CIRIA W29 London, 2009

SAFEGROUNDS

Good practice guidance for the management of contaminated land on nuclear-licensed and defence sites

Version 2

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SAFEGROUNDS Good practice guidance for the management of contaminated land on nuclear-licensed and defence sites. Version 2

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CIRIA

CIRIA W29 RP767

Keywords
Contaminated land, environmental good practice, ground improvement, ground investigation and characterisation, health and safety, *in situ* testing and instrumentation, nuclear, site management, sustainable construction

Reader interest	**Classification**	
This guidance has been developed primarily for site owners, site operators and their contractors. It is also addressed to governmental and non-governmental organisations and other groups within the public	AVAILABILITY	Unrestricted
	CONTENT	Guidance
	STATUS	Committee-guided/ Stakeholder dialogue
	USER	Site owners, site operators, contractors, governmental departments, local authorities, regulators, NGOs, and other groups within the public

Version control	
Document title:	SAFEGROUNDS *Good practice guidance for the management of contaminated land on nuclear-licensed and defence sites*
Version and date:	Version 1, June 2009
Primary author:	Enviros with support from other authors
Prepared for:	SAFEGROUNDS Learning Network
History:	Second issue. Output of stakeholder dialogue The front pages were reformatted in June 2009 for consistency across the SAFEGROUNDS documents
Status:	SAFEGROUNDS good practice guidance document, prepared with the SAFEGROUNDS Project Steering Group This is a live document, subject to revision. Freely available web publication

Published by CIRIA, Classic House, 174–180 Old Street, London EC1V 9BP, UK.

Summary

This document is the second version of the *Land management guidance* (Hill *et al*, 2002) for the approach and process for land quality management on nuclear-licensed sites where legacy radioactive, non-radioactive and mixed radioactive and non-radioactive contamination is present. It also refers to those defence sites on which there is legacy radioactive contamination and mixed radioactive and non-radioactive contamination.

For any site, this guidance provides a strategic approach for the management of all the contaminated land on a case-by-case basis depending on the site, environment and contaminants.

The guidance has been developed mainly to assist those responsible for the management of contaminated land.

The document is intended to be relevant for both planning the future management of contaminated land and in managing the land in practice. It can be used in strategic planning for the overall management of contaminated land on a site, as well as being applied to specific situations or cases.

The guidance recognises that the management of contaminated land may have already started on some sites or in some areas of sites. The SAFEGROUNDS process aims to incorporate previous and existing plans to develop a method for managing these liabilities.

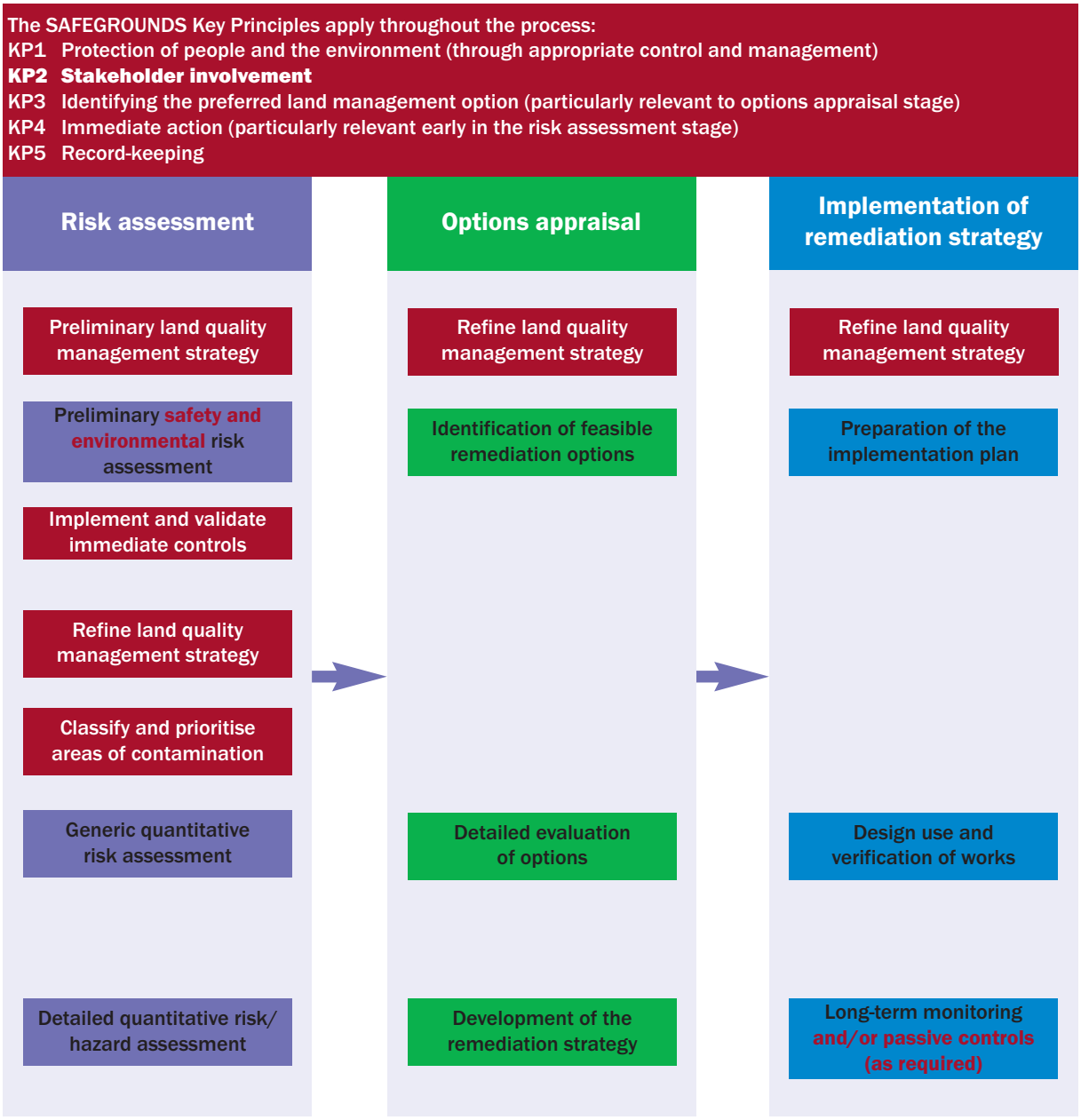
SAFEGROUNDS has identified five key principles for the management of contaminated land on nuclear-licensed and defence sites, and these key principles can be applied at any time to pre-existing contaminated land operations. The key principles have been established through a consultative process involving representatives from a variety of stakeholder groups, and are:

- Key Principle 1 Protection of people and the environment
- Key Principle 2 Stakeholder involvement
- Key Principle 3 Identifying the preferred land management option
- Key Principle 4 Immediate action
- Key Principle 5 Record-keeping

Through the evolution of the SAFEGROUNDS process, the key principles remain unchanged although there has been further refinement and clarification of the descriptions that accompany Key Principles 2 and 4. The key principles and an amplification of them is presented in Part 2 of this guidance.

A systematic approach to the management of contaminated land on nuclear-licensed and defence sites has been developed and is presented in Part 3. The process is illustrated on page 8 in a generic flow diagram based on the process of managing land contamination outlined in Contaminated Land Report 11 (CLR 11) *Model procedures for the management of land contamination* prepared by the Environment Agency (2004), with some modifications. The modifications incorporate the SAFEGROUNDS key principles throughout the process and highlight other factors to be considered on both nuclear-licensed and defence sites. A summary diagram is presented on page 4.

Part 4 of the document contains references and abbreviations used in this document, as well as a glossary.



Note: the modifications to the CLR 11 decision flow diagram for SAFEGROUNDS are highlighted in dark red boxes with tan lettering

A summary diagram of the main flow diagram on page 8

Acknowledgements

Authors

This guidance was prepared by Enviros under contract to CIRIA on behalf of the SAFEGROUNDS Learning Network between early 2007 and April 2009. The project supervisor was P Towler and the principal authors were M Hill, J Penfold, R Walke, M Egan, D Collier, A Eslava-Gomez, P Kruse, A Rankine and P Towler. H Richards from Magnox Electric North, also made a significant contribution.

Project Steering Group

The SAFEGROUNDS project was guided by a steering group comprising project funders, and regulatory and policy-making stakeholders. CIRIA and the research contractors wish to express their appreciation for the technical guidance and support given by the group during the project and in their additional review of drafts of the guidance. The members of the group during the process of production of this document were:

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CIRIA's research managers for this project were Mr Jeff Kersey, Mr Mark Bentley and Miss Rajnika Patel, assisted by Ms Gemma Samlal under the direction of Dr Owen Jenkins.

CIRIA, on behalf of all those involved in preparing this guidance, would like to thank everyone who participated in the SAFEGROUNDS project.

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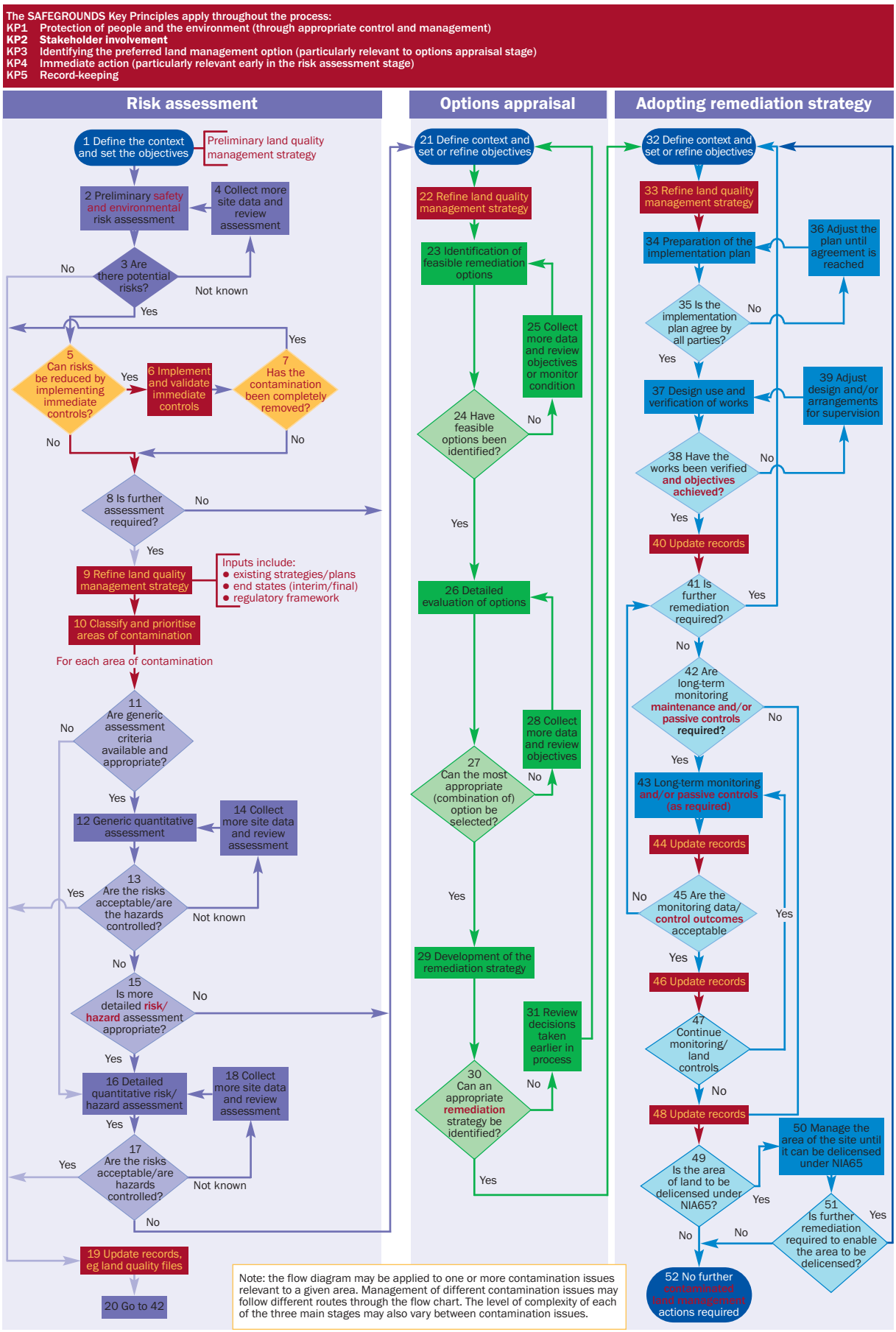

Note: the modifications to the CLR 11 decision flow diagram for SAFEGROUNDS are highlighted in dark red boxes with tan lettering

Figure 1.1 ***Generic flow diagram for management of contaminated land***

PART 1 Introduction and overview

1 Introduction

1.1 Scope

This guidance sets out an approach and process for *land quality*[1] management on *nuclear-licensed sites* where legacy radioactive, non-radioactive and mixed radioactive and non-radioactive *contamination* is present. It also refers to those *defence sites* on which there is legacy radioactive contamination and mixed radioactive and non-radioactive contamination.

Nuclear-licensed sites include civil nuclear sites that are being used for electricity generation or other purposes, and nuclear sites that are being decommissioned and are the responsibility of the Nuclear Decommissioning Authority (NDA).

For the purpose of this guide defence sites include those owned by the Ministry of Defence (MoD) where activities involving radioactive material have been undertaken, such as the maintenance of nuclear propelled vessels and the production and maintenance of radium luminised instruments for vehicles, aircraft and on board ships[2]. While the Nuclear Installations Act 1965 (NIA65) does not apply to MoD certain defence sites are regulated under the Act, and may also be considered to be nuclear-licensed sites.

