

The management of higher activity radioactive waste on nuclear licensed sites

Joint guidance from the Office for Nuclear Regulation, the Environment Agency, the Scottish Environment Protection Agency and Natural Resources Wales to nuclear licensees

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Contents

Foreword	4
Freedom of information	4
Executive Summary	5
Introduction	7
Scope	7
Objective and aims of the guidance	7
Document history	8
Government policy	8
Key applicable legislation	9
Other relevant guidance	10
Section 1 The Regulatory process	12
Prioritisation of projects for regulatory scrutiny.....	12
Joint working and early interactions between licensees and regulators	12
The nuclear site licence and safety cases.....	13
Radioactive waste management cases (RWMCs)	13
The formal regulatory process	14
Section 2 Integrated Waste Strategies (IWS)	19
Strategic Options Study	20
Section 3 Radioactive Waste Management Cases (RWMCs)	21
Purpose	21
Contents and structure	22
Ownership	23
Production	23
Proportionate approach in the production of RWMCs	24
Peer review and independent assessment	24
Maintenance.....	25
Periodic review of safety cases and implications for RWMCs	26
Section 4 Waste Minimisation, Characterisation and Segregation	27
Waste minimisation	28
Waste hierarchy.....	29
Waste characterisation	31
Waste segregation.....	36
Section 5 Waste Conditioning and Disposability	38
Waste Conditioning	38
Preparing wastes for conditioning.....	41
Waste immobilisation.....	41
Guidance on disposability	48
Specific disposability considerations for RWMCs.....	49
Section 6 Storage	51
Fundamental requirement for storage.....	51
Storage of unconditioned waste.....	51
Arrangements for safe and secure storage	51
Passive safety	52
Multiple barrier containment.....	53
Storage building or structure.....	53
Radiation shielding	54
Prevention and mitigation of releases of radioactivity to the environment	54

Design of storage facilities	54
Storage capacity	57
Waste acceptance criteria	57
Inspection and maintenance of the storage facilities	58
Waste packages monitoring programme.....	59
Remedial action.....	59
Store design for inspection and retrieval	60
Records	60
Section 7 Managing information and records relating to radioactive waste	62
Introduction.....	62
Timeframes	63
Information and records management policy and strategy	64
Information and records management systems and procedures	65
Records management: specific issues relating to managing records for the long-term	69
Records storage facilities.....	70
Record review.....	72
Security and the protection of sensitive information and records	73
Complying with this guidance	74
Abbreviations and Glossary	75
Further reading	80
Guidance and documents from the regulators and NDA	80
References	81
Figures	84
Appendix 1: Engagement with the regulators	87
Site waste management strategies and plans.....	87
Options assessment process	87
Conceptual design	88
Detailed design and construction of relevant waste management plant	88
Commissioning of packaging plant	88
Operation of packaging plant	88
Storage.....	88
Appendix 2: Technical contents of a Radioactive Waste Management Case.....	89
General contents	89
Radioactive waste management strategies.....	90
Waste minimisation, characterisation and segregation	90
Conditioning and disposability	91
Storage of radioactive waste.....	92
Control, accountancy and records	92
Contacts	93
Figures	
Figure 1: Development of radioactive waste management case and regulatory process	84
Figure 2: Relationship between specific safety cases and a Radioactive Waste Management Case (RWMC)	85
Figure 3: Opportunities for waste minimisation, characterisation and segregation	86

Foreword

The Office for Nuclear Regulation (ONR), the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA) and Natural Resources Wales (NRW) (together referred to as the regulators) have issued this guidance jointly.

Licensees who follow this guidance will normally be doing enough to comply with the relevant law as interpreted by the regulators at the time of writing, and the regulators may refer to this guidance as illustrating relevant good practice. However, licensees are not required to follow this guidance and compliance with it does not automatically mean that we will approve an application for a nuclear site licence, a consent or agreement under the licence or an environmental permit. The guidance provides information to other parties who may be stakeholders in how radioactive waste is managed on a nuclear licensed site.

Policies for the disposal of higher activity waste differ in England, Scotland and Wales. The regulators consider that packages conditioned in anticipation of geological disposal are also suitable for long-term management in near-surface facilities, as required by government policy in Scotland. On this basis the following guidance can be used equally in England, Scotland and Wales, but any references to geological disposal will mean long-term management when applied to Scotland. The regulators will continue to review the packaging advice being developed by Radioactive Waste Management Limited and if any developments mean that this assertion with respect to Scottish waste is no longer valid, we will provide further guidance.

Given the long timescales involved in radioactive waste management, the current standards, legislation and national policy might change. This guidance forms the best advice that the regulators can give at present; nothing in this guidance overrides, or is intended to pre-empt, regulators to discharge their statutory powers and duties in accordance with legislation, standards and policy applicable at any time.

We will review this guidance periodically to ensure that it continues to provide sound advice.

Freedom of information

The regulators are public authorities for the purposes of the Freedom of Information Act 2000¹ (FOIA00) and the Environmental Information Regulations 2004² (EIR04) in England and Wales, and the Freedom of Information (Scotland) Act 2002³ (FOISA02) and the Environmental Information (Scotland) Regulations 2004⁴ (EISR04) in Scotland. If we receive a request for information that we hold, we are bound to consider the request in accordance with this legislation.

This document is available on or from our respective websites, in accordance with our policies of openness and transparency.

Executive Summary

This document provides guidance covering the management of higher activity radioactive wastes (HAW) on nuclear licensed sites. The document describes the regulatory process and expectations in the following key areas:

Section 1 The Regulatory process

This section explains the regulatory process associated with the management of higher activity radioactive waste on nuclear licensed sites in the UK.

Section 2 Integrated Waste Strategies (IWS)

This section details the expectation for a licensee to produce an integrated waste strategy and what it should contain.

Section 3 Radioactive Waste Management Cases (RWMCs)

This section describes regulatory expectations with respect to the production, content, maintenance and review of radioactive waste management cases (RWMCs), and provides links to further guidance on how the components that support an RWMC may be produced.

Section 4 Waste Minimisation, Characterisation and Segregation

Waste minimisation, characterisation and segregation are central to establishing and updating a radioactive waste inventory, applying the waste management hierarchy and optimising waste management. Opportunities for waste minimisation, characterisation and segregation should be considered in all stages of waste management, including design, construction, operation, decommissioning, storage and disposal.

This section provides an overview of the relevant policy drivers, regulatory requirements and expectations relating to waste minimisation, characterisation and segregation during the management of higher activity radioactive waste on nuclear licensed sites. It identifies the relevant technical considerations that need to be addressed in the requisite radioactive waste management cases.

Section 5 Waste Conditioning and Disposability

This part provides an overview of the expectations relating to waste conditioning and disposability during the management of higher activity radioactive wastes on nuclear licensed sites. It also identifies the technical considerations that need to be addressed in the requisite radioactive waste management cases.

Section 6 Storage

It will be many years before higher activity radioactive waste can be permanently disposed of; therefore storage plays a crucial part in the long-term management strategy by providing an extendable safe and secure means to hold waste and ensure protection of the environment. Where possible, the waste should be stored in a packaged form suitable for eventual disposal.

If raw waste is stored, it should be contained in a manner that avoids deterioration and allows retrieval for processing and eventual disposal, whilst maintaining standards of safety and environmental protection that are as close as reasonably practicable to those for stored packaged wastes.

This part provides an overview of the relevant policy drivers, regulatory requirements and expectations relating to the storage of higher activity radioactive wastes on nuclear licensed sites. It also identifies the relevant technical considerations that need to be addressed in the requisite radioactive waste management cases.

Section 7 Managing information and records relating to radioactive waste

Effective management of knowledge and records associated with waste is an important aspect of radioactive waste management. It is essential to ensure that licensees, both now and in the future, are equipped with the knowledge and records they need to manage radioactive waste

safely, over long timescales and through organisational change. This guidance covers existing national and international standards and practices for managing information. It also discusses some of the specific issues associated with managing information about radioactive waste over the long term.

This part provides an overview of the relevant policy drivers, regulatory requirements and expectations relating to managing information and records about higher activity radioactive wastes on nuclear licensed sites.

Introduction

Scope

1. Higher activity radioactive waste means high-level radioactive waste (HLW), intermediate-level radioactive waste (ILW), and such low-level radioactive waste (LLW) as cannot be disposed of at present. If there is doubt over how to regard a particular waste stream, the owner of that waste stream should consult the regulators.
2. Radioactive substances that are not classified as radioactive waste, which may include spent nuclear fuel, plutonium and uranium, are outside the scope of this joint guidance. When any such radioactive material becomes radioactive waste, this guidance will apply.
3. Advice about the disposal of those categories of radioactive waste that are not covered in this guidance can be obtained from the EA, SEPA or NRW.
4. Policies for the disposal of higher activity radioactive waste differ in England, Scotland and Wales. The regulators consider that packages conditioned in anticipation of geological disposal are also suitable for the long-term management in near-surface facilities as required by the government policy in Scotland. On this basis, the following guidance can be used equally in England, Scotland and Wales, but any references to geological disposal will mean long-term management when applied to Scotland. The regulators will continue to review the packaging advice being developed by Radioactive Waste Management Limited and if any developments mean that this assertion with respect to Scottish waste is no longer valid, we will provide further guidance.
5. Licensees are required to apply the same safety and environmental standards to all activities involving radioactive substances whether or not the substances involved are declared as radioactive waste.

Objective and aims of the guidance

6. The objective of this guidance is to provide advice on complying with the applicable legislation and by describing regulatory expectations with respect to:
 - the regulatory process associated with the management of higher activity radioactive waste on nuclear licensed sites in the UK;
 - the production, content, maintenance and review of radioactive waste management cases;
 - waste minimisation, characterisation and segregation;
 - the conditioning of higher activity wastes, waste disposability and the assessment thereof;
 - the storage of higher activity radioactive waste; and
 - the management of knowledge and records relating to radioactive waste in Great Britain.
7. The main aims of the guidance are to:
 - provide a comprehensive source of information that can be used by nuclear site licensees and the regulators' staff, and referred to by other stakeholders; and
 - advise licensees on how to obtain regulatory acceptance of their proposals for radioactive waste management.
8. This guidance should assist licensees by providing:

- a clear and transparent regulatory process involving early dialogue between the nuclear industry, the regulators, the Nuclear Decommissioning Authority (NDA) and other stakeholders;
 - greater business certainty at a time when the nuclear industry is committing significant resources to radioactive waste management; and
 - a clear, auditable document trail of the basis for current regulatory decisions.
9. When applying this guidance, licensees should have due regard to:
- ONR's principles for assessing nuclear safety cases, as detailed in the Safety Assessment Principles⁵;
 - ONR's Technical Assessment Guide on 'As Low As Reasonably Practicable' (ALARP)⁶;
 - ONR's Technical Assessment Guide on the Management of Radioactive Material and Radioactive Waste on Nuclear Licensed Sites⁷;
 - For England and Wales, the principles for the regulation of radioactive substances as detailed in Radioactive Substances Regulation: Environmental Principles^{8,9} and Principles of optimisation in the management and disposal of radioactive waste¹⁰; and
 - For Scotland, SEPA's guidance on the principle of optimisation as detailed in Satisfying the optimisation requirement and the role of Best Practicable Means¹¹.

Document history

10. This document updates and replaces the previously published Joint Guidance which was comprised of the following documents:
- Part 1: Guidance on the regulatory process;
 - Part 2: Guidance on radioactive waste management cases; and
 - Part 3: Technical guidance modules (a-d)
- Bringing the documents together eliminates duplication and is intended to provide a single comprehensive source of information.
11. Similarly, the Basic Principles of Radioactive Waste Management replace the previously published Fundamentals of the Management of Radioactive Waste.

Government policy

12. The Government maintains and continues to develop a policy and regulatory framework which ensures that:
- radioactive wastes are not unnecessarily created;
 - such wastes as are created are safely and appropriately managed and treated; and
 - they are then safely disposed of at appropriate times and in appropriate ways.
13. The fundamental aim is to ensure that radioactive waste is managed in a way that protects the public, workforce and environment and safeguards the interest of existing and future generations and the wider environment in a manner that commands public confidence and takes due account of costs.

