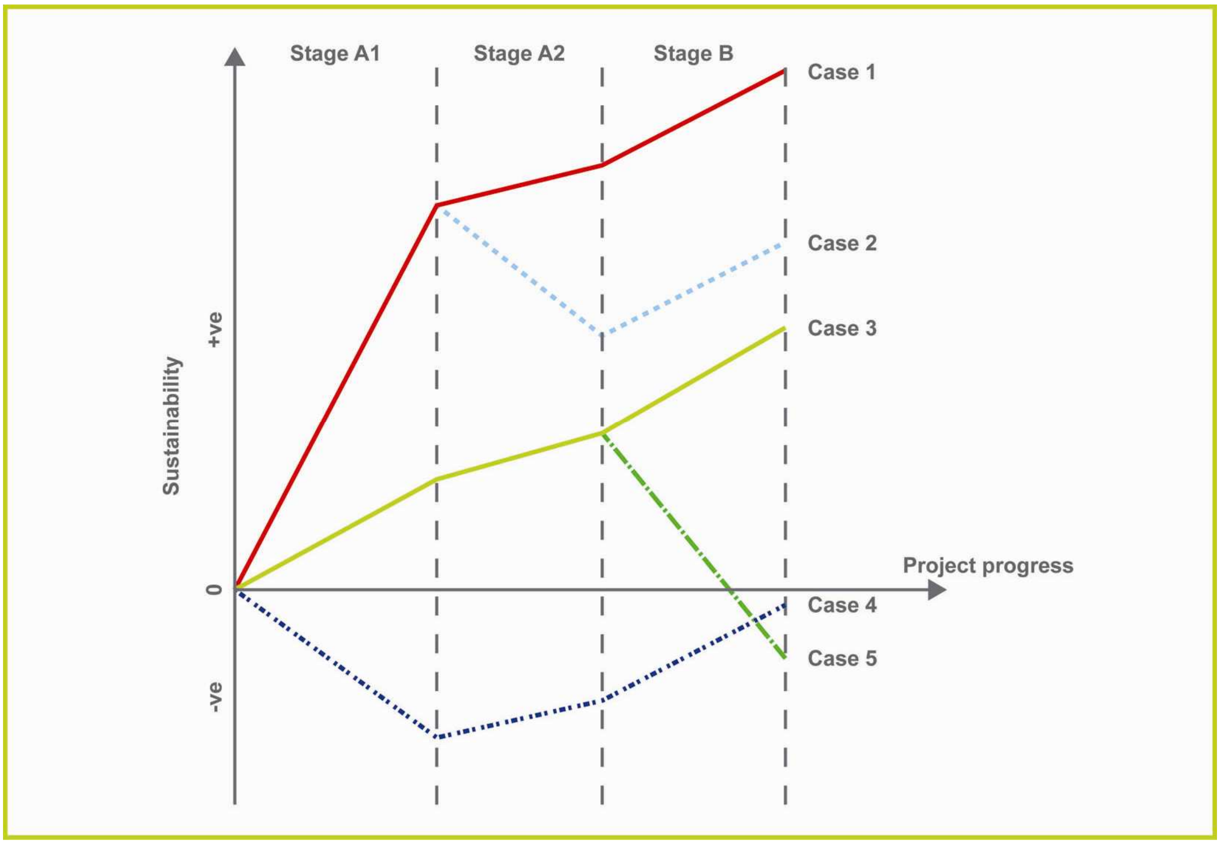

Figure 3.3: Illustrative effect of decisions made at different stages on overall sustainability of brownfield regeneration.

4 Applying the SuRF-UK framework

4.1 A complementary approach to sustainable management of land contamination

The process of sustainable remediation requires an assessment of the environmental, social and economic aspects associated with land and groundwater remediation, in order to demonstrate that net benefit exists, that is to say the benefits delivered by remediation exceed the costs of undertaking remediation. A number of activities are required in this process, which are described in this chapter, including:

- Agree the objectives for the sustainability assessment: what management decision does the assessment support?
- Which stakeholders need to be consulted? [Section 4.4]
- What are the boundaries of the assessment? [Section 4.5]
- What sustainability indicators should be used? [Section 4.6]
- What assessment method should be used? [Section 4.7]
- How certain is the result of the assessment, and what parameters is the outcome most sensitive to? [Section 4.8]

Table 4.1: Summary of site-specific SuRF-UK assessment points aligned to the procedure for managing land contamination (CLR11).

CLR11 Stage →	Risk Assessment	Options Appraisal	Implementation of Strategy
CLR 11 Outcome of stage	Robust conceptual model, risks and uncertainties identified. Decision of need for remedial works, based on risk assessment.	Remedial options reviewed. Preferred strategy identified.	Remedial action complete and verified. Possible long-term monitoring.
SuRF-UK Framework Stage A: Plan/project design	Use remediation design to influence sustainability of detailed project objectives, to either • Design-out unacceptable risks • Minimise action required to manage unacceptable risks • Look ahead and consider likely remedial options when developing risk assessment		None
SuRF-UK Framework Stage B: Remediation selection and implementation	None	Select optimum remedial option to deliver project objectives	None

A risk-based approach for managing land contamination is already in place in the UK, which is based on protecting human health, the environment and other specified receptors. The SuRF-UK framework has been developed to complement the existing risk-based approach by addition of sustainability considerations, and so support a proportionate and risk-based approach. In the UK CLR11 (EA & DEFRA, 2004) describes a process for managing land contamination which has three distinct stages: Risk Assessment, Options Appraisal and Implementation of the Remediation Strategy.

Whilst UK in origin, the CLR11 procedure can be applied to most regulatory regimes that accept risk-based decision making.

The SuRF-UK framework recognises two fundamental stages at which sustainability can be considered: Stage A) Plan/project design and Stage B) Remediation implementation. The two fundamental stages of the SuRF-UK framework are considered to overlap with the procedure for managing land contamination as show in Table 4.1.

4.2 Using SuRF-UK across project lifecycle and land-cycle

In addition to the two stages of the SuRF-UK framework, the effective management of land contamination requires other aspects of the management process to be subject to sustainability considerations. In relation to the project lifecycle these are as shown in Table 4.2.

Table 4.2: Other sustainability considerations related to land contamination management and the project lifecycle.

CLR11 Stage	Risk Assessment	Options Appraisal	Implementation of Strategy
SuRF-UK assessment	Ensure site characterisation: a. Is designed to ensure efficient data collection, focused on improvement of conceptual model. b. Prevents new hazards or Source, Pathway or Receptor (S-P-R) linkages. Ensure site assessment has: a. Risk-based objectives defined. b. Risks assessed with greatest accuracy possible with available evidence and data	Remedial options assessed: a. Optimum remedial strategy identified (i.e. S-P-R, treatment, or a combination, to achieve risk-based remedial goals). b. Select technology to achieve remedial goals in most sustainable way.	Ensure verification: a. Is designed to ensure efficient data collection, focused on demonstrating whether remedial objectives are achieved. b. Verifies sustainability assessment.

In particular, it is important to recognise there is an optimum level of site characterisation that positively supports a risk management strategy. For example, by focusing site characterisation to improve understanding of plausible source-pathway-receptor linkages to refine a conceptual site model; minimise journeys to site for numerous poorly-planned phases of site investigation; minimise waste; use non-intrusive technologies for effective data collection, and design of site characterisation to prevent new contamination by, for example, drilling through low-permeability confining layers.

In respect of any one site's lifecycle, all brownfield land is in at least its second cycle of use. In some areas with a history of industrial development, the land has been recycled on numerous occasions. The land-cycle concept is presented as Figure 2.1.

Application of the SuRF-UK framework in respect of the land-cycle recognises that when planning the use of site, sustainable remediation considerations can be factored in.

Within this stage, the sustainable remediation assessment may form part of a Strategic Environmental Assessment (SEA) or Environmental Impact Assessment (EIA).

Strategic Environmental Assessment (SEA) is a systematic decision support process aiming to ensure that environmental and possibly other sustainability aspects are considered effectively in 'Policy, plan and programme making' (ODPM, 2005b). In Europe (EU), SEA is undertaken to meet the requirements of European Directive 2001/42/EC. Key principles in SEA include the promotion of sustainable development.

Environmental Impact Assessment is a procedure to make a structured appraisal of a broad range of environmental effects of a particular project. In the EU, EIA is subject to Directive 85/337/EEC. EIA affects projects beyond a certain size, and not all remediation projects will trigger the need for an EIA in their own right. EIA could also be triggered for remediation as part of a larger development project. EIA does not consider the full range of factors that would be considered in a full sustainability appraisal. However, it may be beneficial to carry out sustainability appraisal if the EIA requirements have been triggered to provide a balanced comparison of available options.

4.3 A tiered approach to assessing sustainable remediation

Decision-making effort should not be disproportionate. Wherever possible decisions should be based on the simplest sustainability assessment approach, as long as the information it provides is seen as robust and acceptable by the various stakeholders involved in the decision-making process. SuRF-UK recommends a tiered approach to supporting decision-making in relation to sustainable remediation. At its simplest and lowest tier this is a qualitative approach that is adequate to support a justifiable decision (e.g. checklists and conversations between stakeholders). The next tier would be a more analytical approach such as a semi-quantitative multi-criteria analysis. The next tier up would be a more complex approach such as a monetised cost benefit analysis. The process of using a tiered approach to supporting sustainable remediation decision-making is shown in Figure 4.1.

An ideal sustainability assessment approach allows assessors to evaluate the environmental, social and economic factors in a transparent and robust manner, using data and knowledge that are readily available and easily communicated to interested parties. It is possible to make a valid management decision at any tier of assessment, however the decision to move from a simple (and normally quicker/cheaper) assessment to a more complex (and time-consuming/expensive) assessment may result from a number of circumstances, such as:

- A legal requirement (e.g. regulatory, contract at point of divestment etc.);
- Assessment at a low tier does not allow a clear management decision to be made, and more detailed assessment is expected to bring greater clarity to the assessment; and
- The organisation undertaking the assessment requires the output to be reported in financial terms and defaults to a monetised CBA to meet its own financial reporting requirements.

As with tiered risk assessment, the higher the tier of analysis, the greater the accuracy of the assessment, but equally the greater the cost, data and effort required to undertake the assessment. The assessment should normally be undertaken at the lowest tier that allows a robust management decision to be made.

Hypothetical examples of a tiered approach are described in Boxes 1 to 3.

