

## INFORMATION NOTE

BY KIERON DOICK AND TONY HUTCHINGS OF FOREST RESEARCH

DECEMBER 2007

### SUMMARY

This Information Note describes investigation of brownfield land for potential redevelopment into greenspace. Written for site owners, foresters, planners, managers and consultants, it gives step-by-step guidance on site selection and evaluation. Brownfield sites are exemplified by site variability, soil infertility and hazards. An important objective of site evaluation is to identify and quantify potential risks and liabilities, such as contamination, that may be present on site. The presence of a significant pollutant linkage categorises a site as contaminated. The process of identifying and managing pollutant linkages is described. Importantly, the categorisation of contaminated land will not apply to all sites considered for greenspace establishment; examples of the opportunities to progress efficiently through site evaluation to greenspace establishment are given. It is important that key decisions are correct, accountable and substantiated. Attention should be given to the overall sustainability of the site including inclusive accessible use, sustainable establishment of vegetation, environmental protection and enhancement. The foundations of a quality greenspace establishment project are effective site selection and preparation; success will be manifested through site sustainability and local community involvement.

### INTRODUCTION

#### Background

This Information Note describes a method for the selection and investigation of brownfield sites for re-development into community greenspace. The term 'brownfield' describes 'previously developed land', which is defined as land which *is or was occupied by a permanent structure (excluding agricultural or forestry buildings) and associated fixed surface infrastructure* (Department for Communities and Local Government, 2006). The establishment of greenspace on brownfield land can provide many social and environmental benefits, such as opportunities to walk and cycle, increased wildlife and flora, and reduction in noise and air pollution. It can also contribute to the economic regeneration of an area. Greenspace establishment embodies the government's drive towards sustainable development (Office of the Deputy Prime Minister, 2003; 2004).

The national forest strategies for Scotland, England and Wales (Forestry Commission Scotland, 2006; Department for Environment, Food and Rural Affairs, 2007; Forestry Commission Wales, 2001) contain commitments to the regeneration of brownfield land into community woodland and greenspace. Consequently, the Forestry Commission is committed to the establishment of new woodland and to delivering a comprehensive package of

urban, economic and social regeneration through greenspace establishment, for example through the Community Forest Partnership. A 'soft' end-use, greenspace can require less stringent remediation objectives than the building of residential properties (stringency increases in the order: industrial < open space < domestic). Furthermore, trees and plants have been shown to demonstrate huge potential in the reclamation and remediation of brownfield land (Hutchings, 2002).

#### Legislation

Like other industrialised countries, the UK has a legacy of urban and peri-urban brownfield sites, many of which are potentially contaminated (Environment Agency, 2004) (see Defining Contaminated Land on page 4). Current planning guidelines specify that the redevelopment of land in England, Scotland and Wales must ensure 'suitability for use'. In other words, all risks at a site must be assessed and evaluated according to the intended use of the land. Concurrently, Part IIA of the Environmental Protection Act 1990 (Department for Environment, Food and Rural Affairs, 2006) (subsequently referred to herein as Part IIA) requires all local authorities to inspect their area for contaminated land and to secure its remediation to a condition that is suitable for current types of use based upon 'fitness for purpose' principles. Part IIA was implemented in April 2000 in England, July 2000 in

Scotland and July 2001 in Wales. Importantly, not all sites considered for re-development as greenspace will be defined as contaminated land. However, under current legislation an assessment is required to identify all of the risks present at a site and those that may arise following modification, alteration or management, for example as community greenspace.

Other legislation that should also be considered in re-development of brownfield land includes statutory nuisance, food safety, health and safety, waste and landfill legislation; and planning and development control (via the Department for Communities and Local Government). Water legislation (including the Water Resources Act 1991 and the Groundwater Regulations 1998) and the Pollution Prevention and Control Act 1999 should also be considered in consultation with the Environment Agency (Department for Environment, Food and Rural Affairs, 2006).

## Objectives of this Information Note

The objectives of this Information Note are to highlight to site owners, foresters, planners, managers and consultants:

- the processes of site selection and investigation;
- the importance of the site selection process, site assessment, site evaluation and stakeholder involvement to successful greenspace establishment;
- statutory obligations concerning protection of the environment, human health, property, water courses and cultural and natural heritage;
- site properties and characteristics conducive to the sustainable establishment of vegetation and greenspace habitats (including soil, water and hazard assessments);
- what to expect and what to do next, step-by-step.

## OVERVIEW OF GREENSPACE DEVELOPMENT

A greenspace development project can be considered as a four-step process (Figure 1): Step 1: Identification and reclamation, Step 2: Consultation and design, Step 3: Implementation and delivery, Step 4: Management and maintenance. This Information Note is principally

concerned with the actions undertaken in Step 1 - site identification and reclamation. Actions undertaken in Steps 2–4 are discussed in brief to highlight that success at each step is highly dependent upon the effectiveness of preceding steps. An overview of each step is given below to outline the greenspace development process and to set the scene for this Information Note.

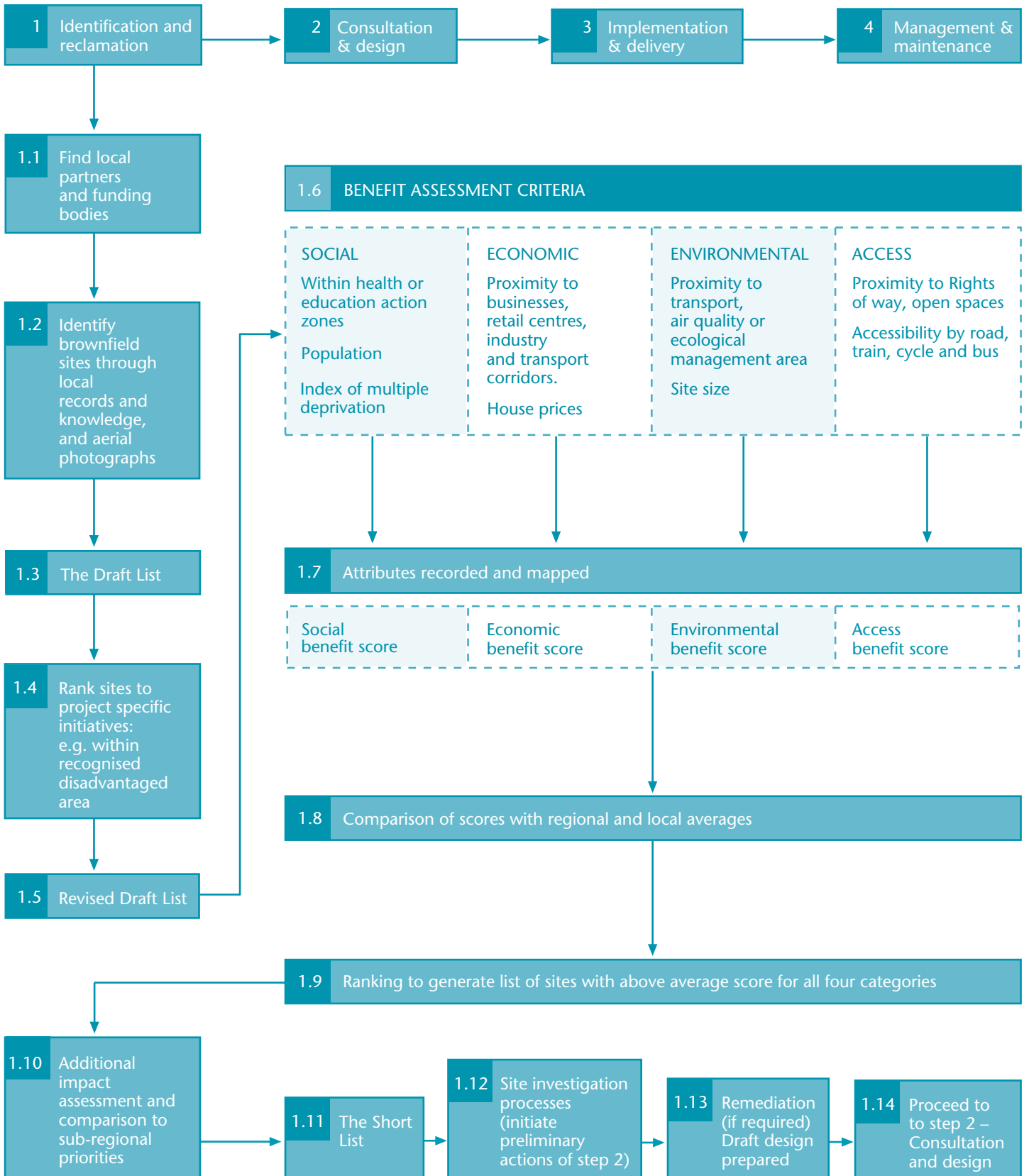
Step 1 can be divided into: site identification and shortlisting according to local availability, project goals and regional priorities; evaluation of shortlisted sites according to soil conditions, likely impacts of vegetation establishment, liabilities and risks, and remediation of unacceptable risks. Alternatively, the site may be dropped from the shortlist. Step 2 can be divided into consultation of statutory and non-statutory stakeholders and design of the master plan for implementation. Step 3 is the implementation step where the reclaimed site is regenerated into a greenspace. Delivery comprises civil engineering of infrastructure (and possibly buildings), provision of facilities and services (e.g. lighting), ground preparation, planting and fencing. Step 4 comprises management, monitoring and maintenance and the on-going processes of health and safety assessments, habitat care, community liaison and pest control.