14. The Government requires that the regulators ensure that the policy and regulatory framework is properly implemented in accordance with their statutory powers. Within the framework, the producers and owners of radioactive waste are responsible for developing their own waste management strategies, consulting the Government, regulatory bodies and disposal organisations as appropriate.
15. The policy for the disposal of higher activity wastes in England¹² is to manage higher activity waste in the long-term through geological disposal, with safe and secure interim storage.
16. The Welsh Government has adopted a policy^{13, 14} of supporting geological disposal to provide a permanent solution to the long-term management of HAW therefore mitigating the responsibility to future generations.
17. The Scottish Government Policy¹⁵ is that the long-term management of higher activity radioactive waste should be in 'near surface, near site' storage and/ or disposal facilities where the waste can be monitored, retrieved (if required) and the need for transportation over long distances is minimised.

Key applicable legislation

18. As required by the following legislation, facilities and activities for predisposal management of radioactive waste, including decommissioning activities, shall be subject to safety and environmental impact assessments to demonstrate that they are adequately safe and, more specifically, that they will be in compliance with safety and environmental requirements established by the regulators.

Nuclear Installations Act 1965

19. The Nuclear Installations Act 1965¹⁶ (NIA65) requires any operator of a defined nuclear installation to be licensed and gives ONR the powers to 'attach to the licence such conditions as may appear ... to be necessary or desirable in the interest of safety' or 'as it may think fit with respect to the handling treatment and disposal of nuclear matter'. The sections of the Nuclear Installations Act relating to the licence and inspection of sites (sections 1, 3–6, 22 and 24A) are 'relevant statutory provisions' under the Energy Act 2013¹⁷ (TEA13). Thus these sections are subject to regulation and enforcement by ONR.

Licence Conditions

20. There are 36 standard licence conditions (LCs) attached to all nuclear site licences (see nuclear site licence conditions¹⁸). All the licence conditions apply and are relevant to activities involving management of radioactive waste. However, a number of licence conditions are particularly relevant to this guidance. These are:
 - **Licence Condition 4** requires that no nuclear matter is stored on the site except in accordance with adequate arrangements made by the licensee for this purpose;
 - **Licence Condition 32** requires adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated;
 - **Licence Condition 33** requires that radioactive waste is disposed of in accordance with an environmental permit.
 - **Licence Condition 34** requires the licensee to ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment; and

- **Licence Condition 35** requires the licensee to make and implement adequate arrangements for the decommissioning of any plant or process that may affect safety. Insofar as decommissioning and radioactive waste management are interlinked activities, this is a relevant licence condition to this guidance.

Health and Safety at Work etc. Act 1974¹⁹ (HASW74)

21. Section 2 of HASW74 requires 'every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees'. Section 3 of the Act requires 'every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that the persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety'. In judging whether licensees have complied with their legal duties ONR makes use of the risk management procedures explained in the Reducing risks, protecting people document²⁰. The fundamental requirement is that the licensee shall take measures to reduce risks 'as low as reasonably practicable' (ALARP). Guidance on the meaning and use of the concept of ALARP in ONR's decision-making is available from ONR's website.

Environmental Legislation

22. The primary role of the environment agencies in the regulatory process covered by this guidance is to advise ONR on the long-term protection of the public and the environment. This includes providing advice on the disposability of conditioned waste in the long term, and ensuring waste is managed in a sustainable way, taking into account long-term environmental considerations.
23. The EA takes a leading role in protecting and improving the environment in England, while SEPA and NRW have similar responsibilities in Scotland and in Wales. The environment agencies regulate radioactive disposals (including the discharge of gaseous and aqueous liquid radioactive wastes) and the transfer of radioactive wastes between nuclear sites.
24. The legislation under which the environment agencies regulate is different. In England and Wales, the EA and NRW regulate the disposal of radioactive waste from nuclear licensed sites under the Environmental Permitting (England and Wales) Regulations 2016²¹ (EPR16). In Scotland, SEPA regulates radioactive substances activities involving radioactive waste on nuclear licensed sites under the Environmental Authorisations (Scotland) Regulations 2018²² (EASR18).
25. Before granting or significantly varying a permit, the appropriate environment agency will wish to ensure that a systematic and proportionate examination has been made of the options for waste management (having regard to the waste hierarchy) and that the waste management strategy chosen represents the optimum to provide proper protection for people and the environment. Waste management strategies should be determined by application of best available techniques (BAT) or best practicable means (BPM) as appropriate to the legislative regime.

Other relevant guidance

26. The ONR's Safety Assessment Principles (SAPs)²³ provide the underlying basis for regulatory judgements made by ONR. Relevant principles include:
 - **SAP RW.1:** A strategy should be produced and implemented for the management of radioactive waste on a site;
 - **SAP RW.2:** The generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms of quantity and activity;

- **SAP RW.3:** The total quantity of radioactive waste accumulated on site at any time should be minimised so far as is reasonably practicable;
 - **SAP RW.4:** Radioactive waste should be characterised and segregated to facilitate subsequent safe and effective management;
 - **SAP RW.5:** Radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition;
 - **SAP RW.6:** Radiological hazards should be reduced systematically and progressively. The waste should be processed into a passive safe state as soon as reasonably practicable; and
 - **SAP RW.7:** Information that might be needed for the current and future safe management of radioactive waste should be recorded and preserved.
27. For England and Wales the principles for the regulation of radioactive substances as detailed in Radioactive Substances Regulation: Environmental Principles. Relevant principles include:
- **Principle RSMDP3 - Use of BAT to minimise waste**, states “The best available techniques should be used to ensure that production of radioactive waste is prevented and where that is not practicable minimised with regard to activity and quantity”;
 - **Principle RSMDP8 - Segregation of wastes**, states “The best available techniques should be used to prevent the mixing of radioactive substances with other materials, including other radioactive substances, where such mixing might compromise subsequent effective management or increase environmental impacts or risks.”; and
 - **Principle RSMDP9 - Characterisation**, states “Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal.”

Section 1 The Regulatory process

28. The objective of this part of the guidance is to explain the regulatory process associated with the management of HAW on nuclear licensed sites in the UK.
29. The main aim is to advise licensees on how to obtain regulatory acceptance of their proposals for radioactive waste management and should assist licensees by providing:
 - a clear and transparent regulatory process involving early dialogue between the nuclear industry, the regulators, the Nuclear Decommissioning Authority (NDA) and other stakeholders;
 - greater business certainty at a time when the nuclear industry is committing significant resources to radioactive waste management; and
 - a clear, auditable document trail of the basis for current regulatory decisions.
30. The regulatory process is designed to be flexible and efficient, and to avoid undue delay. It assumes there will be early and continuing interaction with the regulators during the development of proposals. Our role is to challenge and to provide constructive criticism to make sure that a licensee's proposal satisfies our requirements.
31. The initial point of contact will be ONR's site inspector. Licensees should discuss proposals with the inspector and agree a way forward, including the future point of contact within each relevant organisation.

Prioritisation of projects for regulatory scrutiny

Joint working and early interactions between licensees and regulators

32. Early interaction and joint working are important for efficiently regulating radioactive waste management on nuclear licensed sites.
33. Interaction is especially important at the strategy development, options assessment and concept stages, where licensees can seek the regulators' views about:
 - improving safety and environmental protection;
 - reducing business risk and the potential for unnecessary expenditure by identifying, and if possible resolving, any significant regulatory issues at this early stage; and
 - enabling the regulators to plan their resource commitments.
34. Licensees should communicate to regulators as soon as possible:
 - any issues^a known or considered likely to be significant to the regulators;
 - reasons for their actions or intentions, including any third-party requirements;
 - the options being considered, their merits and the reasons for preferring the selected option;
 - any dependencies on future actions by third parties. Licensees should not await the outcomes of third-party action before revealing proposals that are conditional on third parties;

^a The matters to be addressed during regulatory interactions are generally described in this document as 'issues'. This term should be interpreted very broadly. It may for example include an operator's proposed courses of action, new projects or activities, events and investigations of interest to regulators, including responses to regulatory requirements. Similarly, on a regulator's part, it may for example include any particular regulatory concerns, investigations and audits and their outcomes, and changes to regulatory processes.

- who is empowered to represent the licensee on the issues;
- any changes to the above; and
- any initial suggestions for regulatory hold points (beyond which a licensee cannot proceed without regulatory agreement).

A combination of joint working and early identification and resolution of issues is essential to delivering effective regulation.

35. Regulators will notify licensees, as soon as practicable:
- which issues are of interest to them;
 - which issues they regard as key issues;
 - the planned regulatory processes, including any milestones and hold points;
 - the implications for the involvement of statutory consultees and views on the involvement of other stakeholders;
 - the intended end points of the regulatory processes; and
 - any changes to the above.
36. We will strive to avoid unnecessary delays, conflicts or duplication of activities in nuclear safety and environmental requirements. If a significant problem arises, we will inform the licensee of the relevant issues, together with the process and schedule for resolution.
37. For projects that could result in long or multi-staged regulatory processes, we will try to identify possible issues or technical problems early in the process through effective joint management, so that there is less risk that the proposal will be rejected or subject to unexpected requirements at a later date. It may be necessary to hold early consultations with other stakeholders (including the public) to achieve this. Appendix 1: Engagement with the regulators describes the typical interactions between licensees and the regulators as a project progresses.

The nuclear site licence and safety cases

38. ONR regulates radioactive waste management on nuclear licensed sites through the nuclear site licence. One of the licence conditions of the nuclear site licence is that the licensee must have a detailed safety case substantiating the safety of the plant throughout its life, and considering the waste that will be generated. Any subsequent alteration to the site facilities or operations, such as the modification of existing plant/ processes or the construction of new plant, requires the licensee to review and amend the safety case and for ONR to grant permission where appropriate. Application for permission is made using the licensee's arrangements under the appropriate licence condition or as a result of ONR specifying the need for such an application.

Licensees must have in place a safety and environmental case for each plant, substantiating adequate safety and environmental protection throughout the plant's life.

Radioactive waste management cases (RWMCs)

39. Safety cases are a well-established concept for the nuclear safety community. However, their application in a radioactive waste management context is not

transparent as aspects relating to waste streams will exist in a number of different plant safety cases.

40. An RWMC should provide such transparency by indicating (in summary form) how the key elements of long-term safety and environmental performance will be delivered for the management of the waste stream or streams covered. By 'long-term' we generally mean issues that might occur over decades or as wastes are moved from plant to plant for treatment/ storage. Short-term environmental issues are, in general, regulated by the environment agencies under separate legislation. This separate legislation is not the focus of this guidance. However in certain circumstances the regulators' interests inevitably overlap, particularly at the options selection stage, and issues arise that should not be considered in isolation.
41. The RWMC for a waste stream should cover the period from its generation, through the conditioning, storage and up to the removal of the waste stream from site for eventual disposal. It should provide a complete account of the management of waste streams that cannot necessarily be seen from examination of the individual plant safety cases and environmental documentation.
42. Further detailed guidance on RWMC's can be found in section 3 of this guidance.

The formal regulatory process

Compliance

43. Under the following licence conditions the licensee is required to:
 - ensure that no nuclear matter is stored on the site except in accordance with adequate arrangements made by the licensee for this purpose (LC4);
 - make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated (LC32);
 - make and implement adequate arrangements for the decommissioning of any plant or process which may affect safety (LC35); and
 - make arrangements for the production and implementation of decommissioning programmes for each plant (LC35).
44. When assessing such adequacy ONR will refer to the RWMC and take advice from the Environment Agency, NRW or SEPA as appropriate. Where relevant, the RWMC may also be referred to in assessing the compliance with any Licence Condition.

Permissioning

45. The formal regulatory process is shown in Figure 1.
46. If required by the licensee's arrangements or ONR (in consultation with the appropriate environment agency), a project will be subject to formal regulatory submission under Licence Conditions 19, 20, 21, or 22. In most cases involving formal submission, the process will be staged, i.e. there will be arrangements for continuing dialogue and identified hold points beyond which a licensee cannot proceed without regulatory agreement. These formal hold points and the associated timescales are a matter for discussion and agreement between the licensee and ONR, in conjunction with the appropriate environment agency, on a case-by-case basis. At each hold point, ONR will provide a clearly documented decision.
47. The system of agreed hold points aims to provide a staged approach to formal permission, rather than a timetable for interaction with the regulators. Hold points

would normally apply prior to important stages such as adoption of significant changes in HAW management strategy, the start of construction, commissioning, modification or operation.