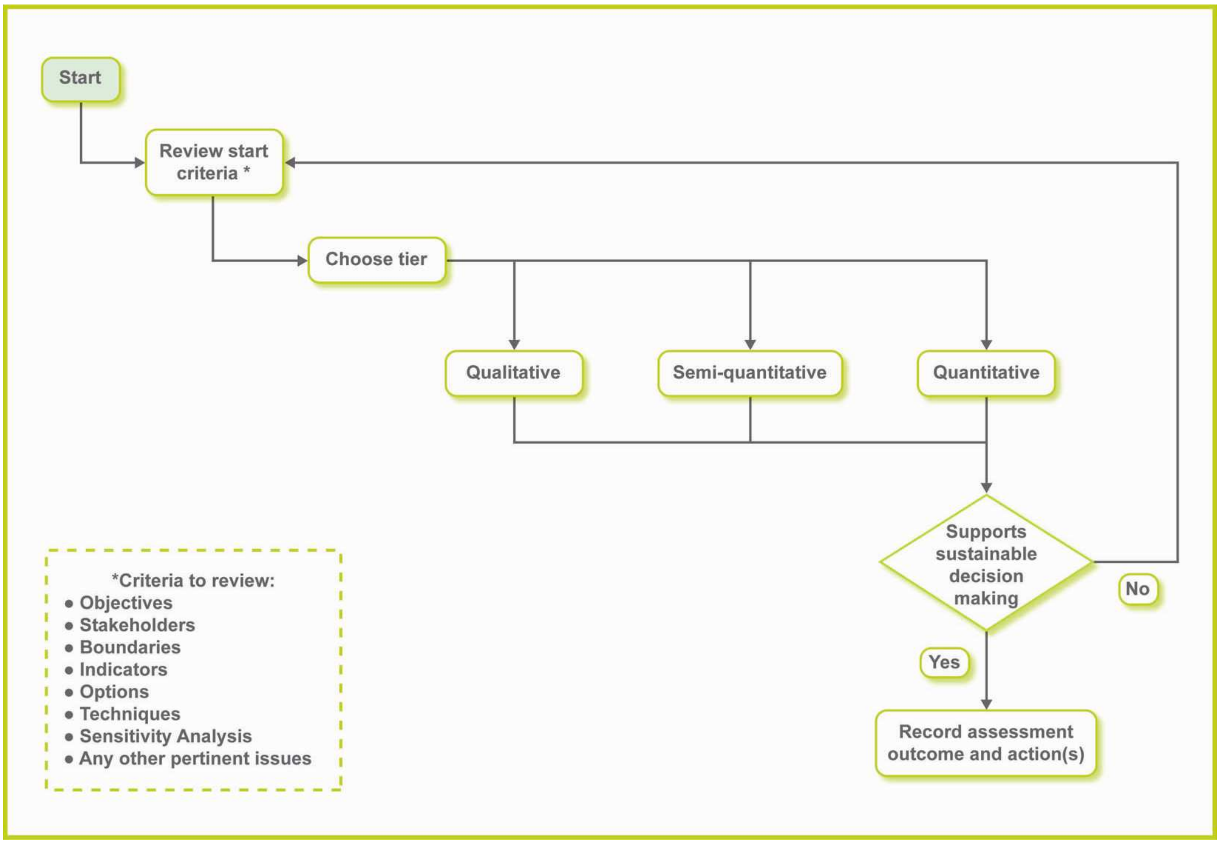

Figure 4.1: Tiered approach to assessing the sustainability of remediation.

Box 1: Example of a simple qualitative approach to sustainable remediation assessment.

A small site was being remediated following an accidental release of contaminating fluids to the ground. The site was to continue to be used for the same industrial activities. Following agreement of risk-based remedial objectives, a stakeholder workshop was held to discuss remediation options. The site owner, EA, local authority Environmental Health Officer (EHO) and a representative of the local Parish Council were invited to attend and represent their respective interests. The scope of the sustainability assessment was agreed initially, and restricted the impacts and benefits of different remediation techniques at the site to achieve the risk-management objectives. It was agreed to include the following aspects: environmental (impacts on water, air, and waste generation), social (nuisance from traffic, noise, visual impact and duration) and economic (direct costs). Other aspects, such as a possible change of use for the site, lifecycle analysis of the mechanical plant used in remediation etc were excluded.

A series of graphic conceptual models were presented to show the site conditions and remedial objectives. A shortlist of identified remediation options that were considered capable of achieving the remedial objectives were tabled by the site owner, together with the key environmental, social and economic impacts and benefits that they identified as being associated with each option. Supporting data (e.g. independent good practice reports and peer reviewed papers) were presented in support of the evidence put forward.

A discussion was held amongst the parties in which they debated the relative merits and dis-benefits of each option against the general headings of 'environment', 'society' and 'economy'.

Following an open discussion, a remedial solution was agreed by consultation that achieved the risk-based remedial objectives, and which minimised both atmospheric emissions and traffic movements through nearby residential areas. It was agreed to operate the plant within a sound-proofed housing to limit potential noise disturbance. The timescales to complete remediation were slightly longer than an alternative, but the consensus was that the reduced disruption and safety hazards from fewer lorry journeys off set the impact from a slightly extended working period.

The discussions were written up and agreed by all workshop participants and a copy submitted to the local authority EHO and EA for inclusion in the public register.

Box 2: Example of a semi-quantitative approach to sustainable remediation assessment.

A Multi-Criteria Analysis (MCA) approach (CLG 2009) was used to help assessors decide on the best remediation strategy as part of a brownfield site redevelopment. The large site, which was derelict but which was previously used for industrial purposes, was allocated for 'mixed end-uses' including residential, commercial, school and public open space in the local plan spatial strategy. As part of the site-specific masterplan and the supporting EIA, remediation was considered alongside other relevant factors in an assessment of the sustainability of different land-use mosaics.

A very simple qualitative assessment was deemed insufficient by the project team to cope with the numerous site layout/remediation options that were available. A detailed cost-benefit approach was also deemed inappropriate due to difficulty monetising many of the data. Consequently it was decided to use a semi-quantitative MCA to help inform the project team and stakeholders.

The allocation of the site for mixed land-uses was made at a local level to contribute to a national-scale strategy that delivered sustainable development. Allocation of individual plots within the site to specific uses was not dictated at the local level. An MCA approach was used to identify how remediation aspects could be most sustainably addressed by land-use masterplanning and integration of redevelopment and remediation.

The assessors started by identifying how risk-based remediation requirements would vary across the heterogeneously-contaminated site if different end-uses were applied in different locations. Having broadly identified remediation requirements for residential, commercial, public open-space and school end-uses, the assessors used an MCA approach. First they started with a list of 18 sustainability indicator categories (see Table 4.3) and identified those that were not relevant to the site in question. This quickly limited the list to 12 sustainability categories. Assessors then ranked those factors that they placed greater or lesser importance to (3-High / 2-Medium / 1-Low weighting), and then scored (out of 5) the environmental, social and economic costs and impacts of undertaking remediation to allow the site to be used for each of six different (but feasible) layouts.

The outcome of the MCA was a ranked list of site-layout designs that showed how the remediation requirements of each varied with regard to sustainability, and with regard to each factor within the sustainability assessment (i.e. environment, society, economy). The output was used by the local authority planners as part of the public consultation process, to seek views on, and then select the preferred site layout (and by implication its remediation strategy).

Box 3: Example of a quantitative approach to sustainable remediation assessment.

Cost-Benefit Analysis (CBA) was used to help assessors consider how the balance of monetised costs and benefits for the available remedial strategies/techniques compared, and whether the benefits of the preferred remediation option exceeded the costs associated with implementing that remedial option. This can be represented by the equation below:

$$SR = \sum_{1}^{n} \left(\left(Benefit_{environment} - Cost_{environment} \right) + \left(Benefit_{society} - Cost_{society} \right) + \left(Benefit_{economy} - Cost_{economy} \right) \right)$$

Where:

- *SR* is the 'sustainable remediation score' for each of the *n* remedial options that can achieve the agreed remedial objectives;
- $Benefit_x$ is the benefit associated with each factor (environment, society or economy) for each remedial option; and
- $Cost_x$ is the cost associated with each factor (environment, society or economy) for each remedial option.

The optimum remedial option achieves:

- SR ≥ 0;
- SR is the maximum for the feasible remedial options 1 to n; and
- A fair distribution of the costs and benefits amongst the affected parties

Using a CBA approach a remedial option was identified that outperformed all other feasible options within the boundaries and assumptions of the CBA. It was duly selected as the preferred remedial solution and the sustainability assessment written up and submitted to the local planning authority in support of a Remedial Action Plan required by a condition of the site's planning permission. The local planning authority accepted the sustainability assessment in support of the remediation action plan and the planning condition was discharged. A more detailed example of a CBA is presented in EA (2001).

4.4 Involving stakeholders

The engagement of stakeholders is an important part of a sustainability assessment for three reasons:

- Stakeholder opinions can be an important source of information about particular aspects of sustainability. Some stakeholders may be directly involved in decision making (for example the site owner and regulator); others may not have a direct involvement but may still be influential (for example local community interests);
- Consultative processes improve the robustness of decisions; and
- Consultation with stakeholders is part of good governance.

Key issues for the communication on risk in contaminated land management are described by SNIFFER (2010) and CL:AIRE (2007a, 2008), and are likely to include:

- Both technical assessments of risk and perceptions of risk need to be addressed. A good understanding of both technically identified risk and perceived risk requires good communication between experts and other stakeholders. The risks that need to be considered may well encompass risks/impacts from the remediation project itself that are of concern to stakeholders, for example: cutting trees, odour, noise or heavy traffic, which can generate objections to a remediation project;

- If the discussion becomes emotional, issues far beyond technical details of the land contamination might govern the eventual outcome, or the dialogue between stakeholders may simply break down;

- Sometimes concerns about financial disadvantage, for example for householders on affected sites, or other issues might determine the process of decision making, and other issues are given less weight;

- If stakeholder groups struggle to converge on acceptable strategies, separating the decisions about what sustainability appraisal tool, from the selection of which indicators or metrics need to be considered can simplify finding practical and acceptable compromises; and

- Pro-activeness pays off. Communication about the contamination problem and possible remediation measures in advance creates trust. In dynamic situations, the availability of experts who answer questions on demand helps to keep a dialogue open and avoid critical situations. However, for this strategy to be successful it is important that the experts can communicate in clear terms and avoid the use of jargon when talking with the general public. Visualisations such as figures and diagrams can be particularly helpful, as can a shared glossary of technical terms, where these are unavoidable.

Risk-based remediation strategies underpin sustainable remediation. In order to share this understanding the strategy should be the result of a process characterised by a consultation with stakeholders.