## SITE IDENTIFICATION AND SHORTLISTING

There are many potentially suitable sites in the UK for re-development as greenspace and it is recommended that a shortlist is made of the sites with the highest potential to provide an optimal range of social, environmental and economic benefits. The Newlands Initiative ([www.forestry.gov.uk/newlands](http://www.forestry.gov.uk/newlands)), a joint North West Development Agency and Forestry Commission project, has developed procedures for identifying and shortlisting sites which have become a model to use for other sites. The procedures are: preliminary site identification; site scoring and ranking according to their advantages and constraints. The scoring uses the 'Public Benefit Recording System' (PBRS) (Public Benefit Recording System, 2006), which considers four topic areas – social, economic, environment and access (Figure 1). A variety of indicators are assessed for each topic, points assigned and the four totals, whilst retaining equal weighting, are used to compare and rank sites based on the benefits that the site would provide, and from that, a shortlist of the most suitable sites can be drawn up.

**Figure 1**

Overview of the four steps in the greenspace development process. Step 1 is given in detail to reveal the process of site selection and ranking. Steps 1.11–1.14 are presented in detail in Figure 2.



# EVALUATION OF SHORTLISTED SITES

## Code of practice

The Forestry Commission asserts that the establishment of woodland and associated greenspace should be in line with environmental good practice, that natural and cultural heritage and important features of the landscape are protected, and that UK Government policy and objectives are observed. Therefore, shortlisted sites are evaluated in detail using desk-top studies and site surveys according to British Standards Codes of Practice (e.g. BSI, 1999 and 2001), and guidelines from government departments and bodies (e.g. Forest Research, 2005a-d; Environment Agency 2000 and 2004; Department for Environment, Food and Rural Affairs, 2006; Office of the Deputy Prime Minister, 2004 and 2005).

## Evaluation of soil condition and the impacts of vegetation establishment

The abundance of soil, its fertility and potential to sustain vegetation, and the consequences of tree and plant growth, such as potential damage to pollution control measures or cultural heritage, all contribute to the overall success and sustainability of a greenspace project. Brownfield land is typified by site variability, site instability, poor drainage, potential contamination, soil infertility and underground hazards (Moffat and McNeill, 1994). Consequently, the soil environment is a focal point of site investigations and it is important to continually address four questions throughout the site investigation process:

- Will the site support trees/vegetation? (Particular consideration should be given to the water holding capacity, contamination, fertility and nutrient status, physical soil characteristics, soil cover and rootable depth, and topography of the site).
- Will the establishment of the greenspace generate, amplify or negate risks and hazards?
- Will vegetation establishment adversely affect the site?
- How will the site be managed in the short and long term?

A checklist of information to be collected is given on page 20.

## Evaluation of Risk and Liabilities

A vital component of evaluation is the assessment of risks and liabilities for each shortlisted site, incorporating the following objectives:

- Identify the potential risks and liabilities that may be present on a site, including the potential for contaminated land.
- Comprehensive review of potential end-uses for the site.
- Assess the potential for, and likelihood of, success of the site for greenspace development.
- Protect developers and future users.
- Protect health of the environment.
- Ensure reclamation does not increase current risks or create new risks.

Details on the definition, identification and management of contaminated land are given below.

## DEFINING CONTAMINATED LAND

As a consequence of industrial usage, brownfield sites have the potential for residual contamination. Some of the brownfield sites shortlisted may not be contaminated. However, a full evaluation is a must as it helps to identify which shortlisted sites will proceed to Step 2: Consultation and design. Contaminated land is defined as *any land which appears to be in such a condition, by reason of substances on, in or under the land, that: a) significant harm is being caused or there is a significant possibility of such harm being caused; or b) pollution of controlled waters is being, or is likely to be caused.* (Department for Environment, Food and Rural Affairs, 2006; s78A(2) of Part IIA of the Environmental Protection Act 1990).

A definition alone does not identify contaminated land; it does not detail the assessment criteria or inform on what to do. Dealing with contaminated land is about risk management, it is a process of *identifying, assessing and judging risks; taking actions to mitigate or anticipate them; monitoring, and reviewing progress* (Environment Agency, 2004). The definition of 'risk' is the combination of the probability (or frequency) of occurrence of a

defined *hazard* and the magnitude (including the seriousness) of the consequences of the occurrence. Where: a ‘hazard’ is an event or situation (including a contamination source) which has the potential to cause ‘harm’ to targets of concerns (i.e. receptors). Harm may refer to, for example, disease, death or reduced yield (Environment Agency, 2004). Harm is described in greater detail below.

Simply, a hazard can be a cracked paving slab. Therefore, the risk is the probability (or likelihood) that someone will trip on the cracked slab and fracture a bone. Similarly, a hazard may be a container of organic solvent waste dumped in a field. The risk is the probability that the container will leak and detrimentally affect life in the vicinity. Risk can be expressed numerically or literally. For example, one in every 10 000 people are likely to fall on the broken slab and break a bone (i.e. a 1 in 10 000 chance); or, there is a very low risk of a person falling on the broken slab and breaking a bone.

In the context of land contamination, there are three essential elements that must be present to constitute viable risk:

A **source** – a substance (contaminant) that is in, on or under the land and has the potential to cause harm, or to cause pollution of controlled waters, and may be point, linear, localised or diffuse.

A **pathway** – a route or means by which a receptor can be exposed to, or affected by, a contaminant. A pathway may be via groundwater, surface water or sediment, via drains, air/dust or vapour, via direct contact (ingestion or dermal), via plant uptake or via the food chain.

A **receptor** – something that could be adversely affected by a contaminant, such as people, an ecological system, property or water body (Table 1). A comprehensive summary of potential receptors is required to fully evaluate the potential impact of contaminant sources.

The linked combination of source–pathway–receptor is termed ‘pollutant linkage’ (Figure 2). Although each of the three elements may exist independently, they must all be present and linked to constitute a pollutant linkage and, therefore, a viable risk. A site will be designated as contaminated land if the pollutant linkage is *significant* – i.e. significant harm will, or is likely to, be caused to the receptor. The conditions considered to constitute significant harm to the various receptors protected under Part IIA are detailed in the harm tables of the legislation guidance (Department for Environment, Food and Rural Affairs, 2006) – see the Appendix on page 19 for a summary.

The following section details the identification and management of contaminated land, via the risk management process, within the context of Step 1 of greenspace development: site selection and reclamation.

**Table 1**

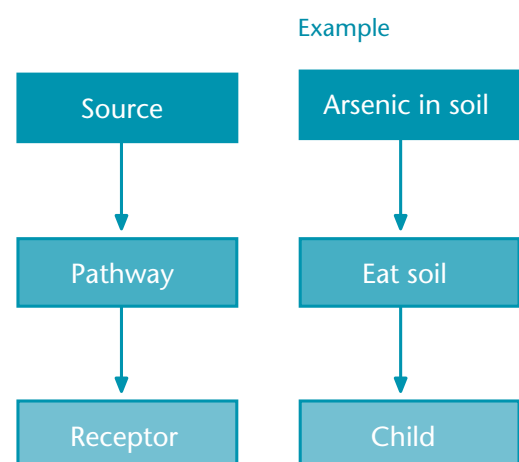
Summary of sources, pathways and receptors used in the determination of potential pollutant linkages.

Sources (contaminants)	Pathways	Receptors
<b>List I substance</b> e.g. heavy metals such as mercury and cadmium; organotin; mineral oils; hydrocarbons	Ingestion Inhalation Dermal Vegetative Subsurface	Humans (current, future and adjacent users)
<b>List II substance</b> e.g. potentially toxic elements such as arsenic, copper, nickel, zinc; also, biocides and derivatives and groundwater contaminants (including those that [potentially] degrade taste and cause odour)		Ecological (floral or faunal; individual, community, population, ecosystem)
		On- or off-site controlled waters (including: coastal, inland, groundwater and soil pore water)
		Property I: livestock and pets, crops and timber, allotment produce, wild animals subject to fishing/shooting rights
		Property II: buildings (including scheduled ancient monuments)

Pathways may apply to list I or list II sources and multiple receptors.

**Figure 2**

A pollutant linkage



# RISK MANAGEMENT: IDENTIFICATION AND MANAGEMENT OF CONTAMINATED LAND

Risk management is the process of identifying and evaluating risks, and then taking and monitoring mitigating actions as required. Risk management can be divided into risk assessment–hazard identification, hazard assessment, risk estimation, risk evaluation; and risk reduction – remediation, verification. Environment Agency guidelines described the risk management process as: risk assessment; options appraisal; and implementation of the remediation strategy (Environment Agency, 2004). Figure 3 presents risk management as directed to the greenspace establishment process and Figure 4 presents this risk management process step-by-step including details on key decisions such as options to exit the process; to proceed with purchase; undertake further enquiries; remediate land; or to conduct monitoring. Risk management is a phased process. One or more of the phases may be necessary to determine which shortlisted sites proceed to greenspace development, with decisions made on a site-by-site basis.

## Risk Assessment

Risk assessment consists of Phase I: the Preliminary site investigation (or Preliminary risk assessment) and Phase II: Intrusive site investigation (or Quantitative risk assessment). The Preliminary site investigation identifies and assesses hazards to determine the potential for risk (e.g. pollutant linkages). The Intrusive site investigation describes the site risks in greater detail through sampling, analysis and interpretation. The requirement for a Phase II depends on the findings of the Phase I (i.e. risks, liabilities and uncertainties identified).

## Phase I: Preliminary site investigation

The Forestry Commission guidelines for woodland and associated greenspace establishment requires a comprehensive Phase I investigation (Boxes 1 and 2 on page 9, Figure 3). The information obtained enables a conclusion to be drawn on the feasibility of a site for greenspace establishment; determines whether community greenspace establishment is the appropriate end use for the site; and enables decisions to be made about how best to proceed to Phase II.