Timing of the introduction of RWMCs

48. A RWMC should be produced as part of the documentation to be submitted to the regulators for any new radioactive waste management facility, any process producing a new radioactive waste stream, or any modification that affects radioactive waste management.
49. For existing waste management activities where no appropriate RWMC exists, the guidance should be applied at the earliest reasonably practicable opportunity, but no later than during a periodic review of a relevant safety case. In certain cases the regulators may advise licensees to prepare a RWMC at an earlier stage.

Regulatory assessment

50. When assessing proposals, we will refer to the following documents:
 - legislative requirements;
 - relevant parts of this guidance;
 - ONR's Safety Assessment Principles, which are used in helping judge whether reducing risks to ALARP has been achieved;
 - the EA and NRW's Radioactive Substances Regulation Environmental Principles;
 - the Environment Agency's Principles of Optimisation;
 - SEPA's guidance Satisfying the optimisation requirement and the role of Best Practicable Means; and
 - NDA's integrated waste strategy specification²⁴.
51. For issues affecting disposability, the EA or SEPA will assess the proposals and provide advice to ONR and licensees in line with the MoUs. The environment agencies will charge licensees directly for their work through the provisions in the environmental legislation.

Involvement of third parties

The involvement of third parties can aid the regulatory process.

52. Although the prime responsibility for safety and environmental protection lies with the licensee, and the responsibility for regulation lies with the regulators, other bodies should be involved in radioactive waste management. The following bodies should be involved in the collaborative working process, where appropriate:
 - NDA, which has a statutory duty to define a strategy for the decommissioning of nuclear sites for which it is responsible and fund the work done by the licensees on these sites;
 - the Ministry of Defence (MoD), which defines the overall strategy for the sites that it owns and funds the work done there;
 - the operators of radioactive waste disposal facilities, who define the acceptance criteria for waste. These include both the operators of current LLW facilities and Radioactive Waste Management Limited (RWM), as the representative of the HAW disposal facility operator; and/ or
 - other parties who may receive radioactive waste from or send it to the site.

53. The regulators will work with these organisations to achieve high-quality radioactive waste management outcomes.

Stakeholder engagement

Stakeholder engagement at appropriate times is good practice.

54. Other stakeholders such as local authorities, trade unions, non-governmental organisations and the general public have an interest in how radioactive waste on a nuclear site is managed. Licensees should engage with such stakeholders when developing their radioactive waste management strategies, options and plans. This may improve the quality of licensees' proposals and achieve broader acceptance or support.

Regulatory scrutiny during HAW conditioning and storage

55. The regulators will periodically inspect conditioning and storage operations to make sure waste is being managed in accordance with the safety case for the plant concerned and with the individual RWMCs for each waste stream. The regulators will do this by conducting periodic inspections of plant used to manage, package, condition and store the waste. ONR and/ or the appropriate environment agency may undertake these inspections as part of normal regulatory activities, and this may lead to enforcement action under existing regulatory powers. The regulators will focus on the issues described in the remainder of this section, relating to waste that has been conditioned. Similar inspections will be carried out where waste is stored in an unconditioned form and in these circumstances evidence that the waste is being managed in accordance with the requirements of the safety case for the plant concerned will be required.

Operation of appropriate quality management systems

56. The regulators will look for evidence that appropriate management systems are in place to control the production and storage of packages to the required specification, and that these systems are adhered to in practice.

Characterisation of the wastes in each package

57. The regulators will look for evidence that licensees characterise their waste with adequate information and records on the radioactive and non-radioactive inventories in each package, to allow us to assess whether they are likely to be acceptable for final disposal. The regulators will also look for evidence that controls are in place, and working, to ensure that no unacceptable items or materials are contained within the packages produced.

Compliance of packages with specifications

58. The regulators will look for evidence that packaged wastes meet the specifications defined in the safety case for the plant concerned. For packages that do not meet the specifications, we will look for evidence that:
- appropriate actions have been taken to ensure their continuing safe management; and
 - a strategy has been developed to ensure that the wastes can be disposed to an appropriate facility, for example by repackaging in packages which meet the defined specifications.

59. The regulators expect appropriate action to have been taken, or planned, to reduce or eliminate the causes of non-compliant packages.

Facility maintenance and monitoring

60. The regulators will look for evidence that:
- waste is being stored in appropriate conditions to ensure that the acceptability of either the waste for conditioning or the conditioned waste form for interim storage or disposal, is not compromised; and
 - the necessary maintenance of processing and storage facilities (as identified in the safety case for the plant concerned) is being carried out to ensure that waste packages are being produced to specification and that appropriate storage conditions are maintained for the envisaged storage period.

Waste package monitoring

61. The regulators will look for evidence that appropriate arrangements are in place to monitor waste packages to make sure that no significant degradation of the packaged waste is occurring, and that these arrangements are being implemented. Where degradation has been identified, evidence that appropriate actions have been or are being taken to remedy the situation will be required.

Production and maintenance of records

62. The regulators will look for evidence that sufficient data and information on each package (and the component raw waste and means of conditioning) are being recorded and stored so that future safety and environmental assessments can be carried out and so that the wastes remain acceptable for disposal or long-term storage.
63. The regulators will also look for evidence that data and information are recorded in a way which allows access and retrieval over the long time periods that may be associated with the storage of radioactive waste.

Integrated waste strategy

64. The regulators will look for evidence that licensees are optimising their approach to waste management and consider it good practice to develop and use an integrated waste strategy (IWS). Where an IWS has been developed (this is a contractual requirement for NDA sites), the RWMC should describe how the management of the waste stream(s) under consideration is consistent with the IWS.

Oversight of packaging advice for future disposal

The regulators will oversee developments in the approach used to provide packaging advice.

65. The regulators recognise RWM as the appropriate body to provide advice to licensees on the packaging and conditioning for geological disposal of higher activity radioactive wastes. Such advice will continue to be provided through their disposability assessment process. We will update this guidance if we agree any new process.
66. The disposability assessment process consists of series of technical evaluations and safety assessments of waste producers' proposals for conditioning and packaging higher activity radioactive waste. The process results in a Letter of Compliance (LoC) if RWM considers the packaged waste is likely to be suitable for disposal in a future geological disposal facility.

67. We will continue to scrutinise proposed developments of the LoC process under our agreements with RWM to ensure that the advice provided to licensees from RWM is fit for purpose. This enables us to:
- develop our understanding and confidence in the basis for packaging advice;
 - provide opportunities to influence developments;
 - maintain and develop regulatory expertise; and
 - understand and scrutinise modifications to the assessment methodology for particular wastes.

Section 2 Integrated Waste Strategies (IWS)

68. An IWS describes:
- how a licensee optimises its approach to waste management in an integrated way; and
 - the waste streams and discharges expected from current and future operations; and actions to improve the licensee's approach to waste management.
69. In line with UK policy, regulators expect the licensees to produce and maintain an IWS that represents an overview of their approach to the current and future management of all wastes generated on or received by the site(s). The IWS should include all waste related activities on site, ranging from operational through to decommissioning activities, with wastes arising from contaminated land management included. The strategy should not be restricted to the consideration of material that the licensee currently regards as waste; it should include all material that may become waste in the future.
70. An IWS should demonstrate that the waste can be appropriately managed at the time and rate at which it will arise. Regulators and other stakeholders should be involved during the development of the IWS.
71. An IWS should be consistent with relevant good practice and should take account of interdependencies between waste streams and processes. The IWS should link with the licensee's decommissioning strategy and other relevant strategies. The IWS should demonstrate:
- consistency with government policy and regulatory expectations, including the Government's overall policy aims on sustainable development;
 - compliance with relevant legal obligations (e.g. licence conditions and instruments, permits, consents);
 - that the hazards posed by historic wastes are adequately characterised, controlled and progressively reduced;
 - the existence of a strategy in line with relevant good practice for the management of all the wastes over the whole lifecycle of the site;
 - the application of the waste management hierarchy; and
 - that all radioactive wastes on site have been identified and assigned long-term management and/ or disposal routes.
72. The strategies should be adequate to allow licensees to cost their radioactive waste management and disposal liabilities and make appropriate financial provision for meeting them. From a safety and environmental regulatory point of view it is not necessary to set out the costs in the IWS.
73. If a licensee is responsible for a number of sites, then it may be appropriate to produce a corporate strategy supported by a series of site-specific strategies. Consideration should also be given as to how the strategy links to those of other licensees where there may be shared resources or where waste is transferred to or from another licensee.
74. As far as practicable, the IWS should be written to avoid the need for protective or commercial marking; if information requiring such markings is necessary as part of the IWS, then the protectively-marked information should be clearly identified (for example in a separate appendix) so that the rest of the document can be published in an unrestricted form.
75. The IWS should contain sufficient information to be self-standing and wherever relevant, provide links to other more detailed, supporting documents.

76. An IWS should use appropriate and consistent quality assurance arrangements that include criteria and specifications for data and information, taking account of health, safety, environmental and security management systems as appropriate.
77. NDA has produced specifications for integrated waste strategies for application on its sites. The regulators view these as examples of relevant good practice.

Strategic Options Study

78. It is anticipated that a strategic options study would be conducted to identify a strategy for a specific waste stream (or parts thereof); which ensures that opportunities for waste minimisation are maximised as far as is practicable throughout the lifecycle, from operations to decommissioning. Where appropriate, waste reuse and recycling should be given precedence over options for waste disposal. This is considered particularly important when a site enters its decommissioning phase because of the increased potential for solid waste volumes to be generated when materials from contaminated facilities, plant and land need to be managed. A licensee's strategic options study should consider a range of options consistent with the concept of the waste hierarchy, including means for recycling and reuse of the materials, and decontamination and segregation, rather than simply a means for bulk waste disposal.
79. An example of how such a strategic options study may be carried out is given in ¹⁰ and supported by an Industry Code of Practice²⁵.

Section 3 Radioactive Waste Management Cases (RWMCs)

80. This section describes the regulatory expectations with respect to the production, content, maintenance and review of RWMCs, and provides links to further guidance on how the components that support an RWMC may be produced
81. The RWMC should indicate in summary form how the key elements of long-term safety and environmental performance will be delivered for the management of the waste stream or streams covered. (By 'long-term' we generally mean issues that might occur over decades or as wastes are moved from plant to plant for treatment/ storage).
82. The RWMC for a waste stream should cover the period from its generation through conditioning, storage and up to removal from site for eventual disposal. It should provide a complete account of the management of waste streams that cannot necessarily be seen from examination of the individual plant safety cases and environmental documentation. At each stage the aim should be to ensure that radioactive waste is managed in a way that protects the health and interests of people and the integrity of the environment, both now and in the future, inspires public confidence and takes account of costs.
83. The long timescales involved may mean that the RWMC cannot cover all eventualities, and that some aspects may not yet be known. The RWMC should make it clear how such uncertainties are being dealt with and refer to a programme of work, where appropriate, that is designed to address any gaps in knowledge.

Purpose

84. The primary purpose of an RWMC is to provide a transparent demonstration of optimised radioactive waste management for the waste stream(s) covered by demonstrating in written form:
 - compliance with regulatory requirements;
 - compliance with national policy for radioactive waste management;
 - consistency with national and international standards of radioactive waste management; and
 - how interdependencies are taken account of among all steps in the generation and subsequent management of radioactive waste.

The RWMC should demonstrate how operations are integrated with the lifetime plans for the waste and the site as a whole.

85. The RWMC should be used to demonstrate how local plant operations are fully integrated with the lifetime plans for the waste and the site as a whole. The RWMC will be a key input into design considerations of future waste processing and storage facilities, ensuring that such facilities are compatible with the wastes they are intended to receive.
86. The RWMC also provides a means of:
 - providing a context within which changes in plant safety cases should be reviewed;
 - providing information on the operator's understanding and intentions with respect to radioactive waste management;
 - providing a means by which plant operators understand the significance of delivering specific strategies with respect to the safe management of radioactive waste; and

- aiding training and awareness of personnel in the radioactive waste management aspects of the plant.

