

Near-surface disposal facilities for solid radioactive waste: Guidance on Requirements for Authorisation (NS-GRA)

Consultation version

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Executive summary

In the UK we use radioactive substances in many different products and processes that benefit society, the environment and our economy, for example, to produce energy or in hospitals. Some uses of radioactive substances pose little risk to human health or the environment while other uses can pose a greater risk. These risks are limited and controlled through rigorous management practices and strict regulation.

The beneficial use of radioactive materials inevitably creates some radioactive waste that must be managed. Where radioactive materials or waste can't be reused, recovered or treated to allow recycling, it may need to be disposed of.

SEPA regulates the disposal of radioactive waste from:

- nuclear licensed sites – for example, those carrying out activities such as nuclear power generation, nuclear fuel manufacturing and reprocessing or radioactive waste processing and disposal
- other premises that use radioactive substances – for example, certain industries, hospitals and universities

Radioactive waste disposal includes:

- discharges into the air, surface water and groundwater
- disposal to land – this is what this consultation relates to

This consultation document covers how we regulate near-surface disposal facilities for solid radioactive waste disposal to land.

A near-surface disposal facility is any facility for the disposal of solid radioactive waste which does not provide sufficient isolation of the waste to enable it to be categorised as a geological disposal facility.

This document is being published by SEPA for the purpose of public consultation. After addressing any points raised by the consultation process a finalised version of the guidance will

be published that will replace our 'Near-surface disposal facilities for solid radioactive waste: Guidance on Requirements for Authorisation, February 2009.

In producing this consultation document, we have taken account of changes to legislation, standards, understanding of environmental risk and good practice that have occurred over the last 15 years. We have also made changes to reflect feedback we've received from users of the guidance and international reviews by the International Atomic Energy Agency and the Western Nuclear Regulators' Association. Finally, to make the guidance clearer, easier to read and more accessible we have significantly updated the writing style and general format of the document.

We have produced this guidance in collaboration with the Environment Agency, Natural Resources Waste and the Northern Ireland Environment Agency to ensure that the technical approach is consistent across the countries of the UK. However, SEPA has published this separate near-surface guidance as Scottish Government do not support geological disposal at this time.

Part 1 – Before you start

1.1 Introduction

Solid radioactive waste is created on nuclear licensed sites and on non-nuclear premises such as hospitals, universities and industrial sites where radioactive materials are used. Operators of these activities are required to minimise the radioactive waste they produce. Where solid radioactive material or waste cannot be reused, recycled or recovered, they will need to be disposed of.

The [UK policy framework](#) for managing radioactive substances and nuclear decommissioning (Department of Energy Security & Net Zero, Scottish Government, Welsh Government and Northern Ireland, May 2024 ('UK policy 2024')) has an overall objective for managing radioactive waste, of reducing the risk to people and the environment to 'as low as is reasonably achievable' taking account of social, environmental and economic factors. The framework highlights that its policies are based on several key considerations, including sustainability and contributing to the United Nations Sustainable Development Goals, and states:

“We want sustainability to be hard wired into thinking on the management of radioactive substances and how nuclear decommissioning is carried out”.

The policies of the UK and devolved governments on radioactive substances are framed within the context of international guidelines, safety standards and conventions (to which the UK is a signatory). A number of different organisations are involved, including the International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP) and the Nuclear Energy Agency (NEA).

The IAEA states in its [Fundamental Safety Principles](#) (Safety Fundamentals (No. SF-1), Principle 7) that “*radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term*

management". The IAEA has also stated in its [Specific Safety Requirements](#) (IAEA SSR-5) that the aims of the disposal of radioactive waste are to:

- contain the waste
- isolate the waste from the accessible biosphere and to reduce substantially the probability, and all possible consequences of inadvertent human intrusion into the waste
- inhibit, reduce and delay the migration of radionuclides at any time from the waste to the accessible biosphere
- ensure that the amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times

The main method of disposal is emplacement of appropriately package waste in engineered disposal facilities where the radioactive waste is emplaced to permanently dispose of that waste. Disposal facilities for solid radioactive waste are typically located on sites which are separate to the activity producing the radioactive waste, but some nuclear sites may have a disposal facility on or adjacent to their site. On-site disposals of radioactive waste as part of decommissioning that are not dedicated disposal facilities, are covered by the environment agencies' joint publication "Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation" (GRR) rather than this guidance.

The type of solid radioactive waste disposal facility required depends on the radioactive and non-radioactive properties of the waste. UK policy 2024 describes 2 main types of solid radioactive waste disposal facility: near-surface disposal facilities and geological disposal facilities.

The IAEA define a near-surface disposal facility as:

"a facility for radioactive waste disposal located at or within a few tens of metres of the Earth's surface".

and a geological disposal facility as:

“a facility for radioactive waste disposal located underground (usually several hundred metres or more below the surface) in a stable geological formation to provide long term isolation of radionuclides from the biosphere”.

These IAEA definitions provide a basis for our guidance. For the purpose of this guidance, near-surface disposal facilities are any facilities for the disposal of solid radioactive waste which do not provide sufficient isolation of radioactive waste to enable them to be categorised as geological disposal facilities. We do not distinguish or define intermediate depth disposal facilities.

The Scottish Government’s policy for managing higher activity radioactive waste sets out a number of other considerations that might be applicable to the near-surface disposal of radioactive waste in Scotland (Scottish Government 2011).

This guidance sets out the requirements that need to be addressed when applying for or holding a permit for a near-surface disposal facility.

1.2 What and who this guidance is for

This guidance applies to near-surface disposal facilities, whether entirely on or under land or accessed from land with waste disposed partially or wholly under the seabed.

This guidance explains to developers and operators of radioactive waste disposal facilities the Scottish Environment Protection Agency’s (SEPA’s numerical standards and 18 requirements for environmental permitting of solid radioactive waste disposal. Such permitting includes any groundwater activity where it is carried on as part of the radioactive substances activity on the same site.

In this guidance the term ‘requirements’ is used to express the expectations SEPA places on the developer or operator of a disposal facility for solid radioactive waste, to enable us to grant a permit.

When this guidance says 'we' or 'us' it means SEPA. When we say 'you' in this guidance we mean the developer or operator of a disposal facility.

We expect you to develop and maintain an environmental safety case (ESC) to show how all the relevant requirements in this guidance have been addressed. Development of your ESC should start before the permit application is made and it should be maintained throughout the period of radioactive substances regulation (RSR).

This guidance [when finally published] supersedes the 2009 Near-surface Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation (GRA).

1.2.1 New applicants

This guidance explains the requirements you should meet in order to obtain an environmental permit for the disposal of solid radioactive waste in a near-surface disposal facility.

We recognise that it may not be possible to address all the requirements in this guidance during the early stages of development of a disposal facility. Therefore, you should adopt a proportionate approach, in which you describe when and how in the later stages of the process you will address those requirements not addressed in the current stage.

1.2.2 Existing permit holders

If you already hold an environmental permit for a radioactive waste disposal facility you should use this guidance when you are:

- planning the next stage in the lifetime of the disposal facility or a significant change to it (for example a new phase of operations, extension, closure)
- planning a significant change to how the facility is operated or the type of waste you intend to dispose of
- updating your ESC (for example to reflect operational experience, new information, changes in policy, legislation, standards or guidance)
- carrying out a scheduled review of your ESC

If you are applying for a variation (change) to your environmental permit, you should show in your application how your disposal facility will meet the requirements set out in this guidance.

1.3 What this guidance doesn't cover

This guidance applies to disposal facilities for solid radioactive waste and not to facilities for the storage of radioactive waste. The purpose of a radioactive waste disposal facility is to dispose of waste without the intention of retrieving it. Waste that has been received for disposal and has been emplaced in a disposal facility is considered disposed, even though further physical works may be needed to close the facility, such as backfilling, capping, sealing of shafts or tunnels etc. The disposal activity is considered to be ongoing until the end of the period of RSR.

This guidance applies to facilities dedicated for solid waste disposal. Therefore, it does not apply to solid waste disposals that take place on a decommissioning site, known as in-situ disposals or disposals for a purpose. For guidance on these types of disposals, you should refer to the environment agencies' Management of Radioactive Waste from Decommissioning of Nuclear Sites: [Guidance on Requirements for Release from Radioactive Substances Regulation](#).

This guidance does not cover the process of selecting a site for a radioactive waste disposal facility. However, early engagement with SEPA will help to identify potential environmental safety issues before there is significant investment of time and money in a particular site (see requirement R1: Early engagement).

Where there is no relevant permit in force, there can be specific circumstances, that are set out in legislation, in which previously disposed of radioactive substances can become radioactive material or waste again and fall under RSR. Such circumstances and other historic disposals may also be covered by other legislation, including the radioactive contaminated land regime under Part 2A of the Environmental Protection Act 1990. If the regulatory situation is unclear, interested parties should seek advice from SEPA.

Other environmental permits may be required for activities associated with the development or operation of a solid radioactive waste disposal facility. Our guidance '[Do I need an authorisation?](#)' will help you check this.

1.4 Regulating solid radioactive waste disposal in different parts of the UK

Radioactive waste management policy is a devolved matter. The Environment Agency (EA), Natural Resources Wales (NRW), SEPA and the Northern Ireland Environment Agency (NIEA) are responsible for regulating the disposal of radioactive waste in England, Wales, Scotland and Northern Ireland respectively.

In Scotland radioactive waste management is regulated under "The Environmental Authorisations (Scotland) Regulations 2018" (EASR) which give SEPA powers and duties to authorise the disposal of radioactive waste on an authorised place in Scotland.

The environment agencies have worked together to prepare this guidance so that standards for protection and safety of the public and the environment, and regulatory expectations for radioactive waste disposal, are as consistent as possible across the UK even though there is some variation in policy and legislation. However, separate documents have been produced and published by:

- SEPA for near-surface disposal facilities in Scotland (current policy in Scotland does not accept geological disposal as an option at this time).
- the EA, NRW and NIEA for near-surface and geological disposal facilities in England Wales and Northern Ireland

We aim to apply this guidance in a way that is transparent, accountable, consistent and proportionate. SEPA must act in accordance with the [Scottish regulators' strategic code of practice](#). We will also work jointly with other regulators in Scotland (see Role of other organisations), to minimise burdens on operators and developers, in accordance with our agreed ways of working.

1.5 Role of other organisations

The [Health and Safety Executive](#) (HSE) regulates the health and safety of work with ionising radiation at non-nuclear sites, including radioactive waste disposal facilities not on a nuclear licensed site.

The [Office for Nuclear Regulation](#) (ONR) regulates nuclear safety and security on nuclear sites, health and safety, the transport of radioactive material, and is responsible for granting nuclear site licences to operators.

SEPA has memoranda of understanding (MoU) with HSE and ONR that set out how we work together with them to regulate radioactive substances and consult each other on matters of mutual interest.

SEPA and ONR have also published a position statement describing how we work together to ensure decisions about radioactive waste management take into account nuclear safety and security considerations and our regulatory requirements: [Regulatory Arrangements for the Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites](#).

Local authorities in Scotland are responsible for determining most planning applications, though there can be a separate authority responsible for minerals and waste planning. We are a statutory consultee for planning applications. In developing our response to consultations on planning, we would consider matters including flood risk, water abstraction, fisheries, biodiversity, groundwater, contaminated land and pollution prevention.

A number of other organisations may be involved in considering the development of radioactive waste disposal facilities, such as [Marine Scotland](#) and [NatureScot](#), and there will be a range of organisations and groups that we consult with on any permit applications that we receive.

1.6 SEPA's objective and principles

We have published our objective and principles which we apply to all regulation of radioactive substances activities: "SEPA's Objective and Principles for regulating radioactive substances activities".

The updated objective and principles supersede the fundamental protection objective and principles that were set out in the 2009 Near-surface GRA.

By fulfilling the requirements in this guidance, you will meet our objective and principles for radiological protection of people and the environment.

1.7 Radiological protection standards

Radiological protection standards are set out in UK legislation and UK policy 2024. They are based on international safety standards published by the IAEA, recommendations from ICRP, and advice from the UK Health Security Agency (UKHSA) (for example, see UKHSA's predecessors (the Health Protection Agency) guidance on [radiological protection objectives for the land-based disposal of solid radioactive wastes \(Ref: RCE-8\)](#)).

In this guidance we refer to various standards including:

- dose limits
- dose constraints
- a risk constraint
- a risk guidance level
- a dose guidance range

These standards, described in part 2, form the basis for a number of requirements in this guidance.

1.8 Whole lifetime assessment of a disposal facility

When we authorise the disposal of solid radioactive waste, we consider the impacts on people and the environment:

- during the operational phase of the facility, including when waste is being disposed and when closure operations are being carried out
- after the facility has been closed but before the period of RSR comes to an end
- after the period of RSR has ended

You will need to address all phases of the disposal facility lifetime in your permit application and environmental safety case. This includes assessing the potential for, and impact of, natural processes affecting the disposal system and events such as inadvertent human intrusion.

The nature of radioactive waste disposal means decisions made now will determine the potential impact on people and the environment far into the future. The standards in this guidance will ensure future generations are afforded at least the same level of protection as current generations. This is consistent with the principle of intergenerational equity.

The radiological protection standards that apply to solid radioactive waste disposal facilities after the period of RSR are equivalent to the standards that apply to the surrender of any radioactive substances activity permit on a nuclear licensed site. These standards represent a low level of radiological risk and do not assume any restrictions for the purpose of radiological protection on the use of the land after the end of regulation.

For sites that hold a nuclear site licence ONR has set out the options and requirements for [delicensing](#).

1.9 Changes in guidance over time

It may take several years, or even decades, to carry out the necessary site investigation and construction activities for a new disposal facility before disposals of radioactive waste can begin. Once operational, a facility may receive radioactive waste over several decades before it is closed.

During this time, SEPA may update this guidance periodically to take account of, for example, changes to:

- government policy or legislation
- environmental protection standards
- experience in the UK and overseas
- developments in science and technology

The current NS-GRA always applies if you hold a RSR solid waste disposal facility permit. When changes to this guidance are made, you should address these changes in your ESC at its next scheduled review; when you update your ESC as a result of significant new information or operations; when you make an application to vary or surrender a permit with a revised ESC; or as otherwise agreed with us, whichever is sooner.

We expect you to revise your ESC to take account of changes to guidance. If necessary, you might have to change your waste acceptance criteria and the waste you can accept for disposal.

You should apply the current guidance, including any new aspects of the guidance, to all permitted disposals. Where a permit remains in force and assessments show that past disposals or elements of past disposals do not meet the current guidance, you should raise this with us. You should implement any agreed actions to optimise the protection provided, for example, by making engineering improvements or putting in place or enhancing operational and other controls.

Where you cannot show that you can comply with current guidance, leaving the waste in-situ may not be acceptable. You should consider options to retrieve some or all the waste or take other actions to upgrade the environmental safety of the facility, economic and social factors being taken into account, that satisfy the relevant regulators (see the sections above on the role of other organisations). It may not be appropriate to retrieve waste where this would:

- need disproportionate resources or cause other significant impacts
- unduly affect the performance of the disposal facility in isolating and containing any remaining radioactive waste
- lead to unreasonable exposure of workers

You will need to liaise with all relevant regulators on such cross-cutting matters and the regulators will also work together to consider your proposals.

1.10 Graded (proportionate) approach

A graded approach means that the level of analysis, documentation and actions necessary to comply with regulatory requirements and criteria should be proportionate to the hazard and risk. You should take a graded approach when applying the requirements in this guidance.

1.11 Engaging with interested parties

SEPA expects you to engage with the planning authority, local community, other interested parties and the general public when you are developing or revising the proposals for your disposal facility.

It is important to involve any interested parties who may be directly or indirectly affected by proposals to dispose of solid radioactive waste. Any process you choose to use to engage with interested parties should be open and inclusive. The aim should be to secure and maintain the confidence of interested parties by addressing their concerns and by presenting your ESC and other documentation in a way that people will understand. Different styles and levels of documentation may be needed for different audiences, but these should be consistent in referring to the same fundamental arguments and evidence. In some cases, the approach to engagement with interested parties is prescribed in government policy.

When you apply for a new permit, or a variation to an existing one, SEPA may consult members of the public and other interested parties during the permit determination process, depending on the significance of the application. We have set out our approach to consulting on permit applications in our [public participation statement](#).

Part 2 – Regulatory standards & requirements

In this part of our guidance, we set out the regulatory standards and requirements that apply to disposal facilities for solid radioactive waste.

2.1 Radiological protection standards

This section summarises the radiological human health protection standards referred to in this guidance. However, please note that other standards also apply for the protection of wildlife and groundwater that appear elsewhere in this guidance.

When applying these radiological protection standards, all disposals of radioactive waste made on a single permitted site will be considered as a single source. Your assessments of dose or risk from all disposals will be assessed together for the purpose of comparison with the appropriate regulatory standard.

For the purpose of dose assessment where there are multiple sources (two or more separately permitted facilities at a single location) guidance on the appropriate dose constraint to use is also provided below.

2.1.1 Standard 1: Dose limits

The dose limits specified in legislation and UK policy 2024 for protection of individual members of the public from ionising radiation are:

- 1 millisievert (mSv) for doses that can be received in a year by any member of the public from all controlled and authorised sources of radiation
- 15 mSv in a year for exposures of the lens of the eye
- 50 mSv in a year for exposures to the skin (averaged over 1 square centimetre)

Meeting these limits is a legal requirement but, in this guidance, we require you to meet the more protective dose constraints and other standards (see below) which ensures these limits are complied with.

2.1.2 Standard 2: Dose constraints during the period of RSR

The dose constraints specified in legislation and UK policy 2024 for protection of a member of the public from any authorised source, or group of sources, of ionising radiation during the period of RSR are:

- 0.3 mSv per year from any single authorised site
- 0.5 mSv per year from the aggregated exposures from a number of separately authorised sources in the same location (e.g. neighbouring but separately authorised sites)

Normal operation of your disposal facility should not exceed the annual dose constraints in any year during the period of RSR. Compliance with the dose constraints means not exceeding them. You should also apply optimisation during this period to further reduce exposures of people to ionising radiation (see requirement R7: Optimisation).

You should compare your dose assessments with the 0.3 mSv per year dose constraint. The assessment of effective dose should take into account both direct radiation from the disposal facility and external and internal radiation from all liquid or gaseous discharges from the disposal facility. For existing disposal facilities, you should take into account any impacts from radionuclides migrating from your facility into the surrounding environment that contribute to doses received by the public. Where the disposal facility is permitted with other facilities under a single permit, the sum of the doses from all the facilities should be compared with the 0.3 mSv per year dose constraint.

If your disposal facility is one of a number of separately authorised sources of radiation at a single location, you also need to compare the sum of the doses with the 0.5 mSv per year dose constraint. The assessment of the total effective dose should take into account external and internal radiation from all discharges from your disposal facility, together with external and internal radiation from planned discharges from any other separately permitted sources and sites at the location.

2.1.3 Standard 3: Risk constraint and risk guidance level after the period of RSR

UK Policy 2024 requires that for the period after permit surrender, the risks to the public of a fatal cancer or heritable defect must not exceed a risk constraint of 1 in 100,000 per year (or 10^{-5} per year). Compliance with the risk constraint means not exceeding this level of risk.

Furthermore, operators should seek to achieve a risk guidance level of 1 in 1,000,000 per year (or 10^{-6} per year), of a fatal cancer or heritable defect to a member of the public. The term 'guidance level' is used because it describes the standard we are seeking consistency with but not absolute adherence to. Compliance with the risk guidance level means consistency with this level of risk.

The risk guidance level has been set lower than the risk constraint to account for uncertainties inherent in exposure projections far into the future. By adopting this as our regulatory standard we ensure the risk constraint is complied with.

A representative person is an individual, usually hypothetical, receiving a dose that is representative of the more highly exposed individuals in the population (see ICRP Publication 101a 'Assessing Dose of the Representative Person for the Purpose of the Radiation Protection of the Public'). When defining a representative person for applying the risk guidance level, you should not differentiate between members of the public and workers. This is because after the period of RSR no planned work involving radioactive substances will be being carried out and hence nobody will be classified as a worker with respect to radiological protection legislation.