**Figure 3**

Flowchart of key stages in site investigation processes (risk assessment and management) at potential sites for greenspace establishment. Risk assessment enables the evaluation of hazards, risks and liabilities at shortlisted sites and, consequently, protection of environmental and human health. Phase I processes are common to all sites. At the end of Phases I, II, III and IV the decision is made to progress to the next phase, to progress directly to Step 2 Consultation and design, or to not to proceed with the greenspace development process. Following evaluation and remediation of risk the brownfield re-development process proceeds to Step 2 Consultation and design and this progression is presented at the end of the figure for completeness.

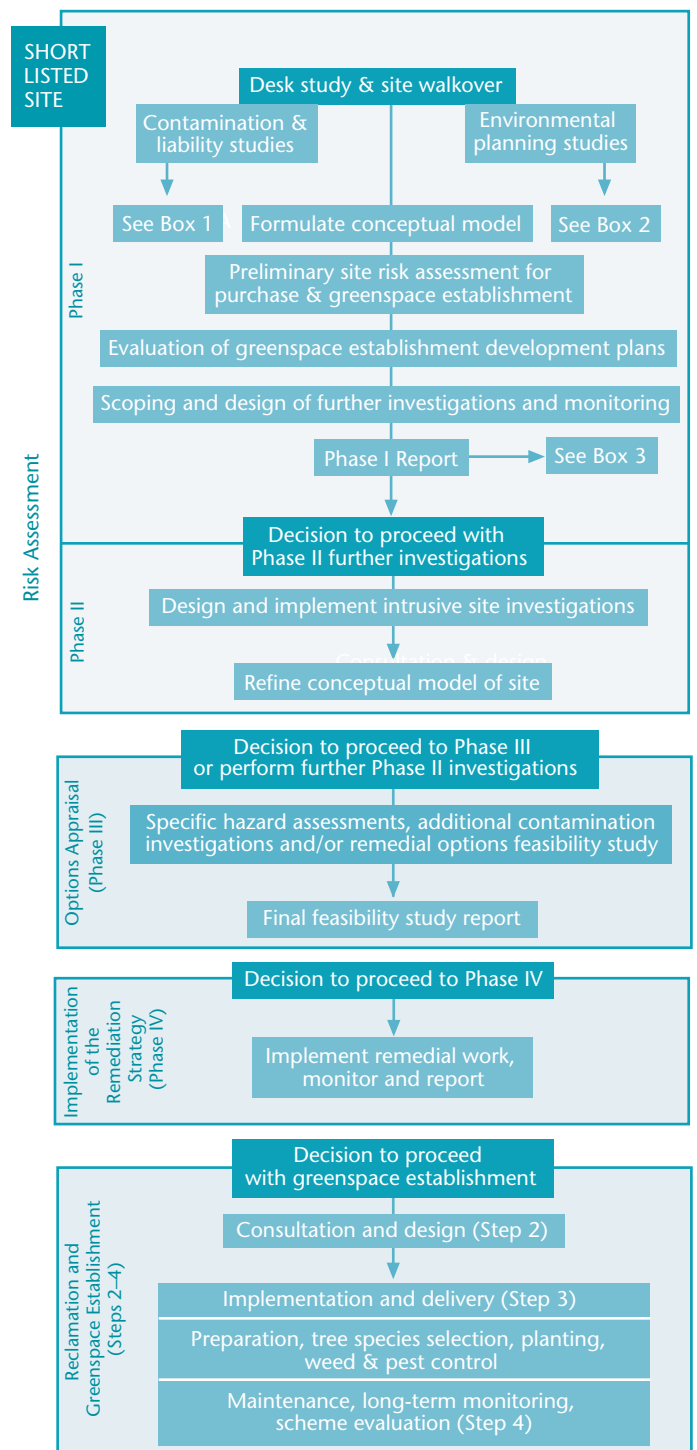


Figure 4

Summary step-by-step guide to the assessment and management of land contamination.

Phase		Step-by-step	Outputs obtained
Risk assessment Phase I: Preliminary investigation	Phase Ia Hazard identification	<ul style="list-style-type: none"> <li>• <b>Define context</b> and state primary objectives</li> <li>• Desk study</li> <li>• Construct site plan and establish user history and contaminant sources (archive search)</li> <li>• Collate previous site data</li> <li>• Consult with authorities and regulators for planning consents, statutory consents</li> <li>• Environmental health, services and building control report, planning consents</li> <li>• Anecdotal and local business information</li> <li>• Detail site topography; geology; hydrogeology; hydrology; geotechnical stability; climatic, atmospheric and general environmental conditions</li> </ul> <p><b>Site walk-over</b></p> <ul style="list-style-type: none"> <li>• Scoping ecological survey</li> <li>• Scoping heritage/archaeology survey</li> <li>• Screening soil survey (type, quantity, suitability for use)</li> <li>• Soil-forming materials survey</li> <li>• Characterise physical hazards</li> </ul>	<ul style="list-style-type: none"> <li>• Detailed summary of site history</li> <li>• Primary zonation of site according to the likelihood of presence of contamination</li> <li>• Contamination and liability study</li> <li>• Environmental planning study</li> <li>• Conceptual model of site</li> <li>• Identification of need for in depth ecological/heritage surveys</li> <li>• Lists of: <ul style="list-style-type: none"> <li>- Possible contaminants</li> <li>- Potential exposure routes</li> <li>- Potential pollutant linkages</li> <li>- Risks to site users and neighbours</li> <li>- Environmental assets to be preserved/ promoted</li> <li>- Assumptions</li> <li>- Limitations</li> <li>- Uncertainties</li> <li>- Site constraints (physical hazards, drainage limitations, subsurface buildings/structures, longterm maintenance issues, liabilities)</li> <li>- Biodiversity to be preserved/ promoted</li> <li>- Potentially useful tree species to be established on site</li> </ul> </li> <li>• Phase I Preliminary Investigation report (decision record) on above, including conclusions on feasibility of greenspace establishment and what should be done next.</li> </ul>
	Phase Ib Hazard assessment	<p><b>Construct conceptual model</b></p> <p><b>Preliminary risk assessment</b></p> <p><b>Evaluation of potential</b> for greenspace establishment, potential user survey</p> <p><b>Scope Phase II investigations</b></p> <p><b>Decision record</b> (outlined in Box 3, page 11)</p> <p>Potential to exit process</p>	

**What further action is appropriate?**

No further assessment required? Or no potential pollutant linkages or risks identified at the site?

*Exit process.*

Potential risks identified? Further in depth risk assessment required? A lack of confidence exists concerning possible risks? Or, the potential for tree/plant growth is uncertain?

*Progress to Risk Assessment Phase II (Intrusive site investigation)*

Phase		Step-by-step	Outputs obtained
Risk assessment Phase II Intrusive site investigation	Phase IIa Risk estimation Hazard quantification	<ul style="list-style-type: none"> <li>• <b>Define context</b> and state objectives</li> <li>• <b>Design sampling strategy</b> for intrusive investigation, plus analytical strategy</li> <li>• Detail methods of site investigation to be employed and justifications</li> <li>• Detail targeted and non-targeted locations for sampling</li> <li>• Detail Quality assurance and Quality control procedures</li> <li>• Undertake site investigation (including in-depth ecological, archaeological or heritage surveys as required)</li> <li>• Data acquisition, analysis and interpretation</li> <li>• <b>Risk Estimation</b></li> <li>• Determine appropriateness of GQRA or DQRA assessment criteria</li> <li>• Undertake risk estimations, refine Conceptual model, and highlight uncertainties outstanding</li> </ul>	<ul style="list-style-type: none"> <li>• Detailed knowledge of locations, nature and concentrations of actual contaminants present, plus clarification of site details</li> <li>• Uncertainties reduced</li> <li>• Refined Conceptual model, incorporating all of the above plus: <ul style="list-style-type: none"> <li>- Sampling strategy</li> <li>- Analytical strategy</li> <li>- Site zonation</li> <li>- Assumptions made</li> <li>- Limitations</li> <li>- Uncertainties</li> <li>- Identification of relevant pollutant linkages</li> </ul> </li> <li>• New plausible pollutant linkages identified</li> <li>• Evaluation of the importance and relevance of each pollutant linkage</li> <li>• Phase I or I+II investigation report (Decision Record) including emphasis on critical pollutant linkages, proposals for forward plan options and appropriate potential remediation strategies</li> </ul>
	Phase IIb Risk evaluation	<ul style="list-style-type: none"> <li>• <b>Risk Evaluation</b></li> <li>• Determine the relevance of individual pollutant linkages</li> <li>• <b>Refine Conceptual model</b></li> <li>• <b>Decision record:</b> report including emphasis on critical pollutant linkages and suggested forward plan options</li> <li>• Potential to exit process</li> <li>• Progress to next stage</li> </ul>	

**What further action is appropriate?**

Potential pollutant linkages *not* significant or risks identified at the site are *acceptable*?

*Exit process.*

Potential risks identified?