Contents and structure

87. The RWMC should demonstrate in particular the longer-term safety and environmental performance of the planned management of specific wastes. Appendix 2: Technical contents of a Radioactive Waste Management Case details the information expected to appear in an RWMC and its supporting documentation.
88. Much of the information required for such a demonstration should already be available in other documents, for example the integrated waste strategy and relevant plant safety cases. The RWMC should not duplicate information that can be incorporated through brief summaries and referencing. The added value of an RWMC is a demonstration of how the various components interact together with a description of any necessary arrangements for managing such interactions. In developing an RWMC it may be that gaps are found between the components and these can be addressed either in the RWMC or in the supporting documentation as appropriate.
89. The regulators recognise that plans, and hence detailed supporting documentation, for the long-term management of some waste streams may be less developed than for others. As a living document we expect that an RWMC will be maintained in line with development of waste strategies and plant safety cases.
90. The scope of an individual RWMC is a matter for the licensee. However, in deciding whether an RWMC covers a single waste stream or a group of waste streams the licensee should ensure that the totality of its RWMCs covers all higher activity radioactive waste on its site.

An RWMC may deal with a single waste stream or many similar waste streams.

91. An RWMC should be structured in a logical manner and should contain, in summary form, all the information necessary to fulfil the purpose described in this guidance. This information should be easily accessible and understandable. Where relevant information already exists, this should be specifically referenced, with an appropriate summary within the RWMC.
92. An RWMC, in most cases, will comprise the top tier of a hierarchy of documents. It should describe the radioactive waste management process, present the main issues and the functions required to deliver an acceptable radioactive waste management outcome, explain the means of delivering these functions, and summarise the main conclusions. The arguments presented should be coherent, consistent and readily understood. It should be meaningful if read in isolation, as well as providing the main entry point with clear links to the detailed arguments in supporting safety cases and other documentation.
93. Before reaching its final disposal or storage destination, radioactive waste may be processed and transferred through various plants and facilities on site, each of which will have a nuclear safety case substantiating its safe operation. Certain sections of these plant safety cases may cover (or partly cover) the topics of concern to the RWMC as shown in Figure 2.
94. Detailed technical documents and supporting analysis to substantiate the radioactive waste management functions will be presented in lower tiers, often as components of plant safety cases or other documents. There needs to be an auditable trail within the document structure providing clear referencing to all the information which underpins the conclusions of the RWMC. A description of the expected technical contents is in Appendix 2: Technical contents of a Radioactive Waste Management Case.

95. Licensees may find it useful to include diagrams or flowcharts to identify information and records and that provide key support for the main elements of radioactive waste management such as waste package disposability.

Ownership

96. The licensee shall be responsible for the overall strategy for the management of its waste, taking into account interdependencies between all stages of waste management, and options available, from generation to disposal, and the overall national radioactive waste management strategy. The owner of the waste stream or streams covered by the RWMC should analyse the available options and provide the reasons for the strategy proposed for those waste streams, for inclusion in the RWMC.
97. As the body with prime responsibility for radioactive waste management, and compliance with licence conditions, the licensee has ultimate responsibility for the RWMC. As stated above, some components of an RWMC may reside in plant safety cases and have their own owners, i.e. those who have direct responsibility for delivering safety in the plant in question.
98. Ownership of an RWMC is a different role from ownership of a plant safety case; it is a more cross-cutting role and the licensee's management systems should ensure adequate interaction with the individual plants or processes involved in the radioactive waste management process.
99. Ownership and responsibility require:
- an understanding of the RWMC, the standards applied, its assumptions and the limits and conditions derived from it;
 - the technical capability to understand and act upon the RWMC work produced by others;
 - the ability to use the RWMC to influence operational decisions on individual plant to ensure optimised management of radioactive waste; and
 - that individual project or facility teams should be involved in the preparation of an RWMC to ensure that it reflects operational needs and reality.
100. The ownership of an RWMC may change through its lifecycle. Management of transitions and changes of ownership from earlier to later stages of the lifecycle are important aspects that need to be controlled. The management system should explain how change is controlled, how relevant information and records are transferred, and demonstrate that there are mechanisms in place to ensure that the RWMC is fully adopted and implemented.

Production

It is the responsibility of the licensee to produce and understand the RWMC.

101. The responsibilities for the production, revision, review and document control should be clearly defined as part of licence compliance arrangements and be discharged by suitably qualified and experienced people. Where the licensee itself does not produce all of the RWMC and uses contractors for this purpose, at all times the licensee should possess (in-house) the technical capability to understand its RWMC and act as an 'intelligent customer' (see Technical Assessment Guide: Principles for the assessment of a licensee's 'intelligent customer capability'²⁶).
102. For new waste streams, production of RWMCs should commence at an early stage. The options assessment in the IWS will be the first reference in the RWMC for a new

waste stream and other components will be added as the relevant safety cases are developed. For existing waste streams RWMCs should be produced as soon as is reasonably practicable. The IWS should identify all waste streams and the list of RWMCs should correlate with this. Significant modifications or the periodic review of plant safety cases would be appropriate triggers for producing such RWMCs.

103. Interdependencies are key to an RWMC. As illustrated in Figure 2, some supporting components of a case should already exist as part of the safety and environmental case for the various plants through which radioactive waste passes. It should be clear from the RWMC how interdependencies are taken into account. The supporting components should be reviewed, if necessary amended, and then referenced.
104. The process for producing RWMCs should take into account the needs of those who will use them. It is essential that the documentation is clear and logically structured so that the information and records are readily accessible to those who need to use them both now and in the future (which may be decades away). This includes operations and maintenance staff, technical personnel, senior managers, regulators and future operators of disposal facilities.
105. The process should also take into account how the different levels and types of documentation fit together to cover the full scope and content of the RWMC. The needs of users should be addressed by ensuring that all descriptions and terms are consistent and easy to understand by the prime audience, that all arguments are cogent and coherently developed, that all references are readily accessible, and that all conclusions are fully supported and follow logically from the arguments. The trail from claims through argument to evidence should be clear.

Proportionate approach in the production of RWMCs

106. RWMCs should be produced in a proportionate way. They should be fit for purpose, taking account of, for example:
 - the magnitude of the hazard presented by the waste;
 - the complexity of the operations involved;
 - the degree of challenge posed by the waste streams under consideration;
 - the timescales over which waste management operations will take place; and
 - the consequences of work not being done, or being delayed.

Peer review and independent assessment

107. As part of the production process the RWMC should undergo appropriate review and approval processes to confirm, among other things, that:
 - the case is complete and addresses all relevant aspects of the Part 3 modules;
 - key assumptions in the RWMC and supporting documentation have been validated and subject to a sensitivity check;
 - fit-for-purpose methods and data have been used;
 - that calculations in the RWMC and supporting documentation have been checked for accuracy; and
 - that the plant and operational details documented are consistent with the actual plant and its operations.
108. For significant RWMCs we would expect the licensee's arrangements to provide for the following additional processes:

- independent assessment by suitably qualified and experienced assessors, who are independent of the authors and verifiers and those directly responsible for the plant's operations; and
- consideration by the licensee's Nuclear Safety Committee.

Maintenance

An RWMC should be actively maintained throughout its lifecycle.

109. An RWMC should be:
- easily accessible and understandable by those who need to use it;
 - managed through formal processes; and
 - reviewed regularly on a defined basis.
110. The RWMC needs to be kept up to date with any changes to waste processing or storage arrangements, new regulatory requirements and relevant standards, as soon as practicable after the new information is available and applicable. The knowledge used at the time of writing needs to be supplemented by monitoring of plant and data from commissioning and continued operation, periodic inspection and testing as well as longer-term research or experience from other facilities. Processes need to be in place to make changes that may be needed on an immediate or a longer-term basis. In practice this requires that proposals for changes in design, equipment, storage conditions, waste or spent fuel characteristics, quality assurance, information and records management, or overall control or management arrangements should be subject to a degree of assessment and scrutiny appropriate to the safety significance of the changes, so that the specific and wider consequences of the changes including retrieval and disposal are adequately assessed. The process should ensure that a review of possible consequences of a foreseen modification or change in one facility will not adversely impact on the operability or safety of associated or adjacent facilities.
111. The RWMC should be an evolving document and subject to review where:
- new information comes to light on referenced information and records that underpins analyses and assumptions in the RWMC and its supporting documentation;
 - changes are suggested or new information arises from:
 - operating experience
 - examination or testing results
 - updated design
 - analysis methods
 - research findings
 - the outcome of any reviews of the integrated waste strategy
 - the outcome from major periodic and interim safety reviews (Licence Condition 15) suggests the need for changes; or
 - other sources; and
 - changes arise from degradation over time.
112. Reviews of incidents, operating experience and other sources of information should not be restricted to the facility or site in question. They should include similar facilities or

equipment and also a wider range of nuclear and non-nuclear experience, both national and international.

113. No modification of radioactive waste management plant or processes should take place without a review of the RWMC as described above and the appropriate permits.
114. Documentation which is no longer needed to support a current RWMC, or which has been superseded, should be identified and archived. This information still forms part of the formal historical record, and remains subject to the arrangements made under Licence Condition 6.

Periodic review of safety cases and implications for RWMCs

A RWMC should be subject to periodic review.

115. Licence Condition 15 requires that 'the licensee shall make and implement adequate arrangements for the periodic and systematic review and reassessment of safety cases'. The purpose of this licence condition is to ensure that throughout its life, each plant remains adequately safe and that its safety case is kept up to date.
116. When considering the adequacy of arrangements a proportionate approach as discussed in this document should be applied.
117. Most of the supporting components of a RWMC are part of individual plant safety cases and should be part of such reviews. Arrangements should be in place to ensure that when a supporting component of the RWMC is reviewed as part of a plant safety case review, then this should be in the context of the whole RWMC.
118. Additionally the RWMC as a whole should be periodically reviewed to ensure that it remains valid and that modifications to its supporting components have been fully considered in the context of the overall radioactive waste management process. Such reviews should be proportionate, being sufficient to verify that changes over time have not adversely affected the validity of the RWMC. They should be planned in the context of the reviews of the component parts, but should be undertaken no less often than every ten years.

Section 4 Waste Minimisation, Characterisation and Segregation

119. The successful implementation of a radioactive waste management strategy requires that several activities are planned, undertaken and reviewed. Among these activities waste minimisation, characterisation and segregation are key to establishing and updating a radioactive waste inventory, applying the waste management hierarchy and optimising waste management.
120. Opportunities for waste minimisation, characterisation and segregation should be considered in all stages (basic steps) of waste management, including design, construction, operation, decommissioning, storage and disposal (Figure 3).
121. For the purposes of this guidance, waste minimisation, characterisation and segregation are discussed as separate activities, but in reality form part of an integrated process for management of waste streams.

Minimisation

122. Minimisation of waste (both in terms of volume and activity) is fundamental good practice in radioactive waste management. It should be considered during the design of facilities and applied during all of the basic steps. Effective methods of minimising the accumulation of radioactive waste include the clearance of waste that is exempt from regulatory control and the reuse or recycling of radioactive material.
123. Minimisation is an important initial step in waste management and, therefore, licensees' procedures should seek to design, construct, operate and decommission plant in such a manner that both the waste volume and radioactivity are minimised.

Characterisation

124. Characterisation of radioactive waste involves determining its physical, chemical, biological and radiological properties. Radioactive waste should be characterised at appropriate stages to determine the best method of managing the waste, for moving the waste between steps and for establishing records of the waste properties.
125. Waste characterisation should also form an integrated part of an overall waste strategy in support of the management of waste throughout its lifecycle. The drivers for the characterisation may differ throughout the lifecycle but the overall purpose should be to support the long-term management option (e.g. disposal). However, at each stage characterisation activities should be undertaken for a specified purpose with cognisance of the next stage and later stages in the lifecycle.
126. With regard to planning an overall waste characterisation strategy, the International Atomic Energy Agency's (IAEA's) Strategy and methodology for radioactive waste characterisation²⁷ notes that activities in the various stages of the lifecycle may have significant effects on the cost and efficiency of the overall characterisation programme, in that:
 - characterisation is generally much easier and cheaper in the earlier stages of the lifecycle e.g. waste properties that could easily be measured in the raw waste state may be difficult or impossible to measure after some treatment stages, particularly after conditioning has been undertaken;
 - if waste streams are appropriately segregated and controlled early in the lifecycle, then a greater proportion of the wastes may fall into the simple and stable waste type; and
 - whereas if raw waste streams are mixed and valuable history lost, more of the waste will fall into the complex and variable type, requiring more intensive and costly characterisation.

Segregation

127. Segregation is an activity where types of waste or material (radioactive or exempt) are separated or are kept separate based on radiological, chemical and/ or physical properties, to facilitate handling and/ or processing and/ or disposal.
128. Segregation of waste materials at source provides an efficient means of managing wastes in relation to their hazard. A mixed waste stream may prove more challenging to manage and may have options foreclosed when compared to segregated waste materials.