The risk guidance level is the radiological assessment standard which applies to assessed risks from radioactive substances arising from the 'expected evolution' of your disposal system. Your assessment should therefore consider the impacts from radionuclides that are dispersed in the environment due to the gradual break down of barriers and the associated transport of radionuclides in groundwater or gas.

The risk guidance level is also the criterion against which variants of the expected evolution should be compared. You should use variants to explore the impact of events occurring that do

not form part of the expected evolution, other uncertainties and sensitivities of your disposal system to provide a greater understanding of how your disposal facility might perform.

When comparing results from your assessments with the risk guidance level you should explain any biases that you include. While it is appropriate to make conservative assumptions in your estimation of risks, compounding conservatisms can make it difficult to get an understanding of the expected risks posed by your facility. As the risk guidance level is a cautiously low level of risk already, understanding your expected estimates of the risks and the uncertainties will provide an important input to assessing your environmental safety case.

You should ensure peak risks are clearly identified and included in your assessment. The timing of peak risks will vary depending on the radiological inventory, the disposal system and on the events and processes acting on it.

To calculate the radiological risk associated with a potential exposure situation you should multiply the estimated effective dose that could be received, by the estimated probability that someone would receive this dose and the estimated probability that death or heritable defect would occur as a consequence of the exposure (the risk coefficient). Assessed risks should be summed over all situations that could lead to exposure of the same person to radiation.

You should use a risk coefficient of 0.06 per sievert (Sv) to assess stochastic effects. This corresponds to recommendations set out in UKHSA advice (HPA, 2009 'Radiological protection objectives for the land-based disposal of solid radioactive wastes').

The risk guidance level applies to situations where only stochastic effects of radiation exposure are being considered. That is, only if the estimated annual effective dose is less than 100 mSv and the estimated equivalent dose to each tissue is below the relevant threshold for deterministic effects (tissue reactions). If your calculations result in doses that exceed these deterministic thresholds your disposal concept may not be acceptable for the inventory proposed.

Your calculations of risk will be important in helping judge the environmental safety of your disposal facility. However, you will also need to include supporting qualitative claims, arguments and evidence in your ESC.

2.1.4 Standard 4: Dose guidance range after the period of RSR for near-surface disposal facilities

For the period after permit surrender potential exposures must not exceed a dose guidance range of around 3 mSv per year (for exposures lasting more than one year) to 20 mSv (for exposures of one year or less). Compliance with the dose guidance range means not exceeding the applicable dose.

The dose guidance range should be used for the assessment and evaluation of specific scenarios in the period after the end of regulation that could involve direct contact with radioactive waste. In these scenarios the emphasis is on avoiding or mitigating the consequences of the potential exposures. The dose guidance range should be used for the assessment of:

- Inadvertent human intrusion into the radioactive waste itself after the period of RSR (see requirement R16)
- Certain scenarios resulting from natural disruptive processes and events after the period of RSR that uncover radioactive waste and could lead to direct encounter with the waste (see requirement R17).

For these scenarios the assessed effective dose to a representative person in the period after RSR should not exceed the range from around 3 millisieverts per year (3 mSv per year) for exposures lasting more than one year to 20 millisieverts (20 mSv) for exposures of one year or less, where there is no recurring exposure in subsequent years.

Disposal facilities should be located and designed so that the waste remains contained and isolated for a long enough period of time given the inventory that has been or will be disposed. A disposal facility should not allow the waste to be uncovered, for example by erosion, before the hazards posed by it have reduced sufficiently to comply with both this standard and the risk

guidance level. We require that such scenarios are assessed for near-surface disposal facilities to ensure that the radiological consequences to people in the future are acceptable.

Similarly, while a disposal facility may include elements in the design to prevent inadvertent human intrusion, at least for a limited period of time, we require that such inadvertent human intrusion scenarios are assumed to occur for near-surface disposal facilities after the end of RSR. The dose consequences from these inadvertent human intrusion scenarios should be compared to this standard to ensure that people in the future are protected (see requirement R16).

If your facility cannot comply with the dose guidance range, this indicates that your proposed radioactive waste inventory is not suitable for your particular disposal concept or facility design, or is not suitable for near-surface disposal at all, and that you will need to explore alternative long-term management options.

2.2 Requirements

2.2.1 Requirement 1: Early engagement

You should engage early with us if you intend to:

- develop a new facility for the disposal of solid radioactive waste
- make changes to an existing facility which may require a variation to your environmental permit
- make significant changes to your ESC

SEPA can provide you with advice prior to your permit application or ESC submission and we may charge for this service. Depending on the type of advice required, a formal contract may be needed.

How early engagement should start will depend on many factors including:

- type of facility and the stage of development it is at
- environmental setting

- availability of resources
- how mature plans are for the proposed facility or change
- how significant, complex or novel the proposed facility or change is

A structured and proportionate programme of engagement should be agreed with interested parties and periodically updated, starting from early in the development of the disposal concept and extending over as many years as is appropriate.

We cannot provide regulatory certainty that we will grant or vary your environmental permit until the permit determination process is completed. However, seeking pre-application advice will help you understand our regulatory requirements and expectations, and the process to be followed, before you make a formal application.

Early engagement also offers other benefits; it should help:

- us prepare for the permit application
- inform our contribution to other decision-making processes, for example, land use planning or nuclear site licensing
- enable us to participate in the operator's or developer's discussions with communities and other interested parties before any consultation on your application for an environmental permit
- inform the operator or developer of how we will engage with other regulators
- inform the operator's or developer's investment decision
- guide the development of innovative waste disposal concepts and how such concepts could be regulated
- reduce the uncertainty in the operator's or developer's programme, including time and cost.

2.2.2 Requirement 2: Management system and environmental safety culture

You should develop and maintain an effective management system, including written arrangements which show how you will design, construct, operate and close your disposal

facility. Your management system should control the development of your ESC, the development of your disposal facility and the disposal of radioactive waste to ensure compliance with the limits and conditions in your environmental permit (for example, the maximum disposal limits for the site).

Your management system should be consistent with international good practice (for example, ISO 14001, ISO 9001, IAEA GSR Part 2, IAEA GSG-16) and address important aspects, including:

- leadership, including policy; organisational structure; roles, responsibilities and accountabilities
- planning, including objectives; risk management; production and maintenance of your ESC
- support, including adequate resources; suitably qualified and experienced personnel; training and continuous learning; succession planning; communication; interactions with waste consignors; knowledge, information, data and records management; intelligent customer capability; supply chain management
- operation, including decision-making; control of work; change control; emergency response; waste acceptance at the disposal facility
- performance evaluation, including quality assurance; internal audits
- improvement, including corrective actions; reviews

You should:

- be able to demonstrate that your organisation is a competent operator (for example, technically and financially competent) and fully capable of assuring environmental safety throughout the period of RSR
- keep your management system 'fit-for-purpose' by regularly reviewing and updating your written arrangements
- adapt your management system as you progress through each stage in the lifetime of the disposal facility

- develop, foster and maintain a positive environmental safety culture, including appropriate individual and collective attitudes and behaviours to environmental safety, which is supported by your management system, and require your suppliers to do the same

Senior management should recognise that the attitude of individuals and the environmental safety culture within an organisation are influenced through leadership. To improve the environmental safety culture and help individuals to develop professionally, managers at all levels are required to demonstrate their commitment to environmental safety as a priority in resource allocation, business planning, documentation and in all waste management activities (see IAEA GSR Part 2 for examples). Your senior management should demonstrate a proactive and long-term approach to environmental safety issues in decision making on radioactive waste management (as recommended in IAEA GSG-16). For example, decision making should include, but not be limited to, asking questions such as:

- can discharges be prevented or reduced?
- has the 'waste hierarchy' been properly applied?
- does a proposed activity increase the risks of barrier failure or leaks – can the proposed activity be further optimised to avoid or reduce this?
- can the activity be undertaken with reduced environmental cost?

You should consult with us and follow any guidance on management systems and environmental safety culture, for example the '[Guide to the standard conditions for radioactive substances activities](#)'.

2.2.3 Requirement 3: Environmental safety case

An ESC is a set of claims about the environmental safety of a facility for the disposal of solid radioactive waste, together with the arguments and evidence that support those claims.

Your ESC should demonstrate that people and the environment will be adequately protected from the radiological and non-radiological hazards and risks associated with the disposal of

waste during the full lifetime of the disposal facility, including the period after the site is released from RSR.

Your ESC should set out why you believe your disposal system will provide the required levels of isolation, containment and protection of people and the environment from the hazards and risks posed by the waste you intend to dispose of and is consistent with sustainable development. These arguments should be based both on qualitative and quantitative evidence.

Your ESC should include quantitative assessments to demonstrate compliance with the dose constraints during the period of RSR (see standard 2). Your ESC should demonstrate consistency with the risk guidance level (see standard 3) and show that the dose guidance range will not be exceeded after the period of RSR. Your ESC should also demonstrate that groundwater is protected (see requirement R14: Protecting groundwater). You must demonstrate all of the above and that you have met all of the other requirements in this guidance.

Uncertainties associated with quantitative assessments will increase for periods further into the future and, at some point, such assessments might no longer serve as a reasonable basis for decision-making. Your ESC needs to provide assurance, beyond quantitative assessments, that the environmental safety requirements (for example, on isolation, containment and disposal system design, construction, operation and closure) will be met. We will take account of a wide range of factors, including all the NS-GRA requirements, when we judge the acceptability of your ESC and proposals for waste disposal.

Your ESC does not have to be a single document (see IAEA SSG-23; IAEA SSG-1 Rev. 1 for guidance) and may consist of information in different forms (for example, paper documents, digital documents, photographs, audio, video, databases). You should list all the information that makes up the ESC and provide a clear explanation of how this information is structured and collectively forms the ESC.

Where the disposal facility is situated on a nuclear licensed site, the ESC for the disposal facility should form part of the site-wide environmental safety case (SWESC – see GRR for details) for

the whole nuclear site. In cases where contamination of ground or groundwater arising from the radioactive substances activity extends beyond the boundary of the authorised premises, such areas should be considered in the scope of the SWESC. This ensures that all potential sources of exposure to people and impacts on the environment are considered.

You should:

- submit an ESC in support of an application for an environmental permit to dispose of solid radioactive waste in a disposal facility
- maintain the ESC as a live document during the period of RSR.
- review and, where necessary, revise the ESC:
 - periodically and at each major stage in the lifetime of the disposal facility or a significant change to it (e.g. new phase of operations, extension, closure)
 - whenever there are significant changes to how the facility is operated or the type of waste you intend to dispose of
 - to take account of new information (for example, operational experience; monitoring, changes in policy, legislation, standards or guidance, site understanding, developments in science and technology)

You should implement management arrangements for the production and maintenance of your ESC, including a change control process (see requirement R2: Management system and environmental safety culture).

You should submit a revised ESC to us:

- as part of a permit variation application (for example, due to plans for a significant change to the facility, how the facility is operated or the type of waste disposed of), unless the proposed variation is supported by the existing ESC
- following completion of a scheduled review and revision of your ESC, if required by your environmental permit

- following a substantial review of the ESC (for example, as a result of significant new information), if agreed with us
- prior to the closure of all or part of your facility
- as part of a permit surrender application

The ESC submitted prior to closure of part or all of your facility should show that the as-built facility with the disposed inventory meets the requirements of this guidance. Your ESC at this stage should consider any additional measures to further optimise your facility during closure. This includes your proposals for backfilling, capping, sealing access tunnels and shafts, for example.

Controls may need to remain in place for the purpose of assuring radiological protection following closure. These assurance measures may for example include monitoring or restrictions on access to or use of the site. These controls will need to continue within the period of RSR, until we determine and grant your application to surrender a permit. The ESC should describe these controls and provide evidence that they will be sufficient and practicable for protecting people and the environment, and that resources will be provided sufficient for the controls to endure and be effective for the period proposed.

You should propose an estimated duration of control for the purposes of radiological protection within your ESC. However, unless there were exceptional circumstances SEPA would not accept a proposal for a period of control for the purpose of radiological protection lasting longer than 300 years after closure of the facility. This is because of the major societal changes that may take place over such long periods of time.

When you apply to surrender your environmental permit, your ESC (and SWESC where relevant) should show that the risks presented by all radioactive waste remaining on site and any non-radioactive hazardous properties of the radioactive waste, including contamination that may have arisen before or during operations, are consistent with the relevant standards and any applicable surrender requirements.

See part 3 for further guidance on the scope and content of an ESC.

2.2.4 Requirement 4: Site characterisation

You should carry out a programme of site characterisation to gather data about the natural and man-made features of the site and to understand how the site and surrounding area has evolved and may evolve in the future.

Your site characterisation programme should:

- adequately determine baseline conditions (also see requirement R5: Monitoring)
- inform development of conceptual and mathematical models of the site and its characteristics
- inform the environmental safety assessments included in your ESC
- inform the development and selection of disposal concepts and engineering design

These are just examples - your characterisation programme might have additional aims.

Your site characterisation programme should provide enough detail but should reflect the:

- radiological and non-radiological hazards and risks presented by the waste
- uncertainties in understanding and the conceptual and mathematical models of the site
- complexity of the environmental setting

Your site characterisation programme will need to record and describe information about the site and surrounding area, including, but not limited to, the:

- geology
- geotechnical properties of the geology
- geochemistry
- background radioactivity
- hydrogeology
- hydrology

- topography
- soil characteristics
- climate
- plant and animal distributions
- human behaviours, activities and settlement patterns, in the past as well as the present
- actual or potentially valuable or exploitable natural resources at and near the site

You should identify the potential for, and effects of, a changing climate and processes such as erosion, seismic events, uplift and ground subsidence and assess how these could affect your conceptual and mathematical models and the environmental safety assessments included in your ESC.

If you carry out any intrusive site investigation activities, you should minimise the disturbance of the geological formations as far as reasonably practicable. This is due to the potential for adverse effects on the natural features which you may later rely on to perform an environmental safety function. Boreholes, wells or other ground penetrations should be suitably decommissioned and sealed, with suitable records kept.

You should consider a phased or iterative approach to site characterisation to support the development of conceptual and mathematical models of your site and the environmental safety assessments included in your ESC, for example:

- early phases of site characterisation should focus on understanding the site and its wider setting to assess whether the site appears broadly suitable and how an ESC might be developed
- later, more detailed, phases of site characterisation should aim to refine the understanding of the site and its surroundings and provide the data for further development of your ESC
- further site characterisation should be undertaken as necessary over the lifetime of the disposal facility to maintain the conceptual and mathematical models and ESC

You should, as appropriate, develop conceptual and mathematical models of the site and its regional setting which cover the current state of the site and the processes affecting site evolution. The extent and level of detail of your models should reflect the complexity of the site and be proportionate to the hazard and risks posed by your disposal facility.

You should review and update your site characterisation programme periodically to take account of new information, advances in investigation or monitoring technologies and emerging priorities for data gathering to reduce uncertainties that are potentially significant to the environmental safety of your disposal system.

You should present each phase of site characterisation as part of a structured forward programme that demonstrates how continually acquiring information will help to develop your conceptual and mathematical models of your site, including its evolution, and support your ESC.

2.2.5 Requirement 5: Monitoring

You should develop, implement and maintain a proportionate programme to monitor the site and the disposal facility for changes caused by site investigation, construction, operation, closure, and evolution of the disposal system, including the impacts of climate change. Monitoring activities must be designed and carried out so that they will not compromise the environmental safety of your disposal system.

You should carry out an appropriate level of baseline monitoring starting before the site is significantly disturbed, for example, by site investigation or construction work. It should continue for long enough to acquire data that adequately represents the baseline condition (including seasonal or other natural variations) against which future changes at the site can be assessed. The same measurements may form part of your site characterisation programme (see requirement R4: Site characterisation).

Baseline monitoring should include:

- measurements of background radioactivity at the site, including natural radioactivity and any contamination from historic discharges, weapons testing and nuclear accidents

- relevant radiological and non-radiological parameters that may change as a result of constructing, operating and closing the facility

During the period of RSR, you should carry out monitoring to show that:

- you are complying with the limits and conditions of your environmental permit
- the disturbance caused by intrusive site investigation, construction, operation and closure activities is not compromising the integrity of the disposal facility
- your conceptual and mathematical models of the site remain fit for purpose
- the disposal system performance is consistent with the claims made in your ESC
- the disposal facility and wider environment are evolving as expected

Monitoring may also be carried out for other purposes, for example, to meet other legal obligations or comply with other regulators' requirements.

You should regularly review your monitoring programme and update it as necessary.

You should clearly set out how you will assess the results of any monitoring, including the levels of specific parameters or identified changes that will trigger action. Where trigger levels are used, you should have management arrangements in place setting out the appropriate course of action if a trigger level is reached or exceeded.

You should recognise that the monitoring of the disposal facility during the period of RSR does not cease when waste emplacement stops. Your monitoring programme will need to continue until the disposal facility permit is surrendered. As the disposal facility's lifetime stage changes, the aims and requirements of the monitoring may also change. The monitoring plans you develop should account for this evolution and should be updated accordingly during the facility lifetime.

Monitoring for public reassurance after release from RSR is not required, although this does not prevent such monitoring from being undertaken so long as it does not compromise the environmental safety of the disposal system. If you intend to carry out any reassurance

monitoring after release from RSR, you should take care not to damage the barriers which perform an environmental safety function. The provision of environmental safety cannot rely on monitoring or other actions by future generations after the period of RSR.

Further guidance on monitoring may be found in:

- [Environmental radiological monitoring in Scotland – Radiological Monitoring Technical Guidance Note 2](#)
- [Monitoring and Surveillance of Radioactive Waste Disposal Facilities](#) – IAEA SSG-31

2.2.6 Requirement 6: Disposal system design

You should design the disposal system (see Glossary) so that it is in accordance with this guidance and good practice nationally and internationally and provides the necessary environmental safety functions for the radioactive waste that you intend to dispose of. Your environmental safety strategy (covered further in part 3) should describe your high-level approach to the design of the disposal system. This should be proportionate to the hazard and risk posed by the radioactive waste in your inventory.

In developing the design of your disposal system, factors you take account of should include, but not be limited to:

- geographical and geological features, including the hydrogeology
- the potential future effects of climate change, for example, from rising sea levels
- the engineering feasibility of your design to be implemented

You should design your disposal system so that events and processes that could prevent or hamper closure of the facility as planned are avoided. Such events and processes might, for example, include flooding or a loss of waste containment before closure. Failure to close the facility as planned could have negative effects on long term protection of people and the environment.

You should demonstrate that the design of the disposal system is optimised. Your design should take account of the amount and type of radioactive and other waste to be disposed (see requirement R7: Optimisation).

Your processes for engineering design, assessment and validation should be fully integrated within your ESC. You should conduct, where appropriate, tests, trials and demonstrations of your engineering methods under relevant conditions. Confidence will need to be established in the ability for example to emplace waste and install engineered barriers to meet design specifications. Engineers and other personnel carrying out design work must be suitably qualified and experienced and understand how the design will inform the ESC.

There will be a number of structures, systems and components of the disposal system which contribute to environmental safety (see part 3). An important aspect of your design will be the multiple barriers that you propose to isolate (see requirement R8: Isolation) and contain (see requirement R9: Containment) the radioactive waste (see [IAEA SSR-5](#) requirement 7).

The barriers can be physical (engineered or a natural part of the geosphere) or they may have other properties which help to slow down the migration of certain radionuclides, for example, chemical properties of the waste form. The barriers should be diverse, to minimise common failure modes impairing more than one of the barriers. They should also be complementary so that together they provide the required level of environmental safety. There is a distinction between these barriers and the environmental safety functions they provide. A given barrier may contribute to the environmental safety case in a number of ways, and these safety functions may be wholly or partly separate from one another. For example, the host geology may provide a physical barrier and may also have chemical properties that help to slow down the migration of certain radionuclides. There may be circumstances where one of these functions is impaired without the other necessarily being affected.