The stakeholders at the centre of decision-making are generally the project team, comprising the site owner, whoever is being affected by the contaminated site, the service provider, the regulator(s) and planners. However, other stakeholders can be influential, such as:

- Those who might use the site (workers, possibly unions, and other visitors);
- Those who have a financial involvement in the site or the site's ownership (e.g. banks, founders, lenders, insurers);
- The site's neighbours (adjacent owners and tenants, local communities and councils); and
- Other technical specialists, researchers, non-governmental organisations (NGOs) and pressure groups, particularly for more complicated problems.

In general, the more complex the site (both from a technical point of view and in the context of its local circumstances) the greater will be the influence of these other stakeholders.

It is generally beneficial to involve key stakeholders from the beginning of a project, particularly for complex or otherwise contentious remediation projects. Generally, projects tend to follow a phased approach of investigation, risk-assessment, remedial options appraisal, remedial design, remediation implementation, execution and verification phases, sometimes followed by a long-term monitoring and maintenance phase. Implementation is preceded by a RAP being submitted to and approved by the competent authority. Although the organisational structure during the investigation/assessment phase can differ from the execution phase, the project manager should always ensure that each stakeholder involved plays a role in the process of developing a risk-based solution.

4.5 Setting the boundaries for a sustainability assessment

A key initial step in a remediation sustainability assessment is to define and agree the boundaries for the assessment. Unless the boundaries are set up-front, it is likely that different assessors will make different assumptions about the scope of the assessment and subsequently have difficulty reaching consensus. Key boundaries to set include:

- **Criteria to evaluate.** Which environmental, social and economic factors are being considered? If the assessment is limited to a restricted list of 'key factors' are those factors agreed by all parties and documented in the sustainability report?

- **System.** Different remediation options manage risks in different ways, such as by destroying contaminants, preventing their movement, or changing the behaviour of a receptor. To allow comparison of, say, a source-removal technique with a pathway-interception method, risk-management criteria must be agreed against an assessment of the effectiveness of different approaches. Different techniques may also achieve different levels of remediation, and over different timescales. Assessment of the overall benefits, the timescales within which they accrue, and the duration for which risk-management is likely to be effective, should be established. The key requirement is that 'like must be compared with like'. For example, at the remedy selection stage it is not helpful to compare a soil washing based approach with an excavation and landfill approach if the soil washing system is defined solely by the inputs and outputs to the process, and does not consider how the soil washing residues would be managed.

- **Component lifecycle.** Is the assessment to include the sustainability of manufacture of remediation plant and equipment, or it is restricted to the transport and use of that equipment (which may be used on numerous sites)?

- **Spatial boundary.** Is the assessment restricted to benefits/impacts within the footprint of the development land, to the immediate surroundings (e.g. a neighbourhood), or over a wider scale (e.g. impact on landfill capacity over a region, or on climate at a global scale)?

- **Timescales.** What is the planning horizon over which benefits/impacts are considered? The duration of the project, 10 years, 1 generation (20 or 30 years), 100 years?

While the overall sustainability assessment should consider all the criteria identified for evaluation, it may be important to also look at subsets. For example, on criteria which are regional or local, temporary versus permanent. Assigning spatial and temporary boundaries allows the sustainability assessment this ability to focus.

4.6 Sustainability indicators for remediation

Sustainable remediation assessment is generally based on an assessment of the performance of different remediation options against a list of sustainability indicators. For example, assessment criteria for remediation technology selection might cover the broad issues presented in Table 4.3. This preliminary list of 18 categories has been found to include a wide range of indicators found in the international peer-reviewed literature on sustainability appraisals (CL:AIRE, 2009). This list of 18 sustainability indicator categories is indicative of the range of issues that may be relevant, and is provided to help assessors identify the most critical issues to evaluate further in a project. It is possible that additional factors may warrant consideration and stakeholder consultation may help to identify those. Perhaps more commonly, it will be agreed by all stakeholders that not all of the 18 categories are of critical concern and warrant analysis in a quantitative assessment.

Sustainability assessment techniques employ some means of aggregating individual assessments of indicators to provide an overall understanding of 'sustainability'. Qualitative or quantitative approaches may be used. In general quantitative approaches are limited to particular aspects of sustainability, but may be useful for gathering evidence as part of an overall appraisal.

A system of estimating, such as by scoring, ranking, or valuing, the relative benefits and impacts that each remediation strategy or option provides against other alternatives is often used. A discussion of the merits and limitations of using scoring, ranking and weighting is presented in Appendix G. The EA's guidance on cost-benefit assessment for groundwater remediation (EA, 1999b) describes how such analysis may be performed by monetising the costs and benefits that each remedial option incurs against relevant sustainability indicators. It is frequently difficult to monetise some environmental and social information, which can cause difficulties unless sufficient resources are directed to the collection and/or generation of relevant data (CL:AIRE, 2007b). However at the simpler assessment tiers a non-monetised approach is typically used, such as 'a score out of ten' or 'high-medium-low' ranking.

Table 4.3: Overarching categories of indicators for sustainability assessment of remediation options.

Environmental	Social	Economic
1. Impacts on air (including climate change); 2. Impacts on soil; 3. Impacts on water; 4. Impacts on ecology; 5. Use of natural resources and generation of wastes; 6. Intrusiveness.	1. Impacts on human health and safety; 2. Ethical and equity considerations; 3. Impacts on neighbourhoods or regions; 4. Community involvement and satisfaction; 5. Compliance with policy objectives and strategies; 6. Uncertainty and evidence.	1. Direct economic costs and benefits; 2. Indirect economic costs and benefits 3. Employment and capital gain; 4. Gearing; 5. Life-span and 'project risks'; 6. Project flexibility.

Indicators are integral to the communication of sustainable development[5]. They help assessors review progress objectively, they highlight where the challenges are, and they help people to understand what sustainable development means globally, nationally, locally and for them as individuals. Indicators appear to serve two broad functions.

Policy orientated indicators that are linked to specific policy goals, often with some threshold or target for "acceptability" included, for example the 'England Sustainable Development Policy: Framework Indicators' (DEFRA, 2005a, 2005b) of guidance on determining 'Regional Development Strategies' (ODPM, 2005b). Alternatively indicators may be orientated towards consistent reporting of sustainability effects, independent of particular regional, national or international policy goals, such as the Global Reporting Initiative[6]. Obviously factors being considered will overlap, for example perhaps carbon or energy intensity, or impacts on water quality may be common to a number of different indicator sets for either function. However, on the whole, indicator sets developed for specific policy goals tend to be more directed in their coverage.
Therivel (2004) provides a detailed review of the qualities of, and uses for, sustainability appraisal indicators. Further detailed review of sustainability indicators application to land and groundwater remediation projects is presented in CL:AIRE (2009).

4.7 Methods for assessing sustainable remediation

SuRF-UK recommends a tiered approach to assessing sustainable remediation, and a range of techniques is available to undertake the sustainability assessment in these different tiers.

SuRF-UK considers that the specific tool used for a sustainable remediation assessment is less important than the process and thought that goes into the assessment. An assessment that considers environmental, social and economic factors from various stakeholder perspectives and which supports a management decision based on a clear and documented process is likely to be more acceptable than one which uses a sustainability assessment tool as a 'black box' and which fails to properly consider or justify input data and assumptions. Sustainability assessment tools should help evaluators undertake an assessment and make a management decision, not be the assessment.

A range of tools and methods are available for undertaking a sustainability assessment (or components of a sustainability assessment) as set out in Table 4.4. In essence they all seek to achieve the same goal: to assess the environmental, social and economic benefits and costs for a range of suitable options that meet a project goal. The assessment methods measure the benefits and costs in some way and seek to identify:

- Whether the overall benefits (of remediation) exceed the overall costs of doing the work; and
- For those methods where benefit exceeds cost, the method or methods that offers the greatest overall net-benefit.

Table 4.4 indicates coverage of the environmental, economic and social elements of sustainable development considered in the different tools; whether techniques are quantitative or qualitative; and whether contaminated land management (CLM) applications are known to exist at present. It also shows whether the scope of analysis

[5] http://www.defra.gov.uk/sustainable/government/progress/index.htm.
[6] Global Reporting Initiative www.globalreporting.org.

is very limited (narrow) for each aspect, or wide-ranging (wide) in its *typical* coverage of particular aspects of sustainability. For example, a carbon footprint appraisal focuses on a "narrow" segment of environmental sustainability issues (ignoring for example soil functionality, biodiversity and landscape impacts), whereas all of these aspects could be considered by a "wide" cost-benefit analysis, providing it was suitably specified.

Table 4.4: Selected decision support techniques with relevance to sustainable remediation assessments.

Technique	Environment	Economy	Society	Type	CLM Application?
Scoring / ranking systems (including multi-criteria analysis)	Narrow to Wide	Narrow to Wide	Narrow to Wide	Both	Yes
Best Available Technique (BAT)	Narrow to Wide	Narrow	-	Qual	Yes
Carbon footprint ("area")	Narrow	-	-	Quan	Yes
Carbon balance (flows)	Narrow	-	-	Quan	-
Cost benefit analysis	Narrow to Wide	Narrow to Wide	Narrow to Wide	Quan	Yes
Cost effectiveness analysis	Narrow to Wide	Narrow to Wide	Narrow to Wide	Both	Yes
Eco-efficiency	Narrow	-	-	Quan	-
Ecological footprint	Narrow	-	-	Quan	-
Energy / intensity efficiency	Narrow	-	-	Quan	Yes
Environmental risk assessment	Narrow to Wide	-	-	Both	Yes
Human health risk assessment	-	-	Narrow	Both	Yes
Environmental impact assessment / Strategic environmental assessment	Narrow to Wide	-	-	Qual	Yes
Financial risk assessment	-	Narrow	-	Quan	Yes
Industrial ecology	Narrow to Wide	Narrow to Wide	-	Quan	-
Life Cycle Assessment (based)	Narrow to Wide	-	-	Quan	Yes
Quality of life assessment	Wide	Wide	Wide	Qual	-

Notes:
Qual = Qualitative
Quan = Quantitative
Both = Qualitative and/or quantitative
CLM = Contaminated Land Management
\- = Technique has no known coverage

4.8 Sensitivity analysis

Sustainability assessments are frequently and necessarily subjective, particularly where they include factors that are not easily measured, such as some social aspects related to community perception, or relating to the economic cost of environmental impacts. It is possible that different groups of stakeholders presented with the same problem and information may reach different judgements on the optimum solution. Where this occurs it is important that a clear process has been followed and documented, and the outcome reflects the difference that different societies place on the different issues.