Waste minimisation

Radioactive waste should not be unnecessarily created, and generation and accumulation of radioactive waste should be minimised.

129. Waste minimisation is central to government radioactive waste management policy and is recognised in international guidance as a fundamental principle of radioactive waste management²⁸. Waste minimisation is also a regulatory requirement:
- Licence Condition 32 requires the licensee to make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on site; and
 - The standard EPR16 permit and EASR18 permit conditions require waste to be minimised.

Waste minimisation is fundamental to radioactive waste management.

130. Steps should be taken to avoid the unnecessary creation of radioactive waste and to minimise the production and accumulation of those wastes that are created, in terms of both the activity and volume. Minimising the generation of waste contributes to effective waste management and reduces the risks arising from such waste.
131. Waste minimisation and control of waste should be taken into account at all stages in the lifecycle of a facility, starting at the planning and design stage through to operation, decommissioning and site clearance. This will require developing commissioning, operational and decommissioning arrangements that avoid the creation of radioactive waste or reduce to the minimum radioactive waste generated during the lifetime of the facility.
132. Useful strategies for waste minimisation include:
- reducing the volume of radioactive waste to be managed through segregation and by keeping non-radioactive material out of controlled areas to prevent contamination;
 - the proper planning of activities and the use of suitable equipment for handling waste so as to control the generation of secondary waste;
 - the decontamination of material, together with the control of secondary waste arising from decontamination; and
 - the recycling and reuse of materials and structures, systems and components.
133. Reducing radioactive waste at source is an important means of waste minimisation. Consideration should also be given to the design of the facility and to operational features for waste minimisation. This includes the following aspects:
- the careful selection of materials, processes and structures, systems and components for the facility;
 - the selection of design options that favour waste minimisation when the facility is eventually decommissioned;

- the use of effective and reliable techniques and equipment;
- the effective containment of radioactive waste and minimisation of contamination; and
- the decontamination of zones and equipment and the prevention of the spread of contamination.

Waste hierarchy

Licensees should manage their waste in accordance with the principles of the waste hierarchy.

134. The waste hierarchy is a stepwise approach to achieving waste minimisation to promote sustainability that considers the lifecycles of both the processes that create waste and the waste that is produced from them. The hierarchy, as set out in the latest European Directive 2008/ 98/ EC on Waste (the Waste Framework Directive)²⁹ encourages the adoption of options for managing waste in the following order of priority:
- **Prevention:** Creation of waste should be prevented, or reduced at source (i.e. minimised), as far as possible to secure the conservation of nature and resources, in particular waste that cannot be managed using current techniques, or techniques under current development;
 - **Preparing for reuse:** Where waste cannot be prevented, waste materials or products should, where appropriate, be reused directly or refurbished then reused;
 - **Recycling:** Waste materials should be recycled or processed into a form that allows them to be reclaimed as a secondary raw material, where appropriate; and
 - **Disposal:** Only if waste cannot be prevented, reused, recycled or recovered should it be disposed of into the environment and this should only be undertaken in a controlled and authorised manner.
135. These principles have been adopted in the UK government policy on LLW management³⁰. The regulators consider that, so far as is reasonably practicable, they should be applied during the planning, design, construction, manufacture, commissioning, operational and decommissioning stages of a facility. Applying the waste management hierarchy to radioactive waste generally requires:
- not creating waste where practicable;
 - reducing waste arisings (both by activity and by volume) to the minimum through the appropriate design and operation of processes and equipment and making effective use of techniques such as waste characterisation, sorting and segregation, volume reduction (e.g. by supercompaction) and surface contamination removal;
 - otherwise minimising quantities of radioactive waste requiring disposal through decay storage, reuse and/ or recycling, and incineration (under appropriately regulated circumstances); and
 - disposal.
136. The objective should be to deal with potential arisings at the highest practicable level of this hierarchy, for example, reducing waste arisings should take precedence over disposal. Avoiding the creation of radioactive waste in the first instance and, secondly, minimising the generation of unavoidable waste is one of the foremost principles of good waste management.
137. A further option – ‘other recovery (e.g. energy recovery)’ follows ‘recycling’ in the standard waste hierarchy. This is rarely an option in dealing with radioactive wastes

and has therefore not been included in the list above. However, this option should be considered where applicable.

138. In applying the waste hierarchy, options should be selected that deliver radiation exposures to workers and members of the public that are as low as reasonably achievable/ practicable (ALARA/ ALARP) over the entire lifecycle of the waste. This may require specific waste streams departing from the hierarchy where this is substantiated by lifecycle thinking on the overall impacts of the generation and management of such waste.
139. It is recognised that there are limitations to the application of the waste hierarchy in the management of legacy wastes. For example, avoidance of waste creation does not apply to radioactive wastes that have already been created as a result of historical activities. In such cases, avoidance should be considered in respect of any secondary wastes which might arise during the storage, treatment and conditioning of the legacy wastes.

Minimisation of both activity and volume

Generation of primary and secondary radioactive waste should be kept to the minimum that is reasonably practicable, in terms of both its activity and volume.

140. As far as reasonably practicable, radioactive waste should be reduced at source. Waste minimisation should take account of the volume and activity of radioactive waste generated and any secondary waste arising from subsequent treatment and conditioning of that waste. Useful strategies for waste minimisation include:
 - reducing the volume of radioactive waste to be managed, by suitable segregation;
 - planning of activities and the use of suitable equipment for handling waste, so as to control the generation of secondary waste;
 - decontamination of material, together with the control of secondary waste arising from decontamination; and
 - recycling and reuse of materials and structures, systems and components.
141. The chemical and physical characteristics of the waste should also be controlled at the source to facilitate subsequent processing and help minimise production of secondary waste. Factors that should be considered in judging what is reasonably practicable include the magnitude of radiological hazard, the potential for the hazard to be realised, the potential dose uptake and the cost.

Waste minimisation through continuous improvement

Waste minimisation should be maintained in operating plant through continuous improvement.

142. At an operating plant, there remains considerable potential for significant reductions in radioactive waste generation through the application of relevant waste minimisation practices. It is acknowledged that significant design changes to operating facilities to minimise radioactive waste arisings may not be a cost-effective option. Nevertheless, reviews of operational processes and implementation of improvements can lead to waste minimisation benefits.
143. Waste minimisation can be achieved through a process of continuous improvement initiated by a commitment from senior management as part of the licensee's policy on radioactive waste management. The continuous improvement programme needs to commit adequate resources to waste minimisation, for example by setting up a dedicated team tasked with identifying and ranking waste generation practices and

reviewing and feeding back into operational procedures. This should be linked to objective performance measures and tracking of performance.

Problematic wastes and waste forms

Waste minimisation should be applied to limit the production of problematic wastes and waste forms.

144. Wherever practicable, waste minimisation should be applied to ensure that production of problematic wastes and waste forms is kept to a minimum. Problematic wastes and waste forms might include those that have no obvious disposal route or are difficult to convert to a passively safe form for storage due to a high reactive organic or reactive metal content.

Record keeping

Good information and records management should aid demonstration of waste minimisation.

145. Recording quantities and activities of different waste streams provides the basis for monitoring the effectiveness of radioactive waste minimisation measures. Trends in radioactive waste generation should be monitored and the effectiveness of applied waste minimisation measures demonstrated. There should be regular reviews of opportunities for further reduction of radioactive waste arisings. See section 7 on records management for additional information.

Environmental management system

Waste minimisation should be part of an environmental management system.

146. Waste minimisation forms part of the objectives of an environmental management system. Accreditation to an appropriate standard may be used as an indication of commitment to waste minimisation. At the time of writing the following British and International standards provide core information for environmental management systems³¹.

Waste characterisation

A quality assured framework for characterisation

Waste should be characterised within a quality framework using the best available techniques.

147. A systematic approach to waste characterisation should be adopted in order to acquire data that are sufficient to support waste management decisions throughout the waste lifecycle. This might be achieved, for example, by adopting an approach based on Data Quality Objectives, which define the quality and quantity of data that are required in the decision context (e.g. the Data Quality Objectives process developed by the US Environmental Protection Agency³², provides a systematic, stepwise approach to the collection of data to support waste management decisions and has been applied to waste characterisation programmes.)
148. An important aspect is finding the balance between the impacts and cost of data gathering and the effects of uncertainties in data on the resulting decisions. It is particularly important to ensure that the resources are committed only in situations where the output will provide net benefits.

149. A strategy for waste characterisation covering the stages from raw waste retrieval to the production of conditioned waste for storage and disposal should be developed by the waste producer. The characterisation programme should be supported, where practicable, by a suitable waste sampling plan that is designed to provide a statistically robust data set. Where comprehensive sampling and characterisation is not practicable, for example due to dose considerations, this should be explained and arguments should be presented as to why any alternative approach is considered appropriate.
150. Appropriate quality assurance arrangements should be adopted throughout the waste characterisation process and beyond to ensure records retention and knowledge management. This should encompass appropriate method development and documentation, staff training, and verification and validation of measurements. Ultimately, the aim should be to ensure that all resulting characterisation data are fully traceable and underpinned.
151. A wide range of approaches to waste characterisation are possible and use should be made of appropriate regulator endorsed industry codes of practice. In general, preference should be given, where practicable, to direct measurement and determination of waste characteristics. This might be achieved using destructive and/or non-destructive techniques applied either in situ or using retrieved waste samples.
152. Where practicalities dictate, reliance may also be necessary on other lines of evidence, such as knowledge of the provenance and history of the raw waste (where supported by records), knowledge of waste evolution during storage, the use of simulants and modelling techniques. Whatever approach is adopted, it should provide corroborated data with suitable uncertainty bounds that are sufficient to demonstrate that the waste meets the relevant waste acceptance criteria. The waste characterisation approach and procedures should be appropriately documented and subject to checking via an independent party (e.g. audits of licensee arrangements, accreditation of operator methods, independent check monitoring).
153. Characterisation information and records generated by the waste producer may be used by other organisations that subsequently handle, treat, store, transport or dispose of the waste and also by the regulatory bodies. Any characterisation data and any associated information and records need to be appropriately managed (refer to section 7) and may eventually need to be passed on to other organisations, for example the duty holders of future waste facilities.

Characterisation for subsequent management and disposal

154. Development of an IWS is contingent upon the availability of information relating to the nature and quantity of wastes. The radiological, physical, chemical and biological properties of waste should be known in sufficient detail so as to provide a sound foundation for its safe and effective management from generation through to disposal. Waste characterisation will be required, for example, to inform decisions about the design, operation, maintenance and decommissioning of facilities; handling, storage, processing and transport of radioactive wastes; remediation of contaminated land; and the disposability of wastes.

Waste should be characterised so as to inform decisions about its subsequent management and disposal.

155. Waste characterisation information will be required at an early stage to support any optioneering studies and to ensure that the waste management hierarchy can be applied appropriately. The characterisation challenge for a given waste stream may vary depending on the nature of the waste and the waste conditioning method that is selected. Characterisation information and requirements might usefully discriminate between options for the future management and disposal of that waste.

156. While adequate waste characterisation is essential, unnecessary over characterisation resulting in inappropriate cost, occupational radiation exposure and secondary waste generation should be avoided. Provision should be made at the earliest stage for identifying, assessing and dealing with radioactive waste that does not meet existing process specifications or disposal criteria.

Inventory

Radioactive waste should be identified and an appropriate inventory established, properly documented and maintained.

157. An inventory should be established and properly documented for each waste stream. Inventory data should be reviewed periodically and kept up to date.
158. The establishment and maintenance of a radioactive waste inventory by waste producers is required for a number of reasons, in particular:
- to assist the waste producer in planning waste management by providing underpinning data for lifetime plans and integrated waste strategies;
 - to assist in the maintenance of a UK radioactive waste inventory³³ which can be used by those government departments and agencies involved in radioactive waste management strategy, regulation and the NDA, which is responsible for the development of long-term management solutions for these wastes; and
 - to assist the UK in fulfilling its requirements under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management^{34, 35}.

Characterisation from generation through to disposal

Waste should be characterised at appropriate stages from generation through to disposal.