The barriers should be designed to perform their required environmental safety functions for the period of time that you claim in your ESC. You should present the arguments and assessments supporting these claims in your ESC.

In your ESC, you should include a description of:

- the barriers which form the disposal system design
- how long they are expected to perform
- how you plan to show that the barriers are performing as required, and will continue to for their design life, to the extent that this is possible
- how your arguments and assessments of your barrier performance take account of how the barriers will degrade over time
- the outcome of ‘what-if’ scenarios for the barriers (for example, loss of barrier) in your environmental safety assessments that support your multi-barrier design approach and any adjustments you have made to optimise the disposal system design
- how the disposal system design provides defence in depth so that environmental safety is not unduly dependent on any single component (for example, barrier)
- the feasibility of implementing the proposed disposal system design (including ease of construction)
- how the layout of the disposal system has been designed to allow for optimised disposal of the waste and to ensure that there are no significant risks related to nuclear criticality (where there are fissile materials present in the waste)

During the period of RSR, your disposal system design should aim to use passive features that do not depend on human actions or on any active engineered system, for example, requiring the operation of electrical circuits or mechanical moving parts, as far as reasonably practicable. This ‘passive safety’ will help reduce risks to people and the environment both during this period of RSR and afterwards. However, in some settings active engineered systems and/or human actions may be necessary in this period. For example, before closure active ventilation systems may be needed in disposal facilities accessed by a shaft or tunnel.

When designing your disposal system, you will need to:

- consider whether the controlled release of any radioactive effluents (liquids or gases) is necessary during the period of RSR

- describe what systems are required to manage such discharges, for example, ventilation or leachate management systems
- demonstrate that your systems represent best practicable means (BPM) (see requirement R7: Optimisation)

After the period of RSR, your disposal system should rely entirely on passive safety.

Proposals for changes to the design of your disposal facility (e.g. revised barriers, extensions) should be made under a formal change control process in accordance with requirement R2: Management system and environmental safety culture. Their implications for environmental safety should be assessed in accordance with the guidance provided in part 3.

2.2.7 Requirement 7: Optimisation of radiological protection of the public

Radiological protection must be optimised during all stages of radioactive waste management, including during the design, construction, operation, closure and post-closure management of a disposal facility. This means making sure that people's exposure to ionising radiation is kept as low as reasonably achievable (ALARA), taking into account environmental, economic and social factors.

For a radioactive waste disposal facility, optimisation should consider both normal exposures during the period of RSR and potential exposures after the period of RSR.

Optimisation is also a requirement of health and safety legislation that is enforced by HSE at non-nuclear sites or by ONR on nuclear licensed sites. This legislation requires that risks to the health and safety of workers and other persons from exposures to ionising radiation are reduced so far as is reasonably practicable. As such, you will need to consider the protection of workers as part of the process of optimisation for the radiological protection of the public.

Optimisation involves the iterative assessment of options to see what further radiological protection improvements can be made, for example, different design features or alternative operating techniques; unless the costs and other disbenefits are grossly disproportionate, you

should adopt any identified improvement. The option identified by the optimisation process can be considered to be the BPM.

Optimisation does not mean minimising exposures regardless of the consequences of doing so. You should take into account wider environmental, economic and social factors when deciding what can reasonably be achieved. You should view optimisation as part of a wider appraisal of options, recognising that there will be competing claims for limited resources, and that no option is completely risk free. The result of optimisation should identify the option(s) resulting in an acceptably low level of exposure to the public, but not necessarily the option with the lowest possible exposure. Your process for optimisation of radiological protection should consider any reasonable measures that could reduce exposures of the public to ionising radiation.

The effort and resources you put into optimisation should be proportionate to the magnitude of the exposure or potential exposure / risk. There is no lower level of exposure below which optimisation is not required, but there are diminishing returns as the exposure is progressively driven lower.

As well as considering economic and social factors, you should also consider protection of the environment in achieving a balanced outcome from the optimisation process. This means taking account of a wide range of environmental factors, including the impact of radioactivity on wildlife (see requirement R13: Protecting wildlife) and the impact of the non-radiological hazards associated with radioactive waste (see requirement R15: Protecting against non-radiological hazards).

By considering what is ALARA and taking account of and balancing social, economic and environmental factors, you should choose options and make decisions that are sustainable. Optimisation requires evaluation of a wide range of diverse factors.

Optimisation is an ongoing process that should continue throughout the period of RSR and take into account the whole lifetime of the disposal facility. You should carry out optimisation:

- as part of your ESC development for the planning and design of a disposal facility

- periodically at each stage when you review your ESC
- to support the choices you need to make between sufficiently different alternatives

For an existing disposal facility, choices may be constrained by past decisions, but you should still ensure exposures are optimised, including whenever you are reviewing and updating your ESC, making a modification to the disposal facility, changing your operations, or changing the wastes that you accept for disposal. Where environmental safety requirements are not met, measures shall be put in place to upgrade the environmental safety of the facility, economic and social factors being taken into account.

The primary goal when disposing of solid radioactive waste is to protect people and the environment, including after the disposal facility has been closed and the period of RSR has ended. During the period of RSR, safety will be subject to active and ongoing regulatory scrutiny by a range of regulators. You should, therefore, focus optimisation on those aspects of the design and its implementation that make a difference to long-term environmental safety.

When comparing options, you should consider the:

- probability of individuals (representative persons) receiving exposure
- the timing and duration of the exposures and the geographical area affected
- the number of people exposed, and the magnitude of their individual doses

If you decide to calculate collective doses to help distinguish between different options, you should use these with caution because of the large uncertainties that can make any comparison of options meaningless (see ICRP 103 for guidance on the appropriate use of collective doses).

For a new disposal facility, optimisation begins by considering the inventory of the waste that is intended to be disposed of in the facility and the characteristics of the site, as this will influence the overall design concept. For example, whether it is constructed as an underground facility accessed by a tunnel or a disposal vault accessed from the surface. You should make initial strategic decisions based on the level of radiological hazard and other characteristics of the inventory. You may choose to select an overall design concept specific to a particular inventory,

or one which provides greater flexibility for the type of waste it can receive. You should set out and fully justify these choices in your ESC. You should also describe the comparison of options you have undertaken to justify your claims regarding optimisation.

Features of the disposal facility where the comparison of options could be undertaken include:

- the depth, design and layout of the facility in relation to its surroundings
- each barrier of the multi-barrier system
- the waste form and package design
- the construction methods
- operations including waste handling and emplacement
- the materials and methods of backfilling around the waste packages
- the engineering measures used to seal and or cap the disposal facility
- the measures used to collect and discharge aqueous or gaseous emissions
- the measures applied to discourage access or reduce the probability of inadvertent human intrusion

The waste forms and package designs acceptable for disposal at your facility should be clearly justified in the ESC (see requirement R3: Environmental safety case) and reflected in the WAC (see requirement R11: Waste acceptance criteria). In cases where the site location or disposal concept is not yet determined, your management system should include a way of providing reassurance that the waste forms and package designs will be suitable for disposal in future.

As you develop the design of a disposal facility, you should document the process to create a written record of the decisions made and show that you have properly carried out optimisation (see requirement R12: Preserving and accessing knowledge, information, data and records). There should be consistency between the optimised design of the disposal facility and the ESC, where the claims, arguments and evidence for their environmental safety functions should be fully set out. There should be a clear link between the documentation that reports the outcome of the optimisation process and the ESC.

We have issued general guidance on [optimisation](#) and [BPM](#). While this guidance is mainly directed at facilities that generate radioactive waste from operational activities, it provides further information on the practical application of optimisation.

2.2.8 Requirement 8: Isolation

The aims of disposal are to isolate radioactive waste from the accessible environment (the subject of this requirement) and to contain the waste and the associated radioactive substances (see requirement R9: Containment) so that there are no unacceptable consequences.

You should ensure that your disposal system provides adequate isolation. This means that, for the necessary length of time, your disposal system physically separates your disposed radioactive waste from the accessible biosphere, i.e. those parts of the environment that people or wildlife are, or may be, in contact with.

As IAEA SSR-5 states, for near-surface disposal facilities, isolation has to be provided by the location and the design of the disposal facility and by operational and other controls for the purposes of radiological protection. For geological disposal of radioactive waste, isolation is provided primarily by the host geological formation as a consequence of the depth of disposal.

Your disposal system should provide sufficient isolation for the length of time that the disposed radioactive waste inventory could cause exposures or risks to people (if they were to come into contact with the waste) greater than the standards set out in this guidance. It should prevent, as far as is reasonably practicable:

- inadvertent human intrusion into the disposal facility
- natural disruptive processes exposing the waste during the period you are relying on isolation

Isolation may be provided by a combination of factors including, but not limited to:

- depth of the disposal or distance to the accessible environment

- properties of the overlying geology and the wider geological environment that might restrict the ability to drill boreholes or excavate material (for example, hardness of rock)
- a low potential for investigation or exploitation of natural resources (for example, minerals, thermal energy)
- poor accessibility of the terrain (for example, beneath the sea, below steep topography)
- remoteness of the location (for example, from human settlements or activities)
- design features of the facility, including the cap for a surface facility, that contribute to isolation (for example, facility layout, waste emplacement strategies, use of durable materials)
- management controls applied during the period of RSR that increase separation between the radioactive waste and people (for example, fencing or surveillance of the site)

Your ESC should include your arguments and evidence that support your case that your disposal system provides adequate isolation of the radioactive waste over a sufficient length of time. You should document the information related to inadvertent human intrusion and natural processes that you rely on in the environmental assessments you use to support your ESC. You should include, but not be limited to:

- a description of the features, events and processes, both surface and subsurface, relevant to your disposal system. You should take account of the potential effects of climate change on your disposal system over the lifetime of your disposal facility. The potential consequences of climate change include changes in rainfall intensity and patterns (which can affect watercourses and aquifers), changes in sea level, changes in rates of erosion including coastal erosion, glaciation and tectonic movements.
- a description of the 'expected evolution' of your disposal system that incorporates your best understanding of the processes acting on your disposal system including the effects of climate change
- a justified list of the events and processes that could affect the degree of isolation provided by your disposal facility

- a description of and justification for inadvertent human intrusion scenarios that could lead to intrusion either directly into radioactive waste or other parts of the disposal facility. You should consider how the evolution of the disposal system may influence the nature of inadvertent human intrusion
- an estimate of the expected timeframe when events and processes might lead to radioactive waste being uncovered
- consideration of the uncertainties associated with all of the above

We refer to this description of the isolation provided by your disposal facility, including the supporting arguments and evidence included in your ESC, as your 'isolation assessment'.

2.2.9 Requirement 9: Containment

The aims of disposal are to contain waste and the associated radioactive substances (the subject of this requirement) and to isolate them (see requirement R8: Isolation) from the accessible environment so that there are no unacceptable consequences.

Containment of radioactive substances should be provided by a combination of natural and engineered barriers and other environmental safety measures. These may include, but are not limited to, the:

- waste form
- waste packaging
- backfill materials
- physical structures which form part of the facility
- properties of the host geology and the wider geological environment

In accordance with the graded approach required by the International Safety Standards, the ability of your disposal system to provide containment of the waste should be commensurate with the hazard posed by the waste.

Disposal facilities do not need to provide complete containment of waste forever - this is neither practicable nor necessary because the hazard associated with waste generally declines with time. You should ensure that the radioactive substances are contained for long enough so that people and wildlife are not exposed to unacceptable levels of radioactivity. Containment should contribute significantly to ensuring that exposures of people are as low as reasonably achievable, taking into account environmental, social and economic factors.

In the case of heat generating waste, you should design the disposal facility to provide adequate containment of the waste and the radioactive substances at least for the period while heat is being produced at a rate that could otherwise adversely affect disposal facility operations and or closure, the radiological performance of the disposal system or pollute the environment. Waste with levels of radioactivity high enough to generate significant quantities of heat by radioactive decay are not suitable for near-surface disposal.

When considering the ability of a disposal facility to contain radioactive substances, you should assess the potential for the barriers to be degraded or eroded.

You should use both quantitative and qualitative arguments and evidence that support any claims made in your ESC about how the barriers and other environmental safety measures will contain the waste and limit the migration of heat and radionuclides.

You should demonstrate how the performance, durability and longevity of your disposal system's barriers contribute to containment, and how you will make sure, using quality control and assurance systems, that the design specifications for engineered structures, systems and components will be fulfilled. You should also demonstrate how the barriers are compatible with each other and with the waste.

Where your disposal system's ability to contain radionuclides relies significantly on the properties of the surrounding geology for containment, you will need to provide detailed evidence of the robustness of its performance in your ESC.

This requirement does not rule out the discharge of radioactive effluents (liquids or gases) from a disposal facility as a controlled release under an environmental permit during the period of RSR.

2.2.10 Requirement 10: Construction, operation and closure

You should construct, operate and close your disposal facility according to your environmental permit, the disposal system design considered in the approved ESC, approved construction proposals and the procedures described in your management system. You must ensure that:

- at the point of closure, the engineered barriers have been installed correctly and are intact such that there is confidence that they will perform their required environmental safety functions
- you preserve the environmental safety functions of any natural barriers your ESC relies on

Your approach to construction, operation and closure must provide environmental safety as well as fulfilling your other legal obligations, including operational safety, security and nuclear safeguards.

The methods you use to construct, operate and close your disposal facility should meet the design requirements and quality standards identified in your ESC and your management system. They should also be flexible enough to allow for variation in actual conditions when compared to design assumptions. Any changes that are made should be controlled by your management system.

You must not start construction of engineering or other infrastructure until we have confirmed that we are satisfied with your construction proposals and associated plans for construction quality assurance (CQA). You should submit a CQA validation report, in accordance with any requirements in your permit, as soon as practicable following the construction of the relevant infrastructure.

In accordance with your management system, you should inspect, test, monitor and maintain all engineered barriers that will perform an environmental safety function as claimed in your ESC. Records of inspections, tests and maintenance should be created and preserved in accordance with requirement R12: Preserving and accessing knowledge, information and data.

If you find that barriers are not installed or functioning as anticipated, you should assess the implications for the ESC. If necessary, you should take corrective actions to make sure that the claims made in your ESC can be fulfilled or modify your ESC accordingly to reflect the differences. The implications of the changes to the ESC will need to be communicated to us.

While your facility is being operated, and until permit surrender, the assessed effective dose from your disposal facility to a representative person should not exceed the relevant dose constraint (see standard 2).

If an accident releases radioactivity into or around the facility, you should assess the implications for your operations, your closure plan and for your ESC. Your management system should include arrangements for appropriate mitigation should such an accidental release of radioactivity occur.

You should have plans in place to close your disposal facility; this could be in a single step or in phases where appropriate. The closure plan should describe how closure will be optimised (see requirement R7: Optimisation) and how any uncertainties associated with implementation of the closure plan will be managed. You should periodically review, and where necessary update, the closure plan while the facility is being constructed and operated.

Your plans to close your disposal facility should be consistent with the assumptions in your ESC. Delay to the backfilling, sealing or capping of the disposal facility, or part of the disposal facility, after the last waste emplacement should be avoided. If for some reason you consider a delay to be desirable, this would need to be fully justified in your ESC. You will need to demonstrate that the integrity of the waste packages and other site infrastructure are adequate and that the long-term performance and hence environmental safety of your disposal facility will not be adversely impacted.

If you wish to make changes to the plans or schedule for construction, operation or closure that are assumed in your permit or ESC, you will need to update your ESC appropriately (see requirement R3: The environmental safety case and part 3 of this guidance).

In situations where construction, operation and closure activities overlap, you should plan and carry out your activities to ensure the safety of people and the environment.

2.2.11 Requirement 11: Waste acceptance

Waste acceptance at your disposal facility needs to be adequately controlled to ensure that people and the environment are protected from ionising radiation and other hazards posed by the waste. To achieve this, you should define waste package specifications and waste acceptance criteria and limits and other relevant considerations for the waste that can be accepted into your facility. Your ESC should clearly set out any assumptions, limits and constraints regarding the waste that can be accepted including activity limits for individual packages as well as the total inventory that can be disposed to the facility. SEPA may incorporate some of these limits and constraints in your environmental permit and may also include additional constraints.

You should use your ESC to develop and maintain waste acceptance criteria (WAC) that can be applied to individual consignments of waste intended for disposal at your waste disposal facility. While the WAC should ensure that waste consignments are consistent with your ESC, they also need to ensure compliance with environmental permit conditions. In practice the ESC and the permit should be aligned as the permit conditions will be informed by your ESC, however, there may be additional permit conditions that you will need to factor into your WAC.

You may include additional criteria in your WAC to ensure that waste can be managed in accordance with other legislative or regulatory requirements (for example, requirements relating to health and safety, transport of the waste and pre-disposal management). You should collate and apply the WAC required for environmental safety with any WAC required for other purposes.

You should review and, where necessary, revise the disposal facility WAC following any updates to your ESC. You should submit any proposed WAC to us when you:

- apply for an environmental permit for disposal of radioactive waste
- submit an ESC to us
- submit a revised version of your ESC to us (for example, in support of an application to vary your environmental permit)
- are required to at any other time or as agreed with us (for example, if you make a substantial change to the WAC)

Your disposal facility waste acceptance limits and package specific WAC should address any features of the waste, waste form (including any encapsulant) or waste package that could affect the performance of the disposal system. These features could include:

- radionuclide content, activity and distribution
- fissile content and distribution
- non-radioactive hazardous substances and pollutants
- heterogeneity of waste, including high activity particles and interesting or noticeable objects that could attract people and hence increase exposures
- susceptibility to microbial action
- chemical stability
- thermal stability
- mechanical stability
- structural integrity
- potential for gas generation
- liquid content in the waste form
- potential for creating voids within the waste mass, resulting in, for example, uneven settlement, engineering stability issues or altered leachate or gas pathways
- potential for leachability

Your disposal facility waste acceptance limits and WAC should specify the radionuclides (or groups of radionuclides) and the maximum concentration and total activity of each that the facility can accept to ensure consistency with your ESC.

The IAEA has provided guidance on how activity limits and activity concentration limits can be set for near-surface disposal facilities, including the option of using the sum of fractions (the summation rule) approach (explained further in IAEA -TECDOC-1380, 2003). The IAEA approach or other approaches may be used.

Your disposal facility waste acceptance limits and package specific WAC should include requirements that make sure that all waste accepted for disposal is passively safe.

Your disposal facility waste acceptance limits and package specific WAC should include, where necessary, parameters relating to the evolution (e.g. degradation) of the waste form and the waste package under the conditions expected in the disposal facility, identified as a result of studies such as literature reviews, modelling or testing. This is to make sure that the waste form and waste package perform adequately during and after the period of RSR.

You should provide guidance to waste consignors on the application of your package specific WAC, for example, on specifications for the acceptable waste containers, levels of heterogeneity in the waste and acceptable unpackaged items that may be disposed of directly to the facility.

You should have controls in place to ensure that the disposal facility waste limits set out in your environmental permit are not exceeded and there is compliance with any other conditions relating to waste packages received by your facility. These should include arrangements to ensure that waste producers and waste consignors manage waste, so that when you receive it at your disposal facility, you can be confident it meets your package specific WAC. These controls should at least cover the following:

- interaction with the waste producers prior to receiving the waste, including providing advice and training as appropriate

- quality assurance of waste consignment information
- monitoring of waste packages
- audits of waste producer facilities
- ensuring that the waste has undergone a BPM assessment and adheres to the waste management hierarchy principles
- ensuring total waste acceptance activity limits for the facility are not exceeded
- arrangements to deal with any non-conforming waste consignments

Your management system (see requirement R2: Management system and environmental safety culture) should ensure that these matters are suitably controlled during the lifetime of your disposal facility.

We may specify environmental permit conditions for situations where:

- a waste consignment does not fully meet the WAC and
- you think that disposing of such waste within the facility would not breach any of the ESC constraints

These conditions may require you to submit a demonstration of environmental safety for the disposal to us, and to obtain formal approval before the waste can be received for disposal.