It is recommended that a sensitivity analysis should be undertaken as part of the sustainability assessment, to inform the assessors how variations in input data and assumptions influence the overall outcome of an assessment. Such an assessment will help to show which criteria most influence the assessment result and may warrant further analysis to accurately measure the value of the benefit/impact associated with that factor. Such a sensitivity analysis may also show that differences of views between stakeholders on certain aspects do not need further study since the sustainability assessment is insensitive to those factors, because either they are given a low weighting by assessors, or there is little variation between the remediation options being considered.

At the end of the process assessors should understand whether a decision is robust, or whether a small change in certain input values significantly alters the outcome of the assessment.

4.9 Incorporating sustainability considerations in a tiered risk assessment

Risk-management requirements commonly dictate the level of remediation that is required at a contaminated site. This framework builds on the risk-based approach (e.g. Principle 1, section 3.2). Environmental risk assessment frameworks are typically tiered, as described in CLR11 (EA & DEFRA, 2004) and implemented for controlled waters through the EA's 'Remedial Targets Methodology' (EA, 2006a). At the lowest tier a simple risk assessment is undertaken using generic and conservative assumptions and data, and the remedial objectives calculated often result in remediation over-design, leading to wider and unnecessary environmental, social and economic impacts. At higher tiers of detailed quantitative risk assessment, site-specific data and information of individual exposure scenarios are included in the conceptual model. Although the required level of risk-management is exactly the same as in a generic assessment, the inclusion of site-specific data commonly (but not invariably) results in a more customised and site-specific risk-management solution, and more optimised remedial objectives. The decision about which tier of risk-assessment to use is generally made on the basis of costs and benefits, that is to say the cost of additional site characterisation/risk assessment versus the potential for reduced remediation cost. However this decision can also have significant impacts on the wider sustainability of a remediation scheme. Progressing to a higher tier of risk assessment results in more accurate risk estimation, and consequently the resulting remediation should better address only those aspects that actually need to be managed (and by inference avoid unnecessary remediation and associated emissions, noise, traffic etc). In general it is considered that progressing to higher tiers of risk assessment, provided the relevant and appropriate data and information are collected to support that assessment, will lead to more sustainable remediation.

5 Recording decisions

Clear recording of decisions and of the assumptions made in reaching decisions on sustainable remediation is an important aspect of the SuRF-UK framework and is reflected in several of the Principles. Reliance on sound science and documentation of decisions are fundamental to communicating, consulting and reaching an outcome that all stakeholders recognise as being reasonable and equitable. A typical sustainable remediation assessment report is likely to be included within standard reporting, such as part of a risk assessment or remediation options appraisal report. The length and complexity of the report should be proportionate to the complexity of the project, but sufficient to explain the decision made to all stakeholders involved. It is likely to include the following:

1. **Sustainability assessment boundaries.** This should include the space, time, system and lifecycle that are being considered. Other assumptions and areas of uncertainty should be specified and recorded. Without defining these it is likely that a different result will be found by different people.

2. **Sustainability indicators used.** A list of sustainability indicators used and how these were considered relevant and applicable to the project should be shown. Data sources drawn upon should be presented so that the result can be justified.

3. **Sustainability method/technique used.** Describe the method used (e.g. qualitative assessment, multi-criteria analysis, cost-benefit analysis) and/or tool (proprietary or in-house tool) used for the assessment. Clarification should be made to its linkages with the conceptual site model, indicators and other assumptions.

Sustainable remediation should achieve risk management objectives, whilst having due regard to the costs and benefits associated with the available remediation strategies and techniques. As part of this process, it must be recognised that on occasions (particularly where remediation is a part of a wider redevelopment project) non-optimum remediation decisions will be made because other factors are more influential in optimising the overall benefits of a scheme. These may include, for example, demographic factors, legally-binding timescales in which to complete a project, flood-risk management and transport considerations (CL:AIRE, 2009).

How these decisions are recorded in the context of the SuRF-UK framework is shown in Figure 5.1.

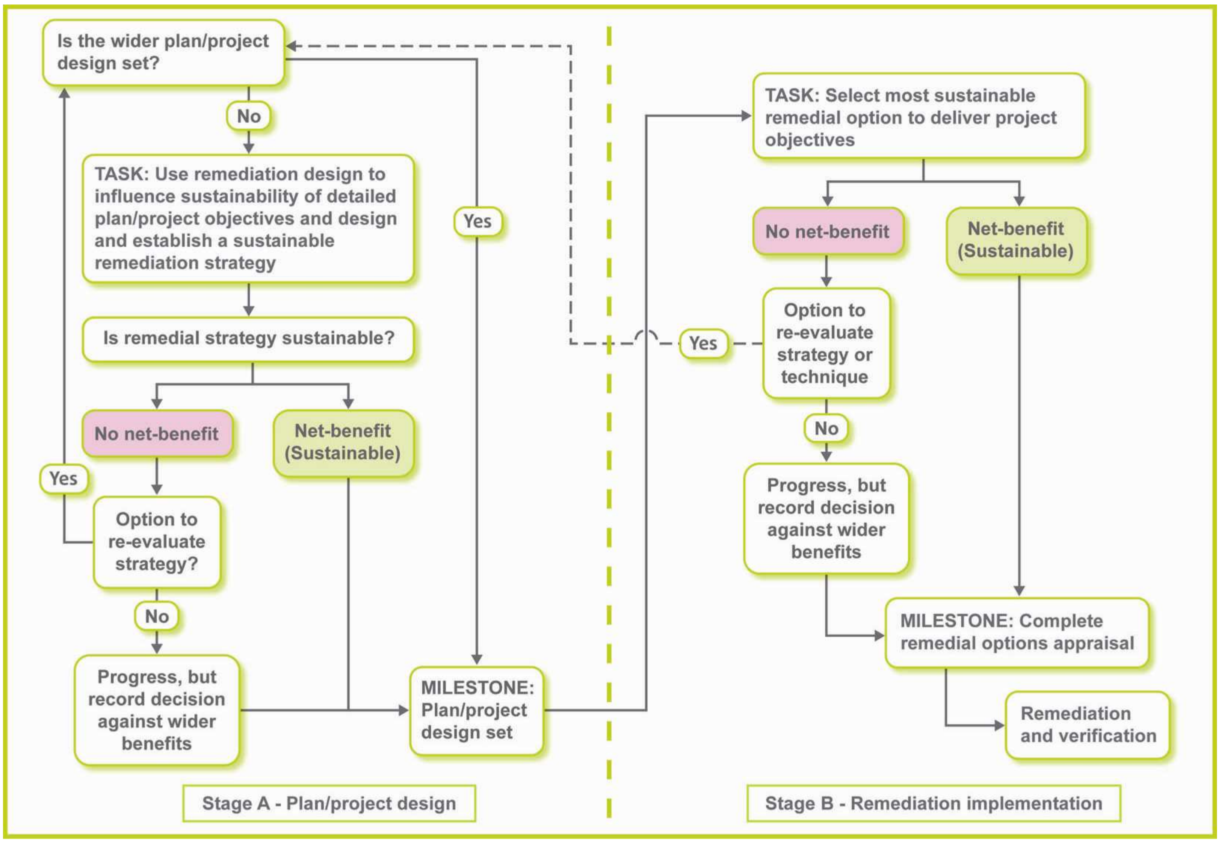

Figure 5.1: Recording decisions where no net-benefit accrues ('unsustainable').

6 Interactions of SuRF-UK with other sustainable remediation initiatives

Sustainable remediation is a rapidly developing research and environmental management topic internationally. This report is the first phase of work by SuRF-UK, and further work on sustainability indicators, metrics and tools is planned. A number of other initiatives are currently active, and are summarised below. There is on-going discussion between the various initiatives, participation by SuRF-UK steering group members in other initiatives, and collaborative work on specific tasks.

6.1 SURF

The Sustainable Remediation Forum (SURF[7]) was the first SURF initiative, based in the USA. It is a collaborative initiative of industry and consultancy members, with federal and state regulator participation, that seeks to develop understanding and methods for sustainable remediation principles that are relevant in a US policy and regulatory context. A thorough overview of sustainable remediation issues is presented in SURF (2009), and latest progress is provided at their website.

SURF's stated working concept is:

- "In fulfilling our obligations to remediate sites to be protective of human health and the environment we will embrace sustainable approaches to remediation that provide a net benefit to the environment. To the extent possible, these approaches will:
    - Minimise or eliminate energy consumption or the consumption of other natural resources.
    - Reduce or eliminate releases to the environment, especially to the air.
    - Harness or mimic a natural process.
    - Result in the reuse or recycling of land or otherwise undesirable materials.
    - Encourage the use of remediation technologies that permanently destroy contamination."

6.2 NICOLE

The Network of Industrially Contaminated Sites in Europe (NICOLE[8]) has a working group on sustainable remediation which seeks to establish a framework for sustainable remediation applicable across Europe. NICOLE is comprised dominantly of private-sector organisations and their approach largely reflects the views of industrial, remediation service-provider and consulting company members. SuRF-UK steering group members are working with NICOLE to ensure consistency of approaches, where appropriate.

NICOLE's working definition of sustainable remediation is:

- "A framework in order to embed balanced decision making in the selection of the strategy to address land [and/or water] contamination as an integral part of sustainable land use. Any definition must allow ability to:

[7] www.sustainableremediation.org.
[8] www.nicole.org.

- Make risk based decisions;
- Consider [and define] boundaries in time and space;
- Ensure a balance of outcomes can be achieved; and
- Consider land [and water] use first as part of the process.

- The basic decision-making rationale behind contaminated land management is a basis in risk assessment. However, the means of achieving risk management must in itself not place unreasonable demands on the environment, economy and society, the three key elements of sustainable development" (Bardos, 2008).

6.3 SuRF-Australia

SuRF-Australia[9] was established in 2009, under the co-ordination of Cooperative Research Centre for Contamination, Assessment and Remediation of the Environment (CRC CARE). SuRF-Australia is working to develop a sustainable remediation framework document applicable to the policy and regulatory framework in Australia. SuRF-UK and SuRF-Australia have close links and early drafts of the Australian framework draw heavily on the principles, definitions and approaches described in this SuRF-UK framework.

6.4 USEPA Green Remediation

'Green Remediation' as defined by the USEPA (2008) is an initiative to encourage the use of renewable energy in remediation activities, and the avoidance of unnecessary use of natural resources and waste generation. It is anticipated to lead, in due course, to development of an American Society for Testing and Materials (ASTM) standard.

The USEPA define 'Green Remediation' as "the practice of considering all environmental effects of remedy implementation and incorporating options to maximise net environmental benefit of cleanup actions". Green Remediation considers a range of impacts: air pollution caused by toxic or priority pollutants such as particulate matter and lead; water cycle imbalance within local and regional hydrologic regimes; soil erosion and nutrient depletion as well as subsurface geochemical changes; ecological diversity and population reductions; and emission of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and other greenhouse gases contributing to climate change" (USEPA, 2008).