159. Characterisation should be carried out:
- where there is a lack of sufficient information or knowledge to support the RWMC and where further information is required to support subsequent phases of management;
 - where information might be out of date or where there is the potential for significant impairment to the safety case as a result of changing waste properties;
 - for quality assurance or checking; and
 - at stages when useful information can be obtained that might otherwise be lost.
160. Characterisation data may be gathered on a progressive basis through the relevant stages of waste management, but there should be sufficient confidence at each stage to support decisions. Characterisation opportunities are perhaps greatest at the time of raw waste generation (i.e. characterisation at source). Characterisation opportunities may be limited for existing wastes, although opportunities may arise at the time of raw waste retrieval for subsequent conditioning.
161. Where waste is being conditioned, it should be sufficiently characterised to inform subsequent decisions about its suitability for disposal. Detailed characterisation is likely to be problematic following waste conditioning, and non-destructive techniques may be of limited utility. Significant package reworking may be required if detailed characterisation is required following waste conditioning and such situations should be avoided

162. Certain wastes (raw or conditioned) might evolve or degrade over time. Understanding such effects, the implications, and any necessary mitigation is important. This should inform, and be informed by characterisation and waste management activities.

Radiological, physical, chemical and biological properties

Radioactive waste should be appropriately characterised in terms of its radiological, physical, chemical and biological properties.

163. Waste characterisation should yield sufficiently accurate and precise information with regard to the radiological, physical, chemical and biological properties of the waste to support the RWMC, including the anticipated requirements for transport and disposal in so far as these are known.
164. Waste characterisation information should encompass the following:
- a) Radioactivity**
165. The radioactivity content of the waste should be known with sufficient accuracy and precision to meet any limits defined within the relevant RWMC, in order to meet any existing Waste Acceptance Criteria (WAC) and those of any facilities to which the waste will be directed, in so far as these are known.
166. As a minimum, the radioactivity content of the waste should be known to the extent that it can be robustly classified in terms of the waste category (i.e. as exempt waste, LLW, ILW or HLW). Knowledge of the radioactive properties of the waste will assist in assessing whether decay to a lower waste category is possible within a reasonable timescale, and therefore inform decisions on its future management and disposal.
167. The requirements may extend to defining the activities of specific radionuclides that are significant to the safety case, either at the individual package or waste stream scale. At the time of waste transport and disposal, knowledge of the radioactivity content of individual waste packages will need to be sufficient to meet the appropriate safety case requirements and WAC for the intended disposal facility.
- b) Dose rate**
168. Dose rates should be known in sufficient detail to indicate compliance with the RWMC. Package external dose rates should be known so that compliance with the limits for facilities and equipment in which they will be handled, stored and/ or transported can be demonstrated. Where shielding has been identified as a means of restricting dose, it should be effective under all operating conditions.
- c) Surface contamination**
169. For conditioned wastes, the amount and extent of any non-fixed surface contamination should be known. Suitable and sufficient decontamination provisions should be provided to meet the relevant safety case requirements. Transferable radioactive contamination on the exterior of the waste packages should be maintained within limits established for the storage, transportation, and packaging facilities where these wastes are to be handled.
- d) Fissile content**
170. For wastes containing fissile matter the nature and quantity of the fissile materials, and any other waste components that may influence the neutron reactivity of the system (e.g. neutron moderating or absorbing material), should be known in sufficient detail to enable assessment of the criticality hazard and to facilitate safe management, safeguards and disposal arrangements. Waste package fissile limits are discussed specifically and in greater detail in section 5 (waste conditioning) of this document.
- e) Chemical properties**

171. The bulk composition and chemical properties of the waste should be understood to the extent that any chemical hazards or challenges posed by the waste can be assessed. Specific information with regard to the following will be required, where applicable:
- organic components: this should include organic components that present a hazard based on their inherent toxicity, might degrade/ decompose to yield gases (such as carbon dioxide, hydrogen and methane), might be radioactive, explosive or present a flammability hazard, might influence the neutron reactivity of the system (e.g. effective neutron moderators), or which might degrade to form species which can enhance or promote the mobility of radionuclides in the disposal environment;
 - reactive components: any waste components that might be expected to react within the waste matrix or within the container should be identified, such that any threat posed to the integrity of the conditioned waste can be assessed. Reactive components might include metals that may react with the waste matrix (forming reaction products causing expansion of the waste form and disruption of the waste package), gases which may be radioactive and/ or flammable, ion exchange resins that may react with the waste matrix (causing expansion and disruption of the waste package), graphite which may have associated Wigner energy, materials which may significantly influence the pH of the waste form and any materials that may challenge the integrity of the waste container via chemical reactions in the long term;
 - explosive, flammable, combustible, corrosive and pyrophoric materials: any such components should be identified. This extends to any waste components which might evolve to form materials with such properties in the long term; and
 - the presence of any materials that would be classed as dangerous goods for transport purposes or material covered under the Hazardous Waste (England and Wales) Regulations³⁶ and the Special Waste (Scotland) Regulations³⁷ and their amendments.

f) Physical properties

172. The bulk physical properties of the waste should be understood to the extent that any risks posed by the waste can be assessed and such that compliance with any related safety case limits can be demonstrated. Such information might be required, for example, to support any waste handling and stacking operations.
173. Knowledge of the following physical properties might be required:
- the physical dimensions and weight of the waste;
 - the physical form of the waste e.g. homogeneity, morphology, grain size, mechanical properties, strength, dimensional stability and resistance to physical stress (e.g. impact resistance);
 - the presence of any mobile, volatile, readily dispersible, leachable or respirable fractions;
 - the presence of any free liquids or pressurised gases;
 - the thermal power output of the waste (including any radiogenic and chemical heat) and its thermal properties (e.g. thermal conductivity) and thermal resistance (e.g. fire resistance, freeze/ thaw stability); and
 - radiation damage resistance/ stability.

g) Biological properties

174. The biological properties of the waste should be understood in terms of:

- The presence of substances within the waste, which through microbial degradation might result in the production of significant volumes of gas and/ or acidic species. This would extend to the presence of any significant quantities of putrescible matter;
- The possibility that the waste will promote and/ or support microbial-induced corrosion of metallic containers; and
- Any specific biological hazards, such as might occur via the presence of pathogenic or infectious species. This is likely to be relevant only to contaminated medical wastes.

Waste segregation

175. Segregation of radioactive waste involves accumulating together those materials with similar characteristics, and avoiding mixing wastes with different characteristics. The IAEA Safety Glossary³⁸ defines segregation as “An activity where types of waste or material (radioactive or exempt) are separated or are kept separate on the basis of radiological, chemical and/ or physical properties, to facilitate waste handling and/ or processing.”

So far as is reasonably practicable, radioactive waste should be segregated to facilitate subsequent safe and effective management.

176. Emphasis should be placed on the segregation of different types of waste to reduce the volume and specific activity of radioactive waste, and facilitate its management and eventual disposal. Specific drivers for waste segregation might include:
- facilitating application of the waste management hierarchy by enabling free-release, reuse, recycling or reclassification to more easily disposed radioactive waste;
 - separation of short-lived wastes to enable decay storage
 - removal of items which need special treatment;
 - removal of items that do not conform to WAC for those facilities where the waste is to be managed or disposed of;
 - separation of waste materials that may react together to challenge the integrity of the wasteform or container significantly;
 - categorisation of waste into various waste streams, which are similar in terms of their properties, conditioning requirements and/ or management arrangements; and
 - simplification or facilitation of particular waste management operations.

Early and appropriate segregation can contribute significantly to the safe and effective management of radioactive waste.

177. Segregation is most efficient if it is taken into account at the process design stage and any opportunities for waste segregation should be an important consideration. Waste segregation should be performed as close to the point of generation as is reasonably practicable. Early and appropriate segregation can contribute significantly to the effective and safe management of radioactive waste.
178. There may be cases in which waste segregation may offer potential benefits but is not pursued in practice, e.g. due to it being impractical and/ or disproportionately costly. In such cases, the RWMC should substantiate why waste segregation is not being pursued.
179. Mixing of wastes need not be precluded where this can be shown to provide net benefits in terms of health, safety and environment. Dilution solely for the purposes of

re-categorisation to a lower category, however, should be avoided (e.g. deliberate mixing of ILW with inactive or lower activity waste to yield a larger volume of LLW).

180. Where segregation is to be pursued, the RWMC should demonstrate provision of suitable and sufficient design features, locations, equipment and arrangements to support segregation operations.

Section 5 Waste Conditioning and Disposability

Waste Conditioning

Wastes should be conditioned to yield products that are passively safe, transportable and ultimately disposable.

181. Waste conditioning involves transforming radioactive waste into a form suitable for handling, transportation, storage and disposal. Conditioning may include some or all of the following stages: the conversion of the waste to a solid wasteform, enclosure of the waste in containers and, if necessary, provision of an overpack. For brevity 'conditioning' is used in this document to include all stages of the process, except where it is necessary to refer to one of the stages specifically.
182. Conditioning may be accomplished in a single stage (e.g. within one facility) or may be achieved through multiple stages. Where a multi-stage conditioning route is chosen risks and environmental impacts during and between all stages should be reduced so far as is reasonably practicable and should be appropriately balanced. Each stage should generally give an overall improvement (e.g. improved containment and/ or passive safety of the waste). Any conditioning process should take account of and not compromise the envisaged downstream management/ disposal arrangements (e.g. acceptance criteria for stores).
183. At all stages of waste management the aim should be to ensure that radioactive waste is managed in a way that protects the health and interests of people and the integrity of the environment, both now and in the future, inspires public confidence and takes account of costs.
184. Waste conditioning should yield waste packages that are:
 - passively safe and suitably robust physically, so as to ensure containment and safe handling during any future periods of storage. The aim should be to minimise the need for active safety systems, monitoring or human intervention whilst the waste remains under institutional control;
 - suitable for safe transport through publicly accessible transport routes in compliance with the relevant waste transport regulations. In this regard the waste packages may themselves be approved transport containers or may be of a design which facilitates transport in approved, preferably reusable, transport containers/ flasks; and
 - disposable, such that the nature and properties of the conditioned waste product are compatible with the anticipated standards for eventual disposal e.g. WAC of an appropriate disposal facility.
185. A wide range of technical, engineering and management considerations are relevant to waste conditioning programmes, to ensure that the conditioned waste products are fit for purpose. Relevant considerations include, but are not limited to, the following:
 - the nature of the waste and its characterisation (related aspects are covered in the previous section);
 - when to condition the waste;
 - whether the activity associated with the waste needs to be immobilised within the waste container and, if so, the method of waste immobilisation;
 - the design, manufacture and quality assurance of the waste containers to be used;

- the conditioning process, including the relevant plant specifications, design and operation, to ensure the production of 'fit for purpose' conditioned waste products;
- understanding potential evolution or degradation mechanisms, the implications and any necessary mitigation;
- interim storage and monitoring arrangements for the conditioned wastes (related aspects are covered in section 6 of this guidance);
- quality assurance arrangements over all stages of waste management until disposal; and
- waste package records and their long-term retention (related aspects are covered in section 7 of this guidance).

Wastes should maintain their safety function throughout the anticipated storage period including as appropriate, after emplacement in a disposal facility.

186. Conditioned waste packages perform a number of important safety functions including:
- Containment of the radioactive inventory during normal operations and accident conditions;
 - Shielding during transport and storage (particularly important for packages that will be transported without over-packs and/ or stored in unshielded stores);
 - Facilitating handling through incorporation of lifting features;
 - Allowing stacking, during interim storage and emplacement in a disposal facility;
 - Allowing packages to be clearly identified and traceable , by using unique markings;
 - Preventing pressurisation through control of the physical and chemical inventory and/ or by incorporation of filters, seals or vents; and
 - Maintaining sub-criticality.
187. Waste packages should maintain their safety functions throughout the anticipated storage period including, as appropriate, after emplacement in a disposal facility. During storage on nuclear licensed sites, waste producers will be expected to monitor waste packages to demonstrate that these safety functions are not being threatened or compromised (see section 7 on storage).

When to condition waste

Wastes should be conditioned to a safe, passive, transportable and disposable form as soon as is reasonably practicable.

188. Our expectation, consistent with Government policy, is that raw wastes will be conditioned to a safe and passive form as soon as is reasonably practicable, unless an alternative strategy has been identified and underpinned as part of an integrated waste strategy (e.g. decay storage). The aim should be to avoid raw waste accumulation, such that new wastes should be conditioned as they arise, where practicable. The regulators expect that full and timely use will be made of any routes for the disposal of radioactive waste once they become available.
189. We recognise that there may be specific drivers for conditioning where, for example:
- wastes are held in deteriorating facilities and retrieval is necessary;
 - existing waste storage arrangements need to be improved;
 - provisions can be made to condition the waste as it arises and the accumulation of raw wastes can be prevented;

- conditioning plant is available that has the capacity and functionality to condition the waste, thus providing an opportunity for appropriate, timely and cost effective waste conditioning; and
- a disposal route already exists and waste requires conditioning to facilitate safe transport to the disposal site and to meet the waste acceptance criteria at the disposal facility.