*Progress to Options Appraisal stage (Phase III)*

Figure 4 (continued)

Phase		Step-by-step	Outputs obtained
Risk reduction Phase III Options Appraisal	Remediation strategy	<ul style="list-style-type: none"> <li>• <b>Define context</b> and state objectives</li> <li>• <b>Detail all pollutant linkages</b> to be targeted</li> <li>• <b>Establish feasible options</b> (single or multiple) that offer the best approach to remediation</li> <li>• <b>Evaluate</b> the options in collaboration with contractors, stakeholders, regulating authority and identify consent and licences required</li> <li>• <b>Detail how progress</b> will be assessed and data feed-back system</li> <li>• <b>Decision record:</b> remediation strategy report demonstrating how site-specific objectives will be met</li> </ul>	<ul style="list-style-type: none"> <li>• Site plans and zones</li> <li>• Phasing of work, time-scales, anticipation of evolution of works</li> <li>• Works validation procedures</li> <li>• Consents, agreements and licences</li> <li>• Procedures for management, protection of neighbours, environment and amenity</li> <li>• Health, safety and security</li> <li>• Dust, odour, noise controls (statutory nuisance) and surface run off</li> <li>• Remediation strategy including monitoring plan</li> <li>• Cost structure for remediation and long term management.</li> <li>• Decision record</li> </ul>
	Risk evaluation (continued)		
Risk reduction Phase IV Implementation of remediation strategy	Remediation and verification	<ul style="list-style-type: none"> <li>• <b>Define context</b> and state objectives</li> <li>• Prepare timetable for remediation</li> <li>• Verify design</li> <li>• Implement remediation</li> <li>• Ongoing verification of remediation progress and feedback loop</li> <li>• Demonstrate Quality assurance/Quality control</li> <li>• Instigate monitoring and maintenance</li> <li>• Reach 'No further action required' step, implement monitoring strategy or progress to Greenspace Establishment Step 2</li> <li>• <b>Final report</b></li> </ul>	<ul style="list-style-type: none"> <li>• Detailed remediation strategy, including:                             <ul style="list-style-type: none"> <li>- Objectives</li> <li>- Timetable</li> <li>- Technologies to be employed</li> <li>- Sampling and analytical strategies for progress assessment</li> <li>- Remediation goals</li> <li>- Post-remediation monitoring</li> <li>- Maintenance strategy</li> </ul> </li> <li>• <b>Remediated site</b></li> <li>• <b>Final report and low risk blank canvas for regeneration</b></li> </ul>
	Risk evaluation (continued)		

**What further action is appropriate?**

Remediation successful?

*Progress to greenspace development process Step 2: Consultation and design.*

Implement maintenance and monitoring strategy. Write concluding report. Long-term survey of site to evaluate Greenspace establishment success and fulfilment of primary objectives

**Box 1 Contamination and liability studies**

Habitats survey	Ecological survey
<ul style="list-style-type: none"> <li>• Identify habitats present (e.g. woodland, scrub, grassland, ruderal, ornamental, ditch, surface waters) and location</li> <li>• Note abundance using DAFOR: Dominant, Abundant, Frequent, Occasional, Rare</li> <li>• Highlight potential of habitats for rare or protected species and need for specialist surveys</li> <li>• Ecological value of habitats present; identify protection status and inclusion in local or national Biodiversity Action Plans</li> <li>• Assessment of nature conservation significance and potential of site for statutory or non-statutory designation</li> <li>• Evaluation index: Size; Diversity; Naturalness; Fragility; Typicalness; Rarity; Position (in an ecological or geographical unit) (Regini, 2000)</li> <li>• Identify habitats to retain/enhance/remove</li> <li>• Potential for existing plants/scrub/woodland/ habitats to be incorporated into proposals (e.g. woodland condition survey)</li> </ul>	<ul style="list-style-type: none"> <li>• Desk-study to locate on-site and local SSSIs</li> <li>• Lists of protected species and Red Data Book species present: fauna (including birds, bats and amphibians) and flora (Joint Nature Conservation Committee, 2005)</li> <li>• Sightings and evidence of birds using the site</li> <li>• Sightings and evidence of all mammals using the site (including bats, vermin, deer)</li> <li>• Location(s) of invasive plant species (especially non-native)</li> <li>• Visual signs of soil nutritional status (e.g. nettles indicate high fertility)</li> <li>• Vegetation health</li> <li>• Areas of bare ground indicative of contamination, landfill gas, etc.</li> <li>• Visible signs of water table depth or water-logging</li> <li>• Survey record to include: date of survey (indicates season), weather conditions (during survey and in preceding days), details of statutory and non-statutory organisations contacted and involved</li> </ul>

## Box 1 Contamination and liability studies (continued)

Heritage/Archaeology survey	Soil screening and Soil-forming materials survey
<ul style="list-style-type: none"> <li>Professional guidance required from either:               <ul style="list-style-type: none"> <li>Institute of Field Archaeologists</li> <li>Archaeological Advisor to the Local Authority</li> <li>English Heritage, Historic Scotland or Cadw</li> <li>Archaeological Data Service (<a href="http://ads.ahds.ac.uk/catalogue/search/map.cfm">http://ads.ahds.ac.uk/catalogue/search/map.cfm</a>)</li> <li>Association of Local Government Archaeological Officers (<a href="http://www.algao.org.uk">www.algao.org.uk</a>)</li> </ul> </li> <li>Survey includes an overview of:               <ul style="list-style-type: none"> <li>Site setting and history (including neighbourhood history)</li> <li>Regional assessment of designated sites (Scheduled Ancient Monuments - SAMs)</li> <li>County-level relevance based on Site and Monuments Record (SMR) and Historic Landscape Characterisation</li> <li>Review of significant archaeological remains (including palaeolimnological records and similar)</li> <li>Review of local 'living heritage' (e.g. veteran trees and coppice rings)</li> </ul> </li> <li>Areas of potential archaeological and heritage interest</li> <li>Evaluation of:               <ul style="list-style-type: none"> <li>The significance of the remains</li> <li>Impact of development on the remains and whether re-development is permitted</li> <li>Mitigation of disturbance to heritage/archaeological sites</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Soil depth (estimate [PI]; measure [PII])</li> <li>Soil-forming material survey: approximate availability and type [PI], suitability for use, fertiliser requirement [PII]</li> <li>Soil characteristics               <ul style="list-style-type: none"> <li>Soil type [PI] (Soil Survey Field Handbook; Hodgson, 1976)</li> <li>Bulk density [PI]</li> <li>Stoniness and debris content [PI]</li> <li>Moisture content [PI]</li> <li>pH [PI]</li> <li>Electrical conductivity [PI]</li> <li>Organic matter content [PII]</li> <li>Water holding capacity [PII]</li> <li>Compaction/ penetration resistance [PII]</li> <li>Cation Exchange Capacity [PII]</li> <li>Nutrient availability/deficiency (e.g. N, P, K, Ca, Mg, Fe, Mn, C:N ratio [PII])</li> <li>Iron pyrite content [PII]</li> <li>Sulphur content [PII]</li> </ul> </li> <li>Permeability               <ul style="list-style-type: none"> <li>Surface water evidence of waterlogging [PI] or soil mottling [PII]</li> </ul> </li> <li>Rootability index scoring: depth of horizon; nature of horizon; hostile horizon (e.g. waterlogged, unrootable) [PII]</li> <li>Water table depth [PII]</li> <li>Heavy metal and potentially toxic element (PTE) concentrations [PII]</li> <li>Organic contaminant content [PII]</li> <li>Landfill gas evolution, ground staining and discolouration               <ul style="list-style-type: none"> <li>Gas monitoring (e.g. methane and carbon dioxide)</li> <li>Bare patches, no vegetation</li> </ul> </li> <li>Watercourses, content and potential significance; evidence of eutrophication</li> <li>Evidence of ochre/pyrites</li> </ul>
<p><b>Characterise physical hazards on site</b></p> <ul style="list-style-type: none"> <li>Uneven, unstable, hazardous ground</li> <li>Large boulders</li> <li>Derelict building hazards (including from glass and masonry).</li> <li>Water bodies, pits, well, trenches</li> <li>Inclines greater than 6–10° offer a fall hazard, poor tree stability and increased soil erosion risk</li> </ul>	

Key: PI = Phase I; PII = Phase II

## Box 2 Environmental planning study considerations

Spatial	Economic
<ul style="list-style-type: none"> <li>Location and historical setting</li> <li>Visibility and aesthetic appeal of site (on site and from surrounding areas)</li> <li>Proximity of communities, schools, open/green spaces</li> <li>Access: pedestrian, bicycle, car, bus and train</li> <li>Surrounding area's economic and social circumstances</li> <li>Topography, landscape quality and potential</li> <li>Geomorphology</li> <li>Geology, hydrology, hydrogeology and geotechnical stability</li> <li>Climate and general weather patterns</li> </ul>	<ul style="list-style-type: none"> <li>Assets (current/potential/preservation)</li> <li>Service provision and fiscal returns</li> <li>Employment potential</li> <li>Remediation and reclamation costs</li> <li>Maintenance and monitoring costs</li> <li>Liabilities</li> </ul>
	<p><b>Activity</b></p> <ul style="list-style-type: none"> <li>Current and potential for public usage</li> <li>Health, education, recreation and social opportunities</li> </ul>
<p><b>Constraints</b></p> <ul style="list-style-type: none"> <li>Contamination and physical hazards</li> <li>Misuse of the land and anti-social behaviour (burning, fly-tipping, vandalism, joy-riders)</li> <li>Security constraints (e.g. status of fencing)</li> <li>Treacherous/unstable ground, subsidence</li> <li>Access and easements, services (including lighting), pipelines, cables, drainage, utilities</li> <li>Subsurface buildings/structures including underground culverts and hazards</li> <li>Long-term maintenance issues and monitoring</li> <li>Liabilities</li> <li>Landfill and/or coal gases/odours</li> </ul>	<p><b>Considerations specific to greenspace establishment</b></p> <ul style="list-style-type: none"> <li>Soil and soil-forming materials abundance, depth of soil cover, physical and chemical characteristics (see Box 1: Soil screening)</li> <li>Removal, storage, loose tipping and cultivation of soil or soil-forming materials</li> <li>Soil compaction (which will constrain vegetation establishment)</li> <li>The potential to reuse surplus, waste or by-products</li> <li>Topography and landscaping</li> <li>Site security</li> <li>Habitat disruption and removal</li> <li>Tree and plant species selection and seeding</li> <li>Protection against animal damage</li> <li>Weed control</li> <li>Long term maintenance</li> <li>Archaeological and Heritage value of site and surrounding area</li> </ul>

It is important that the objectives in Phase I are clearly defined and achieved. A thorough Phase I investigation takes time, but is cost effective in the long term if it clearly identifies the potential hazards, risks and liabilities inherent to each site before implementation contracts are agreed and establishment work begins. A key objective of Phase I is to identify all potential pollutant linkages for subsequent quantification and evaluation in order to identify which are significant and, therefore, need to be managed. The potential pollutant linkages are presented in the form of a conceptual site model.