2.2.12 Requirement 12: Preserving and accessing knowledge, information, and data

You should set up and maintain during the period of RSR a comprehensive system for preserving and accessing knowledge, information and data about the radioactive waste and the disposal system. IAEA and NEA have issued relevant publications (for example, IAEA (2022) General Safety Guide [GSG-16](#), "Leadership, Management and Culture for Safety in Radioactive Waste Management", [NEA \(2019\)](#) "Preservation of Records, Knowledge and Memory (RK&M) Across Generations").

Your system for preserving and accessing knowledge, information and data should include all relevant aspects that affect your ESC and compliance with your environmental permit.

Your arrangements should recognise and be appropriate for the following phases of the facility's lifetime:

- site characterisation including determination of the environmental baseline
- design, construction and operation of the facility up to its closure
- from closure of the facility to an application to surrender the permit
- long-term archiving of records just prior to permit surrender

Your arrangements should transfer appropriate information on the disposal system and its environmental safety to an appropriate organisation (e.g. national government or archive) for preservation in the longer term after permit surrender.

Relevant knowledge, information and data could include, but is not limited to:

- site characterisation data (for example, geology, hydrogeology, geochemistry and other properties), monitoring data including details of baseline conditions and any interpretation of the data
- a description of the facility, its geometry and location
- sufficient versions of the ESC including the environmental safety assessments
- optimisation studies / BPM cases
- facility design documentation, as-built and any subsequent modifications
- waste inventory and waste package records, including where and when waste is emplaced in the facility
- details of facility closure
- measures to prevent or reduce the probability of inadvertent human intrusion

You should:

- not rely on knowledge, information or data held by individuals or other organisations (except those organisations whose archiving has achieved archive service accreditation status)

- as far as reasonably practicable, capture all required knowledge, information and data within a set of records
- produce and organise your records in a way that technical specialists who do not have site-specific knowledge can access and understand
- produce and organise summary information in a form that non-specialists can access and understand so they know if and when to involve technical specialists
- preserve the records in a way in which they are kept safe so they can be managed, accessed and understood over the long-term, taking account of relevant standards, guidance and codes of practice
- ensure that these records are protected from damage and loss (for example, storage of multiple copies at different locations, in different forms or media types)

You should set up retention arrangements for your records that specify how you will decide when they are no longer required (for example, superseded or no longer relevant). These should align with any permit requirements. After the facility is closed, but while it is still under RSR, your retention arrangements may specify a condensed set of relevant documentation which should be retained.

Just before permit surrender, you should transfer relevant records to a suitable organisation for long-term safe-keeping and management. For example, The National Archives or a facility which has achieved archive service accreditation status such as the Nuclear and Caithness Archives (Nucleus). These records should provide enough information so that future generations can have a fundamental understanding of your disposal system, especially its location and contents. We expect these records at least to include:

- a description of the closed facility, its geometry and location
- site characterisation (for example, geology and its properties)
- waste inventory and waste package records, including where and when waste is emplaced in the facility
- the final ESC for the as-built facility at the time of permit surrender

- monitoring results, including those during the closed phase of the facility

2.2.13 Requirement 13: Protecting wildlife

You should protect wildlife from the harmful effects of ionising radiation resulting from the release of radionuclides from your disposal system. In this guidance “wildlife” means populations of wild animals and plants which depend upon designated habitats.

Your assessments should consider releases that could take place in accordance with your expected evolution and variants of it and scenarios that involve natural disruptive processes. There are specific requirements to protect habitat sites and species which have been designated for protection in conservation legislation. There are also international obligations to protect the environment, by considering wild animals and plants.

The IAEA ([IAEA GSG-10](#)) and the ICRP ([ICRP-108](#), [ICRP-124](#)) have recommended the use of Derived Consideration Reference Levels (DCRL) for this purpose. Several research studies have also proposed dose rate criteria and assessment approaches (Coppelstone et al., 2001; Andersson et al., 2008; Brown et al., 2016). These approaches use reference animals and plants as the basis for relating exposure to dose rate, and dose rate to radiation effects, for different types of animals and plants.

Based on these recommendations, we do not expect wildlife populations or the integrity of their habitats to be adversely affected if the total dose rate from all permitted discharges of radioactive substances is about 1 milligray (mGy) per day (40 microgray per hour ($\mu\text{Gy/h}$)) or lower. You may use the current ICRP or IAEA DCRLs for specific reference animals and plants as alternative dose rate guidance levels.

You do not need to carry out more detailed assessments if, on the basis of a simple cautious assessment, the dose rates to wildlife from permitted discharges from your disposal facility are 0.25 mGy/day (10 $\mu\text{Gy/h}$) or lower. More detailed assessments would consider the impact of combined permitted discharges and use more realistic assessment assumptions.

To demonstrate that wildlife is sufficiently protected during the period of RSR, you should assess the exposures of representative animals and plants that depend on habitats which may be affected by releases of radionuclides from your disposal facility. These representative animals and plants may be the same as reference animals and plants. You should make reasonable assumptions about potential future designated habitat sites and species for the period of RSR, based on the best information available at the time of the assessment.

You should also provide an assessment of the potential impact on wildlife from the disposal facility for the period after RSR (though you are not required to compare this with the standards above). You should take a proportionate approach to this assessment. You should consider how the disposal facility will evolve in the period after RSR and how wildlife may be affected. This includes the expected evolution of the disposal facility, variants of the expected evolution and scenarios that involve natural disruptive processes. As the location and status of designated protected habitat sites and species will be unknown after the period of RSR, you should make reasonable assumptions about potential wildlife receptors based on the best information available at the time of your evaluation.

You should demonstrate that your facility is suitably isolated, and waste contained, so that intrusion by animals and plants does not lead to a significant risk.

Your assessment of the impacts on wildlife is an integral part of your ESC. As such, your wildlife assessments should be considered as a factor in the optimisation of the design options for the facility.

We do not expect you to assess the impact of inadvertent human intrusion scenarios on wildlife.

2.2.14 Requirement 14: Protecting groundwater

You should ensure that your radioactive waste disposal facility does not cause pollution of groundwater at any stage during your site investigations, facility construction, operation, closure, and long-term evolution after the period of RSR.

Any activity causing or liable to cause direct or indirect discharge of any hazardous substances or pollutants to groundwater is a controlled activity under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR 2011). The development, operation and closure of a radioactive waste disposal facility is a controlled activity under these regulations as well as a radioactive substances activity under EASR.

Part 4 of this guidance explains what you must do to meet the above requirements.

2.2.15 Requirement 15: Protecting against non-radiological hazards

Some radioactive waste may be potentially harmful to people and the environment because of its non-radioactive properties. A wide range of substances such as asbestos, lead and methane may present non-radiological hazards. These may have been present in the waste package when it was initially disposed of, or may result from subsequent physical, chemical or biological changes following disposal. Properties such as heat generation, acidity or alkalinity may also be considered non-radiological hazards in some circumstances.

You should assess the impact on people and the environment of the non-radiological hazardous properties of the radioactive waste. Additional guidance about how you assess these hazards for groundwater is included in Part 4.

You should demonstrate that the disposal system will provide a level of protection against the non-radiological hazards in radioactive waste that is consistent with that which would be achieved by applying national standards for the disposal of non-radioactive waste.

For some radioactive waste, the non-radiological hazards may be greater or last longer than the radiological hazards. You should take an approach that is proportionate to all of the hazards presented by the waste.

Your ESC should:

- include claims, arguments and evidence that address any non-radiological hazards associated with the radioactive waste

- use methods and approaches appropriate to the nature and magnitude of these hazards and the risks posed

You should set WAC for relevant non-radioactive substances and properties which are consistent with the assumptions made in your ESC (see requirement R11: Waste acceptance).

You should include non-radiological hazards in your decision-making when optimising for radiological risks (see requirement R7: Optimisation).

2.2.16 Requirement 16: Protecting against inadvertent human intrusion into near-surface disposal facilities after the period of RSR

Inadvertent human intrusion could occur after a disposal facility has been released from regulation and could include intrusion into:

- the waste in the disposal facility
- engineered barriers that are part of the disposal facility
- where applicable, any natural geological barriers that are part of the disposal facility

You should assess the range of inadvertent human intrusion scenarios that you have identified in your isolation assessment. Your isolation assessment should have described and justified those scenarios relevant to your disposal system. Your isolation assessment should have taken account of the evolution of the disposal system and how this might change the plausible inadvertent human intrusion scenarios.

The inadvertent human intrusion scenarios that your isolation assessment identified should have been based on present or past examples of human actions that might take place in your disposal facility setting. Your scenarios should also be based on known technology that is or has been used around the world.

You should take account of the inventory that has been or is proposed for disposal in your facility when evaluating your scenarios. For example, you should consider how interesting or

noticeable objects within the waste could influence human behaviours (specifically by attracting people, and hence increasing exposures) after the inadvertent human intrusion occurs.

For your inadvertent human intrusion scenarios you should evaluate the potential radiation exposures for the people who are intruding into the waste and for people who might visit, occupy or live close to the site afterwards. You should assess the potential effective doses that would be incurred by an intruder and a person or persons representative of the more highly exposed individuals in the local population that might be affected by contamination following and inadvertent human intrusion event. You should compare your results with the dose guidance range (see standard 4).

You should use the results from the above assessments to develop or update your WAC (see requirement R11: Waste acceptance criteria) as necessary. You may need to set WAC for specific constituents of the waste that could have a high activity concentration in order to restrict the doses that could be received through scenarios involving direct intrusion into the waste or bringing waste to the surface.

In addition to your evaluation of the impacts on intruders on the local population at or shortly after the intrusion event, you should assess how such intrusion events could impact the long term performance of your disposal facility and protection of the public and the environment more widely. You should treat these assessments as variants of the expected evolution of your disposal facility and compare your results with the risk guidance level (see standard 3).

As well as comparing the results of your assessment to the numerical standards and setting WAC as described above, you should identify measures to reduce the probability and consequences of inadvertent human intrusion when optimising the design of your disposal facility (see requirement R7: Optimisation). Where reasonably practicable, you should implement any measures that you identify, unless the measures could themselves compromise the safety of the disposal system.

To further reduce the probability of inadvertent human intrusion, you should ensure arrangements are in place for the long-term safe-keeping and management of records about the

disposal facility (see requirement R12: Preserving knowledge, information, data and records). You should also consider if it would be appropriate to make use of warning signs or markers, recognising that markers may be of limited effectiveness and also have undesirable effects.

This requirement does not require you to assess the risks from non-radiological hazards of the radioactive waste for your inadvertent human intrusion scenarios but you must address requirement R15: Protecting against non-radiological hazards.

You do not need to consider planned intrusion scenarios. This is because we take the view that a society that preserves full knowledge of the disposal facility is capable of exercising proper control over any planned intrusions into the disposal system.

In the region beyond your disposal facility, human actions such as drilling drinking water wells are not considered to be inadvertent human intrusion. Where appropriate, you should undertake assessments of such scenarios and compare your results with the risk guidance level (see standard 3).

2.2.17 Requirement 17: Protecting against natural disruptive processes acting on near-surface disposal facilities after the period of RSR

All near-surface disposal facilities will be subject to events and processes that degrade the natural and engineered barriers that isolate and contain the radioactive waste. These processes include continuous processes, such as weathering (including biological processes), and riverine and coastal erosion, as well as discrete events, such as flooding or seismicity.

The expected evolution of your disposal facility that you documented in your isolation assessment should have set out how you expect events and processes to affect your disposal facility over its lifetime. This assessment should also include assumptions on climate change based on discussions with the relevant regulators.

Natural processes that affect your near-surface disposal facility will eventually lead to its disruption, recognising that this may take a very long time for more isolated near-surface disposal facilities. Your ESC needs to make the case that your disposal facility will be isolated

for long enough given the inventory that is to be disposed. We characterise the disruption of a near-surface disposal facility in 2 main ways:

- the uncovering of the radioactive waste at the ground surface as part of the expected evolution of the disposal facility
- damage to the barriers of your disposal facility beneath the ground surface such that they no longer perform as assumed in your expected evolution

The results of your assessment should be used to demonstrate consistency with the relevant dose and risk guidance levels and inform the optimisation of your disposal facility (see requirement R7: Optimisation). Where applicable and reasonably practicable, you should implement measures that could enhance the robustness of your disposal facility.

When evaluating and presenting potential exposures for the period after your disposal facility has been disrupted, any quantitative assessment should be supported by appropriate qualitative arguments that together make a reasoned case that potential exposures have been optimised. For long-term environmental safety assessments, reliance on qualitative evidence will increase as the assessment timescale increases. Where the assessment timescales are very long, you should use multiple arguments (for example, including natural analogues) to build confidence in your ESC.

2.2.17.1 Uncovering of radioactive waste as part of the expected evolution

Your isolation assessment (see requirement R8: Isolation) should have identified the events and processes and expected timeframe when radioactive waste will eventually be uncovered at the surface. Your environmental safety case needs to demonstrate that the periods of containment and isolation are long enough, given the physical form and radioactivity of the radioactive waste inventory, to ensure that the radiological exposures to people that might arise at that time and thereafter will be sufficiently low. You should be able to provide confidence that at and after this time, levels of residual radioactivity should be very low, and the physical form of the waste will

have degraded to be relatively homogeneous and unrecognisable such that it would not be interesting, noticeable or attract attention.

Your isolation assessment should have estimated when your disposal facility might be disrupted and should not have placed any reliance on the ongoing maintenance after the period of RSR, for example, of engineered structures such as sea or flood defences, or drainage systems.

You should use a proportionate approach to assess the potential exposures to ionising radiation at and after the estimated time your disposal facility is disrupted and the waste is uncovered at the surface. For cases where your disposal facility is expected to provide isolation for a very long period compared to how long your radioactive waste inventory remains hazardous, a simple argument supported by appropriate evidence may be sufficient.

To build confidence that waste will be isolated for long enough, you should consider other variant and what-if scenarios, for example:

- variant scenarios, for example, the occurrence of higher-than-expected erosion rates, possible due to uncertainty in climate change
- what if scenarios, for example, low probability extreme events that uncover the waste

When developing your post-disruption exposure scenarios for situations where radioactive waste is uncovered, you should take into account how exposure pathways for the relevant representative persons might be affected by the:

- form and distribution of the waste
- distribution of radioactivity within the waste, including the potential for high activity particles
- potential for interesting or noticeable objects that could affect the behaviour of people in the locality (specifically by attracting people and hence increasing exposures)

You should assess these potential exposures against the risk guidance level and the dose guidance range.

We will consider your assessment results and judge the acceptability of your ESC against the full range of NS-GRA requirements, not just the numerical standards.

2.2.17.2 Disruption of barriers below the surface

Where appropriate, you should assess the effect on potential exposures that might arise due to subsurface natural events that you have not included in the expected evolution of your disposal facility. The nature, magnitude and probability of the subsurface natural events assessed should be consistent with your isolation assessment. You should consider how such events might disrupt the engineered or natural barriers your ESC relies on and evaluate the impact on the performance of your disposal system. These impacts should be addressed as either variants of your expected evolution or as 'what-if' scenarios.

You should justify any scenarios that you consider to be variants of your expected evolution and compare your result from any numerical assessments with the risk guidance level (see standard 3). For scenarios based on highly unlikely events, you should consider these to be 'what-if' scenarios to provide insight into the optimisation (see requirement R7: Optimisation) of your facility design to contain radionuclides (see requirement R9: Containment).

2.2.18 Requirement 18: Criticality risk during and after the period of RSR for near-surface disposal facilities

You should demonstrate that a local accumulation of fissile material, such as to produce a neutron chain reaction, will not occur. You should present arguments and evidence in the criticality assessment within your ESC to support your claim.

In your criticality assessment, you should consider controls implemented at the waste packaging stage and controls on the emplacement of waste in the facility.

You will need to consider the full range of processes that might lead to or have consequences for criticality both before and after the closure of the disposal facility. These should include any processes that might remobilise and concentrate fissile material and/or other material that could

influence neutron multiplication. For example, mobilisation of neutron poisons out of waste containing fissile material might influence neutron multiplication within the system.

Your criticality assessment should be proportionate to the concentration and total inventory of fissile material disposed. For a disposal facility with a low concentration and total inventory of fissile material, a simple analysis may be sufficient to show that a criticality will not occur.

Part 3 – Environmental safety case

3.1 The environmental safety case

3.1.1 Definition and purpose of the ESC

An ESC is a set of claims about the environmental safety of facilities for the disposal of solid radioactive waste. It also includes the arguments and evidence that support those claims.

You should refer to requirement R3: Environmental safety case, in part 2 for a high-level explanation of the role of the ESC in regulating a radioactive waste disposal facility. There is also further information at the end of part 3 about how we use the ESC at different stages of the lifetime of a disposal facility.

The purpose of your ESC is to demonstrate that people and the environment will be adequately protected from the radiological and non-radiological hazards associated with the disposal of radioactive waste during the full lifetime of your disposal facility, including the period after the site is released from radioactive substances regulation.

To achieve this purpose, your ESC should have the following objectives:

- show how you have addressed or will address all the relevant requirements of this guidance
- demonstrate to us that your disposal system will achieve the required standard of environmental safety, given the proposed or accepted radioactive waste inventory
- demonstrate to us that you have considered how exposures to radiation can be kept as low as reasonably achievable, taking into account environmental, social and economic factors, and that you have developed your disposal facility to achieve this (in other words, that exposures to radiation are optimised)
- provide a basis for any controls and limits on the construction, operation and closure of your facility necessary in order to achieve the required standard of environmental safety. Where relevant these controls and limits will be reflected in the environmental permits that we issue to you

- help you manage your disposal facility and make decisions in a way that ensures that the required standard of environmental safety is achieved and maintained and that exposures of members of the public to radiation continue to be optimised

You should use a systematic approach to ESC development. Examples of good practice in safety assessment and safety case development for radioactive waste disposal include but are not limited to IAEA SSG-23; NEA MeSA Initiative; IAEA MODARIA Programme Tecdoc-1904, Safety Report Series No. 126. Your ESC may comprise a collection of documents, datasets and other materials. Together, these should present the claims, arguments and evidence you rely on to show that the required standard of environmental safety is met.

You must have an appropriate management system in place to show that you have designed, constructed, operated and closed (or will design, construct, operate and close) your disposal facility in line with the assumptions you have set out in your ESC.

3.1.2 Responsibility for the ESC

You are responsible for the environmental safety of your facility. Therefore, you are responsible for preparing and updating the ESC for your facility.

You should review and update your ESC throughout the lifetime of the disposal facility, in accordance with your environmental permit and when you think it is necessary for operational reasons (see requirement R3: The environmental safety case). Your reviews should take account of operational experience.

If your understanding of your disposal system changes, you must update all your claims and safety arguments that are affected by the changes. You must also update the other aspects of your ESC that are affected by the changes, for example, changes to your assessment input data may require you to revise your waste acceptance criteria.

Your management system should include a change control process to manage any changes to your ESC. You should consider the most appropriate format for reporting updates to your ESC, taking account of any instruction and guidance we have given you.

We will use your ESC to help us regulate your disposal facility throughout its life. We explain how we will use your ESC later in this part of the guidance.

You are responsible for undertaking proportionate research and development, for example to:

- monitor scientific or technological developments relevant to your ESC
- ensure and demonstrate that your planned technical operations can be practically accomplished to provide the required protection for people and the environment
- investigate and understand the processes on which the environmental safety of the disposal system depends

You are responsible for carrying out all necessary investigations of sites and of materials to assess their suitability and obtain data necessary to support your environmental safety assessment.

3.1.3 Scope of the ESC

Your ESC should address all the relevant requirements in part 2 of this guidance. You should take a proportionate approach to addressing these requirements. The emphasis your ESC places on each requirement may change at different stages in the lifetime of your disposal facility.

Your ESC should cover both the period while your disposal facility is subject to radioactive substances regulation and a sufficient period after your permit is surrendered to capture the potential peak risks.

Your ESC should set out and justify how you expect your disposal system will evolve, taking account of natural processes and climate change; also known as the 'expected evolution'. You should set out and consider variants of the expected evolution to investigate uncertainties in the evolution of your disposal system. Your ESC should also consider appropriate 'what-if' scenarios, for example to demonstrate the robustness of your disposal system.