Most of the SAFEGROUNDS guidance relates to radioactive contamination of the land and mixed contamination. Other recent guidance is available with regard to the management of non-radioactive contamination of land (EA, 2008a).

Limited guidance is given for sites outside the scope of SAFEGROUNDS on which there is, or in future could be, radioactive contamination. These are:

- former and current industrial, medical and research sites on which there is radioactive contamination
- land that has recently been contaminated by a nuclear accident or radiological emergency.

In contamination following an accident the guidance is for dealing with radioactive contamination in the long-term, after short- and medium-term countermeasures have been taken, and when the land is being remediated or prepared for new uses.

The SAFEGROUNDS guidance does not directly address land affected by historical authorised *discharges* that may be adjacent to, or remote from the site in question. However the principles may be applied if *remediation* of these areas was considered necessary.

1 Italics indicate definition on first appearance given in glossary

2 Low level radioactive contamination may be present as a result of the historical production, maintenance, storage and disposal of luminised instruments. The peak period for luminising was from the 1930s to the 1970s. In the late 1950s 14 luminising works were registered under the Luminising Regulations 1947 and owned by the MoD. The luminising paint originally contained radium, though more recently promethium and tritium were used. Thoriated metals may also be present as a result of use, maintenance, storage or disposal on some defence site.

1.2 Purpose

The SAFEGROUNDS guidance has been developed primarily to help those responsible for the *management of contaminated land* and to inform other *stakeholders*. It also supplements government and regulatory guidance on the management of contaminated land.

The guidance is intended to be relevant both in planning the future management of contaminated land (including making liability estimates) and in managing the land in practice. It can be used in strategic planning for the overall management of contaminated land on a site, as well as being applied to specific situations or cases.

It is recognised that the management of contaminated land has already begun in some locations. The approach suggested here does not propose that previous actions should be disregarded or information ignored. The accumulation of information over time is valuable for the efficient management of contaminated land. The SAFEGROUNDS process looks to incorporate previous and existing plans to develop a sustainable method for managing these liabilities. Adopting the SAFEGROUNDS key principles can be applied at any time to pre-existing contaminated land operations.

The guidance takes account of the variety of situations that can exist on nuclear-licensed sites and defence sites. It is not intended to be prescriptive but provides a flexible framework so that radioactive, non-radioactive and mixed contamination on nuclear-licensed sites and radioactive contamination on defence sites can be managed.

1.3 Status

This is the second version of the land management guidance and, like the first (CIRIA, 2002), it is a "living document". It is intended to be regularly revised in the future following experience in using it and in response to policy, regulatory and other changes.

The guidance is not binding on site owners/operators and has no legal standing. It represents good practice in accordance with regulatory requirements. However, site specific requirements should always be discussed and negotiated with the appropriate regulators.

1.4 Approach

A systematic approach to the management of contaminated land on nuclear-licensed and defence sites has been integrated in Contaminated Land Report 11 (CLR 11) (EA, 2004) with some modifications. The modifications include the SAFEGROUNDS key principles (Part 2) and highlight extra factors to be considered on both nuclear-licensed and defence sites (Part 3).

CLR 11 provides a technical framework for structured decision making about land contamination and should be consulted alongside the SAFEGROUNDS guidance throughout the land quality management process.

1.5 Structure

This guidance is in four parts:

- **Part 1** contains this introduction, scope, structure and definitions.
- **Part 2** sets out the SAFEGROUNDS key principles for the management of contaminated land on nuclear-licensed sites and defence sites.
- **Part 3** contains an overview of the process of managing contaminated land and further guidance on specific areas of the process. This is illustrated by a flow diagram that was developed as a result of a consultation process before and during the drafting of this guidance (Figure 1.1 see page 8).
- **Part 4** contains a list of references, statutory and regulatory guidance documents, and a glossary, with a key to acronyms, in which the most important ones are highlighted.

1.6 Supporting information

As described above, the land management guidance deals mainly with general approaches to the management of contaminated land. More detailed guidance on specific topics is provided in the following SAFEGROUNDS supporting documents:

- W15 SAFEGROUNDS: *Assessments of health and environmental risks of management options for contaminated land* (Smith, 2007): discusses risk assessments that are to be carried out as part of the land quality management process, and as input to the identification of the remedial options.
- W17 SAFEGROUNDS: *The UK Regulatory Framework for contaminated land on nuclear-licensed sites and defence sites* (Hill, 2007): provides a factual summary of the key features of the UK Regulatory Framework for the management of contaminated land on nuclear-licensed and defence sites.
- W21 SAFEGROUNDS: *Good practice guidance for land quality records management for nuclear-licensed and defence sites* (Cruickshank and George, 2007): provides guidance on land quality records and record-keeping, addressing why information should be kept, what information should be kept and how record-keeping systems should be structured and maintained.
- W28 SAFEGROUNDS: *Guide to the comparison of contaminated land management options* (Penfold, 2009a): this document provides information on methodologies appropriate for the identification of a preferred land management option for a particular site and situation. The focus is on practical guidance and specific advice on application.
- W30 SAFEGROUNDS: *Good practice guidance for site characterisation* (Towler, Rankine, Kruse and Eslava-Gomez, 2009b): this is a largely technical document providing specific guidance on the process of site characterisation.
- W27 SAFEGROUNDS: *Approach to managing contaminated land on nuclear-licensed and defence sites – an introduction* (Collier, 2009c): published in response to requests from community groups for a non-technical overview of the principles that support this guidance and the approach it recommends to decision making and community involvement.

1.7 Definitions

1.7.1 Contaminated land

The term “contaminated land” is used in SAFEGROUNDS guidance in a general way and means any land “in, on or under” which there are radioactive or non-radioactive *contaminants* above the natural and artificial background levels that are typical of the

area of the UK in which the site is located. This definition is broader than the statutory definition in Part 2A of the Environmental Protection Act 1990, which applies only to land in its current use (including any use that has been granted planning permission). It also reflects the intention of the Part 2A regime to focus on sites with potentially the highest risks to people and the environment. The broader definition is employed to cover all cases where the presence of contaminants is or could be a cause for concern to the owners or operators of the site, the regulators and other stakeholders.

The term "in, on or under" includes soils, rocks, groundwater and below ground structures but excludes authorised disposals of radioactive and non-radioactive wastes. Gaseous radioactive contaminants may result in the contamination of land, but those of natural origin (eg radon) and those resulting from authorised disposal are excluded.

Guidance on determining background levels typical of an area is given in the SAFEGROUNDS *Site characterisation guidance* (Towler *et al*, 2009b).

1.7.2 Management and remediation of contaminated land

The terms management (of contaminated land) and remediation (of contaminated land) have the following meanings in SAFEGROUNDS guidance:

Management of contaminated land: includes aspects of taking any actions to assess, characterise, control, monitor, remediate or remove (wholly or partially) legacy contamination in, on or under land and all the processes that lead up to decisions on taking such actions to protect people and the environment. This includes, but is not limited to, development of a conceptual site model and undertaking a risk assessment and a structured comparison of potential management options.

Remediation of contaminated land: Any measures that may be carried out to reduce the risks from legacy contamination of land areas through action applied to the contamination itself (the source) or to the exposure pathways to humans or other receptors.

These definitions are for the purposes of SAFEGROUNDS only and have been chosen to be consistent with the scope of SAFEGROUNDS guidance. From these definitions, remediation is a part of management, because control or removal of contamination or control of pathways manages risks. Prevention of contamination is excluded from management because it is outside the scope of SAFEGROUNDS, however, any management action must consider the potential for migration of contaminants, especially to previously unaffected areas.

Where it is necessary to refer to other definitions in statutory, government or regulatory guidance quotation marks are used and the source of the definition given, eg "remediation" as defined in the Health and Safety Executive (HSE) Safety assessment principles (SAPs) (HSE, 2006). Details of these other definitions are given in the *UK Regulatory Framework for contaminated land on nuclear-licensed sites and defence sites* (Hill, 2007).

1.7.3 Land quality management strategy

In SAFEGROUNDS guidance the *Land quality management strategy* (LQMS) is a document (or suite of documents) setting out the framework of arrangements, processes and broad *objectives* for all aspects of managing contaminated land on the site (or part of a site) to reduce or control the risks from all the relevant *pollutant linkages* associated with the site (or part of the site). The LQMS is also a "living document" that

is progressively refined with time as more information becomes available to identify the preferred land management option.

The framework approach offers flexibility to develop these subordinate elements such as a *remediation strategy*, and so the term "strategy" may also have different meanings in different *contexts* when following the SAFEGROUNDS process. It will be important to ensure that any strategy document dealing with contaminated land clearly states what it intends to cover.

A land management option is any potential method of managing the contaminated land that is relevant to the objectives set in the LQMS. A tiered approach may be needed in which the range of possible solutions is systematically narrowed down through several consultative stages to compare options, and ultimately identify the preferred option that will form the *remediation strategy* [3]. This process is likely to be necessary particularly where the problem is complex. There are three possible stages in the SAFEGROUNDS approach to identifying the appropriate "remediation strategy":

1 An initial stage aims to identify the strategic options at a high-level, concentrating on broad themes such as alternative *end states* and timescales. This stage may not be necessary if there is an established strategy, or the contaminated land is limited in scale and significance.
2 The second stage is an analysis of the suitability of technologies. This stage is more specific and refers to clearly defined options that can be characterised in some detail.
3 A final stage is focused on evaluating practical options for implementation to specific areas of contaminated land. This considers specific issues associated with the practical application of contaminated land management option(s). This stage could be combined with the comparison of technology options.

It may also be appropriate to undertake an initial scoping study, preceding any one of these stages, which will clarify the nature and significance of the problem. The LQMS can be updated once the preferred strategic option is identified. SAFEGROUNDS terminology for identifying an option is known as "options comparison" or "options appraisal", and guidance is available in SAFEGROUNDS W28 (Penfold, 2009a).

1.7.4 Stakeholder involvement

Importantly, stakeholders are all the people with an interest in the management of the contaminated land. They include institutional stakeholders, such as regulators, local and national government and senior management within site *owner/operator* organisations, and others who could be affected by, or have a direct interest in, land management decisions, such as employees, local residents, non-governmental organisations (NGOs), community-based organisations (CBOs) and individuals.

Involvement includes communication, provision of information, consultation and participation in the process to inform, impact on, and demonstrably influence decision making processes. It does not include taking responsibility for final decisions on how to manage contaminated land from those who are responsible, ie the site owner or operator (on nuclear-licensed sites the licensee and on defence sites the MoD).

Within SAFEGROUNDS the term "involvement" is used in preference to "engagement". This is because while engagement usually includes communication, provision of information and consultation, it can be perceived to exclude participation

3 The term remediation strategy is used as it is a specific element in the CLR 11 process.

in processes that inform decision making. To be effective, the decision maker needs to be informed by the views of the stakeholders, while the stakeholders need to have confidence that their input is considered, and has an effective and demonstrable impact on the decision making process. Although often used, the term “stakeholder consultation” is too narrow to accurately describe the full process of stakeholder involvement. The term “consultation” as used here represents one element of the involvement process, ie the collection of views and responses based on the information available.

PART 2 SAFEGROUNDS key principles

2 Key principles for the management of contaminated land

SAFEGROUNDS has identified five key principles for the management of contaminated land on nuclear-licensed and defence sites. The key principles have been established through a consultative process that involved representatives from a variety of stakeholder groups. The key principles are non-overlapping, complementary and should be applied together at various stages in the land management process.

Through the evolution of the SAFEGROUNDS process, while the key principles in essence remain unchanged, there has been further refinement and clarification of the descriptions that accompany these key principles. Refined descriptions for Key Principles 2 and 4 follow: included are the original descriptions and a short explanation of the changes. The key principles are presented in an order of priority of stakeholder importance that were agreed by consultation rather than an order of service:

Key Principle 1 Protection of people and the environment

The fundamental objective of managing contaminated land on nuclear-licensed sites and defence sites should be to achieve a high level of protection of people and the environment, now and in the future.

Key Principle 2 Stakeholder involvement

Principle 2 originally stated that:

"Site owners/operators should develop and use stakeholder involvement strategies in the management of contaminated land. In general, a broad range of stakeholders should be invited to participate in decision making".

The description was changed to clarify that the stakeholders would "inform" the decision making process rather than "participate" in decision making and that the phrase "broad range" was superfluous.

Site owners/operators should involve stakeholders in the management of contaminated land, particularly to inform decision making.

Key Principle 3 Identifying the preferred land management option

Site owners/operators should identify their preferred management option (or options) for contaminated land by carrying out a comprehensive, systematic and consultative assessment of all possible options. The assessment should be based on a range of factors that are of concern to stakeholders, including health, safety and environmental impacts and various technical, social and financial factors.

Key Principle 4 Immediate action

Principle 4 originally stated that:

"Site owners/operators should take measures immediately to monitor and control all known (or suspected) contamination and continue such measures until an acceptable management option has been identified and implemented".

This was changed because the requirement to monitor and control all known and suspected contamination immediately is impractical. Finding all the suspected contamination on a large site may take some years. The previous description could lead to an unrealistic expectation. It is more reasonable to expect that steps to control contamination will occur once it becomes known and that a programme for the investigation of all suspected contamination is in place.

Site owners/operators should assess both potential and known areas of land contamination and where appropriate implement a prioritised programme of investigation and any appropriate monitoring. On confirmation of areas of land contamination being present, control measures should be instigated until an appropriate management option has been identified and implemented.