### The conceptual site model

A main output from Phase I is the conceptual model, which is further refined in Phase II. It is presented in at least two formats in the final Preliminary site investigation (Phase I) report i.e. using either site plans, cross sectional diagrams, network diagram or matrix. The conceptual model is constructed from information collected during the desk study and site walk-over, and it consolidates information into plausible pollutant linkages that need to be verified. Conceptual models allow an informed risk assessment to be undertaken for each pollutant linkage taking into account the potential severity of the risk and the likelihood of the risk occurring. An overall evaluation of the level of risks present at the site is obtained and ranked on a scale from 1–5 (Very low risk (insignificant) to Very high risk). Care should be taken to ensure that the information is comprehensive and up to date. A site walk-over should be used to obtain data and to confirm and update information provided by the desk study. For example, the number and location of water courses, the possibility of an archaeological interest at the site requiring further specialist information and other ‘here today’ information such as access and security issues (e.g. is equipment highly susceptible to theft at the site). Useful sources of information for a desk-study include *inter alia* the local authority, Environment Agency/SEPA, the British Geological Survey, National Soils Reference Data, Ordnance Survey, non departmental public bodies (Box 1 on page 9, Figure 3).

### The Phase I report

The Phase I report is an in-depth, comprehensive appraisal of the site, see Box 3, page 11 for an example of the report structure for a Phase I report. The site is usually assigned broad zones using the following categories: greenfield; uncontaminated brownfield; potentially contaminated brownfield and/or greenfield; actually contaminated brownfield and/or greenfield; and other.

**Table 2**

The range of information required from a desktop study and the site walk-over for the Phase I report.

Desktop study	Site walk-over
Geographical distribution and setting, current and former land use, ownership and surrounding land use and history	Site description, user information and likelihood of contaminants present
Topography and geomorphology	Ecology (Box 1, page 9 and Figure 3)
Probable heritage value and archaeological interests	Heritage and archaeology (Box 1, page 9)
Geotechnical stability and potential for subsidence	Visual consideration of soil abundance and suitability for use
Climatic, atmospheric and general environmental conditions	Visual consideration of the presence and quality of soil-forming materials
Local air quality measurements and statutory consents	Landscape quality and potential
Geology, hydrogeology and hydrology (including controlled waters present)	Visual assessment of potential contamination, e.g., bare ground, ochre, leachate or seepage, unhealthy vegetation
Local, regional and national policy, plans and strategic guidelines (e.g. unitary development plans and National Forest Strategy) relevant to site proposals	Input from local users, inhabitants and businesses Potential site constraints, e.g. evidence of misuse, anti-social behaviour, security
Access, services, pipelines, cables, drainage, utilities and easements	Access, services, pipelines, cables, drainage, utility supplies, easements: e.g. car parks, rights of way, gas/electric/water, underground culverts

The zones accommodate for site complexity arising, for example, from a mixed-use history and allow specific zones or areas to be dealt with individually. Each zone may be sub-divided to more fully describe site characterisation, and constituent areas of the site should be grouped according to these zones. Zones are also useful when designing the sampling strategy in Phase II. The Phase I report also gives a SWOT analysis; this is an overview of the strengths, weaknesses, opportunities and threats of the site. Presented as a table, a SWOT analysis gives the overall potential for greenspace establishment at a glance and allows an overview to be taken. For example, a weakness may also be an opportunity, such as limited services or utilities on site provides an opportunity for the type and location of services to be positioned where required in the future, but may require additional investment.

### Box 3 Outline content of Phase I (preliminary site investigation) report

#### 1. Introduction

- 1.1 Site location and general site details
- 1.2 Objectives of the study
- 1.3 Report structure

#### 2. Contamination and liability studies

- 2.1 Site location and historical setting
- 2.2 Site usage and contaminated land survey
- 2.3 Topography and geomorphology
- 2.4 Geology, soils, hydrology, and hydrogeology, geotechnical stability
- 2.5 Climate, atmospheric and general environmental conditions
- 2.6 Access, services, pipelines, cables, drainage systems, utilities and easements
- 2.7 Site reconnaissance
- 2.8 Technical feasibility of establishing woodland/greenspace
- 2.9 Report on consultations

#### 3. Environmental planning studies

- 3.1 Site walk-over (visual assessment)
- 3.2 Ecological context and condition survey
- 3.3 Archaeological survey
- 3.4 Landscape assessment
- 3.5 Planning context
- 3.6 Current recreational context
- 3.7 Community context
- 3.8 Report on consultations

#### 4. Initial conceptual model of site

- 4.1 Conceptual model

#### 5. Preliminary site risk assessment

- 5.1 Introduction
- 5.2 Hazard identification
- 5.3 Risk estimation assessment
- 5.4 Risk evaluation assessment

#### 6. Evaluation of greenspace development plans

- 6.1 Introduction
- 6.2 Constraints and opportunities
- 6.3 SWOT analysis
- 6.4 Summary of liabilities and responsibilities

#### 7. Further site investigation: scoping, design & monitoring

- 7.1 General investigation design approach
- 7.2 Recommendations for additional desk study
- 7.3 Selection and prioritisation of parameters for further assessment
- 7.4 Design assumptions
- 7.5 Detailed investigation design and costing

#### 8. Conclusions and comments

- 8.1 Conclusions
- 8.2 Recommendations for further study

Conclusions to the Phase I Preliminary site investigation Report should be succinct and include:

- the scope of the proposal;
- the potential opportunities that the re-development affords;
- an indication of potential liabilities at the site and who is responsible, including the possibility that they may be transferred;
- potential constraints of the site;
- limitations of the studies undertaken.

The report should refer to the use of the re-developed land as a community greenspace, works required and give recommendations on the next stages. Finally, uncertainties and limitations of the conceptual model should be noted.

If the site investigation is well-planned and implemented, and quality standards are observed, then the conclusions presented in a Phase I report will be substantiated and considered valid. The basis for the quality assurance of the report is that the information supporting a risk assessment is relevant, sufficient, reliable and transparent. References for codes of best practice for site characterisation include: Department of the Environment (1994); British Standards Institution (1999 and 2001); Environment Agency (2000 and 2004); Nathaniel *et al.* (2002), Robinson and Chesher (2005) and the Land regeneration and urban greening pages of the Forest Research website ([www.forestresearch.gov.uk/fr/inf-d-5suk5s](http://www.forestresearch.gov.uk/fr/inf-d-5suk5s)).

#### Progression to Phase II

Progression to Phase II, Intrusive site investigations will not always be required. For example, if there are no potential pollutant linkages, no potential risks identified at the site and no uncertainties then there is no requirement for further assessment or investigation, and therefore progression to Step 2: Consultation and design may be appropriate. On the other hand, a site may have been shown to be less practical, less economically viable or would offer fewer public benefits than alternative sites on the shortlist and therefore the process would not be continued.

Phase II procedures should be conducted on a site that is acceptable for development to community greenspace yet requires further investigations to reduce uncertainties or to evaluate plausible pollutant linkages. It may be necessary to seek advice from a statutory body. The appropriate body must be contacted and involved in the decision making process where a site contains or has the

potential to contain receptors afforded protection under law (Department for Environment, Food and Rural Affairs, 2006). The ‘Golden Rule’ is to involve all appropriate bodies as early as possible in the process, in particular, the local authority contaminated land officer as they register land as contaminated under Part IIA and pass special cases on to the Environment Agency (EA: in England and Wales) or Scottish Environment Protection Agency (SEPA), other pertinent bodies are given in Table 3.

**Table 3**

Examples of appropriate bodies and their wards that should be consulted as part of a Phase I investigation.

Organisation	Ward
Scottish Natural Heritage, the Countryside Council of Wales or Natural England	Protection of organisms and ecosystems
Cadw (Wales), English Heritage, Historic Scotland, the Archaeological Data Service or the Association of Local Government Archaeological Officers	Historic and protected buildings and archaeological sites (Box 2, page 9 and Figure 3)
Forestry Commission	Forestry environmental impact assessments (EIA); species selection and establishment; site design and management; best practice, and grants for woodland creation and management
Environment Agency (EA, for England and Wales) or Scottish Environment Protection Agency (SEPA)	Controlled waters, catchment boundaries, water abstractions and discharge consents, landfill and waste management sites, sites with IPC/PPC authorizations, and for information on water quality objectives
Department for Environment, Food and Rural Affairs (Defra; England), Department for Environment, Planning and Countryside (Wales) or the Environment and Rural Affairs Department (Scotland)	Land use, livestock and crops
Food Standards Agency	Food production and the assessment of human health exposures through food
Local authority	Historical land contamination, re-development and previous remediation and reclamation works

## Phase II – intrusive site investigations

At this stage, the majority of potential and plausible significant pollutant linkages should have been identified and qualitatively assessed. These need to be described quantitatively to determine their true significance. The processes involved in Phase II are Risk Estimation, the quantification and description of the risks present at a site, and Risk Evaluation, an assessment of the relevance of the risks, see Figure 4, page 7. The objective of Phase II is an intrusive site investigation to obtain site-specific data for use in risk assessment and the refinement of the conceptual model.

### Design and implementation of a Phase II intrusive site investigation

Intrusive site investigations reflect the findings from Phase I, must ensure that all pollutant linkages are addressed and that the location, extent, severity and chemical form of the contaminants are thoroughly characterised. To ensure these aims are met a clear plan and sampling strategy is essential. During the intrusive site investigation, remaining uncertainties about the site such as detail of hydrogeology or soil parameters also can be addressed. An iterative evaluation of potential receptors and pathways should be performed.