A key difference between Green Remediation and the approach taken by SuRF-UK is that SuRF-UK seeks to consider remediation activities as part of the broader sustainable development objectives of the project, rather than simply to select the most 'environmentally-friendly' technology to achieve a given remedial objective. SuRF-UK considers that certain remedial activities and objectives may be 'unsustainable' regardless of the energy source used to achieve them. In these circumstances, the SuRF-UK Framework recommends reconsideration of the fundamental remedial objectives, which is beyond the scope of Green Remediation. Nevertheless, lessons learned through the Green Remediation initiative may be extremely valuable at the SuRF-UK technology selection stage.

[9] http://www.crccare.com/working_with_industry/surf.html.

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8 Glossary

Term	Contemporary Usage
Assessor	Any person who is involved in the process of assessing and judging [the sustainability of remedial strategies or techniques].
Best Available Technique (BAT)	The most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole. The words have the following definitions[10]: • 'Techniques' shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned; • 'Available' techniques shall mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator; and • 'Best' shall mean most effective in achieving a high general level of protection of the environment as a whole.
Best Practical Environmental Option (BPEO)	The outcome of a systematic consultative and decision making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as short term. (This is a UK definition[11] – other countries have similar definitions.)
Brownfield land	Land that has been previously used, interchangeably termed Previously Developed Land. Brownfield land may also be contaminated as a result of those previous uses.
Carbon balance / footprint	A carbon footprint is a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, typically measured in units of tonnes of carbon dioxide equivalent. A carbon balance is calculated by estimating the mass of carbon dioxide e.g. emitted in the various process steps of a system. The scope of a carbon footprint analysis may account for emissions on-site only, on-site including emissions from electricity generation, or throughout the entire supply chain. Related concepts are water and waste footprints.

[10] As defined in the EC Integrated Pollution Prevention and Control Directive (IPPC), 96/61/EC.

[11] As defined by the 12th Report of the UK Royal Commission on Environmental Pollution.

Term	Contemporary Usage
Contaminated Land	Land, which by virtue of the presence of substances in, on or under the land meets the statutory definition of Contaminated Land given under Part IIa of the Environmental Protection Act 1990.
Core aspect	Describes the activities and their outcomes that are a result of the core objectives and project specific factors and constraints. [See EA, 2000b.]
Core objectives	Those remediation objectives that need to be achieved in order to enable redevelopment; to reduce risks to human health, the environment and construction; to reduce liabilities, or some combination of the preceding, reached after consideration of site specific factors / constraints and taking into account the views of the stakeholders for that site. [See EA, 2000b.]
Cost Benefit Analysis (CBA)	A form of economic analysis in which costs and benefits are converted into monetary values for comparison.
Decision making role	The decision making role describes the type of decision making being supported, e.g. for managing a single site, or for prioritising a number of sites. This deals with the overarching decision being made at the site.
Decision support system	A decision support system is the complete decision making approach, including all of its components.
Decision support tool	A decision support tool supports one or more components of decision making. (Note some writers use "tool" and "system" interchangeably.)
Eco-efficiency	Is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle.
Evaluating wider impacts	Assessment systems for the key elements of sustainability appraisal (economic, environmental, resource and social evaluations).
Framework	A skeletal and fundamental structure, as for a written work, outlining a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality.
Green Remediation	United States Environmental Protection Agency (US EPA) definition of "The practice of considering all environmental effects of remedy implementation and incorporating options to maximise net environmental benefit of cleanup actions."
Headline indicator	Some indicators may be selected as headline indicators – usually because they describe key issues. They are often supported by a subset of indicators. Usually they form a quick guide or overview and can be used to engage public awareness and focus attention.
Indicator	An indicator is a single characteristic that can be compared between options to evaluate their relative performance towards specific

Term	Contemporary Usage
	sustainable development concerns. Indicators need to be measurable or comparable in some way that is sufficient to allow this evaluation.
Land contamination	Land which is affected by chemical or biological contamination. Includes both legally determined Contaminated Land under Part IIa of the EPA 1990 as well as land that contains contaminants but which does not meet the legal definition, or is not determined as so.
Land-cycle	The life cycle of a particular piece of land, to encompass its full history of operations, present setting, future aspirations and what is required to achieve those aspirations.
Lifecycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal [See ISO 14040:2006(E)]. Product System is defined as a collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product. [See ISO standards 14044, 14047, 14048, and 14049].
Lifecycle Assessment (LCA)	Compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle [See ISO 14040:2006(E)].
Lifecycle Inventory Analysis (LCI)	Phase of Life Cycle Analysis involving the compilation and quantification of inputs and outputs for a product throughout its life cycle [See ISO 14040:2006(E)].
Multi-Criteria Analysis (MCA)	Any structured approach to determine overall preferences among alternative options, where the options accomplish several objectives. It is often used in government to describe those methods which do not rely predominantly on monetary valuations [See Department for Communities and Local Government, 2009].
Non-core aspect	Describes the effects of and/or desires for a project not addressed by its core aspects. See also core aspect. [See EA, 2000b.]
Non-core objectives	Those secondary remediation objectives that need to be achieved after the core objectives have been set. For example, increasing the retail value of the site. [See EA, 2000b.]
Previously developed land	See 'Brownfield Land'.
Qualitative assessment	A non-quantitative assessment. One which measures impacts and benefits in a descriptive manner and without quantification.
Quantitative assessment	An assessment that uses (ideally objective) measurements of impacts and benefits in a numerically-based manner.
Remediation option	A means of reducing or controlling the risks associated with a particular pollutant linkage to a defined level.

Term	Contemporary Usage
Remediation strategy	A plan that involves one or more remediation options to reduce or control the risks from all the relevant pollutant linkages associated with the site.
Roadmap	A diagram showing the major steps necessary to reach a goal or decision.
Risk assessment	An evaluation of the magnitude and likelihood of a detrimental effect being caused by the presence of a hazard. In relation to contaminated land, an assessment of the magnitude and likelihood of harm or pollution occurring as a consequence of exposure to contaminants in the subsurface.
Risk management	The processes involved in identifying, assessing and determining risks, and the implementation of actions to mitigate the consequences or probabilities of occurrence.
Site/project specific	Pertaining to an individual site or project / dependent on individual site or project characteristics.
Stakeholder	Any individual or group that may be affected by, or have a direct interest in (and are therefore consulted about), the environmental contamination, or by a decision taken to manage such contamination. Stakeholders may include national, regional, and local regulators, members of the general public or their elected representatives, businesses, citizen groups including NGOs, site owners, environmental industry, and public health officials.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).
Sustainable remediation	SuRF-UK definition: 'the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process'.
Verification	The process of demonstrating that the risk has been reduced to meet remediation criteria and objectives, based on a quantitative assessment of remediation performance.

Appendix A: Local (Town and Country) planning scenarios

Within the UK, the Town and Country planning process develops regional and local spatial strategies and formally allocates land for different uses (e.g. employment, residential, retail, etc.). Sustainable development is a core goal of this process.

Remediation requirements represent one of the factors that can be considered when developing the optimal mosaic of land-uses and site-specific designation.

This is essentially a Stage A SuRF-UK framework process only, as shown in Figure A1, with knowledge of the likely remediation requirements of various sites influencing the land-use designation. It is not linked to Stage B remediation implementation since it is exclusively a decision-making process at local planning and the final milestone is the Local Development Framework (LDF) or Local Development Document (LDD).

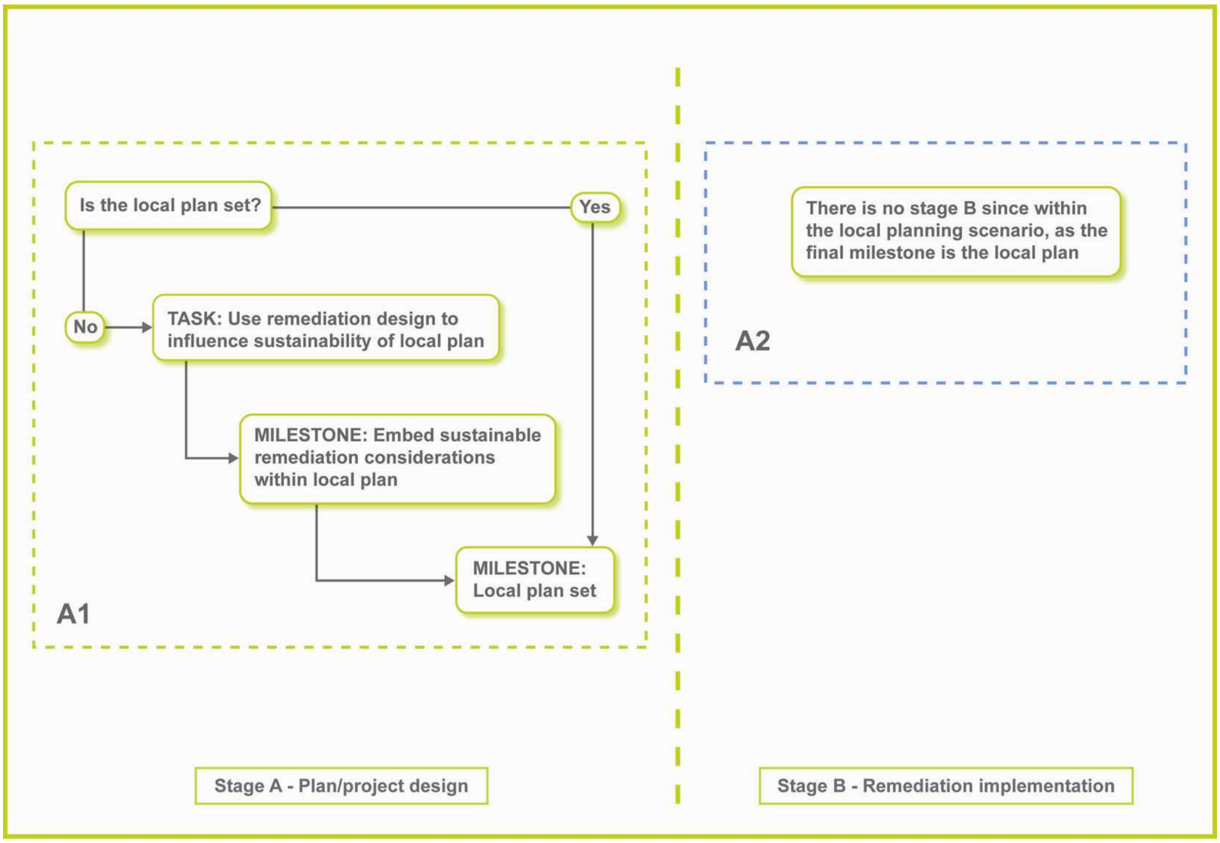


Figure A1: **How the SuRF-UK Framework applies to local planning as Stage A1 only.**

Appendix B: Brownfield land redevelopment

A parcel of brownfield land may be subject to two phases of design, firstly at local-scale planning level (as per Appendix A) and then at the site-specific level. In terms of the SuRF-UK framework a parcel of brownfield land could go through two cycles of the design stage: Stage A1 at local-level and then Stage A2 at a site-specific level, as shown in Figure B1.