Key Principle 5 Record-keeping

Site owners/operators should make comprehensive records of the nature and extent of contamination, the process of deciding on the management option for the contaminated land and the findings during the implementation and validation of the option. All records should be kept and updated as necessary.

The application of each principle is expanded in the following section.

2.1 Amplification of the key principles

2.1.1 Key Principle 1 Protection of people and the environment

The fundamental objective of managing contaminated land on nuclear-licensed sites and defence sites should be to achieve a high level of protection of people and the environment, now and in the future.

2.1.1.1 General commentary

The basic obligation is to ensure that all contamination is appropriately controlled and managed, to address this key principle.

In this key principle, "protection of people" refers to the health and well-being of the public and the site workforce. The "environment" includes land, water (including groundwater), air, flora, fauna, buildings, livestock, crops and sites of historical and cultural importance.

It should not be assumed that protecting people protects the environment or vice versa. The balance between protecting people and protecting the environment has to be resolved in the process of identifying the preferred land management option (see Key Principle 3).

It is necessary to protect people and the environment both from expected situations and those with a lower probability of occurring. This means taking risk mitigation measures to reduce, as far as reasonably possible, the likelihood of adverse effects occurring, as well as reducing the effects themselves should they occur. The level of risk

needs to be considered fully, taking into account both the *hazards* and probability of occurrence.

As stated in Section 1.1, SAFEGROUNDS guidance applies to radioactive, non-radioactive and mixed contamination on nuclear-licensed sites and to radioactive and mixed non-radioactive contamination on defence sites. However, the primary focus of the following discussion of what a *"high level of protection"* means relates to radioactive contamination (including mixed contamination). For more details on the relevant regulatory regimes, the reader is referred to the review undertaken for SAFEGROUNDS (Hill, 2007b), which is due to be updated in the summer of 2009.

Broadly speaking, there are two opposing views represented within the SAFEGROUNDS Learning Network concerning the health risks from radiation exposure:

1 A high level of protection of people and the environment is afforded by a combination of self-regulation and compliance with the relevant radiological regulatory regimes that apply in the UK. These regulatory regimes require the application of the principle of reducing risks "as low as reasonably achievable/practicable" (ALARA/P) and specifically rely on recommendations of the International Commission on Radiological Protection (ICRP) (ICRP, 1991).
2 A high level of protection of people and the environment is not afforded by current UK regulatory regimes, and suggests that risks from exposure to both low level radiation and other contaminants are significantly underestimated by the ICRP. SAFEGROUNDS guidance on this issue is under review at the time of writing (January 2009) and may be updated or replaced during 2009–2010.

Different views among stakeholders may affect whether health protection criteria expressed in terms of exposure to radioactive contamination (eg as radiation dose or intakes of *radionuclides*) are accepted as demonstrating a given level of protection expressed in terms of risk. SAFEGROUNDS recommends that different views among stakeholders about such issues should be recognised, given explicit consideration, and show a demonstrable impact on decision making processes. Recognition of the concerns raised is an important element of stakeholder involvement.

A further general issue concerns the balancing of risks to different receptors, including different groups of people and different environmental receptors. One approach to remediation of contaminated land is the removal of contamination from the site (often as contaminated soil), for disposal as waste by authorised route(s). This may be seen by some stakeholders as being the best way to assure a high level of protection (of the public at least). SAFEGROUNDS recommends that when considering the options for dealing with contaminated land, one or more option(s) that would reduce contaminant concentrations to the lowest achievable levels should always be considered. Such option(s) may result in a high level of protection of the public and/or the environment from the contaminated land, but in some cases they may be screened out as not practicable, or may not emerge from the options comparison as preferred option(s). For example, the exposure of workers during the remediation or the environmental impact of off-site disposal may prove to be unacceptable, or the cost may be grossly disproportionate to the averted risks. So it is important that a comprehensive view is taken, involving the assessment of each option in appropriate detail and the comparison of options using an appropriate range of *criteria*. Part 3 of this guide and the SAFEGROUNDS *Guide to the comparison of contaminated land management options* (Penfold, 2009a) provide information on how this can be done.

2.1.1.2 Levels of protection afforded by radiological regulatory regimes

A general principle that is required in regulation of radiological risks in the UK (and applied to radioactive contaminated land) is that risks should be reduced to be "as low as reasonably achievable, economic and social factors being taken into account" (*ALARA*) or "as low as reasonably achievable practicable" (*ALARP*). The terms ALARA and ALARP are preferred in different contexts but have essentially the same meaning, and are intended to deliver high levels of protection of people, but not at grossly disproportionate cost or to the detriment of society as a whole. ICRP (and regulatory regimes that carry out its recommendations) uses the term *"optimisation"* for the process of consideration of options to demonstrate that doses/risks are kept ALARA/P.

The following paragraphs set out how these principles are adopted in different regulatory contexts. Some regulatory regimes are primarily expressed in increased individual risk of fatal cancer and some in terms of radiological dose. The risk/dose conversion factor used to estimate the fatal cancer risk associated with a given dose for members of the public is taken from the recommendations of the ICRP and is subject to change, but has been in the range 1.5×10^{-5} to 5×10^{-5} per mSv (whole body effective dose) over the past 30 years. The current value is 5×10^{-5} per mSv (whole body *effective dose*) and this value has been recommended since 1990.

An important concept used in setting limits for dose and risk in regulation has been the distinction between what were formerly termed "practices" and "interventions" by ICRP. The recommendations of the ICRP (ICRP, 2007) introduce the terms "planned exposure situations", "existing exposure situations" and "emergency exposure situations".

Existing nuclear-licensed sites

On nuclear-licensed sites, radioactive contaminated land is regulated by HSE as "accumulation(s) of nuclear matter" (SAPs paragraph 740) (HSE, 2006) and should be managed in accordance with the (generic) Site Licence Conditions and included within the safety case(s) for the site. The site safety case(s) must demonstrate that risks to members of the public from the nuclear hazards on the site as a whole are ALARP and always below the "upper tolerable level" as defined by HSE (1992), namely a risk of death not exceeding one in ten thousand (10-4) per annum. This is called the basic safety limit (BSL) in the HSE *Safety assessment principles* (SAPs) (HSE, 2006). The HSE expects risks to the public from a nuclear-licensed site to be minimised and where practicable kept below a basic safety objective (BSO) of one in a million (10^{-6}) per annum. HSE (1992) regards risks to the public below 10^{-6} per annum as being "broadly acceptable" and does not expect an operator to expend significant resource pursuing even greater risk reduction below this level.

The Ionising Radiations Regulations 1999 require that doses to members of the public from normal operations of nuclear sites must not exceed 1 mSv per annum, which (using the ICRP advice) implies a risk less than 10^{-4} per annum.

HSE expects risks arising from radioactive contaminated land on a nuclear-licensed site to be reduced such that when combined with other risks from the site, the total risk to members of the public is below the BSL (10^{-4} per annum) and ALARP. HSE expects radioactive contaminated land should be managed and controlled such that in practice the resulting risk to members of the public is considerably below the BSL and preferably below the BSO of 10^{-6} per annum.

HSE does not regulate solely on the basis of minimising risks to people, but also

emphasises the need to manage and control nuclear matter at all times, including the need to minimise the generation of radioactive waste. As *radioactively contaminated land* has the potential to become waste, HSE makes it clear in the SAPs that it expects licensees to prevent (so far as is reasonably practicable) the spread of radioactive contamination into previously uncontaminated ground.

Delicensing of nuclear-licensed sites

The HSE have published its policy/*criterion* for *delicensing* nuclear sites (HSE, 2005) and guidance to its inspectors on interpretation of the criterion (HSE, 2008). Delicensing means the "ending of the period of responsibility under the Nuclear Installations Act" (NIA65). For delicensing to be approved, the HSE has to be content that there has "ceased to be any danger from *ionising radiation* from anything on the site or, as the case may be, on that part thereof". For the regulator to give this notice the licensee must demonstrate "no danger" and that there has "ceased to be any danger" from ionising radiation as detailed in the NIA65.

The HSE policy, developed after extensive consultation, is that it would be unreasonable to require a licensee to demonstrate "no danger" by demonstrating that the site is completely free of all activity. The policy concludes that, after termination of licensable activities on a site and following rigorous decontamination and clean-up, the residual risk from any radiological hazard remaining on site should be in line with HSE's views on "broadly acceptable" risks and the concept of reducing risks to be ALARP.

HSE would require the licensee to show that any such remaining radiological hazard will not pose a significant residual risk to any person, for all reasonably foreseeable uses the site may be put to and not for just its next *future use*. In general if HSE judges that the operator has demonstrated that the residual risk of death of any individual, due to the material left on site, is less than 1 in a million (10^{-6}) per annum, this will usually be sufficient to satisfy all of its substantive concerns. At such low risks, HSE would not expect an operator to expend significant resource pursuing even greater risk reduction.

Sites other than nuclear-licensed sites (including delicensed nuclear sites and defence sites)

The Health Protection Agency's (HPA) Radiation Protection Division (formerly the National Radiological Protection Board (the NRPB)) has published advice on applying radiation protection principles to land contaminated with radioactivity. This advice is presented in the publication *Radiological protection objectives for land contaminated with radionuclides* (NRPB, 1998) and is summarised in this section.

The UK's framework for radiation protection recognises two broad situations for exposure to ionising radiations:

1 Practices.

2 Interventions.

A practice situation is any controlled situation that increases an individual's exposure to ionising radiation[4], while intervention results in a reduction in an individual's existing exposure. Each situation requires a different approach to protecting the individual. A change in the use of a site affected by radioactive contamination (under the planning

4 The operation of a nuclear licensed site (including any radioactive contaminated land thereon) represents a particular type of practice, which is regulated by HSE under the Nuclear Installations Act.

regime) is considered by HPA to be a practice situation ("planned exposure" situation in the terminology of ICRP 2007). The Part 2A radioactive contaminated land regime relates to intervention situations ("existing exposure" situations in the terminology of ICRP 2007). For this reason, different dose/risk criteria apply in these two regulatory regimes. Further detail is provided in the Environment Agency's *Land contaminated with radioactivity and the principles of radiation protection* (EA, 2008b) and Smith *et al* (2006).

For change of use, the Environment Agency expects that the developer's proposal should consider the available remedial options for cleaning up the site and ensure exposure to future users of the land would be ALARA, taking into account economic and social factors[5]. HPA's advice (accepted by the Environment Agency) is that the planning proposal should also show that the excess risks to an individual representative of those most exposed will not exceed a risk constraint of 1×10^{-5} per year (ie equivalent to an annual effective dose of about 0.3 mSv). These criteria could apply to a planned change in use of part of a delicensed former nuclear site or a defence site or land adjacent to a nuclear-licensed site affected by radioactive contamination. In the case of a delicensed nuclear site subject to planning proposals, the clean-up required for delicensing would have met the risk criterion by a margin of at least an order of size. In the case of change of use on part of an existing nuclear-licensed site, the HSE's safety requirements under the Nuclear Installations Act and Site Licence Conditions would still apply.

Under Part 2A of the Environmental Protection Act 1990 (EPA90) as extended and modified in England[6] by the Radioactive Contaminated Land (Modification of Enactments) (England) Regulations 2006, land should be determined as contaminated by virtue of radioactivity if *"harm"* is caused or if there is a significant possibility of "harm" being caused. "Harm" is defined in the Statutory Guidance (DEFRA, 2006) as being lasting exposure that gives rise to doses in excess of one or more of the following criteria:

- an effective dose of 3 mSv per annum[7]
- an equivalent dose to the lens of the eye of 15 mSv per annum
- an equivalent dose to the skin of 50 mSv per annum.

In practice, it is unlikely that the criterion for the lens of the eye would be exceeded without the other criteria being exceeded.

Doses/risks to the public from residual radioactive contaminated land on a site following remediation of "radioactively contaminated land" determined under Part 2A should be optimised (ALARA) and below the above dose limits.

2.1.1.3 *Protection of people and the environment in the non-radioactive context*

Part 2A of the Environmental Protection Act 1990

The non-radioactive provisions of Part 2A are intended as safety net legislation to provide regulatory powers for local authorities (supported in the case of nuclear and defence sites by the relevant environment agency) to cut unacceptable risks from

5 This process of consideration of options to make risks ALARA represents "optimisation" and good practice would involve following SAFEGROUNDS Key Principle 3. The NRPB (1998) statement considers it unlikely that significant expenditure to reduce risks below 1×10^{-6} per year would be warranted on radiological protection grounds.

6 See the regulatory framework review by Hill (2007) for any differences in Scotland, Wales and Northern Ireland.

7 Equivalent to an increased risk of fatal cancer of the order of 10^{-4} per annum, using ICRP recommendations.

contaminated land in its current condition. Its intended effect is also to encourage voluntary remediation of contaminated sites that can avoid being determined as "contaminated land" under Part 2A.

The terms "significant harm" or the "significant possibility of significant harm" (SPOSH) and/or "significant pollution" of the water environment form the basis for what may be defined as contaminated land under Part 2A[8]. The meanings of these terms are not given in the legislation but statutory guidance is available (DEFRA, 2006, Scottish Executive, 2006 and Welsh Assembly Government, 2006) that develops the concept of "unacceptable intake or direct bodily contact", although no numerical definition of "unacceptable" is provided. DEFRA (2008) have stated that: "science alone cannot answer of whether or not a given possibility of significant harm is significant. The question of what is significant is a matter of policy based firmly on risk assessment taking account of all relevant and available evidence."