Your ESC should assess the impacts on people and the environment from both the radiological and non-radiological properties of the radioactive waste and materials in your disposal facility.

If your disposal facility is on a nuclear licensed site, the licensed site will need to meet the requirements of the [GRR](#). Your ESC should then form part of the SWESC that the nuclear licensed site will be required to submit under the GRR. The relationship between your ESC and the SWESC is explained in the GRR.

3.1.4 Relationship with operational health and safety and nuclear safety

Your ESC should focus on protecting members of the public and the environment, not on protecting workers, nor avoiding and mitigating the immediate consequences of accidents during operations.

If your site holds a nuclear site licence, protecting workers and avoiding and mitigating the immediate consequences of accidents during operations are regulated by the ONR. ONR will require you to prepare and maintain a nuclear safety case demonstrating that your arrangements for protecting workers and avoiding and mitigating the immediate consequences of accidents are adequate (see guidance produced by ONR, for example, Technical Assessment Guide on *The purpose, scope, and content of safety case* NS-TAST-GD-051).

If your site does not hold a nuclear site licence, these and other similar obligations are regulated by the HSE and (the non-RSR parts of) SEPA.

Any arguments you make in your ESC must be compatible with your arrangements for and arguments about the protection of workers and the avoidance and mitigation of the immediate consequences of accidents.

For nuclear licensed sites, these aspects of your nuclear safety case may influence the claims and arguments in your ESC, especially when optimising your disposal facility (see requirement R7: Optimisation of radiological protection of the public). In this case, your ESC should explain this influence and demonstrate that a satisfactory level of environmental safety is still achieved. The need to protect workers and avoid and mitigate the immediate consequences

of accidents does not reduce the need to protect the environment, and you must still address all the relevant requirements in this guidance.

Similarly, the claims and arguments in your ESC may influence your arrangements for, and arguments about, the protection of workers and the avoidance and mitigation of the immediate consequences of accidents.

Some accidents could have consequences for the environmental performance and safety of your disposal facility. For example, an accident could damage a barrier that you rely on to contain radionuclides after closure, or it may make it difficult to operate or close the facility as planned. In the event of such an accident occurring your ESC should explain how you will ensure your facility continues to provide satisfactory environmental performance. You should take action to prevent accidents from occurring and also implement appropriate mitigations to limit the impact of accidents on the long-term environmental safety of your disposal facility, for example by protecting relevant structures, systems and components of the facility such that they are not damaged. You should also explain and have procedures ready for how you would remediate any damage.

Although you do not need to assess the immediate radiation doses arising from accidents for compliance with your environmental permit, you should make such assessments and ensure that people are protected as you satisfy the requirements of other regulators. If an accident does occur while you hold your environmental permit, you will need to account for any immediate and long-term environmental effects.

3.1.5 Graded approach to the ESC

You should take a graded approach when developing your ESC. This means that the level of analysis and documentation in your ESC should be proportionate to the magnitude of the radiological and non-radiological hazards and risks associated with the radioactive waste that your disposal system is designed for.

Using the graded approach does not change any of the protection standards or numerical criteria set out in this guidance. We expect all facilities to comply with these standards and criteria.

When determining the level of effort that you should expend on your ESC, you should consider criteria including:

- the hazard and risk posed by the radioactive waste intended for or disposed of in your disposal facility
- how much experience there is (both in the UK and internationally) with the types of practices, procedures and designs used to construct your disposal facility
- the level of knowledge available about the performance of similar facilities or practices, and the uncertainty in this knowledge
- the complexity of your disposal facility and the safety arguments you rely on

3.1.6 Management system description

All of your work in developing your ESC and in siting, constructing, operating, closing, monitoring and otherwise controlling your disposal facility must be conducted in accordance with an appropriate management system that ensures the work is of the highest quality and is undertaken by suitably qualified and experienced personnel. You should:

- have and apply an appropriate management system that addresses requirement R2: Management system and environmental safety culture, for controlling work
- describe your management system in your ESC
- specify how your programme for developing, reviewing, updating and using your ESC is managed, who is responsible for different aspects of the ESC how the ESC is checked, reviewed, updated, approved and used
- describe your approach to specifying and managing the work required to develop your ESC, including where work is conducted partly or wholly by the supply chain
- describe the actions you will take to update your ESC in response to new information

- describe how you will provide and allocate financial and human resources to the ESC and to the safe management of radioactive waste and provide confidence that it will be possible to implement the controls assumed in your ESC
- explain your approach to ensuring that those managing and developing the safety case and the radioactive waste are suitably qualified and experienced and receive appropriate training

Your management system should ensure that you keep appropriate records of your work on the ESC and on the management of radioactive waste. The records of your work should be traceable and auditable. Your ESC should explain the approach that has been adopted to ensure the environmental safety of the facility. It is important that you record the reasons why decisions were made, and that this information will be available and easily traceable for both present and future generations.

In addition to being subject to internal reviews and audits, your ESC should be subject to independent peer review by suitably qualified and experienced experts. The nature of the reviews will depend on regulatory requirements and be proportionate to the hazards and risks posed by the waste and the facility in question. Peer reviews and your responses to any issues raised should be documented as part of your ESC.

Your management system should explain how your ESC is implemented. In other words, how you ensure that management of the radioactive waste and of your site is consistent with your ESC and how the various controls and limits that are necessary are documented and enforced.

You should:

- describe your arrangements for managing and retaining data and records
- specify how data and records are stored, and which data and records need to be retained
 - the data and records should be stored in a manner appropriate for the time period over which they need to be retained
- ensure your arrangements address requirement R12: Preserving and accessing knowledge, information, and data

You should consider what information and equipment is required to be able to understand and interpret stored data and records.

3.2 Presentation of your ESC

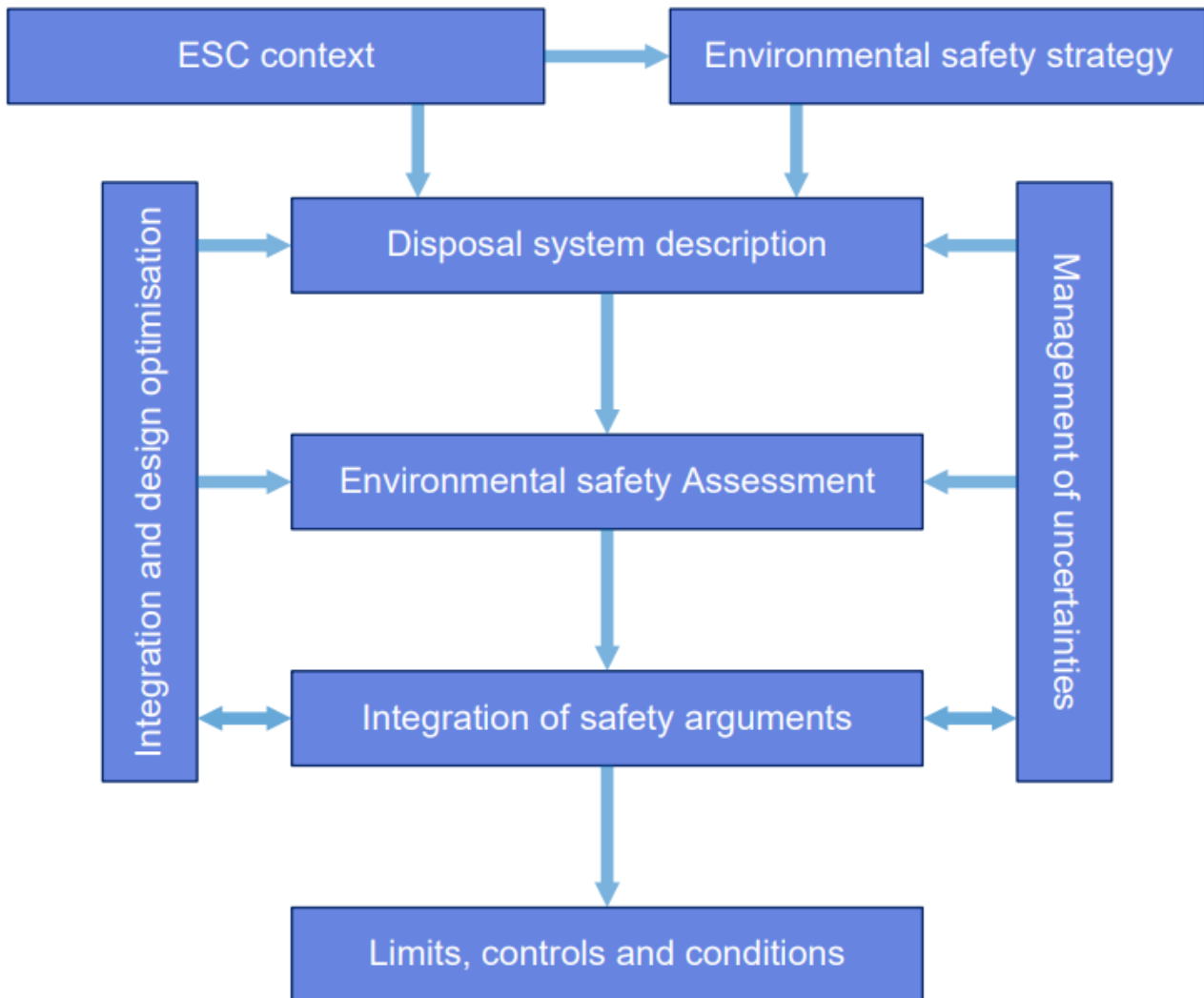
3.2.1 Overview and content of your ESC

You should present your ESC using a structure that allows you to set out your claims, arguments and evidence clearly. It should be clear how you have addressed the relevant requirements of this guidance.

Depending on the complexity and level of detail, your ESC may comprise a hierarchy of documents. These must be effectively cross referenced, such that your claims, arguments and evidence can be easily followed. If you use a document hierarchy, you should include an overview report that summarises the main arguments and evidence and provides an overview of the hierarchy that you have used.

Your ESC content should cover all the components discussed in this guidance; how you choose to structure this content is up to you. However, the relationships between the components of your ESC are important and these are illustrated in Figure 3.1 (adapted from Figure 2 of IAEA SSG-23).

Figure 3.1 – Environmental safety case components showing the relationship between them [adapted from IAEA SSG-23].



The following subsections discuss each of the components that make up your ESC. We describe what we expect the content of these components to comprise and, where applicable, how you should use quantitative and qualitative assessment criteria.

3.2.2 ESC context

You should clearly describe the context of your ESC or your revisions to your ESC. You should explain why you have produced or revised your ESC, for example, for a permit application, to vary or surrender a permit, or as a periodic update. You should include an explanation of how you have applied the graded approach as part of the context of your ESC or revision to your ESC.

The ESC context should, as appropriate, summarise and reflect relevant aspects of the following:

- the legal framework
- the policy and strategy
- international commitments
- international safety standards and guidance
- the environmental permitting process and the stage at which your disposal facility has reached

You should discuss the context for your ESC with us at an early stage before submitting the ESC itself so that there is a common understanding of the objectives and scope of the ESC and what is required and expected. You will need to show that you have identified the legislative and policy contexts and understand their implications for your ESC. You should develop the ESC at a level of detail appropriate to the risk and the stage of disposal facility development.

3.2.3 Environmental safety strategy

Your ESC should include an environmental safety strategy that provides further details on how your disposal system provides the necessary isolation and containment of radioactive waste in accordance with the preference in UK Policy 2024 and IAEA requirements for 'concentrate and contain'. This should summarise your approach to ensuring and demonstrating environmental safety.

The goal of your environmental safety strategy is to set out the high-level approaches you propose to take to satisfying the requirements set out in this guidance and ensuring environmental safety. Your environmental safety strategy by itself does not need to demonstrate that your disposal facility satisfies the requirements; that is done by the whole of your ESC and the control of your operations according to your management system.

In your environmental safety strategy, you should provide a summary of:

- your disposal facility siting and design explaining at a high level your disposal concept
- how your disposal facility provides isolation and containment of the radioactive waste
- the components of your multi-barrier system and any other engineered or natural components of your disposal system with important environmental safety functions
- how your facility design provides defence in depth, robustness and passive safety
- your strategy for demonstrating that your disposal system will provide the environmental safety functions claimed
- the most important arguments and lines of reasoning that your ESC uses to demonstrate environmental safety
- the timeframes for your safety assessments and how uncertainties that are relevant to environmental safety are addressed
- how your management arrangements ensure your disposal facility is operated in line with your ESC and the main management controls that contribute to environmental safety

Although your environmental safety strategy should explain how the location of your disposal facility contributes to environmental safety, it does not need to explain your site selection process.

You should begin to identify your environmental safety strategy at an early stage during the planning of your facility and continue to develop it as your plans advance.

3.2.4 Disposal system description

In your ESC, you should provide an appropriately detailed description of your disposal system which provides the basis for understanding disposal system performance and for your safety assessments (see later section of this part of the guidance). You should describe:

- the characteristics of your site
- the inventory of waste that you either intend to dispose of and or have disposed of
- the characteristics of the waste, including:
 - the radionuclide inventory
 - the waste form
 - heterogeneity
 - any non-radioactive hazardous properties
- the design of your disposal facility, including your multi-barrier system
- areas of the disposal facility that you either plan to construct and or that you have constructed
- how you either plan to operate your disposal facility and or how you have operated it
- how you either plan to close your disposal facility or how you have closed it
- how your disposal system may evolve with time, including the effects of climate change

When describing your disposal system, you should highlight aspects of the system that have significant effects on environmental safety. You should also identify and discuss uncertainties in your knowledge, the possible consequences of these uncertainties and how you manage the uncertainties.

Aspects of your disposal system that you should consider when describing the characteristics of your site include:

- geology
- hydrogeology
- hydrology

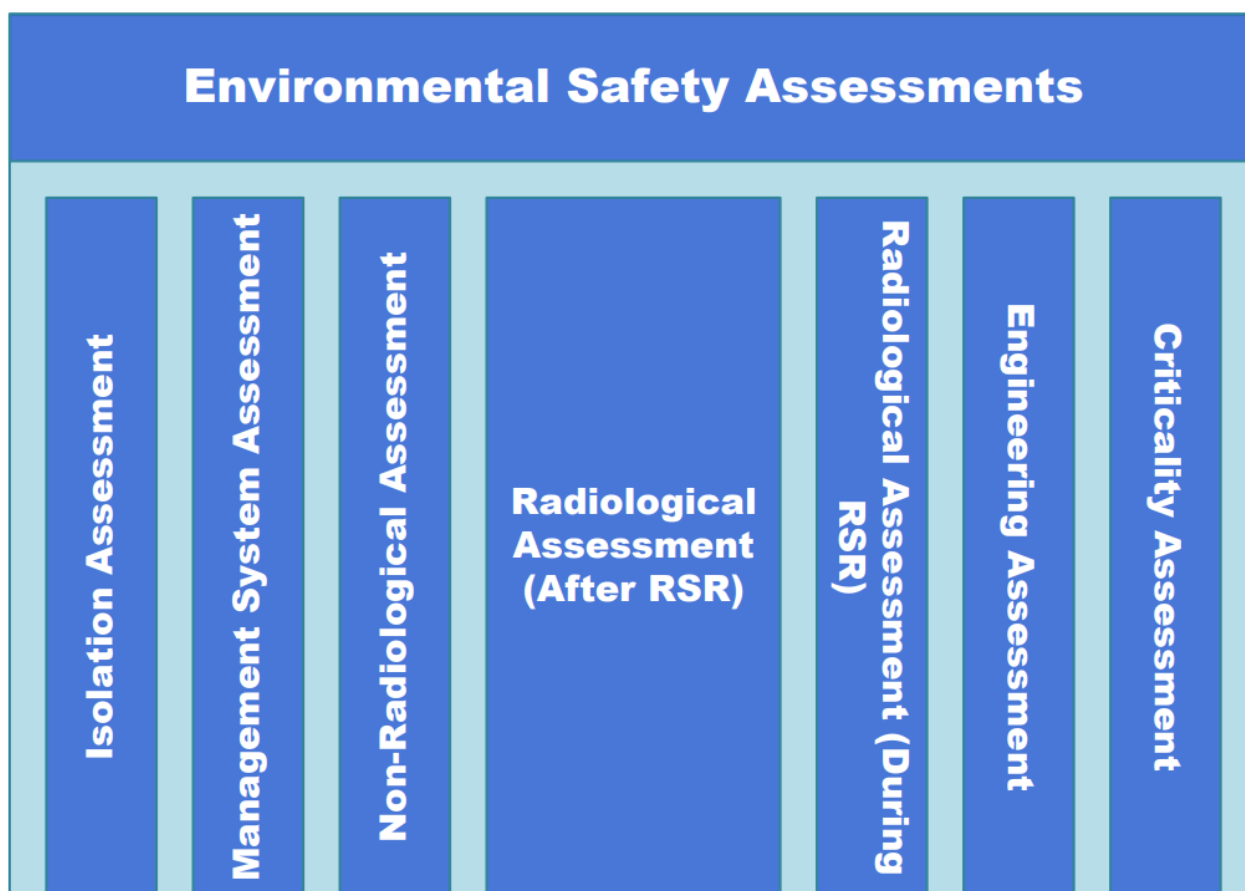
- geochemistry
- natural resources, for example, oil and gas and mineral deposits
- the characteristics of the surface environment at and near to the site, including but not limited to topography, land uses, fauna and flora, the presence and habits of human populations

You should keep your disposal system description updated as new information becomes available. Use your knowledge of your disposal system and the uncertainties in your knowledge to guide your future research, data collection and environmental safety assessment activities.

3.2.5 Environmental safety assessment

3.2.5.1 Introduction

The term ‘environmental safety assessments’ is used here to refer to all assessments that you may need to perform, including, but not limited to, those shown in Figure 3.2 (adapted from Figure 4 of IAEA SSG-23). Your environmental safety assessments should address all aspects of your disposal system that could be significant to radiological protection of people, protection of the environment and protection of groundwater.

Figure 3.2 – The seven key environmental safety assessments.

In your environmental safety assessments, you should:

- consider both the radiological and non-radiological impacts of your facility and consider impacts on people and the environment
- evaluate the environmental safety of your disposal system, including protection of groundwater
- present the results of your assessments to allow us to consider the environmental safety of your disposal facility against the appropriate regulatory criteria as set out in part 2 of this guidance

Your assessments should include evidence that you have an adequate understanding of the behaviour of your disposal system both now and in the future. The results of your assessments should show how your disposal system meets the required standards of environmental safety.

The sub-sections below describe certain aspects relevant to all of the environmental safety assessments, and then focus on each assessment included in figure 3.2 in turn. The sub-sections included are:

- representative persons
- scenario development
- the environmental safety assessments as a whole
- radiological environmental safety assessment for the period of RSR
- radiological environmental safety assessment for after the period of RSR
- non-radiological environmental safety assessment
- criticality assessment for the operational phases and after the period of RSR
- engineering assessment
- isolation assessment
- management system assessment

3.2.5.2 Representative persons

You will need to define one or more persons to be used for determining compliance with the dose constraint. These are the representative persons. These individuals, who will almost always be hypothetical, receive a dose that is representative of the more highly exposed individuals in the population.

The radiological impact on the public should be estimated using the individual effective dose to the representative persons, which is the sum of the committed effective dose from intakes of radionuclides (i.e. from internal exposure by ingestion and inhalation) and the effective dose from external exposure. Doses from internal exposure are calculated using dose coefficients

from intakes of radionuclides by ingestion and inhalation, which provide the committed effective dose per unit activity of intake, expressed in units of sieverts per becquerel (Sv/Bq).

In considering dose to the representative persons, you should take a number of factors into account:

- the dose assessment must account for all relevant pathways of exposure
- the dose assessment must consider spatial distribution of radionuclides to ensure that the groups receiving the highest dose is included in the assessment
- habit data should be based on the groups or populations exposed and must be reasonable, sustainable, and homogeneous
- dose coefficients have to be applied according to specific age categories

When selecting characteristics of the representative persons, you should address three important concepts: reasonableness, sustainability, and homogeneity. You should define the representative persons such that the probability is less than about 5% that a person drawn at random from the populations will receive a greater dose.