A sampling strategy is designed in accordance with the contaminants expected from information collected in Phase I and may be based on the site zones or according to geology, watercourses, historical building distribution or projected end use. A sampling strategy will also detail the methods of intrusive investigation that may be employed (e.g. boreholes, trial pits, groundwater sampling, gas monitoring) and whether the sampling will be targeted (i.e. directed towards specific locations) or non-targeted, see Nathaniel *et al.* (2002) or Forest Research (2005a) for further details. The sampling strategy will identify the location, depth and frequency of sampling. The objectives of the site investigation should be well defined to ensure that they are fulfilled and that the correct samples are taken. Equally, the sampling strategy should have flexibility and adaptability to accommodate uncertainties on site.

A well-planned site investigation gives confidence in the sampling results. Quality control must also be strict (Nathaniel *et al.*, 2002; Environment Agency, 2004). Minimum sampling requirements include:

- the location of each sampling point should be accurately defined on the site survey map;

- clear evidence should be presented to show that a sufficient number of samples were taken and that each was of sufficient size/volume;
- chain of custody guidelines for labelling, handling, storage and transport of samples should be adhered to;
- field conditions during the site survey should be recorded;
- precautions to protect the environment, prevent cross contamination and prevent the creation of new pollutant linkages should be evident;
- health and safety concerns for the site surveyor(s) should be evaluated prior to the survey being undertaken.

In addition, photographic evidence may be used to support site observations. Sources of further information for a site investigation include Environment Agency, (2004), British Standards Institution (1999 and 2001), Environment Agency (2000), and Nathaniel *et al.* (2002).

### Risk estimation

Risk estimation requires a comparison of representative site concentrations for each pollutant to be made against soil guideline values (SGVs) to determine if the risks are unacceptable. A limited number of SGVs have been published by the Environment Agency (see the Land contamination web pages at [www.environment-agency.gov.uk](http://www.environment-agency.gov.uk)) these values should only be used if the site under investigation closely resembles the ‘model’ site described by the Environment Agency for the purpose of deriving these published SGVs.

It is important that, where published SGVs are not applicable to the site, site-specific values need to be calculated. To derive an SGV for any site, detailed information about each component of the pollutant linkage is required, including:

- contaminant data: occurrence, chemical form and characteristics, location and concentration;
- soil properties: texture, organic matter content, pH, cation exchange capacity, bulk density and moisture content;
- toxicological data: acceptable background exposure rate, human toxicity of the pollutant in question, likely uptake or exposure rate versus acceptable/safe intake, routes of uptake.

The pollutant linkage and site information data is input to a risk assessment model to derive the SGV for that site. Subsequently, the derived SGV is statistically compared to the representative site concentrations for the pollutant to

determine if the risks are unacceptable. Statistical analyses are an important part of the risk estimation process as they enable the effect of data variability, which is inherent in an environmental setting and when sampling a heterogeneous material such as soil, to be considered. Statistical analyses also enable a degree of confidence in the final assessment to be stated.

The types of models used in risk estimation are either Generic or Detailed Quantitative Risk Assessment (GQRA or DQRA) models (Environment Agency, 2004). GQRA uses mainly generic, conservative assumptions about receptors and pathways, and the characteristics and behaviour of sources in its model algorithms. DQRA models are used when the generic assessment criteria (used in GQRA) are not appropriate to a site or result in unacceptable uncertainties. GQRA models (such as the Environment Agency’s contaminated land exposure assessment (CLEA) model) relate only to chronic human health risks, they do not relate to acute human health risks, to groundwater, ecosystems or the occupational health of site workers during site investigations and remediation. Other limitations include:

- a limited range of conceptual model scenarios;
- only three types of land use are defined – residential, allotments and commercial/industrial;
- the land is assumed to be derelict with no schools in the vicinity;
- limited numbers of contaminants are considered;
- there is no allowance for on-site use of water;
- CLEA assumes that there is no contaminant degradation (Nathaniel *et al.*, 2002).

Although DQRA models also have their limitations, site assessment should be performed in a DQRA model where site conditions are outside the generic, conservative structure and limitations of GQRA models. An example of a DQRA model is the SNIFFER Framework (Method for deriving site-specific human health assessment criteria for contaminants in soil, project reference LQ01, [www.sniffer.org.uk](http://www.sniffer.org.uk)). A worst-case scenario should always be assumed where there are uncertainties or data limitations.

In summary, risk estimation involves a comparison of representative site contaminant concentrations with appropriate generic or site-specific assessment criteria to estimate the presence of unacceptable risks. Note that the GQRA and DQRA processes described above relate to human health only, and where environmental receptors (such as a great crested newt, an archaeological treasure

or a veteran tree) are present and potentially at risk, Natural England should be consulted and an environmental risk estimation should be performed. Depending on the site, risk estimations for both human health and environmental risks may be required.

The quantitative risk assessment may require additional information or further investigations to clarify uncertainties. It should be remembered that each step in the risk assessment process requires decisions to be made on the basis of information collected about the site; for example, the extent or location of potential contaminants. As more information is collected, the conceptual model can be refined, risk assessments re-evaluated and conclusions updated. This iterative approach helps to ensure that the level of input at each stage of the risk assessment is appropriate and defensible.

### **Risk evaluation and concluding the Risk assessment**

Risk evaluation is a process of collating the numbers, uncertainties and site conditions into an answer to the over-riding question of whether the risks are relevant. For each pollutant linkage identified, the potential 'severity' of the risk (ranked: minor, mild, medium or severe) is cross tabulated with the 'probability' of the risk occurring (ranked: unlikely, low likelihood, likely or high likelihood) to obtain an overall evaluation of the level of risk (after Rudland *et al.*, 2001). The overall risk is then ranked 1–5 (very low to very high) and this enables a consideration of its acceptability to be made. As a general guide, all risks above 'low' should be considered for further investigation, management or monitoring, although appropriately qualified personnel should always make these decisions on a site-by-site basis and by taking into account all information pertinent to the conceptual model.

In concluding a Phase II investigation, the report may advise on exiting the assessment process, for example, because no significant pollutant linkages exist). Alternatively, if the risk management process is to be continued to the next stage, the report should contain a revised conceptual site model highlighting all the significant pollutant linkages identified in the risk estimation that require management. A more in-depth evaluation of the potential of the site should also be detailed, updating the Phase I SWOT analysis. Finally, the report may suggest a Phase III Options appraisal to introduce potential remediation strategies and offer notification of any licences that have to be applied for (e.g. discharge consents and waste management licences). An account of outstanding uncertainties, assumptions and site limitations are imperative.

## **Risk Reduction**

### **Phase III: options appraisal**

Following the risk assessment processes (Phases I and II), a risk management strategy is required to address all of the significant pollutant linkages (as detailed in the refined Phase II conceptual model) so that after remediation they will be treated and/or removed (sometimes termed 'demonstrably broken'). Options Appraisal is a process to establish the options that offer the best overall approach to remediation taking into consideration site specific circumstances (Environment Agency, 2004). Options appraisal comprises three stages: identify feasible options; evaluate the options; and produce a remediation strategy.

#### **Evaluating the options**

Identification of feasible options is directly based upon Phase II and requires that all significant pollutant linkages for the site are known. Hence, thorough and detailed reporting for all phases is essential. The feasible options for any remediation strategy will depend on several factors:

- The site characteristics (location, size, security, local users, constraints to the establishment of a greenspace as identified in the Phase I and II reports).
- The contaminants present, their concentration and chemical form, and the environmental matrix (air, soil, water) involved.
- The legal context of the remediation programme.
- Stakeholder opinions.
- Timescales.

These factors are site specific, as are the evaluations of the options and, therefore, are not covered in-detail in this Information Note. Environment Agency (2004) gives further information.

#### **Remediation strategy**

Following identification and evaluation of the options, the remediation strategy (also called a method statement) details works to be carried out, type and scale of contamination to be remediated, and the remediation methodologies to be employed (remedial/protective/other). The purpose and scope of the work, together with the site objectives should be clearly presented in the strategy. A remediation strategy document will include:

- site plans and zoning;
- phasing of work, approximate time-scales and an

anticipation of evolution or variations of plans arising over the course of the works;

- works validation procedures;
- consents, agreements and licences;
- procedures for management and protection of neighbours, environment and amenity;
- health, safety and security issues;
- matters of environmental health, including dust, odour and noise controls;
- surface water or liquid run-off;
- a demonstration that the strategy meets the overall site-specific objectives.

There are some additional points to the remediation strategy applicable to the establishment of greenspace. At this stage in the site re-development process, draft plans for the new design of the site, such as the types and locations of habitats, should be available. The remediation strategy needs to take into account the effect that the remediation will have on trees and plants, and the effect of those on the identified pollutant linkages; examples are:

1. Various methods of soil treatment for organic contaminants de-nature the soil. For example, thermal treatments or solvent washing techniques reduce macro and micro soil fauna populations, reduce the soil organic matter content, and potentially leave washing reagent residues in the soil. This is an example of a negative impact of remediation on the ability of the site to support vegetation.
2. Brownfield land is often characterised by compact, stony ground. The addition of organic matter such as compost reduces bulk density (increasing aeration and the water holding capacity), provides essential nutrients to support soil biota and plant life, and may stabilise contaminants by sequestering (binding) heavy metals and organics. This is an example of a positive impact of remediation on the ability of the site to support vegetation.
3. An example of integrating the remediation and establishment of vegetation processes is a site where the source is heavy metal contaminated soils, the receptor is a nearby housing estate and the pathway is wind-blown dust. Tree planting is both greening and a means of affecting the pollutant linkage/pathway (trapping air-borne dust, reducing wind speed blowing over the contaminated soils and limiting dust release, and uptake of heavy metals by the plants).