DEFRA (2008) states that: in setting "minimal risk" *screening thresholds* for use in non-radioactive Part 2A decisions (but not identification of SPOSH), Government considers that an excess lifetime cancer risk of 1 in 100 000 would be appropriate, and goes on to say that this is "broadly consistent with similar risk levels applied … for the protection of health from chemicals in other environmental media."

In the context of harm to human health, it may be noted that other UK guidance (HSE, 2001) judges that the boundary between tolerable and unacceptable risks for members of the public who have a risk imposed on them "in the wider interest of society" is an additional extra risk of death of one in ten thousand (10^{-4}) per annum. As previously described, this level of risk has been used in setting the dose criteria for defining "harm" from radioactivity in the Part 2A context.

Planning regime and building control

The principal planning objective is to ensure that any unacceptable risks to human health, buildings and other property and the natural and historical environment from contaminated land are identified and appropriate action taken to address those risks on the basis of the proposed future use.

Local planning authorities (LPA) should take account of contamination or the potential for contamination both in preparing development plans, which set out the policies and proposals for future land-use and development within their area, and in determining individual applications for planning permission. Planning permission may be granted on condition that the site is remediated to the satisfaction of the local authority. Guidance for planning authorities in England is currently provided in Planning Policy Statement 23 (PPS 23) *Planning and pollution control* (ODPM, 2004). In Scotland, Planning Advice Note 23 (PAN 23) applies (Scottish Executive, 2000). In Wales, Technical Advice Note 8 (TAN 8) applies (Welsh Assembly Government, 1997).

Land contamination is a material planning consideration in the preparation of development plan documents as well as the decision making process associated with individual planning applications. The landowner/developer is responsible for identifying land affected by contamination and ensuring remediation is undertaken to achieve a safe development.

The local planning authority must satisfy itself that contaminated land and the associated risks are adequately assessed and that the remediation to mitigate any unacceptable risks is suitably managed. PPS23 states that as a minimum after carrying

8 See Glossary definition of "contaminated land" under Part 2A.

out the development and at the start of its use: "the land should not be capable of being determined as contaminated land under Part 2A of the EPA 90". So the criteria for Part 2A contaminated land will apply.

Building work is subject to building control under the Building Regulations 1991. The approval process is carried out by building control bodies that include local authority technical officers or approved inspectors. Under Schedule 1 of these Regulations requirement C2 states that: "precautions shall be taken to avoid danger to health and safety caused by substances found on or in the ground covered by the building."

Water Resources Act 1991 and Water Environment and Water Services Act (Scotland) (WEWSA) 2003

The Part 2A regime covers the pollution of *"controlled waters"* (or the "water environment" in Scotland) where contaminated land is the cause. In other cases the EA or SEPA have powers under the Water Resources Act 1991 (WRA) to prevent and remedy the pollution of relevant water bodies.

The WRA is concerned with contamination of controlled waters (groundwater, surface water and coastal waters) and gives powers to the EA to address remedial contamination of such controlled water and also of land where pollution may enter controlled waters. The provisions of the WRA (and the powers of the EA) can apply even when the land is not statutory contaminated land under the terms of Part 2A. The EA have indicated that in general Part 2A will be applied in preference to WRA powers if it is applicable.

The WEWSA (2003) contains a requirement for "remedial or restoration measures", which includes the carrying out of any operations or works to mitigate the effects of any pollution of the water environment (groundwater, surface water and coastal waters). SEPA has the power to make the appropriate person undertake these actions to protect the water environment.

Groundwater Regulations 1998 and Water Environment (Controlled Activities) (Scotland) Regulations 2005

The Groundwater Regulations 1998[9] and Water Environment (Controlled Activities) (Scotland) Regulations 2005 implement the EEC Groundwater Directive. These regulations control the disposal of listed substances to groundwater. Activities resulting in indirect discharges may be authorised, following prior investigation. Any intention to dispose of listed substances in a way that might cause a discharge into groundwater would require an authorisation. While radioactive substances are explicitly excluded from the groundwater regulations other substances that could make groundwater unfit to drink may result in the environment agencies taking action to protect the groundwater. This includes the accidental contamination of groundwater from substances such as hydrocarbons. When undertaking an activity on or in the ground all necessary measures to prevent an accidental discharge of listed substances to groundwater must be taken. These regulations could be used to compel the landowner to clean-up contamination that could affect groundwater quality.

2.1.1.4 *Protection of people and the environment in the cases of mixed contamination*

Non-radioactively contaminated land protection is structured on a different technical basis from radiological protection. This leads to the need to establish with all

9 The existing Groundwater Directive is to be repealed by the Water Framework Directive in 2013. In May 2008 DEFRA consulted on the means of implementing the requirements of the new Groundwater (Daughter) Directive 2006/118/EC in England.

stakeholders the approach on a site-by-site basis where mixed radioactive and non-radioactive contamination is present.

On any site where there is radioactive and non-radioactive contamination it is recommended good practice that a single integrated strategy for the management of radioactive, non-radioactive and mixed contamination of the land is prepared. This strategy should be developed using the case-by-case approach to levels of protection taking into account specific regulator requirements that apply to the installation/site in question and the need for stakeholder involvement. It is recognised that this is not without its difficulties given that there are potentially different bodies involved in the regulation of radioactively and non-radioactively contaminated land. On nuclear-licensed sites mixed contamination is required to be managed as radioactive material.

When considering areas of mixed contamination, it is important to ensure an equitable comparison of the risks because some contaminants will exhibit a response threshold while others, such as radiation at lower doses, do not or are assumed not to have a threshold. This enables a balanced and reasoned approach to determining the appropriate actions.

Although very few reports of interactions between ionising radiation and other (non-radiological) agents are available, one notable exception is the epidemiological study of lung cancer in those exposed to radon gas, which demonstrates a strong synergy between tobacco smoke and radon in the development of lung cancer (Darby *et al*, 2005). It should of course be noted that in epidemiological studies of radiation risk, the exposed populations will have received exposures to other environmental agents. In this respect current institutional radiation protection philosophy argues that interactions between radiation and other agents are implicitly taken into account in the ICRP radiation risk estimates.

However, because data on actual exposure levels of multiple sources in the population are scarce, alternative scientific commentators maintain that this represents a fundamental lacuna in knowledge (Koppe *et al*, 2006). Some experimental evidence does suggest one way that radiation may play a role in the aetiology of diseases of environmental origin connection, for example, Lord *et al* (1998) have explored the possibility that a priming radiation insult pre-disposes an organism to the development of cancer following a subsequent conventional carcinogenic insult. So, it may be important to acknowledge that interactions between radiation and other toxic insults – whether antagonistic, additive or multiplicative – are not explicitly accounted for in current radiation protection models.

2.1.1.5 Defence sites

MoD policy is to comply with relevant UK statutory provisions. Where Defence Estates can rely on extensions or derogations from either domestic or international law, the MoD introduces standards and management arrangements that are, so far as reasonably practicable, at least as good as those required by legislation (*Safety, health, environmental protection and sustainable development in the Ministry of Defence*. A policy statement by the Secretary of State for Defence, March 2008).

2.1.1.6 Concluding statement

There are specific legal obligations in respect of protection of people and the environment from risks associated with contaminated land. The specific minimum requirements depend on the regulatory context.

This guidance recommends a case-by-case approach with stakeholder involvement to achieve the required high level of protection by a process of risk assessment (based on characterisation) and structured options appraisal to identify preferred options for the management of the contaminated land. The options appraisal process is described in Section 3.4 and set out in more detail Penfold (2009).

2.1.2 Key Principle 2 Stakeholder involvement

Site owners/operators should involve stakeholders in the management of contaminated land, particularly to inform decision making.

The description associated with this key principle has been revised as part of the consultation associated with this revision of the document (see Part 2).

General guidance

The intent of Key Principle 2 is to ensure effective external participation to meet stakeholder expectations and to inform, influence, and demonstrably impact on decision making processes. This is whether it is, or is not, required by organisational policy or regulatory frameworks.

Importantly, stakeholders are all the people with an interest in the management of the contaminated land. They include institutional stakeholders, such as regulators, local and national government and senior management within site owner/operator organisations, and others who could be affected by, or have a direct interest in, land management decisions, such as employees, local residents, non-governmental organisations (NGOs), community-based organisations (CBOs) and individuals.

The approach to stakeholder relations on contaminated land issues is partly motivated by the sense that good governance, as understood by the community and major shareholders, requires it. However, the wider implications are to make better decisions, to develop approaches that can be used with community support, to improve transparency and to build trust. The benefits include acquiring new perspectives on problems, drawing attention to issues that may otherwise escape scrutiny, reinforcement of safety and environmental protection cultures, and generally improving safety and environmental protection performance (IAEA, 2006a).

Stakeholder involvement includes communication, provision of information, consultation and participation in the process to inform, impact on, and demonstrably influence decision making processes. For legal and practical reasons, final decisions on how to manage contaminated land have to be the sole responsibility of the site owner or operator. It is essential that site owners/operators take stakeholders' views into account in making these decisions and demonstrate to those stakeholders how their input effectively impacted on, and influenced the decision making processes.

The validity of external participation depends crucially on the integrity of those running it and their responsiveness. Contributions should be objectively considered, and there should be a genuine willingness to take a different course of action if new information or insights are provided. It is essential that site owners/operators can demonstrate to stakeholders that their views have been taken into account. Establishing a two-way dialogue between "experts" and the "community" on difficult concepts, such as risk perception and acceptability, are important to ensure open and straightforward communication.

Beginning stakeholder participation early in the process is important as this allows people to have a legitimate opportunity to help frame the questions to be addressed, as well as to participate, and to influence the outcome. Other advantages of early involvement include: not wasting time in carrying out technical work on options that most stakeholders will never accept, shorter formal public consultation processes, and shorter regulatory approval procedures (IAEA, 2006a).

Involvement of stakeholders throughout a cycle of planning and decision making is more effective than separate consultations on several issues. It should not simply be when a particular project is in the late stages of planning or being carried out, but at the start. At sites where management of contaminated land will continue over many months, years, or even decades, means should be established to involve stakeholders throughout this period and at the different levels of LQMS development. This will help stakeholders to maintain a comprehensive view as well as focusing on the more detailed elements. An example of good practice is given in the health industry (Tritter and Wilson, 2007).

Adherence to Key Principle 2 does not mean that all stakeholders have to be involved in all decision making steps for every contaminated land issue on every site, ie there should be a proportionate level of involvement. The range of stakeholders to include, and the extent of their involvement, depends on both the significance of the contaminated land problem (technical and societal) and the stage in the land management process. A broad range of stakeholders should be involved in informing, influencing, and demonstrably impacting on strategic decision making for problems that are seen as significant by many groups within society. Lower profile decisions for smaller problems warrant less involvement. The presumption, in case of doubt, should be for inclusion. The options comparison guidance (Penfold, 2009) presents methods for comparing problems of different scales with different levels of stakeholder involvement.

If there is doubt about who to involve and how, then the best course of action for the site owner/operator is to "reach out" to statutory and non-statutory stakeholders and involve a broad range of people. Communities remote from the site also need to be consulted if they may be affected by management of the contaminated land for a site, for example, where communities live near, or on route to, a disposal facility that could be used for remediation wastes.

Each stakeholder involvement program is unique and needs to be tailored for its purposes and its audience using appropriate communication tools and techniques. In general, the larger the scope and reach, the better defined and more formal the stages will be. In a smaller consultation the stages may be implicit or merged together.

Stakeholders should be given enough information to enable them to participate effectively. Every effort should be made to avoid relying on national security or commercial confidentiality as reasons for failing to involve a wide range of stakeholders, or for denying them information.

The resources required by stakeholders should be discussed with them at the planning stage. The stakeholder involvement programme should be designed to be reasonable in terms of the time, effort and financial resources required from all concerned, and commensurate with the scale of the problem. Where there is less experience of involvement, there may need to be an initial capacity-building stage (provision of funds and expertise) to strengthen community institutions to allow them to participate fully.

Guidance for nuclear-licensed sites

Stakeholder involvement activities for the management of contaminated land should be integrated with the engagement programme for all the activities on a site. This is because there are close links between a site's, LQMS, decommissioning strategy, integrated waste strategy (IWS) and related issues such as choice of end state(s). Many of the same stakeholders need to be involved in each case.

It is important that site owners/operators build and maintain relationships with their stakeholders, particularly local communities. Events such as consultations on particular topics should be recurrent features in a continuing programme, not self-contained, one-off exercises.

The current arrangement for site stakeholder groups offers a limited avenue for stakeholder involvement, however good practice strongly recommends that a broader range of stakeholders should be encouraged to participate. In many cases there will also be a need to consult communities affected by waste transport and disposal. It is possible that local communities will wish to employ experts in particular aspects of contaminated land to advise them and it is good practice for site owners/operators to consider requests for resourcing the involvement of such alternative expertise.

There are examples of continuing stakeholder involvement in decommissioning and restoration of nuclear sites in the UK where resources are provided to improve public participation, for example:

Site end state: <www.dounreay.com/social-responsibility/consultations/complete/site-end-state>

All waste: <www.dounreay.com/social-responsibility/consultations/complete/all-waste>

The appropriate level of stakeholder involvement in the management of contaminated land varies throughout the process. The level of involvement is highest when plans are being formulated and when a long-term strategy for the management of all the contaminated land on a site is being established. However, even when low levels of stakeholder involvement are anticipated flexibility should be considered to accommodate escalating issues.

Guidance for defence sites

On defence sites the nature and level of stakeholder involvement should also be proportionate and reflect the nature, context and significance of the contaminated land situation.