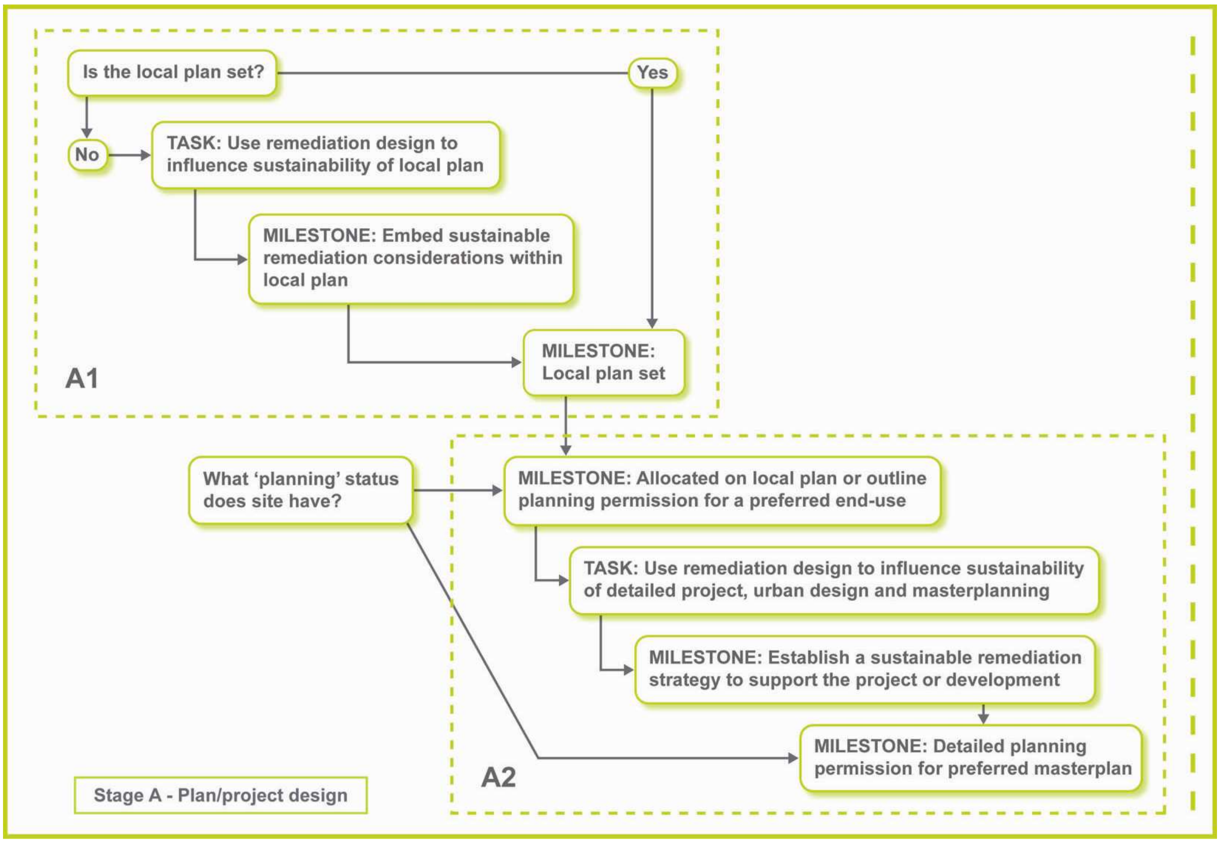


Figure B1: How the SuRF-UK Framework applies to brownfield redevelopment, covering Stages A1 and A2.

However, in practice the more frequent use of the SuRF-UK framework for brownfield land will be at a site-specific level where the local plan is set and only the site-specific design issues remain to be considered.

Site-specific design examples of sustainability considerations might include:

- Masterplanning and urban design of different land-use types in a mixed-use scheme, given different risk-based remediation criteria and a heterogeneous distribution of contaminants across a site (e.g. locate most vulnerable receptors and land-uses away from most contaminated areas);

- Considerations for basement parking related to remediation requirements (e.g. avoid excavating clean soil to create basements while at the same time remediating other soils *in-situ*);

- Location of sustainable drainage system (SuDS) related to remediation requirements (e.g. locate SuDS percolation areas in areas of clean soil to prevent leaching from contaminated soils); and

- Considering use of vapour membranes to intercept a potential 'pathway' rather than excavating and disposing of large volumes of soil (providing risks to other receptors, such as groundwater, are also appropriately protected).

In terms of any brownfield development scenario Stage A design will link to Stage B implementation, with the pre-break point milestone frequently being the granting of detailed (often called full) planning permission, as shown in Figure B2.

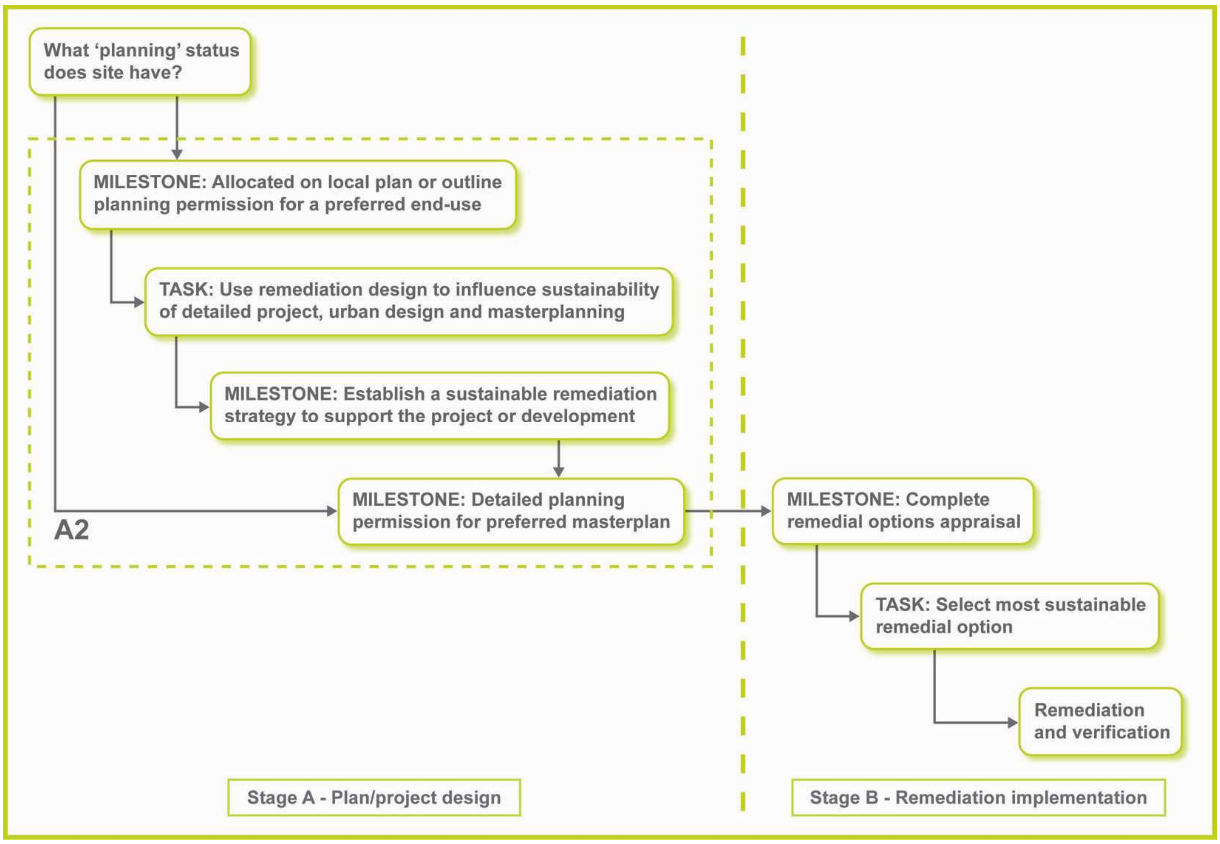


Figure B2: How the SuRF-UK Framework applies to brownfield redevelopment, covering both Stages A2 and B.

Appendix C: Remediation of operational land (no change of use)

Remediation work on operational land invariably drives the sustainability of the project since the remediation work is the project. Normally, establishing a sustainable remediation strategy to embed within the plan/project design and agreeing the overall project design contribute to the same milestone. Sustainable remediation decision in such circumstances making is shown on Figure C1.