It is important to reiterate that any remediation strategy

should be designed carefully to prevent the creation of new pollutant linkages during the works. Similarly, the Options appraisal must give due consideration, to the potential effects of remediation of the receptors (e.g. surface waters should be protected against receiving contaminated materials, soil or debris as suspended solids). Equally, the effects of remediation on the surrounding environment should be considered (e.g. neutralising acidic waters that are the sustaining source of an SSSI acid wetland).

Another important consideration is how vegetation will perform when planted in the soil inherent to the site or in soil forming materials. Remediation is likely to alter the chemical profile of the soil or other planting material. Selected analyses will give an indication of the ability of the site to sustain vegetation and the potential of the additions or amendments to the soil to improve nutrition, soil structure and/or immobilise contaminants. It is cost effective to conduct soil sampling to determine chemical and physical properties at the same time as the Phase II Intrusive site investigation, although this may require the use of different laboratories. Details of relevant analyses and target levels for both nutrients and contaminants are given in Forest Research (2005b; 2005c).

Regardless of the chemical nature of the soils they may be inadequate for supporting appropriate vegetation; this is particularly the case on landfill sites established before the Waste Management Licensing regulations 1994 and the Landfill Regulations 1994 and 2002. It is therefore important to take this in to account when creating the remediation strategy rather than identifying at a later stage that there is a need to import additional materials to support the vegetation.

If the site has any archaeological interest the relevant statutory body, English Heritage, Cadw (in Wales) or Scottish Natural Heritage should be contacted, see the list of statutory bodies and their wards given in Table 3, page 12.

#### **Phase IV: implementation of the remediation strategy**

The final phase in the risk management process is to implement remediation and ensure that the remediation achieves the planned objectives, with appropriate quality assurance. CLR 11 (Environment Agency, 2004) lists three parts to implementation:

- prepare a plan design;
- implement and verify remediation;

- long-term monitoring, and maintenance where required.

Implementation is a site-specific exercise usually undertaken by consultants and contractors. Verification is an on-going process during remediation, with feed-back loops (e.g. remediate – analyse – evaluate progress – proceed/work complete). In multi-partnership projects, a project manager will ensure timely and efficient management of the remediation strategy and will report progress to the stakeholders.

When the remediation is completed, a final report should be produced, and should cover:

- background information;
- methodologies employed;
- compliance to regulatory permits held;
- the analytical protocol employed;
- the readiness for greenspace establishment ;
- remediation success, detailing the final extent of the work undertaken and the status of the contamination upon completion;
- on-going monitoring required.

## STEPS 2–4 OF GREENSPACE DEVELOPMENT: FROM CONSULTATION TO MANAGEMENT

The Forestry Commission requires that the establishment of woodland and associated greenspace preserves and protects important features of the landscape, cultural and natural resource heritage, in accordance with best practice. Consequently, the potential and feasibility of a site for greenspace establishment is assessed and revised regularly during the site selection, investigation and remediation works process. In effect, a greenspace establishment feasibility study is conducted alongside the risk assessment and management process (Phases I–IV described above) and considers aspects such as:

- whether tree growth will adversely affect the site;
- the types of habitats to be created at this site;
- the species of trees and plants most appropriate for the site.

Forest Research will give guidance on many of these points, e.g. native or non-native tree selection (Forest Research, 2005d); soil cultivation and ripping (Forest Research, 2005e). Also, the software package ‘ROOTS –

Software for greening brownfield land’, developed by the Forestry Commission, gives specifications for all aspects of site restoration, including nutrient requirements, weed control and species selection; ([www.roots-software.co.uk](http://www.roots-software.co.uk)).

### Step 2: Consultation and design

Following risk management and/or remediation to the satisfaction of the regulating authority, usually the local authority, reclamation of a site would proceed to Step 2: Consultation and design. Design is an iterative process between experts (landscape architects, engineers and scientists), site owners/managers and public stakeholder groups that leads to the production of the master plan. A master plan reflects project aims and stakeholder desires. Examples may include: public benefit (improve health and well-being, increase access, recreation and education), catalyse local regeneration, and promote environmental improvement (landscape, aesthetics and biodiversity). Deviations from projects aims or from local demand are likely to be highlighted as part of the stakeholder–designer consultation iteration, and must be suitably addressed to enhance the inclusive nature of greenspace provision.

Adopted ownership and involvement by the local community in a greenspace is pivotal to the long-term success of a greenspace. Feelings of pride and ownership manifest in respectful site use patterns and community engagement in, for example, volunteering and education events held on site. Consultation with key stakeholders, including local community groups, businesses and interest groups enables desires for the site to be considered and discussed when impractical (e.g. constrained by site topography, geography, hydrology or history). Providing a site that is appealing helps ensure that it is well used and well looked after. To assist in design, Forest Research Best Practice Guidance Notes provide advice on tree species selection and maximising biodiversity. Forestry Commission ‘Guidelines’ are another helpful reference source in Step 2: Consultation and design (Forestry Commission, 1991).

### Step 3: Implementation and delivery

Implementation and delivery, builds upon the SWOT analysis created and refined in the Phase I and II reports. Delivery encompasses civil engineering of infrastructure through to provision of facilities and services, ground preparation, planting and fencing. Wherever possible, delivery must actively involve all stakeholders, especially the local community, to promote the fostering of ownership. Constraints and limitations to the delivery programme are identified during the design phase, enabling bottle-necks

to be appropriately time-tabled. For example, habitats or species may require protection during delivery to minimise disturbance or may cause works to cease completely at certain times of the year, such as in the breeding birds season. Restricted access areas are useful in such cases. Floral and faunal considerations include: trees with preservation orders, bryophytes, certain mammals (such as dormice and badgers), all breeding birds, reptiles, amphibians and many insects. In all cases, licenses from the appropriate statutory body must be obtained; such requirements should be anticipated during Step 2: Consultation and design. Specific guidance can be obtained from Natural England, Department for Environment, Food and Rural Affairs (Defra) and your local authority.

Forest Research Best Practice Guidance Notes detail advice and minimum standards acceptable for the establishment of greenspaces. Further guidance on establishing robust greenspaces in the urban environment and working with communities is provided by the BTCV (Agate, 2002).

#### Step 4: Management and maintenance

Step 4 extends beyond the establishment of a greenspace to management, monitoring and maintenance and the on-going processes of pest control, health and safety assessments, habitat care, and community liaison. Post regeneration a new greenspace requires management in the short- (e.g. weed control, tree protection), medium- (e.g. pest control) and long-term (e.g. path maintenance, health and safety check on trees and recreational facilities and silviculture). Maintaining the site in a manner that is appealing and safe for communities to enjoy increases use and helps minimise anti-social behaviour. Management also includes stewardship to promote biodiversity and maintain habitats in the designed state. Management plans written according to the site priorities assist in these matters and help to resolve potentially conflicting uses, for example recreational use close to areas that are designed for wildlife. Community engagement and volunteering should be encouraged to promote site sustainability.

## CONCLUSIONS

Site investigations follow a risk based assessment that has been designed to be a practical, achievable and protective process for investigating land contamination which enables informed, defensible decisions to be made. The process rationalises site hazards to offer phased negotiable risk management based on priorities. Although the process is potentially long, costly and complex, some steps

are not required for many brownfield sites being re-developed as community greenspace. It is therefore important to undertake each step and phase thoroughly to allow the identification of opportunities to exit the risk management process and proceed with reclamation and establishment, in the knowledge that key decisions were correct, accountable and valid. Finally, it is important that the suitability of a site for greenspace establishment is thoroughly assessed and appropriately demonstrated and it is recommended that the checklist given on page 20 is used to ensure that all appropriate information is collected.

## REFERENCES

- AGATE, E. (2002). *The urban handbook: a practical guide to community environmental work*. BTCV, Wallingford, Oxon.
- BRITISH STANDARDS INSTITUTION (1999). *Code of practice for site investigations*. BS 5930:1999. BSI, London
- BRITISH STANDARDS INSTITUTION (2001). *Investigation of potentially contaminated site. Code of practice*. BS 10175:2001. BSI, London.
- DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT (2006). *Housing*. Planning Policy Statement 3. TSO, London.
- DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (2006). *Defra circular 01/2006 environmental protection act 1990: Part 2A contaminated land September 2006*. Defra, London.
- DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (2007). *A strategy for England's trees, woods and forests*. DEFRA, London.
- DEPARTMENT OF THE ENVIRONMENT (1994). *Contaminated land report 2 – guidance on preliminary site inspection of contaminated land*. Environment Agency, Bristol.
- ENVIRONMENT AGENCY (2000). *Technical aspects of site investigation in relation to land contamination*. R&D Technical Report P5-065TR. Environment Agency, Bristol.
- ENVIRONMENT AGENCY (2004). *Model procedures for the management of land contamination*. Contaminated Land Report 11. Environment Agency, Bristol.