Where appropriate for sites continuing in their current use consideration should be given to setting up a local liaison group from a cross-section of people representing the local community, other affected communities, NGO's, CBOs, regulators, academics, local authorities and perhaps consultants, contractors and prospective developers. The group would work throughout the land management process, with varying levels of involvement. Careful consideration could be given to terms of reference, process and procedure of governance of these groups, and some discussion of issues relating to prioritising, evaluating, balancing and weighting views. Where a site is to be sold and redeveloped then stakeholder involvement is most likely to occur during the planning consultation process, usually initiated by the developing organisation.

In the case of nuclear defence sites, site stakeholder groups are in existence.

Guidance for industrial, medical and research sites

SAFEGROUNDS guidance is also largely applicable to former and current industrial, medical and research sites. If the site is large and complex it may be beneficial to set up a project liaison group comprising key stakeholders. They can be involved to varying extents throughout the process of managing the contaminated land, and any related demolition or redevelopment activities.

At smaller sites simpler stakeholder involvement mechanisms can be used but it will be necessary to involve a broad range of stakeholders in high profile situations. If such sites are to change use and be redeveloped then consultation will take place through the planning process.

Stakeholders should always be informed as soon as it is known or suspected that radioactive contamination is present. Full information should be given about the contamination, the likely health risks and the process that will be used to decide on and implement an appropriate land management strategy and options. This is particularly important for sites that were contaminated by past activities and are now being used for other purposes.

Sites contaminated by accidents or emergencies

The stakeholders in this case are people who used the land before the accident and may use it again after remediation. This includes nearby communities, local authorities, regulators and others who have been involved in the short- and medium-term emergency response.

The involvement approach depends on the size of the affected area and the severity of the contamination. The "stakeholder group"[10] approach could be appropriate for large areas that will take a long time to remediate, especially if the land was, and will be, used for a variety of purposes. One-off consultation exercises could be carried out for smaller areas with less diverse land-use patterns.

There may be a difference in approach between "legacy" accidental situations, ie those that have happened in the past where there is time to consider the options and attention is focused solely on the contaminated land issue, and those situations that arise today. In the latter case, contaminated land is just one issue among many that the Recovery Working Group would need to consider (NEPLG, 2006). It would be misleading to think that contaminated land would necessarily be the only or key issue. Guidance on dealing with the recovery phase following an accidental or emergency situation is provided in the *UK recovery handbook for radiation incidents: 2005* (HPA, 2005).

Stakeholder involvement culture

In addition to its other benefits, timely and appropriate stakeholder involvement increases openness and accountability, and helps to strengthen safety and environmental protection cultures.

A culture of stakeholder involvement will make it easier for a site owner/operator to sustain an involvement programme throughout the management of contaminated land. Such a culture is particularly important for long programmes, in which effective participation depends on building and maintaining good relationships with stakeholders.

10 This may be a sub group of the formal recovery working group (RWG) that would be set up in response to an accidental or emergency situation, as advocated in the Nuclear Emergency Planning and Liaison Group (NEPLG) *Consolidated guidance* (2006)

2.1.3 Key Principle 3 Identifying the preferred land management option

Site owners/operators should identify their preferred management option (or options) for contaminated land by carrying out a comprehensive, systematic and consultative assessment of all possible options. The assessment should be based on a range of factors that are of concern to stakeholders, including health, safety and environmental impacts and various technical, social and financial factors.

Site owners and operators should demonstrate a commitment to considering systematically all the options for the long-term management of contaminated land, as well as strategic options where they do not exist or require review. In either case stakeholders should be involved in accordance with Key Principle 2.

Both strategic and management options should be considered for all parts of the site and for individual cases and specific situations. It is emphasised that it is not appropriate to deal with a whole site only as a series of small problems that are considered sequentially: an overall LQMS is required.

The first stage of the recommended approach is to identify all possible options, ie all options that could possibly be applied to the problem. The list is then reduced to those that are appropriate for more detailed consideration by excluding those that, for reasons all can agree on, are not capable of being applied in practice. This is usually referred to as "screening". Options should not be excluded from further consideration only because they appear to be very expensive, have costs greater than existing budgets or because they appear to be logistically or practically very difficult to adopt.

The remaining options can then be assessed using "criteria" to distinguish between options. Examples of criteria are: health risks to the public and to workers, impacts on ecosystems, effects on natural resources, cost, the technical difficulty of implementing the options and the degree of experience with the option (and any associated *uncertainty*). The phased process of comparing and evaluating options is discussed in detail in Penfold (2009).

Most options comparison methods work best with 5–10 options. These should embody the key features of the range of courses of action. If a larger number of options remain after the screening process, consideration should be given to a tiered options assessment. Here groups of options are compared initially, with more detailed options assessed after a broad strategic approach has been identified.

It is important to include at least one option that would return contaminated land to a state fit for any use that the type of land would support. It is also important to include an option in which land is controlled and monitored for the foreseeable future but not used for any particular purpose. A "do nothing" option should be included in the analysis.

Identification of a range of criteria is also needed that reflect the concerns of the stakeholders. Different stakeholders may see some criteria as more important than others. This information reflects their preferences, and it can be a valuable record.

2.1.4 Key Principle 4 Immediate action

Site owners/operators should assess both potential and known areas of land contamination and where appropriate implement a prioritised programme of investigation and any appropriate monitoring. On confirmation of areas of land contamination being present, control measures should be instigated until an appropriate management option has been identified.

The description of this key principle has been refined following experience in implementing previous SAFEGROUNDS guidance. It was changed because the requirement to monitor and control all known and suspected contamination immediately was impractical given the potential time it could take to find all the suspected contamination on a large site. It is more reasonable to expect that steps to control contamination will occur once it becomes known and that a programme for the investigation of all suspected contamination is in place.

The type of action taken depends on the scale, nature and complexity of the contamination. Different measures may be needed for different areas. Where the contamination is widespread or historic it is most likely that *monitoring* and an interim control measure will be implemented until a long-term management option is selected. Historic contamination is unlikely to change quickly and the interim control measures should be designed to limit risks and prevent adverse disturbance of the situation.

For situations such as spills or other present day incidents immediate clean-up is often preferable, to avoid further immediate dispersion of contamination. For sites with several different areas of contamination it will be necessary to prioritise them. An initial threat assessment approach could be used to prioritise areas for monitoring and action, but low risks should not be used as an argument not to take prompt action to control and monitor contamination.

Once it is established that immediate controls are necessary then a plan to adopt and validate the actions is required. This would be subject to review and revision. Once immediate controls are in place and validated then longer-term solutions can be developed.

2.1.5 Key Principle 5 Record-keeping

Site owners/operators should make comprehensive records of the nature and extent of contamination, the process of deciding on the management option for the contaminated land and the findings during the implementation and validation of the option. All records should be kept and updated as necessary.

SAFEGROUNDS Key Principle 5 requires site owners/operators to make comprehensive records about the management of contaminated land, to keep these records, and to update them as necessary.

The records should cover all site characterisation work, the process of deciding how to manage the contaminated land, implementing the chosen strategy, validation, and interactions with stakeholders throughout the process.

The aim of record-keeping is to document the condition of the land and particularly those features that might encourage risk in future uses. The record of condition attains greater credibility with a comprehensive history of the actions taken to achieve the current condition.

Practical guidance on record-keeping is given in a separate document (Cruickshank and George, 2007). The document recommends that a land quality file (LQF) is set up for each nuclear or defence site so that information about contaminated land can be held in a formalised structure. The LQF should be part of the record management system of the organisation that owns or operates the site.

The LQF concept is applicable to all sites covered by this record-keeping guidance. Organisations that make and keep the records will depend on the situation. For

example, at a former industrial site that is being remediated under Part 2A, whoever is responsible for remediation should maintain records but these could be kept by the current owner of the site. If the organisations concerned have no formal system for managing records of this type it would be sensible to create one, either on their own or together with other organisations involved in the management of radioactively contaminated land.

There is an unresolved national problem of how to keep records of radioactively contaminated land in the long-term. Nuclear site licensees have to keep records until their "period of responsibility" ends, which may be decades away. There is no mechanism for keeping records in an accessible form after this, or for updating records for land that has been delicensed and sold for use in non-nuclear circumstances. The NDA is looking at establishing a National Nuclear Archive (NNA) to instigate consistency in recording across all the different data and information centres. The aim of this is to achieve Public Records Place of Deposit status where data of historical and local interest can be managed effectively and made available to as wide an audience as possible. However, SLCs are entirely responsible for the management of records on their sites and should not anticipate a transfer of operational records to this entity until those records are suitable for inclusion in such a facility.

MoD has arrangements for keeping records for considerable periods but would not ordinarily update these once a site or land has been sold. Local authorities and the environment agencies maintain registers of "special sites" and of other land that has been designated as "contaminated land under Part 2A". These registers are not suited to keeping or maintaining detailed records such as in an LQF.

It is recommended that site owners hold records that can be readily accessed for the duration of their ownership of the site and pass the records on to new owners. All records should be maintained in line with legal obligations and SAFEGROUNDS guidance until some form of national system is established for keeping records of radioactively contaminated land in the long-term.

Part 3 The process of managing contaminated land

3 Overview of the process of managing contaminated land

Figure 1.1 shows a decision flow diagram for the development of a LQMS for contaminated land in the SAFEGROUNDS context. It is a systematic approach integrated with the Contaminated Land Report 11 (CLR 11) *Model procedures for the management of land contamination* prepared by the Environment Agency (2004) with some modifications. The modifications incorporate the SAFEGROUNDS key principles and other factors to be considered on both nuclear-licensed and defence sites, particularly in relation to managing radiological hazards. Each element of the process is numbered 1 to 52 for ease of reference.

CLR 11 contains a wealth of supporting information, together with an information map to provide understanding and direction when using the model procedures. To support the SAFEGROUNDS modifications the Learning Network has produced its own guidance as given in Section 1.6 and signposted throughout this document. Both sets of information should be consulted when adopting the SAFEGROUNDS process.

The decision flow diagram follows the three main stages of CLR 11:

1 Risk assessment.
2 Options appraisal.
3 Implementation of the remediation strategy[11].

Each stage of strategy development and use contains a series of main activities, as follows:

Risk assessment:

- planning: define context, objectives and timescale in preliminary LQMS
- preliminary safety and environmental risk assessment
- management of immediate risks
- refinement of LQMS
- classification and prioritisation of areas of contamination
- generic quantitative risk assessment
- detailed quantitative risk assessment.

Options appraisal:

- planning: review/refine context, objectives and timescale in LQMS
- define feasible remedial options
- detailed options evaluation
- develop remediation strategy.

11 The term "remediation strategy" is used as it is a specific element (No 28) in the CLR 11 modified process.

Implementation of remedial strategy:

- planning: review/refine context, objectives and timescale in LQMS
- prepare the implementation plan
- design, implement and verify the remediation works
- long-term monitoring and maintenance and passive controls (if required)
- delicensing of a nuclear licensed site or part of a site.

These activities within the flow diagram follow a logical sequence with iterative loops at main points.

The SAFEGROUNDS process places more emphasis than CLR 11 on the short- and medium-term management of the contamination before implementation of the remediation strategy through the following aspects:

- development and particularly refinement of the LQMS
- planning a safety and environmental risk assessment
- management of immediate risks
- classification, prioritisation and management of contaminated areas
- use of passive management processes such as monitoring and restricting access
- achieving delicensing of a nuclear-licensed site or part of a site under NIA65.

The key principles apply throughout the land management process. Specific reference to actions relating to stakeholder involvement and record-keeping are expanded upon in the discussion of the SAFEGROUNDS process.

3.1 SAFEGROUNDS application

The process begins with a decision as to whether SAFEGROUNDS guidance applies. It applies to nuclear-licensed and defence sites if it is known, or suspected, that radioactive contamination is present on the site, with or without non-radioactive contamination. In this context, radioactive contamination is defined to be any concentration of radionuclides above the ubiquitous natural and artificial background for the area where the site is located.

SAFEGROUNDS guidance does not normally apply where there is only non-radioactive contamination on a site. For consistency the SAFEGROUNDS process may be applied to an individual site without radioactive contamination if it is being managed as part of a portfolio of sites where SAFEGROUNDS is applicable.

The LQMS development process can be applied to a whole land-holding and to pre-defined zones of it. These zones could potentially be distinguished on the basis of depth or hydrogeology as well as area and current/former use.

3.2 Develop land quality management strategy

Nuclear-licensed sites, or defence sites managed as such, are required to prepare, for the regulator, a nuclear safety case to demonstrate the totality of the measures that will be in place to ensure the safe operations on their site. This includes the operations associated with contaminated land. The safety assessment principles (SAPs) published by the regulator (HSE, 2006) provide inspectors with a framework for making

regulatory judgements on nuclear safety cases. The SAPs for radioactively contaminated land use the term strategy in the broad sense to encompass the risk assessment and options appraisal stages. SAFEGROUNDS takes this further to also include Implementation of the remediation strategy and achievement of delicensing a nuclear licensed site or part of a site.

On defence sites and other sites with radioactive contamination, the development of a LQMS is primarily driven by compliance with environmental management systems and other regulatory regimes.

The development and refinement of a site LQMS is fundamental to the long-term management of contaminated land. At the preliminary stage a strategy framework should be set up to establish several enabling arrangements and scene-setting activities that will provide a basis for future refinement. This framework should include the following:

- the context of contaminated land management defined in relation to overall strategic objectives for the site, such as:
  - continued commercial nuclear operations
  - decommissioning objectives
  - redevelopment
  - divestment.