Your prospective dose (and risk) assessments should be carried out in a manner that provides confidence that they are appropriate, covering all reasonably foreseeable situations and exposure routes using realistic information on habits and land use.

Where the hazard presented by the waste warrants a detailed assessment, you should provide a probability distribution of dose from each risk assessment that you undertake. This probability distribution should cover the range of potential doses that the representative persons could receive and the probability that they receive any given dose.

You should consider three age categories in your scenarios when estimating annual dose to the representative persons for prospective assessments. These categories are 0–5 years (infant), 6–15 years (child), and 16–70 years (adult). For practical implementation of this recommendation, you may use dose coefficients and habit data for a 1-year-old infant, a 10-year-old child, and an adult to represent the three age categories.

You will need to show that your choice of potentially exposed groups is reasonable and suited to the particular circumstances. The location and characteristics of the potentially exposed people considered should be based on assessments of releases or potential releases of radioactivity and on assumptions about changing environmental conditions.

Your assumptions about the habits and behaviour assumed of potentially exposed people should be based on present and past habits and behaviour that have been observed or that are judged relevant. You should not exclude from consideration any pattern of behaviour which a reasonable person might adopt, whether or not anyone actually engages in such behaviour at a given time. You should not assume behaviour which a reasonable person would regard as extreme and which habit surveys have not revealed.

Metabolic characteristics similar to those of present-day populations should be assumed. Other parameters used to characterise the representative persons should be generic enough to give confidence that the assessment of risk will apply to a range of possible future populations.

If specific habit data for the exposed populations are not available, you may derive values from appropriate national or regional population data. A distribution of these data may be used in probabilistic assessments, or a value on the distribution may be selected for deterministic calculations.

Using the 95th percentile of behaviour in deterministic calculations is a cautious assumption for defining an intake rate. Care should be exercised to avoid selecting extreme percentile values for every variable to prevent excessive conservatism in the assessment. The overall selection of parameter values should provide a reasonable and sustainable representation of the exposures.

Any one representative person may be exposed to all the discharges of radioactive waste and emissions of radiation from the site in combination. The habits data should therefore address all potential combinations of habits that may lead to exposure from each element of discharge and emissions separately and in combination.

You should agree with us how to include uncertainties in the estimation of dose for compliance purposes. To demonstrate adequate radiological protection your ESC should show both compliance with the relevant quantitative standards and optimisation of radiological protection.

3.2.5.3 Scenario development

Your environmental safety assessments need to address the performance of your disposal system for both present and future conditions. When considering future conditions, you will need to consider many different factors that could affect the performance of your disposal facility, including, but not limited to:

- future human actions
- climate and other environmental changes
- events and processes

You can address these considerations through the formulation and analysis of a set of scenarios. Your scenario development is a significant part of the development of your quantitative safety assessments.

Scenarios are descriptions of alternative possible evolutions of your disposal system. The development of your scenarios forms the basis of your environmental safety assessments that make up an important part of your environmental safety case.

The scenarios that you develop may represent or bound a range of similar possible evolutions of your disposal system. Your choice and the rationale for your choice of an appropriate range of scenarios and your associated environmental safety assessment cases are important, as they will strongly influence your assessment of the performance of your disposal system.

Scenarios represent structured combinations of features, events and processes relevant to the performance of your disposal system. You will need to consider different types of scenarios that should include your expected evolution scenario, variants of your expected evolution scenario

(which will include disturbing events and processes) and “what-if” scenarios to explore more extreme, or even unrealistic, events and processes.

The “what-if” scenarios you include in your environmental safety assessments are useful to explore particular properties of your disposal system, for example one or more of the natural or engineered barriers. The aim of your what-if scenarios that assume extreme conditions, is to examine the robustness of different aspects of your disposal system.

When constructing your scenarios you should use robust and systematic methodologies, such as methods based on:

- screening of features, events and processes (FEPs)
- analysis of the safety functions that your structures, systems and components are intended to fulfil

Regardless of the method you use for developing your scenarios, all features, events and processes that could significantly influence the performance of the disposal system should be addressed in your assessments. Using such a structured methodology should allow you to demonstrate that all potentially significant migration pathways for the migration of radionuclides have been considered as well as taking account of the possible evolutions of your disposal system.

Your scenario development should be clearly documented, setting out your claims, arguments and evidence. It is important to clearly identify your expected evolution, variant and what-if scenarios and the rationale for how these are to be used in your environmental safety assessments.

The design of your disposal system will determine the time frames your environmental safety assessments need to consider. Regardless of these timeframes, you will need to consider who might be affected in the future (representative persons). You should assume that humans will be present in your scenarios and that they will make use of local resources. As it is not possible to predict future human behaviour with any certainty, you should assume that humans in the future

will have similar habits to present humans, or habits that have been observed in the past. Where your consideration of climate change means conditions at your site will be different in the future, the habits of humans at this time should be consistent with the expected climatic conditions.

When developing your scenarios you should clearly document all of the events and processes that you have included and where necessary the probabilities of their occurrence. Your environmental safety assessments will need to take this information into account when evaluating doses and risks to your identified representative persons.

3.2.5.4 The environmental safety assessments as a whole

Your environmental safety assessments should have both quantitative and qualitative components. You should use quantitative assessments where you understand enough about a particular aspect of your disposal system and where you are able to quantify uncertainties. If you don't understand enough or if a detailed quantitative assessment would be disproportionate or inappropriate, you may place a greater emphasis on qualitative arguments.

Your environmental safety assessments should be consistent with your ESC context, environmental safety strategy and disposal system description. This does not mean that every assessment you do has to represent every detail of your disposal system. Your assessments will inevitably include simplified representations of some parts or all of your disposal system. You should identify and justify the levels of simplifications in your assessments.

You should aim to represent the disposal system in a realistic way, but where this is not possible or would be disproportionate, you should err on the side of caution (i.e. your mathematical models should be realistic or over-estimate the possible impacts on people and the environment). It may be appropriate for individual assessments to be more cautious or to focus on a particular aspect of the disposal system.

As appropriate, you should consider the concentrations of radionuclides that might build up in environmental media and the harm to humans that could result.

Your environmental safety assessments should extend in time at least until the time of peak impact (for example, dose and risk). You should justify the length of time assessed in your assessments and demonstrate why impacts will not increase further after the period you have considered.

Where your assessment considers a particular event (such as a natural disruptive event), you should justify the assumed timing of the event.

For inadvertent human intrusion events you should present assessment results from the point in time immediately following the end of RSR. You may also need to present results at a range of points in time to capture the maximum assessed doses to take account of both radioactive decay and in-growth.

3.2.5.5 Radiological environmental safety assessment for the period of RSR

You should assess the environmental impacts that will or could occur while the permit is in place. This includes the period over which your disposal facility is operational, during closure and during any post-closure period of control for the purposes of radiological protection.

Your assessments should be informed by the results of monitoring at and around your site. You should assess the radiological impacts to members of the public from all of the releases from your disposal facility during the period of RSR. These could include:

- permitted discharges, for example of leachate to surface or marine waters
- releases to the environment across the barriers of the disposal facility, for example older areas of an existing facility that were not designed to modern standards
- external irradiation from radioactive waste both before and after emplacement

You should use monitoring data and your assessments to understand the distribution of any radionuclides released from your facility during the period of RSR, for example to groundwater. You should use this knowledge in your assessments of the environmental safety of the disposal system in the period after RSR (see below)

Your assessments should demonstrate that during the period of RSR doses arising from your site, combined with those from any sites close by, if applicable, during the period of RSR do not and will not exceed the dose constraints for members of the public set out in standard 2.

You should also carry out assessments of the radiological impacts on wildlife so that we can consider how your results relate to the dose rate criteria set out in requirement R13: Protecting wildlife.

You do not need to present assessments of the immediate impacts of potential accidents in your ESC. However, in the event of an accident where it could affect the long-term environmental performance of your disposal system, you will need to factor the consequences into any future assessments.

3.2.5.6 Radiological environmental safety assessment for after the period of RSR

You should assess the radiological impacts that could occur in the future, including the far future, after you surrender your permit. These are referred to as 'planned potential exposures' by the ICRP. You should consider potential impacts to people and the environment, including groundwater.

The timeframes for your assessments will depend on how the disposal facility and the surrounding environment may evolve over time. The timeframes you choose may also need to reflect:

- the scenarios you are considering for inadvertent human intrusion
- whether natural processes could uncover the radioactive waste in your disposal facility and how long this might take

For the purpose of your assessments, you must assume that there will be no control over, nor restriction on the use of your site after the period of RSR (see requirement R3: The environmental safety case).

You should identify the pathways by which members of the public could be exposed to radiation from the expected evolution of your disposal facility and assess them against the risk guidance level (see standard 3).

As appropriate, you should consider the concentrations of radionuclides that might build up in environmental media and the harm to humans that could result. We will consider your assessment results and judge the acceptability of any releases of radionuclides from your disposal facility.

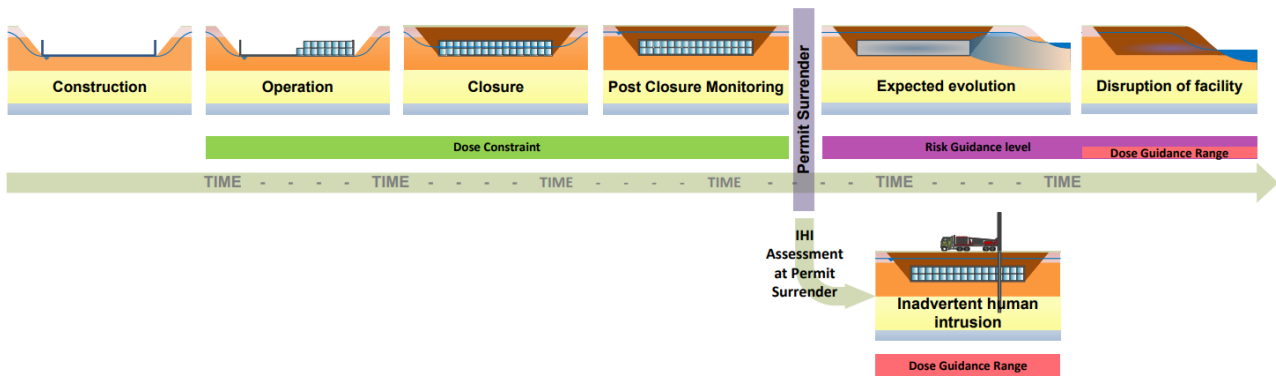
You should assess the consequences of inadvertent human intrusion into the disposal facility (see requirement R16: Protecting against inadvertent human intrusion into near-surface disposal facilities after the period of RSR) and of natural disruptive processes uncovering the radioactive waste (see requirement R17: Protecting against natural disruptive processes acting on near-surface disposal facilities after the period of RSR).

You should assess the consequences of inadvertent human intrusion and of sub-surface natural disruptive processes affecting the disposal system barriers. This should include considering how the timings of such events affect your results. Your assessment should consider how the consequential degradation of the barriers affects the long-term performance and environmental safety of the disposal system including the time and the magnitude of peak risk (see requirements R16 and R17).

You should compare your assessment results with the risk guidance level (see standard 3) and the dose guidance range (see standard 4). Figure 3.3 illustrates the lifetime of a site and the relevant standards that apply.

Figure 3.3 – Lifetime of a radioactive waste disposal site showing a stylised facility through the different stages of its life; including construction, operation, closure, permit surrender and longer-term site evolution, potentially involving disruption of the facility. For each stage the applicable radiological protection standards are indicated.

Near-surface disposal facilities for solid radioactive waste: Guidance on Requirements for Authorisation (NS-GRA) Nov 2024



You should evaluate the impact on the environment, including wildlife, for the period after RSR. Assessing impacts on wildlife for the period after RSR may also involve presenting qualitative arguments rather than a quantitative evaluation (see requirement R13).

3.2.5.7 Non-radiological environmental safety assessment

You should assess the non-radiological impacts that could occur until the time when your disposal facility will no longer pose an environmental hazard.

You should refer to our guidance for conventional [landfills](#) for further information. However, as explained in the following paragraphs, for your RSR permit you do not need to comply directly with the guidance for conventional waste landfills. Instead, you should meet the standards set out in this document.

In all cases you should demonstrate that the:

- disposal system provides adequate protection of people and the environment against non-radiological hazards associated with the radioactive waste
- level of protection against non-radiological hazards is consistent with that achieved by national standards for non-radioactive waste, in accordance with requirement R15: Protecting against non-radiological hazards

In your assessment you should consider any substances that have the potential to be harmful to people or the environment. Your list of substances should include any substances that would be

regulated for a non-radioactive waste disposal facility. For example, asbestos, lead, mercury and all chemicals on the relevant published list. We have published a “[List of Hazardous Substances as determined in accordance with Schedule 2 of the Water Environment \(Controlled Activities\) \(Scotland\) Regulations \(CAR\)](#)”. This list is based on recommendations from the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) in [JAGDAG Hazardous Substances/ Non-Hazardous Pollutants Consultation June 2018](#).

As part of your assessment, you should consider both the potentially harmful substances present in the radioactive waste and substances that might result from the degradation or reaction of precursors present in the radioactive waste. To identify substances present, you should draw on inventory records and investigations, and on relevant monitoring data.

There may be substances present in the radioactive waste that are not directly harmful to the environment or to human health, but which affect disposal system performance. For example, some substances may react or form complexes with certain radioactive or non-radiological substances and enhance their transport. You should consider these substances in your ESC. Where appropriate, you should account for these substances and their possible effects in your assessments.

As appropriate, you should consider the concentrations of non-radiological hazardous substances that might build up in environmental media and the harm to humans that could result. We will consider your assessment results and judge the acceptability of any releases of non-radiological hazardous substances from the disposal facility.

As far as is appropriate, you should use assumptions and mathematical models for non-radiological substances that are consistent with those you use to assess the potential impacts of radioactive substances.

In your assessment, you should consider the pathways that may result in impacts to humans and the environment during the evolution of your facility (for example, releases to groundwater and gas release). You should also consider the variant scenarios developed in your assessments for radioactive substances.

You do not need to assess the impact of non-radiological hazards in radioactive waste brought to the surface by inadvertent human intrusion.

Protecting groundwater should also be a focus of your assessment. You should refer to part 4 for further guidance on what you need to do to demonstrate that groundwater is protected.

- In your ESC, you do not need to consider wider non-radiological environmental impacts associated with your disposal facility, for example, noise and traffic (because these would be considered in an Environmental Impact Assessment, and where relevant under other permits).

3.2.5.8 Criticality assessment

As part of your ESC, you will need to consider the possibility of a local accumulation of fissile material that could cause a neutron chain reaction (see requirement R18: Criticality risk during and after the period of RSR for near-surface disposal facilities). Your assessment should consider controls implemented at the waste packaging stage (for example, limits on the quantity of fissile material in an individual waste item, waste container or waste package) and/or controls exercised during the emplacement of waste in the facility (for example, physical separation of packages with a high loading of fissile material). Any controls that you require for packaging radioactive waste will need to be reflected in your waste acceptance criteria and compliance arrangements (see requirement R11: Waste acceptance). We may specify permit conditions relating to waste emplacement as appropriate.

You will need to consider the full range of processes that might lead to or have consequences for criticality both before and after the closure of your disposal facility. These should include any processes that might remobilise and concentrate fissile material and/or other material that could influence a neutron chain reaction such as neutron multiplication. For example, mobilisation of neutron poisons out of waste containing fissile material might influence neutron multiplication within the system.

The detail of the assessment should be proportionate to the amount and concentration of fissile material disposed.

3.2.5.9 Engineering assessment

You should provide an assessment that sets out the arguments and evidence to support the claims and assumptions that you make in your ESC regarding the construction, quality and performance of engineered structures, systems and components. You should demonstrate that you have applied good scientific and engineering practice. Your engineering assessment should be developed in accordance with your management system (see requirement R2: Management system and environmental safety culture) and should address the relevant aspects of requirements R4, R6, R7, R8, R9 and R10. The outputs from this engineering assessment should be used appropriately to support your other assessments and your environmental safety case.

Your engineering assessment should:

- be consistent with the other assessments in your environmental safety case- in particular, the timeframes that you consider for your assessment of engineering and properties of your disposal system should be informed by your isolation assessment and your environmental safety assessments
- be consistent with your current plans for the construction, operation and closure of the disposal facility
- include a justification of any claims and assumptions you make about the constructability of the engineered components of your disposal system and how well they will perform and how long they will perform for
- describe and take account of the evolution of the properties of the engineered barriers over an appropriate period and the uncertainties in these properties to support your environmental safety case

You should inform your engineering assessment using operating experience, wider practical engineering experience and observation, as well as relevant research, modelling and other (for example, analogue) studies into the long-term behaviour of materials. For example, studies on the evolution of concrete over time, modelling and or experimental data on the performance of waste forms such as ceramics, metals and glasses. You should show that you have considered the relevant features of the disposal system and the events and processes that could affect their performance. The processes you may need to consider include, but are not limited to:

- physical (for example, thermal, hydrological, mechanical, radiological)
- chemical (for example, corrosion, dissolution)
- biological (for example, microbial)

You should consider the uncertainties associated with the properties, behaviour and performance of the engineered barriers and other components of the disposal system at an appropriate level of detail.

Your engineering assessment should be proportionate. For a small inventory of relatively low hazard and/or risk, a simple analysis may be appropriate. However, for disposal facilities for larger inventories and higher hazards and or risks, we expect a detailed engineering assessment, including a thorough assessment of uncertainties.

You should carry out proportionate research and development to support your ESC, which should include appropriate studies and data collection to enhance knowledge of the properties and performance of your engineered barriers, structures and components. You should use this knowledge and data to update your engineering assessment, your understanding of the disposal system and your environmental safety case.

3.2.5.10 Isolation assessment

You should present an isolation assessment for your disposal system to address requirement R8: Isolation. Your isolation assessment should form the basis for the scenarios that you develop describing the evolution of your disposal facility, inadvertent human intrusion and

natural disruptive processes in your environmental safety assessments. When developing your isolation assessment, you should take account of the guidance provided on inadvertent human intrusion and natural disruptive processes.

Your isolation assessment is an integral part of your environmental safety case and your claims, arguments and evidence that your disposal facility will provide sufficient isolation for the length of time that the disposed radioactive waste inventory could cause exposures or risks to people (if they were to come into contact with the waste) greater than the standards set out in this guidance. Your isolation assessment should capture all the relevant information when considering how your disposal system will evolve and the types of human actions that might lead to inadvertent human intrusion into your disposal facility.

As set out in the isolation requirement, your isolation assessment should include, but not be limited to, a description of all the natural processes affecting your disposal system, how you expect it to evolve and the scenarios that could lead to inadvertent human intrusion.

When considering inadvertent human intrusion scenarios, your isolation assessment should identify the range of human activities that could lead to direct exposures to the disposed radioactive waste and/or disrupt the barriers of your disposal facility. These might include, but are not limited to, construction, borehole drilling, agriculture, scavenging for materials, archaeological or other excavations and mining. The relevant activities will be different for different locations and types of disposal facility. For example, agriculture activities on the cap of some near-surface disposal facilities may disturb them but might not disturb a deeper facility.

When considering inadvertent human intrusion events, you should consider the degree of physical isolation that your disposal facility design provides.

For near-surface disposal facilities you should assume that activities leading to inadvertent human intrusion into the radioactive waste will occur and you should assess the consequences accordingly (see requirement R16: Protecting against inadvertent human intrusion into near-surface disposal facilities after the period of RSR). You do not need to evaluate all possible

inadvertent human intrusion scenarios where you can show that a sub-set of scenarios provide suitable bounding cases.