- FOREST RESEARCH (2005a).  
*Soil sampling strategies for derelict, underused and neglected land prior to greenspace establishment.*  
Best Practice Guidance Note 1.  
Land Regeneration and Urban Greening Group, Farnham.
- FOREST RESEARCH (2005b).  
*Laboratory analysis of soils and spoils.*  
Best Practice Guidance Note 2.  
Land Regeneration and Urban Greening Group, Farnham.
- FOREST RESEARCH (2005c).  
*Imported soil or soil-forming materials placement.*  
Best Practice Guidance Note 5.  
Land Regeneration and Urban Greening Group, Farnham.
- FOREST RESEARCH (2005d).  
*Native and non-native trees: how and why to choose.*  
Best Practice Guidance Note 8.  
Land Regeneration and Urban Greening Group, Farnham.
- FOREST RESEARCH (2005e).  
*Do you need to cultivate?*  
Best Practice Guidance Note 3.  
Land Regeneration and Urban Greening Group, Farnham.
- FORESTRY COMMISSION (1991).  
*Community woodland design guidelines.*  
Forestry Commission, Edinburgh.
- FORESTRY COMMISSION SCOTLAND (2006).  
*The Scottish forestry strategy.*  
Scottish Executive, Edinburgh.
- FORESTRY COMMISSION WALES (2001).  
*Woodlands for Wales: the National Assembly for Wales strategy for trees and woodlands.*  
National Assembly for Wales, Aberystwyth.
- HODGSON, J.M. (1976)  
*Soil Survey field handbook: describing and sampling soil profiles.* Technical Monograph 5.  
Soil Survey of England and Wales, Harpenden, Herts.
- HUTCHINGS, T. (2002).  
*The opportunities for woodland on contaminated land.*  
Forestry Commission Information Note 44.  
Forestry Commission, Edinburgh.
- JOINT NATURE CONSERVATION COMMITTEE (2005).  
*Red data books.* (List on website)  
[www.jncc.gov.uk/page-2133](http://www.jncc.gov.uk/page-2133)
- MOFFAT, A.J. and McNEILL, J.D. (1994).  
*Reclaiming disturbed land for forestry.* Forestry Commission Bulletin 110. Forestry Commission, Edinburgh.
- NATHANAIL, J., BARDOS, P. and NATHANAIL, P. (2002).  
*Contaminated land management: ready reference.* Land Quality Press/EPP Publications Ltd, Nottingham/Chiswick.
- OFFICE OF THE DEPUTY PRIME MINISTER (2003).  
*Sustainable communities: building for the future.*  
ODPM, London.
- OFFICE OF THE DEPUTY PRIME MINISTER (2004).  
*Planning and pollution control.* Planning Policy Statement 23. TSO, London.
- OFFICE OF THE DEPUTY PRIME MINISTER (2005).  
*Biodiversity and geological conservation.* Planning Policy Statement 9. TSO, London.
- PUBLIC BENEFIT RECORDING SYSTEM (2006).  
*The Public Benefit recording System briefing note.*  
NWDA (North West Regional Development Agency)/Forestry Commission England/TEP.  
[www.pbrs.org.uk](http://www.pbrs.org.uk)
- REGINI, K. (2000).  
Guidelines for ecological evaluation and impact assessment. In Practice, Bulletin of the Institute of Ecology and Environmental Management no. 29.
- ROBINSON, C. and CHESHER, L. (2005).  
Specification for: Phase 1 site investigation. Forestry Commission England, Land Regeneration Unit, Stafford.  
[www.forestresearch.gov.uk/pdf/LRUFRPhase1specification12.pdf/\\$FILE/LRUFRPhase1specification12.pdf](http://www.forestresearch.gov.uk/pdf/LRUFRPhase1specification12.pdf/$FILE/LRUFRPhase1specification12.pdf)
- RUDLAND, D.J., LANCEFIELD, R.M. and MAYELL, P.N. (2001)  
*Contaminated land risk assessment: a guide to good practice.* C552. CIRIA (Construction Industry Research and Information Association), London.
- Enquiries relating to this publication should be addressed to:
- Kieron Doick  
Environmental and Human Sciences Division  
Forest Research  
Alice Holt Lodge  
Farnham  
Surrey GU10 4LH
- T: 01420 22255  
F: 01420 520180  
E: [kieron.doick@forestry.gsi.gov.uk](mailto:kieron.doick@forestry.gsi.gov.uk)  
[www.forestresearch.gov.uk](http://www.forestresearch.gov.uk)

## Appendix

Summary of 'Harm Tables' (adapted from Tables A and B, Annex 3, Defra Circular 01/2006, Department for Environment, Food and Rural Affairs, 2006).

Type of receptor	Description of categories of significant harm (after Table A of Circular 01/2006)	Description of conditions of significant possibility of significant harm (after Table B of Circular 01/2006)
<p><b>Human beings</b></p>	<ul style="list-style-type: none"> <li>• Death</li> <li>• Disease</li> <li>• Serious injury</li> <li>• Genetic mutation</li> <li>• Birth defects</li> <li>• Impairment of reproductive functions.</li> </ul> <p>For these purposes, disease is an unhealthy condition of the body or a part of it and can include, e.g., cancer, liver dysfunction or extensive skin ailments. Mental dysfunction is included only insofar as it is attributable to the effects of a pollutant on the body.</p> <p>In this Chapter, this description of significant harm is referred to as a 'human health effect'.</p>	<p>An assessment should take into account:</p> <ul style="list-style-type: none"> <li>• likely total intake or exposure;</li> <li>• relative contribution of the pollutant linkage to the aggregate intake or exposure;</li> <li>• duration of intake or exposure</li> <li>• toxicological properties including carcinogenic, mutagenic, teratogenic, pathogenic, endocrine-disrupting</li> </ul> <p>Harm which:</p> <ul style="list-style-type: none"> <li>• would be irreversible or incapable of being treated;</li> <li>• would result from a single incident such as a fire;</li> <li>• would be likely to result from a chronic exposure.</li> </ul> <p>Assessment is independent of the number of people who might be affected.</p>
<p>Any <b>ecological system</b> or living part of an ecological system:</p> <ul style="list-style-type: none"> <li>• an SSSI;</li> <li>• a national nature reserve;</li> <li>• a marine nature reserve;</li> <li>• an area of special protection for birds;</li> <li>• a Special Area of Conservation or a Special Protection Area</li> <li>• a listed Ramsar site</li> <li>• a National Park/reserve</li> </ul>	<p>For any protected location:</p> <ul style="list-style-type: none"> <li>• harm which results in an irreversible or substantial adverse change in the functioning of the ecological system within any substantial part of that location; or</li> <li>• harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.</li> </ul> <p>This description of significant harm is referred to as an 'ecological system effect'.</p>	<p>If:</p> <ul style="list-style-type: none"> <li>• significant harm is more likely than not to result from the pollutant linkage in question;</li> <li>• there is a reasonable possibility of significant harm being caused, and if that harm were to occur, it would result in such a degree of damage at the location that it would be beyond any practicable possibility of restoration;</li> </ul> <p>taking into account relevant information for the type of pollutant linkage, particularly in relation to the ecotoxicological effects of the pollutant.</p>
<p><b>Property (I)</b> in the form of:</p> <ul style="list-style-type: none"> <li>• crops, including timber;</li> <li>• produce grown domestically, or on allotments, for consumption;</li> <li>• livestock;</li> <li>• other owned or domesticated animals;</li> <li>• wild animals which are the subject of shooting or fishing rights.</li> </ul>	<p>For crops: substantial diminution in yield or loss in value resulting from death, disease or damage.</p> <p>For domestic pets or other property in this category, death, serious disease or serious physical damage.</p> <p>Substantial loss in value occurs only when a substantial proportion of the animals or crops are dead or otherwise no longer fit for their intended purpose. A benchmark for diminution in yield or loss is taken to be 20% or greater.</p>	<p>If significant harm of that description is more likely than not to result from the pollutant linkage in question, taking into account relevant information for that type of pollutant linkage, particularly in relation to the ecotoxicological effects of the pollutant.</p>
<p><b>Property (II)</b> in the form of buildings, where "building" means any structure or erection, and any part of a building including any part below ground level, but does not include plant or machinery comprised in a building.</p>	<p>Structural failure.</p> <p>Substantial damage or substantial interference (when any part of the building ceases to be capable of being used for the purpose for which it is or was intended).</p> <p>In the case of a Scheduled Ancient Monument, substantial damage should be regarded as occurring when the damage significantly impairs the historic, architectural, traditional, artistic or archaeological interest for which the monument was scheduled.</p>	<p>If significant harm of that description is more likely than not to result from the pollutant linkage in question during the expected economic life of the building (or, in the case of a Scheduled Ancient Monument, the foreseeable future), taking into account relevant information for that type of pollutant linkage.</p>

## Checklist

Criterion	Significance	Variable	Information available?
Soil screening survey	Impact on tree establishment	Abundance/Availability	
		Depth	
Soil physical characterisation	Rooting and stability of trees. Hydrology and water availability	Soil type	
		Stoniness	
		Compaction	
		Bulk density	
		Debris content	
Soil chemical characteristics	Vegetation selection and survival	pH	
		Cation Exchange Capacity	
		Organic matter	
		Electrical conductivity	
		Nutrient availability	
		Nutrient deficiencies	
		Essential element availability	
		Potentially toxic elements	
Soil-forming materials	Required if shortage of soil	Iron pyrite and acid generating materials	
		Physical characteristics	
		Chemical characteristics	
(Physical and chemical characterisation criteria for soil-forming materials are the same as for soil, above)			
Hydrology and hydrogeology survey	Water availability Likelihood of flooding Habitat design	Water table characteristics (depth and variability)	
Topography	Hazardous steep sides Risk of land-slide Tree instability	Actual or need for regrading (Landform control of soil water regime)	
Ecological survey	Identify rare, protected and 'weed' species Proxy evidence of contamination	Flora survey	
		Faunal survey	
		Red List species	
		Intrusive species	
		Further surveys required	
Habitats survey	Impacts site design, protection of rare habitats	Terrestrial	
		Aquatic	
		Areas to be protected	
		Further surveys required	
Tree, vegetation and habitat selection	Identify species and habitats to be established	Tree/Vegetation	
		Habitats	
Heritage or historic environment survey	Identify presence of designated heritage for protection	Site, monument and ancient monument record	
		Living heritage	
		Historic landscape characterisation	
Archaeology survey	Archaeological remains present	Need for steps to mitigate disturbance	
Physical hazards survey	Identify and assess site hazards and risks	(e.g. large boulders, glass, unstable ground)	