- a review or establishment of the regulatory context, in terms of applicable regulatory regimes, requirements and guidance
- setting up, or adapting existing, internal management arrangements and accountabilities in relation to contaminated land management (including decision making)
- setting up or adapting existing, arrangements for stakeholder involvement in relation to contaminated land management (including development of a stakeholder plan, if appropriate)
- if possible, the definition of further broad strategic objectives for contaminated land management, or identification of a limited number of options, one of which might become the preferred option. For example:
  - ensuring the land remains fit for its current use for an indefinite period
  - a strategy of progressive remediation to release zones of land for new uses
  - a strategy of thorough remediation to maximise the asset value of land
  - a strategy of targeted remediation to facilitate early divestment.

- setting up of quality management arrangements for contaminated land management, including record-keeping. Guidance on records management, including recommendations for a land quality file is given in Cruickshank and George (2007)
- if possible, establishment of quantitative assessment criteria for later quantitative risk assessment, considering both current and future land-use.

The length and complexity of each of the various steps in strategy development depends on the scale/complexity of the land contamination, and on the outcome of the previous step. They also depend on whether the immediate objective is to decide upon the option or strategy to be used, or to reach agreement in principle for the purposes of financial planning or other planning for the site.

By Element 9 of the SAFEGROUNDS process the LQMS is a more developed document with refined the objectives and context, and it has benefited from the information gathered about potential contamination on the site. The document will include the defined regulatory framework, the site context in terms of end states (interim and final) and any planned end uses for the site. It will also include outline schedules for site developments, decommissioning and restoration, with the LQMS being an integral part. It should also include a well defined strategy for stakeholder involvement.

Once site characterisation and risk assessment have yielded important results, the further focusing of the strategy development can occur within the options appraisal section (Element 21) and at the stage of Implementation of the remediation strategy (Element 32) within the SAFEGROUNDS process.

At sites that are their responsibility, the NDA needs to approve the contaminated land management strategy through acceptance of lifetime plans and funding requirements. Such a strategy should also take account of NDA requirements for an integrated waste strategy and prioritisation.

3.3 Risk assessment

The risk assessment stage of the SAFEGROUNDS process is a tiered approach and includes:

- a preliminary safety and environmental risk assessment
- implementation of immediate controls to reduce risks
- classifying and prioritising areas of contamination
- generic and detailed qualitative risk assessment.

On nuclear-licensed sites this stage is consistent with the HSE SAPs radioactive contaminated land principle RL2 and RL3: “steps should be undertaken to detect any areas of radioactively contaminated land on or adjacent to the site” and “where radioactively contaminated land is discovered, appropriate arrangements should be in place to ensure the source is identified and controlled”.

3.3.1 Preliminary safety and environmental risk assessment

Undertaking a preliminary qualitative risk assessment, including identifying safety and environmental risk, for what appears at this stage to be important areas of potential contamination is essential early in the process (Element 2). Such an assessment will focus on the hazards and consider actual and potential pollutant links (source-pathway-receptor) and may provide a basis for prioritising site characterisation. It might in some cases identify the need for immediate action that was not apparent from the start.

Where risks are found to be below the point where intervention is required then the land quality file should be updated accordingly. Where risks are identified and may need intervention this early risk assessment can also help in identifying data gaps and requirements for site characterisation. Moreover, it can assist in defining the areas to be characterised and assessed and, where appropriate, defining a rationale for zonation of the site into manageable areas. The preliminary risk assessment is the first stage in developing a conceptual model of the site that, for more complex sites, will evolve over time.

For sites with complex contamination (eg many/diverse areas of potential contamination) and/or multiple potential pathways/receptors it may be that there is insufficient information available to provide discrimination in the prioritisation purposes. In such cases, risk assessment may need to be integrated with non-intrusive and/or intrusive characterisation.

As outputs from this preliminary risk assessment a register of areas of potential contamination should be established, to be updated as new information from future site characterisation, monitoring or other sources of information becomes available. This is recommended as part of the land quality file (Cruickshank and George, 2007).

3.3.2 Implementing and validating immediate controls

Arising from the preliminary risk assessment a process of managing immediate risks by implementation and validation of immediate controls (Elements 5 to 7) may be identified to ensure the protection of people and the environment (Key Principle 1), and in line with Key Principle 4. On nuclear-licensed sites this stage is consistent with the HSE SAPs radioactive contaminated land principle RL2 and RL3, "steps should be undertaken to detect any areas of radioactively contaminated land on or adjacent to the site" and "where radioactively contaminated land is discovered, appropriate arrangements should be in place to ensure the source is identified and controlled".

If immediate action is required a plan should be developed. The resources to develop this plan should be proportionate to the threat that is being addressed, and it is important that actions are not delayed while unnecessarily detailed plans are prepared. Ideally when undertaking short-term management it is important that care is taken not to compromise long-term management of the contaminated land. So, where practicable, both short-term and long-term measures should be planned as a continuum.

The objectives of immediate control and management are to:

1 Control the source of the contamination (if it is still present).
2 Prevent further spread of the contamination (especially if it is moving towards the site boundary).
3 Control exposures to contaminants (for example by limiting people's access to areas).
4 Institute appropriate monitoring until long-term management methods are implemented.

At sites where contamination has been present for a long time (eg where contamination has been built over or been sealed by a new surface that blocks a pollutant link) it may not be practicable, or necessary, to take immediate or short-term action other than to maintain existing monitoring arrangements. Such existing monitoring arrangements may be voluntary or non-statutory rather than in compliance with specific regulatory requirements. However, longer term management will be required if the contaminated area or site is likely to be redeveloped at a later date. In such cases it is best to proceed in a timely manner, involving stakeholders, to establish and use an accepted long-term management strategy.

Immediate clean-up can be appropriate for small spills and incidents, provided that there are routes for the management of any wastes generated. Where such routes are not in place a dialogue with the regulator and other stakeholders will be necessary. This can be a lengthy procedure and may require careful interim management of the

contaminated land until the authorisation is given. If a situation arises where no management route is available and the contamination poses an immediate risk to human health and the environment, then the regulators should be contacted immediately.

The extent of stakeholder involvement in decisions on immediate and short-term management methods may vary from one site to another. Site owners/operators do not need to involve anyone in advance when they take immediate action on small patches of contamination. Where the extent of contamination is greater, and other factors such as the sensitivity of the site or the potential receptor are higher, then stakeholder involvement will be required.

Appropriate and proportionate actions should then be used to ensure protection. On some sites it may be necessary to assess and compare short-term management options for particular areas. This can be done using option comparison techniques (Penfold, 2009).

Once measures are in place they should be validated to ensure that they are effective and this may require some interaction with the regulators. Such measures do not need to be onerous but could require periodic checking to ensure effectiveness, for example that a fence is maintained to restrict access or routine sampling to check there is no migration of contaminants.

3.3.3 Classification and prioritisation of contaminated areas

Assuming that at least some threats/risks are identified in the preliminary assessment and that there is insufficient information now available to quantify the risks and determine the management option, then further assessment is required to define the problem (Element 18). HSE SAPs RL4 states that "radioactively contaminated land should be characterised to facilitate its safe and effective control and remediation", plus RL5 states "radiological survey, investigation, monitoring and surveillance of radioactively contaminated land should be carried out at suitable intervals so that its characterisation is kept up-to-date" (HSE, 2006).

Once this is achieved the LQMS can be refined (Element 9) and areas of contaminated land can be classified and prioritised (Element 10). Each area of contamination can then be treated according to the remainder of the decision flow diagram.

It is recommended that the site conceptual model and the qualitative source-pathway-receptor risk assessment in the preliminary risk assessment are included in the initial prioritisation (Element 10), with consideration given to:

- the nature of the contaminants (their toxicity for people and other organisms), including potential for additive or multiplicative negative synergistic effects
- contaminant concentration levels (in relation to background measurements and any agreed screening levels)
- the mobility of contaminants in the environment (especially if they are moving both on and off-site via water, air, burrowing animals etc)
- the locations of receptors including potentially exposed people, other organisms, surface water and groundwater and other sensitive areas
- climate and landscape changes (including flooding risk) for much longer-term options.

Prioritisation of areas should be kept under review as the risk assessment process

(including generic quantitative and detailed quantitative assessments) is undertaken. Supporting guidance on the types of assessments for health and environmental risks required at each stage is given in Smith (2005).

Also it is important to recognise that in some situations the land-use (either current or planned) could influence prioritising some areas. For example, higher priority may be given to land that is outside of the current site boundary or to land where there is a need to excavate or otherwise disturb the ground for other reasons, eg for construction of new facilities or decommissioning of old ones. So it may be necessary to adopt an approach that combines these methods and considers not only the source-pathway-receptor method but also the land-use zonation.

A final consideration on prioritisation is promptly dealing with a source of contamination if it is highly mobile and has the potential to cause a greater area of contamination if left for a period of time.

3.3.4 Generic and quantitative risk assessments

In Element 11 the availability and appropriateness of generic assessment criteria should be reviewed, and the guidance followed in Smith (2005) (to be updated in 2009). Consultation with the regulator(s) may also be applicable to decide the criteria and compliance points.

Site characterisation (part of Elements 12, 14, 16 and 18) is an activity that provides information on the site conceptual model that risk assessments are based on. Conceptual models for sub-areas should also be produced. The model(s) should direct further characterisation and be refined as more data are acquired.

The activity may be desk-based including the acquisition of historical information or it may involve non-intrusive or intrusive investigation methods with associated sampling, analysis and monitoring. In many cases the investigation will be phased to match the level of detail required for the tier of risk assessment, but also to allow further refinement depending on the information obtained. Further guidance on planning appropriate and targeted site characterisation is given in Towler *et al* (2009).

Stakeholders, particularly those with specialist knowledge and experience, should be asked for their views on various aspects of site characterisation, for example:

- the contaminants of most concern (eg which radionuclides and in which physical or chemical forms, as well as other non-radioactive contaminants)
- the areas of most interest (eg around the boundary of the site)
- characterisation techniques (eg based on experience elsewhere).

When dealing with radioactive contamination it is important to plan for making background measurements off-site. There should be enough measurements to establish the concentrations of ubiquitous contaminants (eg fallout radionuclides, or natural background radiation) that are typical of the area, and to fingerprint contaminant concentrations due to the site, from those due to nearby sites. Industry experience suggests that plans for background measurements should be consulted on with the relevant environment agency.

As the conceptual model evolves and the need for better definition of risks, then the quantitative risk assessment may take place against generic criteria (Element 12), or against site specific criteria in a detailed quantitative assessment (Element 16). Guidance

on assessment of human health and environmental risks specific to SAFEGROUNDS is given in Smith (2005).

As a result of the risk assessment stage the main output will be:

- identified pollutant links based on a fully developed and characterised conceptual site model
- an updated register of areas of potential contamination
- documented tools and criteria used to estimate and assess risks
- identified unacceptable risks that require management (if not undertaken through immediate actions)
- the basis and proposal for future refinement of the land quality management strategy
- an updated land quality file.

Where risks are deemed to be acceptable and hazards controlled only long-term monitoring may be required and the land quality management process may move on to Element 42.

3.4 Options appraisal

The options appraisal stage starts with a planning activity. This will define the context and set or refine the objectives based on the site conceptual model updated from any characterisation and risk assessment (Element 21). Refinement of the LQMS will follow (Element 22) to direct the approach to the remaining elements of the stage that involve:

1 Site owner/operator and stakeholders identifying, assessing and comparing feasible remedial options (Elements 23 to 25).
2 Site owner/operator identifying preferred strategy, with stakeholder input (Elements 26 to 28).
3 Regulators, decision makers and stakeholders assessing and developing the proposed remediation strategy (Element 29).
4 Site owner/operator deciding on the strategy to be adopted, demonstrating how involvement impacted on the decision making process (essentially Elements 30 to 31).

Further site characterisation works may also be required to support the decision making in Elements 25 and 28.

Guidance on a systematic comparison of the management options to cover Elements 23 to 28 has been developed (Penfold, 2009). The guide presents a selection of methods and discusses how they can be applied to determine the preferred option(s) for a range of situations from the simple (eg a small patch of well defined contamination on an operating site) to the complex (eg a restoration strategy for a multi-zoned site). The guide focuses on methods and does not comment on the particular issues that would, in practice, be considered when determining a preferred option. These will be specific to the problem being considered and the range of stakeholders involved.

If the site is “radioactive contaminated land” in the Part 2A sense, there is a need to carry out justification and optimisation studies to determine whether remediation is required, and if so, what form it should take (DEFRA, 2006a). The justification study

can be included as an extra step in the assessment and comparison of candidate strategies. This assessment and comparison includes all the matters that would be considered in an optimisation study so no further work is needed to fulfil this requirement (Penfold, 2009).

A key decision point occurs after the evaluation of options. It is then necessary to determine a preferred remediation method(s) from the list of options. Input from the stakeholders will inform and influence the decision making process. No generic guidance can be given on the most appropriate process for decision making because it will be specific to each problem. However, it will always include a structured comparison of options to determine which is, on balance, most appropriate, having taken account of all stakeholders' views.

Decision making is seldom a linear or straightforward process. The options comparison process might not result in a single preferred option (Penfold, 2009), in which case it may be appropriate to gather more information and to make an iterative step to reassess and evaluate the options (Element 28). Alternatively a decision may still need to be made on the remaining options available. Even if there is a clearly preferred option this does not necessarily mean that this option is the one that will be finally adopted.

Where there is not a clear preferred option at this stage iteration through the elements of the process will be required, and taking into account:

1 Implications for other sites (if appropriate).
2 Corporate objectives.
3 Stakeholder views and knowledge.
4 Current and/or future site activities and management plans.