3.2.5.11 Management system assessment

Your management system assessment should:

- include evidence to show that your management arrangements and data retention arrangements address requirements R2: Management system and environmental safety culture and R12: Preserving and accessing knowledge, information, and data
- provide the required assurance that your management arrangements will provide the required quality for all safety related activities - this includes all of the other assessments within your environmental safety case, as well as the quality of the work to construct, operate, close and monitor your disposal facility
- support and provide confidence in the claims, arguments and evidence you use to make your ESC
- include evidence of the use of reviews and internal audits of processes and procedures for the control and quality assurance of the development and use of your ESC and of your disposal facility (see IAEA GSG-16 for guidance on assessing and improving management systems)

3.2.6 Iteration and design optimisation

You should follow an iterative approach to the design of your disposal system and the development of your ESC. Your ESC needs to show how and why you have reached the environmental safety decisions you have, which environmental safety decisions you are making now and how you are making them. It should also show how you will ensure that appropriate environmental safety decisions are made in a systematic way in the future.

You must show how such decisions remain consistent with past decisions or have to deviate from them in light of new evidence or analysis. Your design decisions should be guided by the

requirement to optimise for radiological protection of the public, in particular with respect to the long-term environmental safety.

Requirement R7: Optimisation of radiological protection of the public, sets out what you should consider when optimising your disposal facility design.

Your ESC needs to demonstrate that you have optimised and continue to optimise your disposal facility design such that public exposure to ionising radiation from the disposal of radioactive waste is kept as low as reasonably achievable, taking into account environmental, economic and social factors.

You should set out your arguments that the disposal facility design presented in your ESC is optimised. This should include setting out the other options you considered and why you did not choose them.

You may set out optimisation arguments for decisions about individual structures, systems and components of your disposal system. Where you do this, you should explain how you managed the whole environmental safety case development process to ensure that the decisions about one component give the desired outcome for protection and for the disposal system as a whole. We expect you to have followed and documented an iterative process to design optimisation.

When you are developing or updating your ESC you should use your optimisation process to identify areas where further research and development work are required and indicate how you will incorporate the results of this work into your process of optimisation. Your ESC should document this process so that it is included in the ESC that you formally submit for regulatory approval.

You should explain how your optimisation process takes account of new information and how you will use the process when you need to make new decisions.

Optimisation is fundamentally a judgement process, conditioned by decisions that have already been taken. In order to achieve an optimised disposal facility, you will also need to make good

engineering decisions about the technical and management solutions that you adopt and apply your management system to ensure the quality of work that your ESC relies on. You should, as appropriate, follow good practice and consider the use of requirements management systems in developing your disposal system and justifying that it is optimised. You should set out your approach in your ESC.

3.2.7 Management of uncertainty

You should demonstrate that you have identified and where appropriate investigated all the significant uncertainties in your ESC. You should produce and maintain a register of all your significant uncertainties.

A systematic approach to managing uncertainties is an important part of your ESC. When developing your ESC and when updating it you should implement a clear plan and forward programme for managing significant uncertainties.

Your plan should clearly set out objectives, approaches and anticipated timescales for work aimed at managing and resolving uncertainties.

Your consideration of uncertainty should not be limited to numerical uncertainties in input data or results. You should also consider other types of uncertainty. For example, there will be uncertainty in the future evolution of the site and facility, and in your conceptual understanding of some aspects of your disposal system and how it will evolve. There may also be uncertainties relating to the design of your facility and further issues may derive from new information, changed circumstances, regulatory review and peer reviews. You should make sure that you account for such uncertainties in your ESC.

When presenting the results of your assessments, you will need to account for uncertainties explicitly and analyse their possible consequences. This should cover both the period when the site is subject to radioactive substances regulation and the period after the site's environmental permit has been surrendered.

During the development of your ESC, you should use your knowledge of the uncertainties in your ESC to identify future information needs (for example, information you will need to optimise your disposal facility) and guide any research and data collection work (for example, site characterisation).

You should develop, describe and apply an appropriate strategy for undertaking environmental safety assessments that addresses the uncertainties in the performance of your disposal system. Your strategy should be appropriate to the level of hazard and risks associated with your disposal system. Your strategy could include carrying out one or more of the following:

- probabilistic calculations in which input parameters are sampled from probability density functions
- deterministic calculations with fixed values of input parameters for a range of values within a probability density function
- calculations for a cautious or bounding value of a particular parameter
- calculations for different scenarios or cases, for example to address uncertainties in conceptual models or modelling uncertainty or where uncertainties are difficult to quantify

You should develop, describe and apply an appropriate strategy for uncertainty and risk management. You should, as appropriate, undertake activities to reduce uncertainties and risks. Such activities might for example include research, revised modelling, design changes, revised waste acceptance and management practices. You should document the options considered and the reasons for selecting the chosen approach.

If you choose not to take steps to reduce a specific uncertainty, you should explain your reasoning.

Simplifications in environmental safety assessments are unavoidable. As part of the ESC, you need to show that any simplifications adopted either have an insignificant effect on the outcome of the assessment or are cautious.

3.2.8 Integration of safety arguments

Your ESC should synthesise all of your claims, arguments and evidence into a coherent whole. You should show how the structures, systems and components of your disposal system work together to provide environmental safety and meet the relevant requirements set out in this guidance.

Your integration of safety arguments could address various aspects such as the following:

- evidence that your organisation has appropriate leadership, management and culture for safety
- evidence of the development and use of a suitable management system by suitably qualified and experienced staff
- estimates of the impacts from exposure to ionising radiation from your disposal facility for comparison with the relevant quantitative criteria, including an explanation of how uncertainties have been addressed
- an explanation of how non-radiological impacts have been considered in your assessments, including comparison of releases with appropriate quantitative criteria
- evidence of compliance with relevant requirements for groundwater protection
- multiple lines of reasoning including evidence of appropriate facility design, optimisation, robustness, defence in depth
- results from monitoring and evidence of operational experience at relevant (e.g. similar) facilities
- discussion of complementary environmental safety indicators
- an acknowledgement of uncertainties and any limitations in your ESC, a description of the effects they might have, and description of a programme of work aimed at addressing and reducing these uncertainties and limitations as appropriate
- a discussion of any findings or information that are not in line with the claims, arguments and evidence you present in your ESC and of their significance and an explanation of why you still have confidence in your arguments

- how you will ensure that you will operate your disposal facility in accordance with appropriate limits, controls and conditions

3.2.9 Limits, controls and conditions

You should use your ESC to propose limits, controls and conditions to be applied to your disposal facility. Your proposed limits, controls and conditions should be consistent with your environmental safety assessments and take account of other relevant factors and should be documented in your ESC. We will review your ESC and proposed limits, controls and conditions and use the information as a basis for any permit we issue.

The limits, controls and conditions proposed in your ESC should ensure that any assumptions and arguments you rely on remain valid and, therefore, that your facility provides, or will provide, the requisite standard of environmental safety and protection. When you undertake periodic reviews and updates of your ESC you should, if necessary, also propose updated limits, controls and conditions consistent with your updated ESC.

Examples of such limits, controls and conditions may include, but are not limited to:

- maximum inventories of radioactive and non-radioactive constituents of waste to be accepted
- maximum activity concentration limits for radioactive constituents and concentration limits for non-radioactive hazardous substances
- waste packaging specifications, including the types, sizes and properties of waste containers and packages and details of waste conditioning and packaging processes
- requirements for characterisation and monitoring
- waste emplacement requirements
- construction quality assurance standards to be used in controlling construction

You should clearly identify all such proposed limits, controls and conditions along with suitable justifications and statements of how you would ensure that they would be complied with. How

you have calculated or defined each proposed limit, control and condition should be explained clearly and in appropriate detail.

Limits, controls and conditions may be based on the claims, assumptions and results from your environmental assessments, and any other relevant part of the radioactive waste management system (for example, transport safety requirements).

3.3 Guidance about modelling

You should apply the guidance in this section to all relevant mathematical models. This will include mathematical models related to design, optimisation, characterisation and monitoring, and environmental safety assessments.

3.3.1 Using models in the development of your ESC

You should develop and use appropriate conceptual and mathematical models to understand and assess the environmental safety of your disposal system.

The conceptual models you use for your environmental safety assessments should be based on your disposal system description. As far as possible, conceptual and mathematical models should be consistent between different assessments. You should aim as far as possible to make your models realistic so that they represent your best estimate of the behaviour of your disposal system.

You should update your conceptual and mathematical models as your understanding of your disposal system changes.

The complexity and detail in your mathematical models should be proportionate to the hazards and risks presented by the waste you have disposed and propose to dispose of. Your mathematical models should also be appropriate to the complexity of your disposal system and the quality of the available data. You should not produce complex numerical models unless you understand and have enough data about your system to support the models.

It is often helpful to use a combination of deterministic and probabilistic mathematical models to address different types of uncertainty. You should use your models to undertake structured sensitivity and uncertainty analyses.

When presenting and interpreting mathematical model results, especially for the far future, you should recognise that they are not predictions. Rather, they show how your system may behave, given certain input parameters or ranges and assumptions. They are aids to help you (and us) understand your system and how different properties, events or design decisions may affect its behaviour. You should use mathematical model results for the far future to support judgements about environmental safety in conjunction with other lines of reasoning.

You should adopt a systematic approach to developing and using conceptual and mathematical models. You should clearly record and describe:

- the objectives of the modelling
- your considerations of alternative conceptual and mathematical models and your reasons for choosing the models you have
- the input data you used, the source of that data, why you chose that input data and how you have ensured it is in line with other conceptual and mathematical models
- any assumptions, simplifications or omissions you make in your models, which should be justified, including an evaluation of their significance
- the level of confidence you have in your models, and your reasons for this
- the sensitivity and uncertainty analyses that you have done
- the work you have done to improve the confidence you have in your models

You should explain why your conceptual and mathematical models are fit for purpose, how you have built confidence in the results of your models and the work you have done to improve your confidence. This may include:

- describing your management system and approach to quality assurance for your models
- describing the verification and validation steps you have undertaken

- describing your peer-review arrangements and the results of peer reviews of your modelling work
- comparing your mathematical model results to site-specific measurements
- comparing your mathematical model results to the results of other models
- using your models to model analogues of your disposal system (or part of it) and comparing your model results with measurements and observations
- describing the sensitivity and uncertainty analyses you have done
- applying your mathematical models to benchmark (e.g. international comparison project) problems

We encourage you to discuss your modelling objectives and approach with us.

You should regularly review your modelling objectives to see whether they still meet the needs of your ESC. You should review your conceptual and mathematical models and update them as needed to take account of new information or understanding.

To the extent possible, you should verify and validate your mathematical models. The effort you expend on model validation should be proportionate to the importance of the model to demonstrating the environmental safety of your disposal system. You should describe your approach to verification and validation and justify that you have sufficient confidence in your model results for the role they play in your ESC. You should establish that there are no significant errors in your models.

Full validation of a mathematical model is not possible. For example, it may not be practicable to collect the necessary experimental or monitoring data, or you may be modelling processes that will only occur far in the future and cannot be measured.

You should evaluate whether alternative conceptual models would significantly affect your environmental safety assessments and, if this is the case, assess the implications of these alternative conceptual models. The results from your assessments using alternative conceptual models should contribute to your overall understanding of uncertainty.

3.3.2 Deterministic and probabilistic approaches

It is often helpful to use a combination of deterministic and probabilistic mathematical models to address uncertainty. You may combine these approaches, such that a model may be deterministic for some parameters and probabilistic for others.

A deterministic mathematical model is one in which single values are used for all input parameters and a single value calculated for all results.

A probabilistic mathematical model is one in which probability density functions are specified for some or all input parameters. The probability density functions are used to capture uncertainty, for example, in the value that a certain parameter might have. Before the model is run, the probability density functions are sampled to select input parameter values for that model run. The model is run many times and the results for all runs combined to produce probability density functions of results.

For each run of a deterministic model, you will have to choose a specific set of parameters from the range of possible values. When choosing these, you should provide arguments and evidence supporting your choice. Where appropriate, you should complete several runs of the model with different parameter values to understand the range of possible outcomes.

When compiling data to use in probabilistic assessments, you will need to specify probability density functions. You should explain and justify the function, parameters and values chosen for the probability distribution.

When using probabilistic models, you should justify your selection of parameters, take due account of possible correlations between parameters, justify your approach to sampling probability distribution functions, and show that you have run enough simulations.

You should show that the spatial and temporal discretisation of your mathematical models is fit for purpose and such that they do not introduce modelling artefacts (e.g. inappropriate averaging or dilution).

If you undertake probabilistic assessments, you should present the probability density function of effective dose and risk to the representative person in your environmental safety case. When interpreting results from probabilistic models, you should consider whether certain model runs might have involved unrealistic combinations of parameter values.

3.3.3 Choosing model input data

You should aim to use input data that is as realistic as possible. You should give preference to site-specific input data, where possible. Where you use conservative or site-generic input data, you should make this choice clear. Your choice of input parameter values should not lead to underestimation of impacts (e.g. dose or risk).

When doing uncertainty and sensitivity analysis or assessing 'what-if' scenarios, you should choose input data appropriate to the expected variation in the parameter or phenomenon you are investigating.

Your input data should be consistent between mathematical models unless there are good reasons otherwise.

You may ask experts to elicit input data for your mathematical models. If you do this, you should:

- explain the choice of experts and the method of elicitation used
- document their judgements and the reasoning behind them
- identify any biases and seek to eliminate or minimise them

3.3.4 Making comparisons with quantitative standards

You should compare the results from your environmental safety assessments with the standards set out in part 2 of this guidance and the groundwater standards described in part 4. Which you use will depend on:

- the assessment you are doing

- whether the calculations are for scenarios during or after the period of regulation and what exposure situation is being assessed

Parts 1, 2 and 4 of the guidance explain when each should be used.

When comparing calculated doses or risks with the standards in this guidance, you should sum the dose or risk over all pathways to which the representative persons could be exposed. When calculating doses or risks from a number of cases or scenarios, you should consider whether the doses or risks should be aggregated. Such aggregation would be necessary, for example, if the representative persons could receive impacts from more than one exposure pathway.

The mathematical model results you compare with the standards should include those for the time of peak radiological impact.

When comparing the results of your environmental safety assessment calculations with our standards you should also present the assessed impacts as a function of time after waste disposal. You should explain whether your assessment results are for cautious calculations or not.

When comparing results from deterministic assessments with the relevant standards, you should explicitly include the range of uncertainty in the calculated result as determined by a sensitivity analysis (or importance analysis) in the comparison. When comparing results from probabilistic models with the relevant standards, you should present the full range of results obtained and identify and use appropriate statistical measures including the expectation value. You should provide explanations for results that are significant outliers and/or that exceed relevant regulatory criterion. You should demonstrate that there is at least a 95 percent level of statistical confidence that the mean value of risk complies with the relevant standards. Other statistical measures are also important factors in demonstrating the adequacy of the results of your assessment.

When you present calculated risks, you should also present the values of the assessed probability and conditional impacts separately.

If aggregating calculated risks for a number of cases or scenarios, you may assign each scenario or case a probability of occurrence, before summing and comparing them with the risk guidance level. Alternatively, you may compare the result of each case or scenario with the risk guidance level, assuming that the probability of occurrence is one. The approach that you follow must be documented in a fully traceable way.

Your mathematical models may give rise to calculated doses that are high or even above the point at which the effects of radiation are purely stochastic (around 100 mSv). If this occurs, you should investigate and explain whether these model results could be realistic and in what circumstances they might arise. You should present this information as part of your environmental safety case.

The standards apply regardless of whether you have conducted simplified, conservative assessments or more detailed assessments.

3.4 Use of the ESC in regulating disposal facilities

This section provides guidance on how your ESC is used in regulating a disposal facility over its full lifetime, including during the:

- environmental permit application process
- period of regulation
- environmental permit surrender process

You should start discussing the ESC with us before entering the permit application process (see requirement R1: Early engagement).

3.4.1 During the environmental permit application process

3.4.1.1 Obtaining an environmental permit

If you do not yet have an environmental permit but you intend to develop a disposal facility for radioactive waste you should obtain permit pre-application advice (including ESC pre-submission advice), in line with requirement R1: Early engagement, from SEPA at the start of

planning and design of your radioactive waste disposal facility. You should agree an appropriate point with us to apply for an environmental permit. If you wish to seek a change to an existing permit you should also agree when this would be done with us.

You should:

- apply for an environmental permit for your radioactive waste disposal facility using the relevant application form and guidance on our website
- submit your ESC to support your environmental permit application

We will generally consult interested parties (for example, the planning authority, potential host community, other regulators) and other members of the public on new applications for radioactive substances activity permits for radioactive waste disposal facilities. We may also consult on applications for variations to existing permits. Therefore, you should engage with and involve interested parties and members of the public when developing your ESC. You should seek to secure and maintain the confidence of interested parties by presenting your ESC in a way that people will understand and involving them in its development. Different styles and levels of documentation may be needed to present your ESC to different audiences, but these should be consistent. The expectations of interested parties should be taken into account (see IAEA GSG-16, paras 5.27 - 5.30).

Our reviews of your ESC and of any associated permit application will depend on the stage you have reached in developing your disposal facility. We will focus on the most important hazards and risks. We will give greater scrutiny to higher hazard and higher risk proposals, such as the disposal of higher activity waste. Facilities and activities must be appropriate to the sensitivity of the site. We will give greater scrutiny to disposals in locations that may be sensitive, for example to climate change, and where people might come into proximity with radiation.

We will perform an initial phase of review to determine if your ESC and any associated permit application are complete and of sufficient quality to facilitate further, more detailed review. Our

more detailed ESC reviews will consider the claims, arguments and evidence presented in your ESC against this guidance.

Our reviews will be independent, traceable, evidence-based and made against our published and applicable guidance by suitably qualified and experienced personnel.

During our reviews you may need to provide us with further information. We may conduct or commission assessment studies on key issues as part of our reviews.

The results of our reviews will be documented and used by us to provide you with advice and to determine your environmental permit application. We will document the rationale for our judgements on whether the arguments presented in your ESC are adequately supported and whether they are in accordance with our regulatory requirements, standards and other guidance.

Your ESC, including quantitative environmental safety assessments, will need to be detailed and comprehensive enough to support any claims that you make. Quantitative assessments are important in our consideration of your ESC, but regulatory acceptance of your case will involve judgement taking account of many factors. Therefore, both the qualitative arguments supported by the quantitative assessments provided in your ESC will be important in informing the judgements we make.

Depending on the comments received during the initial consultation stage on the environmental permit application, we may consult interested parties and members of the public on our proposed decision, as the determination process draws to a close.

If you are issued with an environmental permit for a radioactive waste disposal facility it will be on the basis of a particular version of your ESC. However, we expect you to keep your ESC under review (see requirement R3) and, therefore, your ESC will evolve over time. You must inform SEPA if, based on your developing ESC or otherwise, you want to make significant changes to the way you operate your disposal facility.

3.4.1.2 Environmental permit conditions for a disposal facility

SEPA specifies limits and conditions in environmental permits to ensure that people and the environment are protected to a standard consistent with legal requirements and this guidance.

As described above, you should propose your own limits, controls and conditions that reflect the environmental safety assessments in your ESC. We will use these proposals to develop the limits and conditions in the environmental permit for the waste disposal facility. We might wish to impose, for example, inventory limits or allowable activity concentrations for specified radionuclides.

These limits and conditions are not restricted to radiological aspects. They could be related to chemical and physical characteristics of the waste.

We may also place limits and conditions in the environmental permit relating to features and techniques which support significant claims and arguments in your ESC, as well as conditions relating to how the facility may be operated and closed (for example, quality assurance of elements of the construction, effluent management). These may include measures that you need to take before you begin particular operations or phases of work (for example, first waste emplacement, commencement of closure).

You may impose additional limits, controls and conditions (e.g. on waste producers) to those set out within your environmental permit, so long as they do not conflict with your environmental permit.

As a minimum, you should ensure your ESC contains the following information about your proposals, to enable SEPA to set environmental permit limits and conditions:

- maximum inventories of radioactive and non-radioactive constituents of waste which can be accepted
- maximum activity concentration of radioactive constituents and concentration limits for non-radioactive constituents of the waste

- other proposed WAC
- limits on any planned discharges from your disposal facility

Your ESC should also provide enough information to justify the method you propose to use for managing waste acceptance and disposal facility capacity. The IAEA has published technical information on how activity limits can be set using a 'sum of fractions', or the summation rule approach ([IAEA-TECDOC-1380](#), 2003). Other approaches may be used. When using such approaches you should ensure that they are appropriate to your waste and that you take appropriate account of waste heterogeneity.