Waste conditioning approaches

The Licensee should appraise the available options to ensure that the conditioning approach chosen is demonstrably optimised for radiological protection of workers and the public.

190. Council Directive 2013/59/EURATOM, Article 5(b)39 requires that the management of radioactive waste is optimised, so that all resulting exposures to ionising radiation of any members of the public and of the population are kept as low as reasonably achievable (ALARA), taking into account economic and social factors. This requirement is enacted in England, Wales and Scotland by a number of statutory instruments, including the Ionising Radiation Regulations 201740 (IRRs17) and the Radiation (Emergency Preparedness and Public Information) Regulations 201941 (REPIR 19).
191. The environment agencies have published guidance on the principles of optimisation in the management and disposal of radioactive waste. The optimisation requirement applies not only to the conditioning process itself, but throughout the lifetime of the conditioned waste package. To decide which conditioning process to use, the licensee should identify the available options and choose the one which best meets the optimisation requirement for the radiological protection of workers and the public, both during and after conditioning.
192. We expect the licensee to use an options assessment process which follows the environment agencies' guidance. The process should be robustly supported by well informed and substantiated decision-making, be open to scrutiny by regulators and by other stakeholders, and take account of, amongst other things:
 - possible imbalances or biases in the information that supports competing options;
 - optimisation constraints such as secondary waste generation, practicality, reliability, cost and wider social and economic factors;
 - uncertainties in the:
 - performance of the conditioning process
 - capability of conditioned waste packages to withstand the anticipated storage environment
 - future handling and transport requirements up to the time of disposal
 - eventual disposal site, including WAC; and
 - information from the operator or prospective operator of the relevant disposal facility about the disposability of the waste conditioned in accordance with each available option; and about the length of time relevant parts of the facility might remain open after emplacement.
193. The overall conditioning process should be technically underpinned and this may require programmes of experimental and developmental work and/ or reliance on established knowledge and operational experience. Development work may need to include both inactive and active development trials, which may include both small-scale (laboratory) and full-scale trials (e.g. on development rigs or plant prior to active commissioning). The combined development programme will need to demonstrate that

the conditioning process will produce fit-for-purpose, quality-assured waste products and that the process can accommodate any potential variations in waste feeds.

Preparing wastes for conditioning

The need for, and benefits of, waste pre-treatment processes prior to conditioning, should be evaluated.

194. For some wastes e.g. those with a high degree of homogeneity, it may be appropriate to condition the raw waste directly with minimum pre-treatment or sorting and segregation. However, this will not be appropriate for all wastes.
195. Sorting and segregation of wastes should be adopted, where practicable, if this provides:
 - a net benefit in terms of radiological risks overall; or
 - significantly reduces HAW disposal volumes; or
 - significantly reduces risks and/ or uncertainties for future waste management.
196. The need for, and benefits of, waste pre-treatment processes (e.g. drying, dissolution, incineration, pyrolysis or super compaction) prior to conditioning, should be evaluated by the licensee as a part of the overall options appraisal process. Waste pre-treatments should be implemented if they are needed, or are practicable and can be shown to provide a net benefit. In particular, pre-treatment should be considered for the purpose of:
 - removing or suppressing chemical reactivity or biological degradation within the waste that could present a challenge to its long-term management and eventual disposal;
 - drying wastes (particularly if containerisation without immobilisation is pursued) to minimise the risk of corrosion and gas generation; and
 - enabling reduction in conditioned waste volumes or activities.

Waste immobilisation

The immobilised wasteform provides an important contribution to the waste package performance.

197. Immobilisation of readily mobilised or dispersible waste is usually achieved by conversion of the raw waste into a solid wasteform as a part of the waste conditioning process. Immobilisation will generally be required for wastes that contain free liquids, slurries, sludges or readily dispersible particulate material. In particular, free liquids should be eliminated and, ideally, readily dispersible material fixed, eliminated or minimised. The resultant wasteform then contributes to the overall waste package performance and package safety functions. For example, immobilisation may yield wasteforms that in themselves provide a containment barrier and also provide structural support. Both the performance of the wasteform and the container need to be considered as constituents of the waste package.
198. The immobilisation process should be selected by the licensee as part of the overall options appraisal, on the basis of the properties of the waste to be treated and the hazard that it presents. Examples include dewatering, encapsulation in a suitable matrix (e.g. composite cement, thermosetting polymer), vitrification or conversion to a ceramic form. Following immobilisation, the resulting wasteform should be shown to restrict the movement of radioactive and hazardous waste constituents as expected.

199. Where wastes are not to be immobilised, the licensee should demonstrate that the waste container will provide sufficient containment at all times so as to ensure safety during all operations, transport, storage and disposal, during both normal and accident scenarios. Consideration should also be given to the possibility of any constituents of the waste becoming mobile during storage (e.g. through reactions to yield powders, gases or to generate liquid phases from the degradation of organic matter). Appropriate measures should be taken to avoid or minimise the possibility of such effects.

Wasteforms

200. The properties of the wasteform^b are a significant factor in determining package safety, particularly with respect to the potential for migration and/ or dispersion of waste constituents. Its performance should be evaluated for handling, transportation, storage and disposal under both normal and accident conditions.
201. Wasteforms should typically:
- contribute, as far as is practicable, to the retention of radionuclides and hazardous waste constituents under both normal and accident conditions during handling, transportation, storage and disposal. The risks to the health and safety of the public or workers from normal and potential accident scenarios should be optimised and reduced so far as is reasonably practicable;
 - contribute to meeting the requirements of the waste transport regulations;
 - exhibit and retain sufficient mechanical strength as required for safe handling, stacking and transportation;
 - contain minimal voidage, as far as is practicable;
 - contain minimal free liquids, as far as is practicable;
 - be stable against physical, chemical and biological degradation, such that they evolve only slowly under normal conditions, as anticipated during storage, transport and disposal. Any deleterious reactions which may pose a threat to package performance should exhibit very low reaction rates such that any resulting impacts are avoided or can be safely managed;
 - not undergo extensive dimensional changes or cracking, and should not allow the formation of significant quantities of gas, liquid or expansive solid secondary products if these might compromise safety or result in significant environmental impacts; and
 - be suitably resistant to the expected thermal and radiation environments such that any degradation will not compromise the safety case.
202. Wasteforms will also contribute to the overall performance of the eventual disposal facility and should ideally:
- exhibit good resistance to leaching and low solubility in groundwater;
 - be homogeneous (as far as is reasonably practicable), so as to minimise any local effects within the wasteform and provide a better basis for assessment of likely performance over time; and
 - evolve in a controlled manner, such that their long-term behaviour can be more readily assessed.
203. Waste container integrity could be threatened by corrosive constituents of the wasteform or by by-products of reactions occurring within the wasteform. Wastes and

^b In the case of wastes that are not encapsulated or immobilised (e.g. containerised raw wastes that are intended for direct disposal) the waste itself constitutes the wasteform.

wasteforms should not contain or give rise to materials that might significantly threaten the integrity of the waste container.

Waste containers

Waste containers should incorporate suitable design features to ensure the safety functions required are maintained for package handling through the successive phases of waste management.

204. The waste container should provide appropriate containment of the waste through all phases of waste management, consistent with the relevant safety cases required. The container materials should be chosen to provide the necessary performance for the envisaged storage and disposal environments, for the required periods.
205. Waste containers should incorporate suitable design features to ensure the safety functions required are maintained for package handling through the successive phases of waste management, including off-site transport and eventual disposal. There may be significant advantages in adopting standardised, fit-for-purpose container designs.
206. Where gas generation is anticipated, containers should be designed appropriately e.g. to include features to avoid over-pressurisation (e.g. gas vents) but to retain particulates (e.g. filters in the gas venting system).
207. The waste container, including any integral handling or lifting features, should be suitably resistant to processes that could adversely alter material properties and cause early failure. For metallic containers this should include resistance to general and local corrosion mechanisms (e.g. pitting or crevice corrosion) and stress corrosion cracking under the envisaged storage conditions.
208. Corrosion resistance might be achieved through an appropriate combination or choice of materials, suitable storage conditions, protective coatings and/ or other methods, such as anodic protection. The corrosion resistance of waste container materials should be known or investigated experimentally, taking into account the time periods and environments relevant to the anticipated storage, transport and disposal of the waste packages.
209. Atmospheric corrosion of waste containers should be minimised by ensuring favourable environmental storage conditions (with active control as required) and by appropriate store management and inspection arrangements (see section 6).
210. Containers should be manufactured to defined specifications within an appropriate quality assurance regime. Arrangements should be established to ensure that any defective or damaged containers are identified prior to use and rejected or repaired. Handling and storage of containers prior to use should be managed to minimise the possibility of surface contamination (e.g. by corrosive agents).
211. The location and the exact contents of each waste package should be known at all times. To facilitate this, each container should be marked with a unique identifier linked to its appropriate package and location records. Package identifiers will need to remain legible for the long period until the end of institutional control of that waste (e.g. for packages destined for geological disposal this could be several hundred years after closure of a geological facility).

Waste package performance and longevity

The design life of waste packages should be consistent with the national strategies for waste management.

212. During the functional lifetime of a package its safety functions should be such that they meet the requirements of the relevant safety cases at that time, including the case for transport where appropriate and other anticipated package movements.
213. The design life of waste packages should be consistent with the national strategies for waste management and, in England and Wales, disposal. Package design life should encompass the timescales associated with the future phases of waste management, including storage, transport and disposal, as anticipated at the time of manufacture.
214. Waste package designs, waste conditioning practices and management arrangements for conditioned waste during storage should be appropriate to maximise package longevity, so far as is reasonable practicable (further discussed in section 6).
215. Good engineering practice should be adopted for container and package construction. A minimum package lifetime of 150 years should be set for design purposes. Caution is needed in projecting package lifetimes to several centuries or more given the current state of knowledge and the uncertainties relating to waste package ageing and the ability to maintain appropriate storage conditions over extended timescales (see section 6). Appropriate strategies to produce robust packages and to promote package longevity should be considered and adopted, where practicable.
216. A programme of package monitoring and inspection should be implemented (see section 6).
217. Identification of any potential package degradation mechanisms that may threaten package safety functions will be expected as a part of the RWMC. Such information should be used to inform package monitoring and inspection strategies and to underpin early thinking as to what package rework or remediation measures may be required.
218. Particular approaches to maximise longevity include, but are not limited to, the following:
 - sorting and segregation of mixed wastes that may be mutually incompatible (see section 4);
 - removing or reducing waste reactivity by treatment prior to or during waste conditioning;
 - using waste conditioning matrices that are inert or beneficial with respect to the container material and the waste; and
 - periodic package inspection followed by appropriate remedial action, where necessary. For example, this could include remediation of any early package faults to mitigate further degradation, or checking of waste containers for signs of corrosion (followed by appropriate remedial actions where problems are identified).
219. Package remediation or reworking should be considered at any time between package manufacture and disposal in cases where:
 - packages fail to meet the appropriate safety case requirements for the current phase of waste management;
 - it becomes apparent that package safety functions are being threatened (e.g. by corrosion); and
 - it becomes apparent that the packages are not compatible with the requirements of a subsequent phase of waste management or disposal.

Radionuclide inventory

The radionuclide content of each waste package should be known in sufficient detail, and with sufficient accuracy, to meet safety case and disposal requirements.

220. The radionuclide inventory of each waste package or waste stream should be known with sufficient detail and accuracy to meet the appropriate safety cases and disposal requirements.
221. Knowledge of the radionuclide inventory of each waste package should extend through measurement and/ or assessment to an understanding of:
- the radionuclide inventory of the package (noting this is needed for storage and handling purposes and to define the total inventory for a disposal facility);
 - package dose rates;
 - contamination levels on external container surfaces; and
 - the radiogenic heat output of the package.
222. The aim should be to fully characterise the waste prior to and following conditioning, taking account of the information needs through to disposal. Good record keeping is particularly important given information and records will be required over extended timescales to support on-going waste management and disposal (see section 7). Package records and monitoring history should be readily available for inspection.