In deciding the appropriate remediation strategy, the implications should be reviewed in a wider context including:

- assessing whether the stakeholders views have been suitably incorporated into the decision making process
- evaluating whether the interests and involvement of other decision makers or stakeholders in the decision making process should be considered
- considering whether the decision has an impact on wider external issues, and if the externalities are being adequately covered
- clarifying whether the decision has been demonstrably optimised. This may include consideration of the scale of the contamination, the drivers for prompt implementation, the impacts associated with any remedial actions and regulatory compliance.

Guidance on the decisions and outputs of this stage is given in CLR 11 (EA, 2004).

3.5 Implementation of remediation strategy

The CLR11 guidance for non-radioactively contaminated land envisages a sequential progress through the major stages leading to relatively prompt implementation of the remedial strategy. In the case of SAFEGROUNDS guidance the timescales may vary considerably. On defence sites with radioactive contamination arising from luminising compounds the timescales to final remediation will be relatively short. However, on nuclear-licensed sites that are being decommissioned, full implementation may take

place a long time in the future, for even the care and maintenance preparations period can be over a decade.

The remediation strategy stage also starts with a planning activity. This will define the context and set or refine the objectives based on the LQMS updated from the options appraisal stage (Elements 32 and 33).

Once a chosen option is selected a plan should be developed (Element 34) to carry it out. This will need to include a programme and actions necessary to complete the work (including resources) as well as the supporting documents such as health, safety, security, environment and waste management plans. A validation plan should also be included to show how the owner/operator will demonstrate achievement of objectives.

Detailed design and planning (Element 37) should be completed for each area before implementing the long-term management option. Planning is especially important for large projects and those that take place on large and complex sites. Further guidance is available on this topic, for example in EA (2004 and 2000), Macleod *et al* (2004) and IAEA (2006b.

The planning should develop a systematic approach for the chosen option using appropriate procedures. Matters to be considered are:

- health, safety and environmental protection procedures (HSE, 1991 and 1999 and Steeds *et al*, 1996)
- monitoring procedures (Penfold, 2009b)
- waste management arrangements (Hill 2007a, Hill 2007b, Miller and Tooley 2005)
- contingency measures through development of project risk registers
- record-keeping arrangements (Cruickshank and George, 2007)
- stakeholder involvement programme (Collier, 2005a).

Performance measures, such as residual contaminant concentrations, should be made clear, as should quality assurance indicators that demonstrate that quality procedures are followed.

The outcome of an assessment and comparison of options may show that no further action is needed to reduce long-term risks, or that it would be best to maintain passive controls by monitoring the area and reassessing options at a later date. In this case the site moves on and iterates between Elements 41 and 47.

Asking whether further remediation is required (Element 41) before asking whether monitoring is required recognises that the remediation strategy may involve a combination of remediation, long-term monitoring and long-term passive control before delicensing can be reached. It also implies that the remediation strategy may involve several steps (ie the remediation option adopted at Element 37 may only be a provisional measure, eg containing contamination until it can be accessed safely) and further elements may need to be implemented.

3.5.1 Validating options

The purpose of validation (Element 45) is to check that the management option for the area has been implemented correctly and that it will achieve the desired level of protection of people and the environment for the area in question. For nuclear licensed-sites the validation will need to satisfy the stringent arrangements for delicensing.

Surveys are required throughout implementation and when work has been completed. Continuing monitoring may also be needed over many years (for example, to check that contaminants are not moving into groundwater).

The results of validation surveys and monitoring should be evaluated against the original objectives of the management option to make sure that these have been met. Once site owner/operator(s) are satisfied the interim or final end-points (Collier, 2005a) have been reached, they should provide regulators and other stakeholders with the validation findings to agree that the option has been correctly and/or fully implemented. If it is apparent that further work is required, stakeholders should be consulted about what is to be done.

It is particularly important to keep records of validation monitoring and surveys and of the evaluation of results. Especially where land is to be released for new uses, it is valuable for there to be checks by an organisation that is independent of the site owner/operator and of those who have carried out remediation. The extent of the checks should be agreed with the relevant stakeholders, who may also wish to be involved in choosing who carries out the checks.

Site owners/operators should arrange to hold a complete set of records of validation, check surveys and monitoring. On nuclear-licensed sites these records will form the basis for the delicensing application.

Where an interim state is validated it is suggested that an interim state management plan records all necessary data to enable future remediation work to be undertaken.

In all cases a final survey or surveys should be performed to validate that the final end state has been achieved in all areas of a site. This may be in accordance with HSE SAP RL8, which states that: “radioactively contaminated land should first be remediated before any construction of new facilities takes place”, or as the SAP elaborates: “any proposals not to remediate prior to construction should be substantiated and demonstration provided that alternative options have been properly considered and rejected” (HSE, 2006).

Guidance on the decisions and outputs of this stage is given in CLR 11 (EA, 2004).

3.5.2 Achieving delicensing

The last stage in the land management process on a nuclear-licensed site is to delicensed the site or part of the site (Elements 49 to 51), ie the state beyond which no further regulatory controlled action by the current site owner/operator is required. For some sites achieving suitable land quality for the purpose of divestment/sale may be a recognised end to the land quality management process for the vendor. The responsibility for completion of the process would then be the passed to the new owner. On defence sites that are not licensed sites, and on other non-licensed sites, the land quality management process will therefore flow from Element 48 through Element 49 to the final Element 52.

Before delicensing on nuclear-licensed sites it is also worth identifying whether there may be a period where an interim state is attained. For example at nuclear power stations a period of care and maintenance might last for many years once initial work to make the site passively safe has been completed. Where the chosen long-term management option does not achieve delicensing (Element 49), then further action may be needed (return to Element 32). For example, if over many years long-term control and monitoring has been used to allow radioactive decay, and at the end of the

designated period verification testing indicates residual contamination, then removal and disposal of the remaining contamination may be required.

Delicensing does not affect the requirement for continuing controls under other applicable regulatory regimes. Such regimes could potentially include planning and Part 2A. The funding of such controls (and any related maintenance and monitoring) would be a matter for the current site owner. Only once all regulatory obligations have been completed and the objective land quality for a given use has been achieved can Element 52 of the SAFEGROUNDS decision flow diagram be reached on nuclear-licensed sites.

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Applies to England and Wales, and Scotland

Environmental Protection Act 1990: Part 2A Contaminated Land. Statutory Guidance: Edition 2. Paper SE/2006/44 (inserted by the Environment Act 1995)
Applies to England and Wales, and Scotland

Radioactive Substances Act 1993
Applies to England and Wales, and Scotland

Water Resources Act (England and Wales) 1991

Water Environment and Water Services (Scotland) Act 2003

Water (Scotland) Act 1980 and Sewage (Scotland) Act 1968

Water Services etc (Scotland) Act 2005

Regulations

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Contaminated Land (England) Regulations 2000 (SI No 227)

Contaminated Land (Scotland) Regulations 2000 (SSI No 178)

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Applies to England and Wales, and Scotland

Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 (SI No 2892)
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Applies to England and Wales, and Scotland

Glossary

Key:

Bold = terms with special meanings in the SAFEGROUNDS context

Underlined = terms with defined meanings in other contexts (eg regulatory contexts or units definitions).

Plain text = technical terms to assist non-technical audiences.

ALARP	As low as reasonably practicable – a standard for assessing necessary control measures taking into account the practicalities of the task in hand. Note: "reasonably practicable" has a defined legal meaning in the UK. ALARP incorporates this legal meaning as opposed to any other meaning that may be implied from technical publications such as those by the International Commission on Radiological Protection (ICRP).
Assumption	**A supposition to provide a clear and well defined basis for the options comparison. Assumptions are necessary where there is some uncertainty concerning factors that have the potential to influence the options assessment, eg the availability of particular waste management routes.**
Background radioactivity	Radioactivity from *naturally occurring radionuclides*, and *anthropogenic radionuclides* from man-made sources (such as global fallout as it exists in the environment from the testing of nuclear weapons or from accidents like Chernobyl) that are not under the control of the owner/operator.
Becquerel (Bq)	The International System (SI) unit of activity equal to one nuclear transformation (disintegration) per second.
Conceptual model	A representation of the characteristics of the site in diagrammatic or written form that may show the possible relationships between contaminants, pathways and receptors.
Constraint	**Any factor that limits the range of options that can be considered in the options comparison, and is outside the control of those with responsibility for making the decision about the management of the contaminated land. Financial issues should not be used as constraints unless all stakeholders agree.**
Contaminant	**A substance that is in, on or under the land and that has the potential to cause harm or to cause pollution of controlled waters.**
Contamination	**The presence of a substance that is in, on or under the land and that has the potential to cause harm or to cause pollution of controlled waters.**
Contaminated land	**Any land in, on or under which there are radioactive or non-radioactive contaminants at levels above the natural and artificial background levels that are typical of the area of the UK in which the site is located.**
Context	**A definition of the existing situation in which the decisions on the management of the contaminated land need to be taken. The context will include information about the contamination and its status, timescales, regulatory factors and stakeholders and any issues of particular importance.**

Controlled waters	Defined in Part III (Section 104) of the Water Resources Act 1991, which includes all groundwater, inland water, estuaries and coastal water to three nautical miles from the shore.
Criterion	**A property or measure of an option's performance that is relevant to the comparison of options. Criteria should be capable of being objectively quantified for all options under consideration (even if only with a simple scoring or ranking scheme). Criteria should also be unique and independent of one another and be defined at a similar level of detail. Criteria are sometimes referred to as "attributes".**
Decision making	**The process of deciding which option should be implemented. A major input into decision making is a formal comparison of options. However, other factors may play a role in determining which option is used.**
Decommissioning	The set of actions taken at the end of a nuclear facility's operational life to take it permanently out of service. It includes actions to systematically and progressively reduce the level of hazard on a site and may include the physical dismantling of facilities. The ultimate aim of decommissioning of a *nuclear-licensed site* is to make the site safely available for other purposes. The endpoint for decommissioning may be delicensing or reuse of the site for nuclear purposes, or the keeping of the site under institutional control.
Defence site	**In this guidance, defence sites include: non-nuclear sites that have been or are being used for defence activities, nuclear sites that are not regulated under NIA65, and nuclear sites that are operated for MoD by contractors and that are licensed and regulated by HSE under the Nuclear Installations Act (*nuclear-licensed sites*).**
Delicensing	The process of releasing a nuclear-licensed site from regulation under the Nuclear Installations Act and of releasing the operator from his period of responsibility for any nuclear liability.
Detailed quantitative assessment	Risk assessment carried out using detailed site-specific risk information to estimate risk or to develop site-specific assessment criteria.
Discharge	Any emission of a contaminant into the environment.
Effective dose	A radiation dose quantity that is a modification of equivalent dose. It takes into account the susceptibility of different organs and tissues in the body to stochastic effects such as cancer induction, as well as the different radiation types included in the definition of equivalent dose. The unit of effective dose is the Sievert.
Environment	**The environment includes land, water (including groundwater), air, flora, fauna, buildings, animals, crops and sites of historical and cultural importance. In this guidance, people are regarded separately from the environment. The distinction is made for consistency with health and safety, and radiological protection, terminology.**
End state	**The state beyond which no further regulatory controlled action by the current site owner/operator is required.**

	Note this differs from the NDA definition that is specific to the NDA alone: **"The 'end state' of a site is the physical condition of the site at the point at which the NDA has finished its business".** **Note that with this definition it does not necessarily require all radiological material to be removed from the site, because it is possible for the site to remain under long-term institutional control even after the NDA has finished its work.** **It is possible that a site end state may be mixed – it may consist of several areas remediated to standards appropriate for differing potential reuses.**
Equivalent dose	A radiation dose quantity which is a modification of the absorbed dose that takes into account the different amounts of damage done by different radioactive decay types (see quality factor and absorbed dose). The unit of equivalent dose is the Sievert.
Fingerprint (radiological)	A distinctive or identifying characteristic set of radioactive isotopes that distinguish a particular emission.
Future use	**The range of uses the *contaminated land* will be able to be put to after the *selected option* has been carried out successfully. The range of future uses may be restricted to reduce the potential hazards associated with residual contamination. Alternatively, the site may be made available for any future use, in which case lower levels of residual concentrations of contaminants are likely to be required.**
Generic assessment criteria	Criteria derived using general assumptions about the characteristics and behaviour of sources, pathways and receptors. These assumptions will be protective in a range of defined conditions.
Generic quantitative assessment	Risk assessment carried out using generic assumptions to estimate risk or to develop generic assessment criteria.
Groundwater	All water that is below the surface of the ground in the saturation zone and is in direct contact with the ground or subsoil.
Harm	Adverse effect on the health of living organisms, or other interference with ecological systems of which they form a part, and, in the case of humans, includes property.
Hazard	A property or situation that in particular circumstances could lead to harm or pollution.
High level of protection	**The level of potential impacts on people and the environment that all stakeholders agree can be tolerated. SAFEGROUNDS does not recommend a particular level of protection, rather it is recommended that the level of protection should be defined on a case-by case basis.**
Ionising radiation	Any form of radiation that is capable of ionising matter. Typically this ionisation takes the form of displacing an electron from an atom.
Involvement	The processes of communication, consultation and participation of stakeholders.