You should present a reasoned forward programme of work which could include, but not be limited to:

- further development and updating of your ESC
- reducing and managing uncertainties
- the further development, operation and closure of your disposal facility
- review and continuous improvement of your management system

We may decide to place requirements relating to these and other factors within your environmental permit.

3.4.2 During the period of regulation

3.4.2.1 Maintaining the ESC

You should maintain your ESC as a live document during the period of RSR. Updates to your ESC should reflect growing knowledge about the disposal system. They should also increasingly reflect the facility as-built, and wastes as disposed of, rather than as planned. The aim is to show that the disposal system as realised in practice is providing and will continue to provide proper protection to people and the environment.

You will need to ensure that there is legal clarity over the documents that comprise the ESC referred to in your environmental permit. Your ESC documents should be controlled documents,

subject to formal change control. You should agree with SEPA any significant changes to your ESC in accordance with any requirements in your permit. You should engage with us as your ESC evolves so that it is always clear which version(s) of the ESC documents are used for regulatory purposes. You must develop, operate, close and control your disposal facility in accordance with your environmental permit and the relevant ESC documents.

You should revise your ESC in accordance with requirement R3: The environmental safety case. The updates to your ESC should consider:

- knowledge and experience gained during the construction, operation and closure of the facility
- understanding gained from site characterisation work and monitoring
- learning from regulators and operators of other relevant facilities, both nationally and in other countries
- learning from accidents and events during the operation of your and other relevant facilities nationally and in other countries
- developments in environmental safety assessment techniques and in scientific and technical understanding
- technological advances e.g. in the management of radioactive waste
- changes to national and international guidance and standards
- changes in policy and legislation
- results of research and development studies (for example, on specific techniques or optimisation)

You should discuss and agree with SEPA how and when updates to your ESC will be structured and made available to promote traceability and transparency. You should maintain a detailed audit trail of changes to the ESC.

You should use updates to your ESC in your ongoing decision-making. This decision-making may relate to environmental safety, waste management, the provision and allocation of

resources, organisational change, environmental safety assessment, waste acceptance criteria or research, development and demonstration work.

You should submit your updated ESC to us in accordance with requirement R3: The environmental safety case, and your environmental permit.

We will periodically review your environmental permit, and this will be informed by our reviews of your updated ESC. If necessary, we will revise relevant limits and conditions specified in your permit.

Whether or how we update the environmental permit will depend on how the ESC has changed and the outcome of any public consultation or other relevant (e.g. judicial) process. The process of reviewing an environmental permit may be initiated in response to a permit variation application or may be initiated by us.

3.4.2.2 Long-term preservation of the ESC

You are responsible throughout the period of RSR for preserving relevant versions of your ESC and all other relevant records in accordance with requirement R12: Preserving and accessing knowledge, information, and data. You should provide access to the records for interested parties where this is compatible with any security restrictions. You are also responsible for making suitable arrangements to promote the preservation of information about the disposal facility in the period after RSR.

3.4.2.3 Quality assurance checking during construction, operation and closure

As described above, you should maintain a management system that includes details of your quality assurance processes, including for construction. It should ensure the quality of all environmental safety-related work throughout the planning, construction, operation, monitoring and closure of the disposal facility.

For construction, proposals should cover the design, specifications of materials selected, a stability assessment (if relevant) and the CQA plan. The construction of infrastructure must be in accordance with the approved construction proposals unless:

- any change to the approved construction proposals would have no impact on the performance of any element of the design
- a change has otherwise been agreed by us

For CQA, you should take account of our [Landfill site management plan guidance](#) as far as it is relevant to your disposal facility:

The scope of your management system should include all aspects that your ESC relies on. This includes the quality of data that supports your ESC as well as ensuring that the facility is constructed, operated and closed in accordance with the claims made in your ESC.

3.4.2.4 Monitoring and surveillance programmes

Your ESC should be used to help specify programmes for monitoring and surveillance of your disposal facility and surrounding area. Your programmes should be developed and implemented to provide evidence that the disposal facility is performing as expected and that system components are fulfilling their environmental safety functions.

Monitoring activities should include establishing background radiation levels and measuring potential releases to environmental media (for example, soil, surface water, ground water and atmosphere) as well as monitoring other relevant parameters that might be used to reflect aspects of disposal system performance such as surface waters and groundwaters, land deformation, land use, engineered barrier characteristics, temperature etc. You should provide and justify a reasoned monitoring plan and programme and carry out monitoring systematically throughout the lifetime of your disposal facility. On the basis of monitoring data, you should review system performance and, if necessary, consider and implement corrective actions.

In particular you should consider monitoring the effects of construction and operation of your disposal facility on the groundwater levels and chemistry around your disposal facility and comparing these to the effects assessed in your ESC to help improve your understanding of your disposal system.

You should also consider monitoring the borders of your disposal system so that you can identify any changes that might be a consequence of the migration of contaminants onto your site from other sources.

3.4.2.5 Controlling the waste that is disposed of

You should have arrangements in place to ensure that radioactive waste disposed of to your disposal facility is consistent with your ESC and complies with your permit conditions. This should be achieved by implementing a suitable waste acceptance system that includes measures to control disposals both for the facility as a whole (facility waste acceptance limits) and for individual waste consignments (waste acceptance criteria) (see requirement R11: Waste acceptance).

You may review and propose revisions to the WAC at any time, so long as you retain consistency with your permit and ESC. When you update your ESC, you should also review the WAC and propose any changes to them to maintain consistency with your ESC.

Your arrangements should include proportionate measures to confirm that waste consignments conform to the WAC (for example, inspection of consignments and paperwork, auditing of waste consignors). You should also have arrangements for dealing with waste consignments that do not conform to your WAC.

3.4.2.6 Applying for a variation to the environmental permit

You should use the application form and guidance on our website if you wish to apply for a variation to your environmental permit. If necessary, you should submit a revised ESC in support of your application.

We will consult on your permit variation application and our proposed decision, if this is required by our policies and procedures for consultations.

We will consider any revised ESC you submit against the requirements of this guidance as part of determining your environmental permit variation application. We will scrutinise the claims, arguments and evidence in your revised ESC as part of our determination.

Your varied permit will make reference to your ESC - this will be to the version of the ESC submitted and assessed as part of your application.

3.4.3 During the permit surrender application

3.4.3.1 Application for surrender

You should engage with and take account of the views of interested parties when considering the surrender of your permit. You must discuss and agree with us the process to follow for applying to surrender your environmental permit.

Permit surrender cannot take place before we are satisfied that you have closed your disposal facility in accordance with your permit and your ESC. It may be the case that permit surrender cannot take place until after a further period of:

- control for the purposes of radiological protection (for example during which radioactive decay and other attenuation processes allow the radiological protection standards in this guidance to be met for your disposal facility)
- monitoring to demonstrate that the closed facility is evolving in line with your ESC

The period of control for the purposes of radiological protection must be agreed with us and may be many years, decades or even longer after closure, depending on the type of radioactive waste facility and the nature of waste disposed of within it. You should:

- use the application form and guidance provided by us to apply to surrender your environmental permit

- submit a final ESC in support of your permit surrender application - the final ESC should reflect the as-built and closed waste disposal facility, including an accurate record of the radioactive waste disposed

We will consult on your surrender application and our proposed decision if this is required by our policies and procedures for consultations.

We will consider your final ESC against the requirements of this guidance (and any amendments to it) as part of determining your surrender application. For nuclear sites, there may be aspects of the scope of your permit surrender application which we will assess against separate guidance (see Management of radioactive waste from decommissioning of nuclear site: [Guidance on Requirements for Release from Radioactive Substances Regulation](#)).

3.4.3.2 After the end of regulation

Once your application for permit surrender has been granted, we will have satisfied ourselves that the closed waste disposal facility meets the requirements of this guidance and, therefore, people and the environment are sufficiently protected for the long-term. There will be no need for any on-going human action to maintain environmental safety.

Part 4 – Groundwater Protection

4.1 Introduction

This Part of the NS-GRA explains how the groundwater protection requirements apply to a radioactive waste disposal facility and what you need to do to meet them.

As specified in requirement R14: Protecting groundwater, you must ensure that your radioactive waste disposal facility does not cause pollution of groundwater at any stage both during and after the period of RSR.

The obligations for protection of groundwater come through the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR). CAR requires compliance with the Water Framework Directive or WFD (Directive 2000/60/EC), and the Groundwater Daughter Directive or GWDD (Directive 2006/118/EC).

4.2 Applying CAR to radioactive waste disposal facilities

CAR applies to a range of “controlled activities” which may affect the water environment. The activity of operating a near-surface radioactive waste disposal facility meets the criteria to be considered a controlled activity and so must be authorised under CAR. You will not need a separate CAR authorisation for a radioactive substances activity authorised under EASR in accordance with Schedule 8 as the latter is a “relevant authorisation” for the purposes of CAR.

However, you may need separate authorisation under CAR for activities you undertake during the investigation and construction phases of your facility. CAR allows for proportionate regulation of some low-risk activities through a system of “general binding rules” (GBRs), some of which may be relevant to the investigation and construction phases.

CAR specifies what SEPA must consider when assessing any application for a permit to operate a radioactive waste disposal facility. For radioactive waste disposal facilities, we are primarily concerned with ensuring that you comply with the requirements of Article 6 of the Groundwater

Directive, to prevent and limit inputs of pollutants into groundwater. These requirements may be eased by certain exemptions.

4.3 Scope of this guidance regarding CAR

This guidance only deals with the protection of groundwater from your disposal facility, as built and operated in accordance with an EASR permit for radioactive substances activities. This guidance does not cover impacts on groundwater associated with the construction of your disposal facility. You will need to consider these other risks to groundwater, for example for dewatering operations, and ensure you are appropriately authorised. If you are not sure what activities might require to be separately authorised under CAR, please get in touch with us for advice.

4.4 Defining groundwater

The “Water Environment and Water Services (Scotland) Act 2003” at section 3(4) defines groundwater as:

“water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.”

The definition above potentially covers nearly all water beneath the surface of the ground. However, we make a distinction between groundwater that is used as a resource or has the potential to be used as a resource, and groundwater that is not a potential resource:

1. The environmental standards for inputs into groundwater of hazardous substances should not be applied to:
 - a. groundwater that is below mean high-water springs or
 - b. is greater than 400m below ground level
2. provided these waters have a level of natural electrical conductivity of greater than or equal to the Scottish Drinking Water Standard as set out in The Water Intended For

Human Consumption (Private Supplies) (Scotland) Regulations 2017 and The Public Water Supplies (Scotland) Regulations 2014 and there is no significant pathway to surface ecosystems.

Therefore, requirement R14 does not apply to groundwater beneath the sea or at depths greater than 400m below ground level, if it is saline enough to exceed the relevant level of electrical conductivity.

4.5 Demonstrating compliance with requirement R14

You should use your ESC to demonstrate that your radioactive waste disposal facility will comply with requirement R14. You should integrate your assessment of groundwater impacts into the relevant environmental safety assessments that form part of your ESC.

You must demonstrate that your radioactive waste disposal facility is:

- designed and constructed with a suitable barrier system to prevent all direct discharges of pollutants to groundwater; and
- operated and closed so that any indirect inputs of pollutants to groundwater comply with the standards described below.

You do not need to undertake a specific groundwater assessment for radioactive substances, but you should ensure that the relevant assessments that you undertake for other purposes address the protecting groundwater requirement. The relevant assessments include your:

- radiological assessment relating to the protection of people from migration of radionuclides from your disposal facility both during and after RSR
- radiological assessment relating to the protection of wild animals and plants
- assessment of impacts of non-radioactive hazardous and non-hazardous substances.

For your radiological assessments, if you can show compliance with the radiological standards in this guidance for the protection of people from a source or sites [standards 2 and 3], and of plants and animals [requirement R13] you will also have demonstrated that the groundwater is protected. This is in accordance with our “Environmental Standards for Inputs of Radioactive Substances into Groundwater Consultation document October 2024”

For your assessment of the non-radiological hazards associated with the radioactive waste (requirement R15), you will need to demonstrate that you have met the appropriate standards for non-radioactive hazardous and non-hazardous substances entering groundwater. The standards that you should be aiming to achieve are set out in SEPA’s position statement “Assigning Groundwater Assessment Criteria for Pollutant Inputs (WAT-PS-10-01)”.

If you are unable to show full compliance with the standards set out in WAT-PS-10-01 for the non-radiological properties of the radioactive waste, you may be able to provide suitable arguments to allow SEPA to consider if any of the Groundwater Directive Article 6 exemptions should apply.

Part 5– Glossary and references

5.1 Glossary

Where terms are not defined in this glossary, we are using them with their normal dictionary meaning.

Accessible environment

Those parts of the environment in contact with or readily available for use by humans and non-human organisms.

Closure

Administrative and technical actions directed at a disposal facility at the end of its operating lifetime — for example, covering of the disposed waste or backfilling and/or sealing shafts and tunnels— and the termination and completion of activities in any associated structures

Conceptual model

A set of qualitative assumptions used to describe a system, or part of a system, in the real world.

Containment

Methods or physical structures designed to prevent or control the release and the dispersion of radioactive substances. The containment of the radionuclides associated with the waste is through the provision of engineered barriers and natural barriers - including the waste form and packaging, backfill materials, host geology and the wider geological environment.

Criticality

The state of a nuclear chain reacting medium when the chain reaction is just self-sustaining (or critical), i.e. when the reactivity is zero

Defence in depth

A hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of physical

barriers placed between a radiation source or radioactive material and workers, members of the public or the environment, in operational states and, for some barriers, in accident conditions

Deterministic effect

A radiation induced health effect for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose

Disposal facility

An engineered facility where waste is emplaced for disposal. Synonymous with repository.

Disposal system

The system of properties of the site for a disposal facility, design of the disposal facility, physical structures and items, procedures for control, characteristics of waste and other elements that contribute in different ways and over different timescales to the fulfilment of safety functions for disposal.

Dose constraint

A prospective and source related value of individual dose that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization

Dose guidance range

The dose standard against which the radiological consequences of the following are assessed:

- inadvertent human intrusion into the radioactive waste itself after the period of RSR.
- certain scenarios resulting from natural disruptive processes and events after the period of RSR that uncover radioactive waste and could lead to direct encounter with the waste

It indicates the standard of environmental safety expected but does not suggest that there is an absolute requirement for this level to be met.

Effective dose

Effective dose is a measure of dose designed to reflect the amount of radiation detriment likely to result from the dose.

Emplace or emplacement

The placement of a waste package in a designated location for disposal, with no intent to reposition or retrieve it subsequently

Environmental safety

The safety of people and the environment both during the period of RSR and afterwards into the indefinite future

Environmental safety case

A documented set of claims, made by the developer or operator of a disposal facility, to demonstrate achievement of the required standard of environmental safety.

Environmental safety culture

The characteristics and attitudes of organisations and individuals that ensure that the protection of people and the environment receives proper attention

Environmental safety function

The various ways in which components of the disposal system may contribute towards environmental safety, such as the geology providing a physical barrier function and also having chemical properties that help to retard the migration of radionuclides

Environmental safety strategy

An approach or course of action designed to achieve and demonstrate Environmental safety.

Equivalent dose

Equivalent dose is a measure of the dose to a tissue or organ designed to reflect the amount of harm caused

Expected evolution scenario

A scenario that describes how the disposal facility and its environment are expected to develop over time. The expected evolution scenario may be considered to be almost certain or highly likely to occur. This can be contrasted with relatively less likely variants scenarios and highly unlikely 'what-if' scenarios?

Exposure (potential)

Prospectively considered exposure that is not expected to be delivered with certainty but that may result from an anticipated operational occurrence or accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

Exposure scenarios

A postulated or assumed set of conditions and/or events that could result in exposure to ionising radiation

Fissile content

The component of waste that contains any of the fissile nuclides in sufficient proportion to enable a self-sustained nuclear chain reaction with slow (thermal) neutrons

Groundwater quality

The chemical, physical, biological, thermal and radiological quality of groundwater within a subsurface aquifer.

Host geology

The geological medium in which a disposal facility is located.

Inadvertent human intrusion

Any human action that unintentionally affects the integrity of a disposal facility and which could potentially give rise to radiological consequences after the release from RSR. Only those human activities (such as construction work, mining or drilling) that could result in direct disturbance of

the disposal facility (i.e. disturbance of the waste itself, of the contaminated near field or of materials of the engineered barrier) are included.

Interesting or noticeable objects

A distinct item of waste that, by its characteristics, is recognisable as unusual or not of natural origin and as a result could change the behaviour of those who encounter it (specifically, by attracting people leading to collecting / hoarding and/or further intrusion into the waste and hence increasing exposures). It could be a focus of interest out of general curiosity or because of its potential for collectability, sale, recovery, recycling or re-use should the waste item be exposed after site closure.

Isolation

The physical separation of radioactive waste away from people and from the accessible environment. Isolation of radioactive waste with its associated hazards in a disposal facility involves the minimisation of the influence of factors that could reduce the integrity of the disposal facility and making access to the waste by people without special technical capabilities difficult.

Management system

A set of interrelated or interacting elements (system) for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner.

Multiple barriers

Two or more natural or engineered barriers used to isolate radioactive waste in, and to prevent or to inhibit migration of radionuclides from, a disposal facility.

Natural analogues

A situation in nature used as a model for processes affecting human made systems

Nuclear licenced site

(a) Any site in respect of which a nuclear site licence is for the time being in force, or

(b) Any site in respect of which, after the revocation or surrender of a nuclear site licence, the period of responsibility of the licensee has not yet come to an end, and “licensee”, when used in relation to a nuclear site, and “period of responsibility” have the same meaning as in the Nuclear Installations Act 1965.

Passively safe

Not placing reliance on safety systems whose functioning depends on an external input, such as a power supply, or human intervention to ensure safety

Radiation stability

The ability of a material to withstand radiation damage.

Radiological risk

The probability per unit time that an individual will suffer a serious radiation-induced health effect as a result of the presence of a radiation source, for example, a disposal facility. In this context, a serious radiation-induced health effect is a fatal cancer or a severe hereditary defect.

Radiological risk can only be assessed and not measured.

Radionuclide

Any isotope of any element that is radioactive. Some occur naturally in the environment, while others are man-made, either deliberately or as byproducts of nuclear reactions.

Representative person

For the purpose of protection of the public, a hypothetical individual who receives a dose that is representative of the more highly exposed individuals in the population.

Risk coefficient

The lifetime risk or radiation detriment assumed to result from exposure to unit equivalent dose or effective dose

Risk guidance level

A level of radiological risk from a nuclear site which provides a numerical standard for assessing the environmental safety of the site after the release from RSR

Scenario

A postulated or assumed set of conditions and/or events.

Stochastic effects

A radiation induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose.

Structures, systems and components

A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors

Structural integrity

The ability of an engineered structure to function safely and reliability throughout its life

Thermal stability

The ability of a material to withstand damage caused by heat or changes in temperature.

Variant scenarios

Scenarios that describe alternative possibilities for how the disposal facility and its environment may evolve. These can be contrasted with expected evolution and what-if scenarios

Waste acceptance criteria

Quantitative and/or qualitative criteria for solid radioactive waste to be accepted for disposal. These are specified by the operator of a disposal facility and should include any criteria specified in the operator's permit.

Waste form

Waste in its physical and chemical form after treatment and/or conditioning (resulting in a solid product) but not including the packaging.

Waste consignment

Any waste sent by a consignor to a disposal facility

Waste package

The product of conditioning that includes the waste form and any container(s) and internal barriers (e.g. absorbing materials and liner), as prepared in accordance with requirements for handling, transport, storage and/or disposal.

'What-if' scenarios

Scenarios used to explore the consequences of highly unlikely assumptions (e.g. events). What-if scenarios can be used to inform optimisation.

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