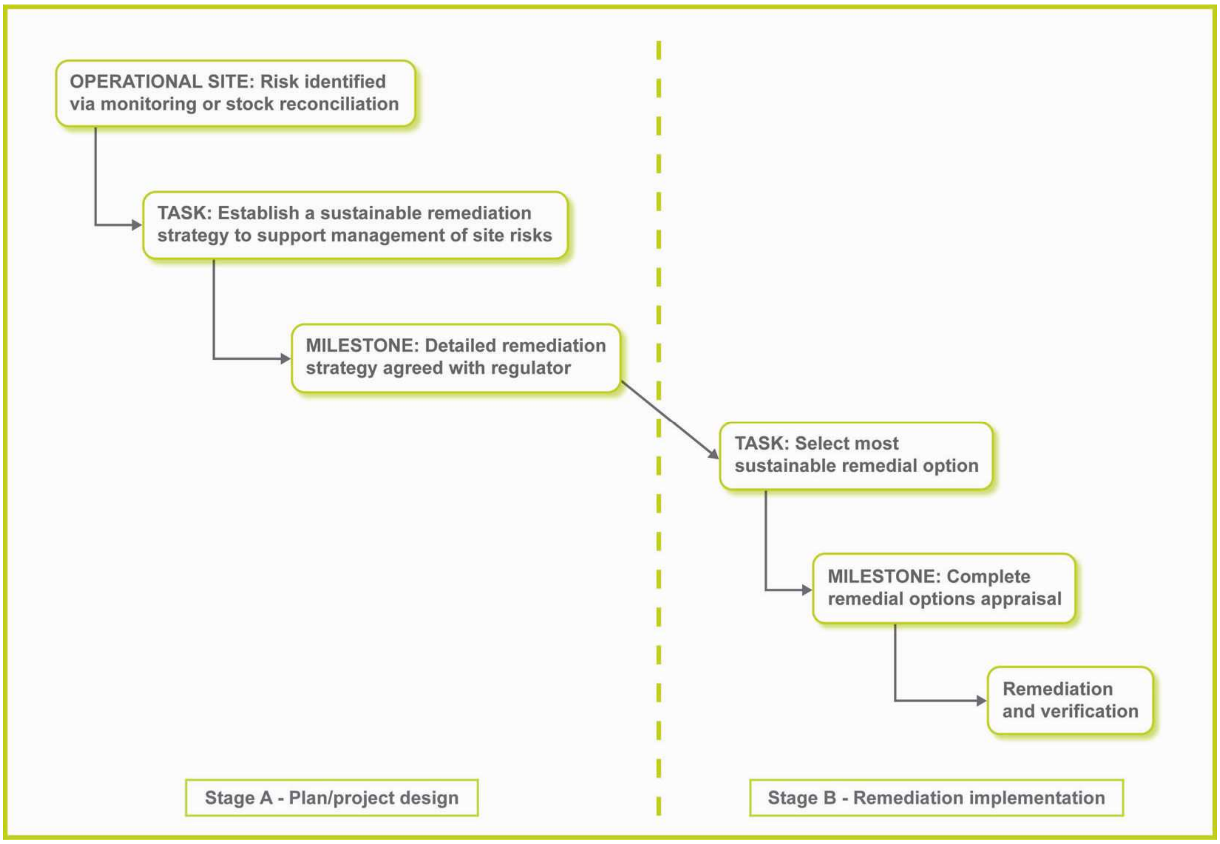


Figure C1: How the SuRF-UK Framework applies to the remediation of operational land, covering both Stages A and B.

Appendix D: Land restoration schemes

Remediation work as part of land restoration projects invariably represents one of the main drivers of the sustainability of the project since the remediation work is a significant part of project together with non-remediation earthworks.

Unlike brownfield development, the subsequent lifetime impacts of the scheme will be much less. Often, establishing a sustainable remediation strategy to embed within the plan/project design and agreeing the overall project design is the same milestone.

It is possible that the remediation design is an integral part of the overall project design, for example where soil materials and organic matter are brought on site both to support the growth of particular vegetation and as part of a risk management (pathway interception) strategy.

Like the brownfield scenario, Stage A design will link to Stage B implementation, as shown in Figure D1, with the pre-break point milestone frequently being the granting of detailed (often called full) planning permission.

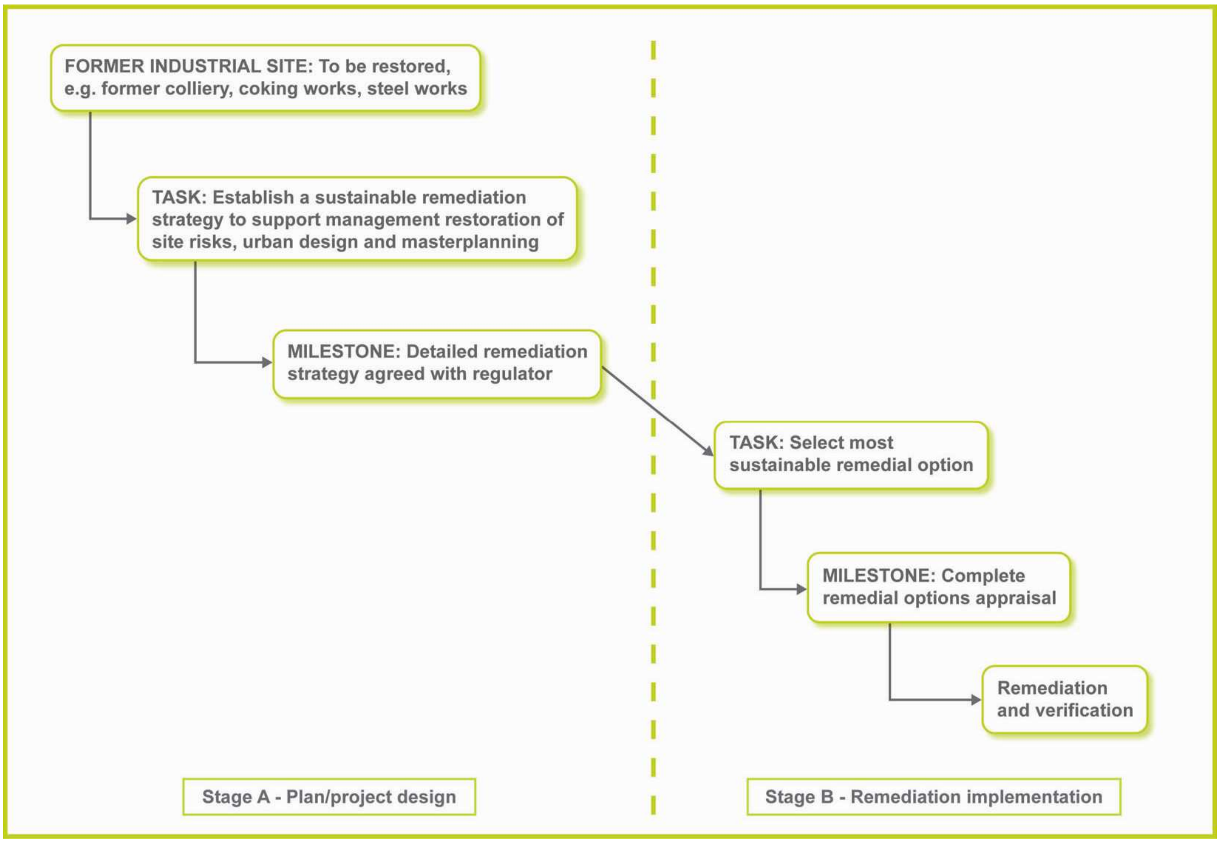


Figure D1: **How the SuRF-UK Framework applies to land restoration schemes, covering both Stages A and B.**

Appendix E: Remediation implementation only

The SuRF-UK framework recognises that in many circumstances, a practitioner does not have an opportunity to influence the design work. They are only asked to implement the remediation solution to deliver the design requirement. This represents a Stage B framework process, as shown in Figure E1.

At this stage the remediation options appraisal can only seek to identify the technologies or techniques to achieve risk-based remedial objectives and also optimise the net (social, environmental and economic) benefit provided by the remediation.

Operating with Stage B is effectively the realm of Green Remediation as described in Chapter 6 of this framework document.

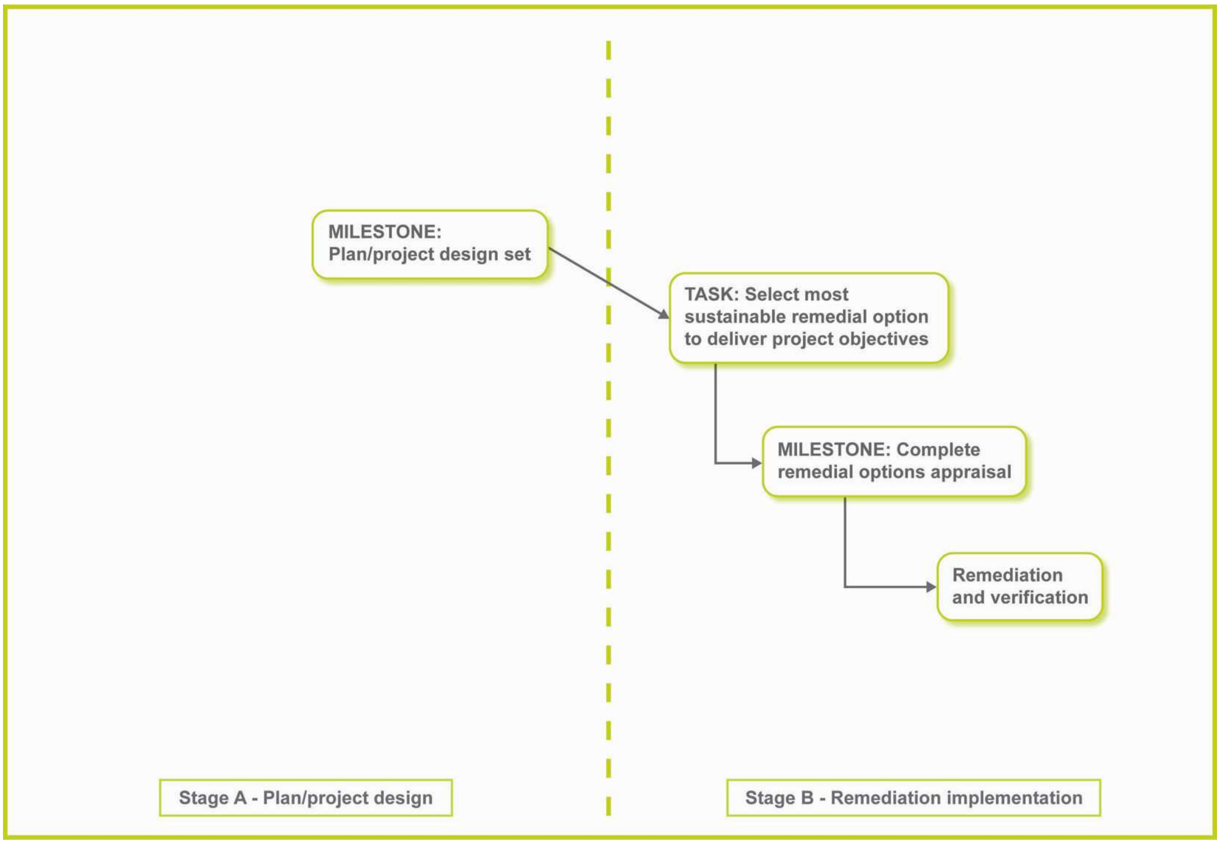


Figure E1: How the SuRF-UK Framework applies to remediation implementation, being effectively Stage B only.