Key principle	**A fundamental principle that should be adhered to during *land management*. Through consultation, SAFEGROUNDS has developed five key principles on the protection of *people* and the *environment*, *stakeholder* involvement, the identification of the preferred *land management option*, taking immediate action and record-keeping.**
Land quality	**The condition of ground (soil, underlying strata, water and buried structures) due to natural or man-made factors that could have an impact on people or the environment.**
Land quality management strategy	**A document (or document suite) setting out a framework of arrangements, processes and broad objectives for all aspects of management of contaminated land on a site (or part of a site).**
Licensee	The organisation that is the holder of the nuclear site licence on a *nuclear-licensed site*. The licensee is responsible for nuclear safety on the site and for discharging all the obligations and liabilities associated with the nuclear site licence.
Management of contaminated land	**Aspects of taking any actions to assess, characterise, control, monitor, remediate or remove (wholly or partially) legacy contamination in, on and under land. Also all the processes that lead up to decisions to take such actions to protect people and the environment. This includes, but is not limited to, development of a conceptual site model and undertaking a risk assessment and a structured comparison of potential management options.**
Monitoring	**A continuous or regular period check to determine the presence or absence of contamination, its nature and the performance of any remediation works. This includes measurements undertaken for compliance purposes, and those undertaken to assess remedial performance.**
Non-radioactively contaminated land	**Any land in, on or under which there are non-radioactive contaminants at levels above the natural and artificial background levels that are typical of the area of the UK in which the site is located.**
Nuclear-licensed site	Sites that are regulated by HSE under the provisions of the Nuclear Installations Act 1965 (as amended) with a nuclear-site licence. The Act applies to fixed sites for the purposes of constructing and operating nuclear reactors and other prescribed nuclear installations. The guidance applies to operating sites and those being *decommissioned*, whether or not they are to be *delicensed*.
Objectives	**This is what management of contaminated land is intended to achieve. Objectives are set by considering factors such as government policy, corporate/organisational policy and the views of *stakeholders*. It is recommended that environment, health and safety objectives are established separately from those of a commercial and administrative nature.**
Option	**Any potential method of managing the contaminated land that is relevant to the objectives. Options can include, but may go further than, some or all of the actions defined as "remediation" in Part 2A of the Environmental Protection Act 1990. In evaluating options, consideration should always**

	be given to "doing nothing more" to the contamination or to removing contamination to background levels while ensuring continued control of the existing situation.
Optimisation	The form, scale and duration of the intervention (remedial action) that maximises the net benefit. The principle of optimisation means that there is no predetermined end point for remediation that is applicable in all circumstances. In the extension to Part 2A, where a remediation scheme addresses significant pollutant linkages, some but not all relating to lasting exposure, any intervention should be optimised having regard to their benefit in respect of any remedial treatment actions relating to non-radioactive significant pollutant linkages. Within a radiation protection context optimisation is an essential part, and in practice the most important part, of a system of dose limitation because reliance on dose limits is not enough to achieve an acceptable level of protection. Safety shall be optimized so that the scale of individual doses, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable. Economic and social factors should be taken into account, within the restriction that the doses to individuals delivered by the source are subject to dose constraints as defined in the *Basic safety standards for protection against ionising radiation and for the Safety of radiation sources* (IAEA, 1996).
Owner/operator	**The organisation with responsibility for the site and any associated *contaminated* land. At *nuclear-licensed sites* the operator is the licensee. Owners/operators are responsible for taking final decisions to implement the proposed option for *land management*.**
Pathway	A route or means by which a *contaminant* can reach, or be made to affect, a *receptor*.
People	**Those individuals that could be affected by *contaminated land*. People are distinguished from *environment* following health and safety and radiological protection convention. Separate consideration may be given to "workers" (who receive a direct financial benefit from the *owner/operator*) and the public (who do not). Consideration should also be given to people at present and in the *future*.**
Pollutant linkage	The relationship between a *contaminant*, a *pathway* and a *receptor*.
Possible options	**All the options that would be effective for managing the *contaminated land*.**
Preferred option	**An option which, on the basis of the options comparison, represents the best balance of features to achieve the overall objectives for the management of the *contaminated land*.**
Preferred strategy	**The strategy that is identified by an *owner/operator* as their preferred one following a comprehensive, systematic and consultative assessment of potential strategies derived by considering the *options* for the various areas on a site.**

Preliminary risk conceptual assessment	**First tier of risk assessment that develops the initial model of the site and establishes whether or not there are any potentially unacceptable risks.**
Proposed option	**The *option* that is formally submitted by an *owner/operator* to regulators and decision makers for approval to use. This follows a comparison of options, identification of a *preferred option*, and consideration of this preferred option in regulatory and other acceptance procedures.**
Proposed strategy	**The *strategy* that is formally submitted by an *owner/operator* to regulators and decision makers for approval to implement. This follows a comparison of strategies, identification of a *preferred strategy*, and consideration of this preferred strategy in regulatory and other acceptance procedures.**
Radiation	Normally used in place of ionising radiation. Radiation is the emission of energy by means of particles or waves.
Radioactive decay	The spontaneous transformation of an unstable atom into one or more different nuclides accompanied by either the emission of energy and/or particles from the nucleus, nuclear capture or ejection of orbital electrons, or fission. Unstable atoms decay into a more stable state, eventually reaching a form that does not decay further nor has a very long *half-life*.
Radioactive material	Often used to describe any material containing radionuclides. The statutory definition of radioactive material is given in the Radioactive Substances Act 1993.
Radioactively contaminated land	**Any land in, on or under which there are radioactive contaminants at levels above the natural and artificial background levels that are typical of the area of the UK in which the site is located.** **The phrase "in, on or under" includes soils, rocks groundwater and below ground structures but excludes authorised disposals of radioactive and non-radioactive wastes. These definitions are for the purposes of SAFEGROUNDS only. They have been chosen because they best reflect the views of stakeholders on the levels of contamination with which the SAFEGROUNDS guidance should be concerned.** **The term radioactively contaminated land-use here is not the same as the precise legal definition taken within the EPA 1990 Part 2A.**
Radioactivity	The mean number of nuclear transformations occurring in a given quantity of radioactive material per unit time. The International System (SI) unit of radioactivity is the *Becquerel* (Bq).
Radionuclide	An unstable nuclide that undergoes *radioactive decay*.
Receptor	An entity (persons, living organisms, ecological systems, controlled waters, atmosphere, structures etc) that may be adversely affected by a *contaminant*.
Records	**Information including details of site characterisation work, the process of deciding on the land management option/strategy, implementing the option/strategy and**

	validating its use, as well as interaction with stakeholders throughout the process. There is a key principle about the keeping of records.
Remediation	**Any measures that may be carried out to reduce the risks from legacy contamination of land areas through action applied to the contamination itself (the source) or to the exposure pathways to humans or other receptors.**
Remediation (Part 2A, Environmental Protection Act 1990)	Defined in Section 78A(7) as: a) The doing of anything for the purpose of assessing the condition of: (i) the contaminated land in question (ii) any controlled waters affected by that land (iii) any land adjoining or adjacent to that land b) The doing of any works, the carrying out of any operations or the taking of any steps in relation to any such land or waters for the purpose: (i) of preventing or minimising, or remedying or mitigating the effects of any significant harm, or any pollution of controlled waters, by reason of which the contaminated land is such land (ii) of restoring the land or waters to their former state c) The making of subsequent inspections from time to time for the purpose of keeping under review the condition of the land or waters. OR with respect to radioactive contamination defined in Section 78A(7)(as modified) as: a) The doing of anything for the purposes of assessing the condition of: (i) the contaminated land in question (ii) any land adjoining or adjacent to that land. b) The doing of any works, the carrying out of any operation or the taking of any steps in relation to any such land for the purpose: (iii) of preventing or minimising, or remedying or mitigating the effects of any harm by reason of which the contaminated land is such land (iv) of restoring the land to their former state c) The making of subsequent inspections from time to time for the purpose of keeping under review the condition of the land.
Remediation strategy	A strategy to organise and manage the action taken to prevent, minimise, remedy or mitigate the effects of any unacceptable risks.
Risk	A combination of probability, or frequency of occurrence, of a defined hazard and the magnitude of the consequences of the occurrence.
Risk assessment	The formal process of identifying, assessing and evaluating the health and environmental risks that may be associated with a hazard.
Risk management	The processes involved in identifying, assessing and determining risks, and/or the use of actions to mitigate the consequences or probabilities of occurrence.

Safety case	Documentation for a nuclear installation that demonstrates safety. Safety cases must be produced and maintained during the design, construction, manufacture, commissioning, operation and *decommissioning* of the installation. It is a requirement in the SAPs for contaminated land on a nuclear-licensed site.
Screening (related consideration. to options)	**The process of excluding options from detailed consideration. to options) Screening is usually undertaken with reference to one or more "screening criteria" that represent basic expectations that must be met by any option. Screening criteria usually reflect the need for legality, technical feasibility, and a measure of proportionality between effort and benefits.**
Sievert	The name for the International System (SI) unit of equivalent dose or effective dose, abbreviated to Sv. Fractions of a sievert follow conventional nomenclature with one thousandths of a sievert called a millisievert (mSv) and one millionths of a sievert called a microsievert (microSv or μSv).
Site	**A contiguous area of land on which contamination is known or suspected to be present. In most cases, a site will have a single *owner/operator*. Sites considered in this guidance are further classified as *nuclear-licensed sites* or *defence sites*.**
Site characterisation	**The process of gathering information about a site (or group of sites) and its setting(s) for the purpose of assessing and, where necessary, managing health and environmental risk. Guidance on site characterisation has been developed by SAFEGROUNDS.**
Source	A hazardous substance or agent (for example a contaminant) that is capable of causing harm.
Stakeholder	**Stakeholders are all the people with an interest in the management of the contaminated land. They include institutional stakeholders, such as regulators, local and national government and senior management within site owner/operator organisations, and others who could be affected by, or have a direct interest in, land management decisions, such as employees, local residents, non-governmental organisations (NGOs), community-based organisations (CBOs) and individuals.**
Threshold	The dose or exposure below which a significant adverse effect is not expected. Carcinogens are thought to be non-threshold substances to which no exposure can be presumed without some risk of adverse effect.
Uncertainty	A lack of knowledge about specific factors in a risk or exposure assessment including parameter uncertainty, model uncertainty and scenario uncertainty.
Validation of remediation	**The process of demonstrating, by means of inspection, sampling, testing and recording, that the risk has been reduced to meet remediation criteria and objectives based on a quantitative assessment of remediation performance.**

PART 5 Abbreviations, acronyms and symbols

ALARP	As low as reasonably practicable
BPEO	Best practicable environmental option
BPM	Best practicable means
Bq	Becquerel – a unit of radioactivity (one nuclear transformation per second)
BSL	Basic safety limit
BSO	Basic safety objective
BSS	(International) **Basic Safety Standards** for protection against ionising radiation
CBO	Community based organisation
CIRIA	Construction Industry Research and Information Association
CLEA	Contaminated Land Exposure Assessment
CLR 11	Contaminated Land Report 11 (EA, 2004)
COSHH	Control of Substances Hazardous to Human Health (COSHH) Regulations (consolidated) 2002
DE	MoD Defence Estates Organisation
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions (no longer exists; most of its responsibilities relevant to this guidance have been transferred to DEFRA, the remainder to DTLR)
DNSR	Defence nuclear safety regulator
DTI	Department of Trade and Industry replaced by Department for Business Enterprise and Regulatory Reform (BERR) <www.berr.gov.uk/>
EA	Environment Agency
EEC	European Economic Community
EHS(NI)	Environment and Heritage Service (Northern Ireland)
EIA	Environmental impact assessment
EIAD	Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations, 1999
EPA90	Environmental Protection Act 1990
HPA	Health Protection Agency
HSE	Health and Safety Executive
HSWA	Health and Safety at Work etc Act 1974
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IRR	Ionising Radiations Regulations, 1999
IWS	Integrated Waste Strategy
LLW	Low-level radioactive waste
LQMS	Land quality management strategy
LPA	Local planning authority
LQF	Land quality file

MADA	Multi-attribute decision analysis
MoD	Ministry of Defence
MHSW	Management of Health and Safety of Work Regulations 1999
NDA	Nuclear Decommissioning Authority
NEPLG	Nuclear Emergency Planning Liaison Group
NGO	Non-governmental organisation
NIA65	Nuclear Installations Act 1965 (as amended)
NII	Nuclear Installations Inspectorate, part of HSE
NNA	Nuclear National Archive
NRPB	National Radiological Protection Board (now the HPA)
ODPM	Office of the Deputy Prime Minister
PAN	Planning Advice Note (Scotland)
Part 2A	Environmental Protection Act 1990: Part 2A Contaminated Land (inserted by the Environment Act 1995)
PPC	Pollution prevention and control
PPS	Planning Policy Statement
RCEP	Royal Commission on Environmental Pollution
QRA	Quantitative risk assessment
RCLEA	Radioactive contaminated land exposure assessment
RL2	Radioactively Contaminated Land SAP No 2
RPA	Radiation protection advisor
RSA93	Radioactive Substances Act 1993
RWG	Recovery Working Group
SAFEGROUNDS	SAFety and Environmental Guidance for Remediation Of UK Nuclear and Defence Sites
SAP	Safety assessment principles
SD:SPUR	Site Decommissioning: Sustainable Practices in the Use of Resources
SEPA	Scottish Environment Protection Agency
SI	Statutory Instrument
SLC	Site licence company
SoLA	Substances of Low Activity Exemption Order (made under RSA)
SPOSH	Significant possibility of significant harm
SSG	Site Stakeholder Group
Sv	Sievert, a unit of dose from ionising radiation
TAN	Technical Advice Note
TDI	Tolerable daily intakes
UK	United Kingdom
US	United States
WEWSA	Water Environment and Water Services Act (Scotland) (WEWSA) 2003