Appendix F: Some techniques used in sustainability assessments

Technique	Overview Description
Cost Benefit Analysis (CBA)	Cost Benefit Analysis (CBA) is widely used in policy and project appraisal in both the private and public sectors, for example the Green Book (HM Treasury). CBA is a form of economic analysis in which costs and benefits are converted into monetary values for comparison. The aim of an assessment of costs and benefits is to consider the diverse range of impacts that may differ from one proposed solution to another such as the effect on human health, the environment, the land use, and issues of stakeholder concern and acceptability by assigning values to each impact in common units. Deciding which impacts to include or exclude from the assessment is likely to vary on a site-by-site basis. In many instances, it is difficult to assign a strictly monetary or quantitative value to many of the impacts. Hence, assessments can involve a combination of qualitative and quantitative methods. It is also useful to include a sensitivity analysis step, particularly where this encourages decision-makers to question their judgements and assumptions through the eyes of other stakeholders (Eunomia *et al*., 2002, Hanley and Spash, 1994). However, CBA has some serious weaknesses (Therivel, 2004), which include the following: there is no standard "checklist" of indicators, so CBA is highly specific to the circumstances and method used for each particular assessment; the valuation procedures for public costs are both highly technical and also subject to serious inherent weaknesses.
Cost Effectiveness Analysis (CEA)	Cost-effectiveness analysis (CEA) is a simplified derivative of cost-benefit analysis. The aim of CEA is to determine "…the least cost option of attaining a predefined target…" without a monetary measurement of benefits (DETR, 1999). Costs are calculated conventionally and benefits are scored individually. An aggregate score for benefits is then divided by cost to provide a measure of "cost effectiveness". The derivation of scores is an application of MCA. An example applied to land remediation is given by Harbottle *et al*. (2008a and 2008b).

Technique	Overview Description
Lifecycle Assessment (LCA)	Life cycle assessment (LCA) is a technique to evaluate the environmental consequences of products or services from cradle-to-grave, and their use (Wrisberg *et al*., 2002). In the context of contaminated land, such a function might be the remediation of a contaminated site. CHAINET describes the main features of LCA as follows: • LCA follows a cradle-to-grave approach: all processes connected with the function, from the extraction of resources until the final disposal of waste, are considered. • LCA is comprehensive with respect to the environmental interventions and environmental issues considered. In principle, all environmental issues connected with the function are specified as resulting from extractions, emissions and other physical interventions like changes in land use. LCA may provide quantitative or qualitative results. With quantitative results it is easier to identify problematical parts of the lifecycle and to specify what can be gained by alternative ways to fulfil the function. LCA reports may also be accompanied by assessments of the economic cost of any impacts reported (e.g. “human toxicity” and may include impacts that could be considered social rather than environmental such as injuries at work (Koneczny and Pennington, 2007). LCA based approaches have been used in several decision support tools for remediation assessment. Perhaps the most widely used of these tools is the Dutch REC system. The REC approach derives quantitative criteria for “risk reduction” (R), “environmental merit” (E) and “cost” (C). The “environmental merit” assessment is based on a Life Cycle Assessment related approach (Bardos *et al*., in Publication).
Multi-Criteria Analysis (MCA)	Multi-criteria analysis (MCA) is often used in decision making. MCA is a structured system for ranking alternatives and making selections and decisions. Considerations used in MCA are: how great an effect is (score) and how important it is (weight). MCA describes a system of assigning scores to individual effects (e.g. impact on traffic, human health risk reduction, use of energy etc). These can then be combined into overall aggregates on the basis of the perceived importance (weighting) of each score. With MCA, ranking and decision making processes can be made very transparent (EA, 2000b, Wrisberg *et al*., 2002). A range of qualitative sustainability appraisal techniques have been published based on scoring systems, for example for regional spatial strategies (ODPM, 2005b). These are typically fairly simple. The technique developed in the MOD Sustainability and Environmental Appraisal Tools Handbook (MOD, 2006) is more detailed. MCA is a more sophisticated technique for combining scores and weightings that can be applied to sustainability appraisal or aspects of it (e.g. Harbottle *et al*., 2008a, 2008b).

Technique	Overview Description
	MCA is not a technique that directly analyses physical information or monetary information. Rather it is an analytical technique at a higher level, bringing together different considerations in a structured way. However, techniques such as CBA, CEA and LCA apply MCA principles in their use of weightings, scoring (valuations) and aggregation. MCA describes a range of techniques, and at its most complex might include analyses of individual preferences of stakeholders for weightings and quantitative valuations (such as LCA techniques) for deriving scores.

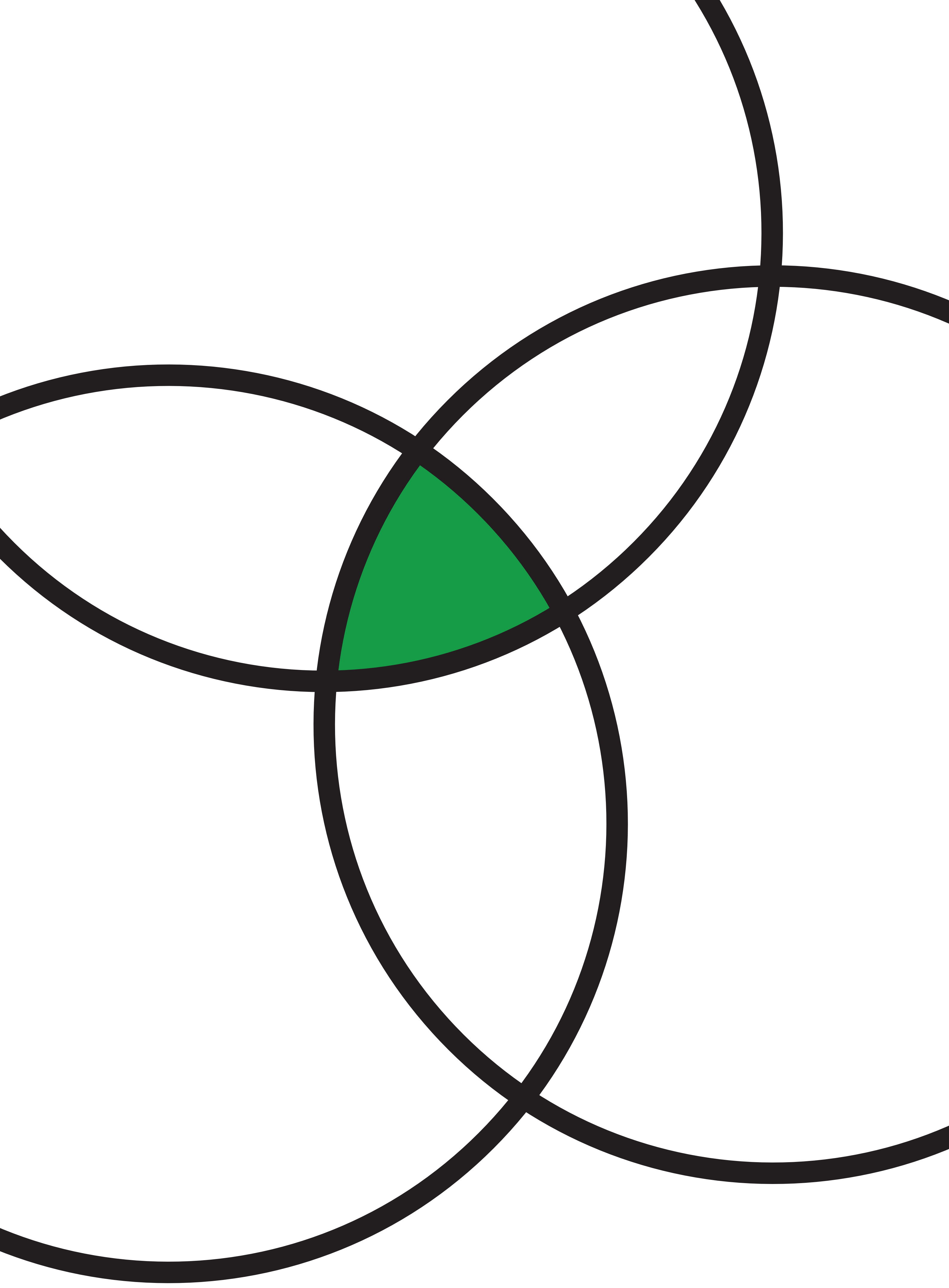
Appendix G: Pros and cons of scoring, weighting and ranking sustainability criteria

There is no perfect approach to "valuing" and aggregating different sustainability criteria. Particular stakeholders may prefer an approach based on using ranking, scoring and weighting, or an approach linked to some form of quantification, such as a cost benefit analysis. Each has its advantages and its disadvantages.

Both scores and weightings are numeric values that are supposed to be suggestive of quantity or metric, without having to carry out a formal valuation. **A score addresses the question 'how much'**, for example 'how great is the impact on the water environment?'; **a weight addresses the question 'how important'**, for example 'how important are effects on the water environment compared with other environmental, social or economic effects?'. They reflect opinions of the assessors carrying out the sustainability appraisal, who may ask other stakeholders to comment to get an overall agreed score and/or weight. In some cases scores may be linked to a quantification of an effect, where that effect is measurable or can be estimated in some way, such as risks from contaminants (e.g. Harbottle *et al.,* 2008a, 2008b).

Systems that use **scores** and **weightings** are sometimes described as being semi-quantitative. Opinion-based scores and weightings have significant disadvantages, as they have no direct valuation step. Not only is the scale of effect (or importance) entirely subjective, but the numeric value given will likely vary from person to person. For example, one person's "++" may be another's "+"; one person's "6 out of 10", another's "4 out of 10". This opinion-based approach to valuation for scores and weightings is therefore not always reliable, and this may limit the acceptability of the outcome. For instance, if one assessor disagrees with particular scores and weightings they may reject the sustainability appraisal in total. Where the prevailing view is that scores must be used, it is better to base these on a formal quantification, but this may not be possible for all indicators (e.g. effects on landscape). The use of weightings may be particularly contentious. Certain stakeholders may argue that particular indicators are more important than others because these link to their current set of political, organisational or corporate priorities. However, from a holistic point of view, sustainability does not depend on such organisational priorities. Weightings can be a cause of dissent between different stakeholder interests, who may have different perceptions of the importance of different indicators.

Rankings have the advantage that they can be directly linked to available evidence without the need for a quantitative valuation process, yet generate a number which can be manipulated in an aggregation process for sustainability appraisal indicators. This avoids the subjectivity of scoring or weighting. Rankings are also very effective where an indicator may not be capable of easy quantification or valuation, for example an indicator considering impacts on a landscape. Indeed, in this situation ranking also readily distinguishes the possibly different views of different stakeholders in a way that is transparent and robustly linked to each party's evidence or rationale. Rankings are efficient in terms of decision-making effort as they avoid stakeholders wasting effort on whether a particular option should be scored, say, "+" or "++", or 60% versus 65% etc. This could amount to a significant amount of time saved for several options being compared over a large indicator set, particularly as scoring or weighting could be linked to an intuitive ranking in any case. However, ranking is subject to a significant limitation. The limitation of a ranking is that it does not convey the scale of differences, for example a difference between two options for a particular indicator could equate to 20% or 200%; the ranking would still be 1, 2 or 3, 4, etc.



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