Reactive, hazardous and challenging materials

Appropriate controls or limits should be placed on materials that might react adversely within waste packages, or which might pose a threat to passively safe storage, transport or disposal.

223. The conditioning process and processing environment should ensure that any chemically reactive, biologically degradable, hazardous and challenging materials^c present within the waste are identified, characterised and appropriately controlled, both before and after conditioning. This requires understanding potential evolution or degradation mechanisms, the implications and any necessary mitigation. Controls might extend, for example, to placing limits on the quantities of such material per package or ensuring that any related hazards are suitably managed by the choice of encapsulating matrix and/ or container design. Specific consideration should be given to:
- organic waste constituents: particularly those that present a hazard based on their inherent toxicity, might degrade to yield gases that may be toxic, may contain radioactive isotopes, might be explosive or present a flammability hazard, might influence the neutron reactivity of the system, might degrade to form species which challenge the integrity of the waste container or might enhance/ promote the mobility of radionuclides in the disposal environment;
 - chemically reactive constituents: particularly those that might be expected to react adversely within the waste matrix, with the container or with each other. Examples include metals or ion exchange materials that may react with the waste matrix and disrupt the waste package by an increase in volume, graphite which may have stored Wigner energy, and materials which may significantly influence the pH of the wastefrom or challenge the container integrity;
 - explosive, flammable, combustible, corrosive and pyrophoric materials: including any waste constituents which might evolve to form materials with such properties in the long term; and

^c In this context reactive, hazardous and challenging materials are those that are significantly toxic or hazardous to health, gas generating and/ or corrosive.

- any materials that would be classed as dangerous goods for transport purposes or material covered under the Hazardous Waste (England and Wales) Regulations and the Special Waste (Scotland) Regulations and their amendments

Fissile material

Waste package fissile limits should be derived via appropriate assessments covering the handling, storage, transport and disposal phases of waste management.

224. Criticality safety principles apply to the processing, handling, storage, conditioning, transport and disposal of waste containing fissile material. Criticality safety should be achieved (as far as is reasonably practicable) through appropriate system design in preference to reliance on administrative safety measures.
225. Facility safety cases will need to demonstrate acceptable sub-criticality margins during storage, taking account of possible accident conditions (e.g. flooding), and any uncertainties that may exist. Engineered controls may include safe geometry, structural separation and the use of neutron absorber materials (i.e. neutron reactivity poisons), where appropriate. Safety cases for multiple fissile units in storage arrays should take account of neutronic interactions between the units.
226. Waste package fissile limits should be defined such that criticality events are not credible. Limits should be derived via assessments to cover the handling, storage, transport and disposal phases of waste management.
227. It may be appropriate to characterise waste streams according to their intrinsic neutron absorption and moderation properties. Reduction in the uncertainty in the quantities of neutron absorbers and moderators present in the waste may in turn lead to an increase in permissible levels of fissile material per waste package.
228. Package design and loadings should be such that a criticality event is not credible against identified faults during operations and transport for both normal and accident scenarios. Whenever transported, the fissile content of the waste, its packaging and condition must be such as to satisfy the requirements of the waste transport regulations.
229. Waste conditioning operations should be suitably controlled so as to ensure compliance with the relevant waste package fissile limit. Where the fissile content of the waste is determined during the conditioning operation, sampling error and assay system error should be considered in calculations to determine operational compliance with fissile mass limits. Following conditioning the fissile content of the waste package should be known with sufficient accuracy to ensure compliance with the relevant fissile limits and any other requirements, such as safeguards.

Waste package specifications

230. The Radioactive Waste Management Limited (RWM) disposal concept is underpinned by a suite of documentation on waste package specifications and guidance produced by RWM. The waste package specifications are owned by RWM. Early engagement with both the regulators and RWM is essential for waste which does not meet the standard published waste package specifications. The current guidance can be found on the RWM website⁴².
231. For higher activity wastes, licensees will make proposals for the packaging of the wastes, and RWM will conduct disposability assessments of the proposals through comparison with published waste package specifications and their disposal concept. RWM assess licensees' packaging proposals through the Disposability Assessment process and, where additional information or safety arguments are required, issue Disposability Assessment reports containing action points. Where compliance can be

demonstrated, this is recognised by RWM through issue of Letters of Compliance (LoC).

Waste Product Specifications

232. Waste product specifications are owned by the licensee and endorsed by RWM through the Disposability Assessment process. Waste product specifications are written to ensure that the overall packaging process is quality assured and documented such that the packages produced will be compliant with RWM's LoC endorsement.
233. Waste product specifications will be used, together with lifetime package records, to demonstrate that waste packages meet the facility safety cases and the (anticipated) WAC for future stages of waste management and disposal.
234. Waste product specifications should be kept up to date and revised as appropriate to reflect the 'as made' packages (e.g. if waste feeds or processing parameters are subsequently changed from those originally endorsed by RWM). Where any changes may affect disposability, they should be shared with RWM in addition to any local product quality review committee, and may require resubmission of a LoC.
235. The relevant RWMC should describe the control measures for detecting any non-conformance, and the associated management arrangements for non-conforming packages.

Information and records relating to conditioned waste

It is the responsibility of the licensee to provide the necessary assurances on the quality of the waste product.

236. Information management requirements are discussed in detail in section 7, managing information and records relating to radioactive waste.
237. Quality management should be applied to all aspects of the conditioning of radioactive wastes that affect the quality of the waste package product. The Quality Management System (QMS) should comply with a suitable quality standard (e.g. ISO 9001).
238. It is the responsibility of the licensee to provide the necessary assurances related to the quality of the waste product.
239. Information and records should be assembled for and about each waste package (referenced by unique package identifier) containing all relevant details of the package including manufacture and contents. Such information will normally include, but is not limited to:
 - the wastes, including description and origin;
 - the wasteforms, including formulation and chemical constituents;
 - the containers in which the waste is placed;
 - the conditioning and packaging processes;
 - process conditions;
 - storage conditions;
 - all relevant supporting R&D (including product properties and performance);
 - waste package radionuclide and physical/ chemical inventory;
 - conditioned waste package properties, including reference to the relevant waste product specification;
 - waste package history, including the storage conditions it has encountered;

- specific safety and other criteria such as those imposed, for example, by criticality compliance, international safeguards and hazardous waste regulations; and
 - administrative information, including records of authorisation for final disposal.
240. Package information and records must be suitable for use by the licensee and others e.g. RWM, third party auditors and regulators. For example, they may be required to support on-going endorsement through the LoC process (where appropriate), to demonstrate compliance with transport requirements or to meet acceptance criteria at storage and disposal facilities.
241. Arrangements for assuring the quality of processed waste should be addressed in the licensee's quality management system. This will include the identification and monitoring of a range of properties sufficient to demonstrate that the waste product corresponds to the Waste Product Specification endorsed through the LoC process. Audits should be undertaken at appropriate intervals to provide confirmation that the overall packaging process, resultant products and records are compliant.

Guidance on disposability

Disposability

242. Disposability refers to the degree to which conditioned waste meets the standards and specifications for final disposal. To ensure disposability, waste packages should be designed to ensure safe handling, storage and transport to the disposal site. At the point of consignment, waste packages will need to meet the safety case and corresponding WAC for that disposal facility which may include specific UK safeguards and security requirements. After disposal, the waste packages will provide barriers within the disposal system and hence their performance characteristics will have a direct effect on the post-closure performance of the disposal system. The safety case for the disposal system will need to include consideration of the combined performance of all the barriers for an extended timescale, beyond the period of institutional control. Separate guidance discusses regulatory expectations in relation to waste disposal^{43, 44}. Although the separate guidance is aimed predominantly at the designers and implementers of disposal facilities, rather than waste producers who are conditioning waste destined for disposal in such a facility, it is important that programmes to condition waste fully take into account the end requirements.
243. It is not possible to provide an absolute guarantee of disposability in the absence of a licensed and permitted/ authorised disposal facility with fully developed and approved safety case and corresponding WAC. Accepting this limitation, RWMCs should demonstrate how wastes are being managed in this respect. Specifically RWMCs should include arguments and evidence to provide confidence that proposed or on-going waste conditioning and storage operations will result in disposable waste products, to the extent that this can be demonstrated at any time. The level of detail that is provided by the licensee to demonstrate disposability should be appropriate in the relevant decision context. Disposability arguments are expected to become increasingly mature as waste conditioning programmes develop from the conceptual to the implementation phase. In particular, prior to waste conditioning there should be a high level of confidence that waste products will be disposable in the context of Government policy current at that time, taking into account the status of any related national disposal programme.

Demonstrating disposability

244. It is the responsibility of the licensee to demonstrate disposability and to produce and maintain the RWMC. However, information provided by the disposal facility operator, prospective operator (e.g. RWM) or other third party (e.g. contractor) will form an

important part of that demonstration. For wastes destined for deep geological disposal, the regulators expect that a Letter of Compliance (LoC) will be issued by RWM stating that the conditioned waste is likely to be acceptable for future disposal. The regulators expect the licensee to understand the basis of any such third party information or endorsement and to condition waste in accordance with any related endorsement conditions. The conditioning processes should be audited periodically to ensure the latter and to demonstrate appropriate waste product quality.

Ultimately, disposability will be demonstrated by meeting the safety case and corresponding WAC of the recipient disposal facility.

245. The licensee's demonstration of disposability should be based on appropriate disposability assessments. In cases where waste is to be directed to an operating, licensed and permitted/ authorised disposal facility with fully developed and approved WAC, this would involve establishing compliance with the facility safety case and corresponding WAC. The supporting arguments should be consistent with the scheduling of waste disposals at the proposed disposal site (e.g. whether the site will be accepting wastes at that time and if the site is likely to have sufficient remaining capacity).
246. Prior to the availability of an operating disposal facility, disposability assessments should be performed against suitable facility designs (or a reference concept or concepts), which are supported by safety cases, including environmental safety cases. It would not be acceptable, for example, to argue that a bespoke disposal facility could be designed and developed at a future date to accommodate a particular waste stream, without underpinning this with detailed arguments relating to the proposed disposal facility design and the related safety case arguments.
247. The regulators recognise RWM as the appropriate body to provide advice to licensees on the packaging and conditioning for geological disposal of higher activity radioactive wastes. Provision of a LoC by RWM indicates its endorsement of proposed or existing waste packages for geological disposal (noting LoC endorsements are subject to Periodic Review by RWM). Endorsement through the disposability assessment process should not be confused with (and does not necessarily imply) regulatory endorsement, nor should it be viewed, necessarily, as a prerequisite to obtaining regulatory consent for waste conditioning.
248. The regulators have a well-established programme to jointly scrutinise and advise on RWM's Disposability Assessment process and its underpinning programme of research and development, with the aim of building and maintaining confidence that the process is fit for purpose. While licensees are not obliged to obtain disposability assessments only via RWM's process, any licensee proposing an alternative process for assessing the disposability of waste should recognise the risks of not seeking RWM's advice, and the time and effort required by both licensee and regulators to build a comparable degree of confidence in a proposed process.

Specific disposability considerations for RWMCs

Disposability considerations should encompass any potential interactions of significance between the waste and its disposal environment.

249. The following paragraphs provide further guidance on what we expect to see in RWMCs, specifically relating to disposability.
250. The RWMC should highlight any impacts that the waste package will have on the performance of the relevant disposal facility and any implications for handling and transport operations between the site of origin and the disposal facility.
251. Specific considerations should include, for example, assurance that:

- the composition of the conditioned waste, e.g. its radionuclide inventory and the presence of any reactive or toxic constituents, is known in sufficient detail to allow future compliance with the safety case and corresponding WAC to be determined (see section 4);
 - the conditioned waste package meets current requirements for transport to a future disposal site; and
 - the waste can be safely handled and managed within a disposal facility during emplacement and prior to facility closure (including any package retrieval operations where the design includes that provision);
252. Key issues should be assessed and assurances given that there will be no significant concerns in relation to the performance of the disposal facility. Such issues may include for example:
- radionuclide transport through the gas and groundwater pathways;
 - package decay heat and potential effects on the proposed barrier components and safety functions of the disposal system;
 - maintenance of sub-criticality during operations;
 - adverse reactions between the waste and the conditioning matrix, e.g. assessment of the potential for cracking and chemical degradation;
 - detrimental effects due to chemical species that may be present in the wastes or might be expected to form as a result of chemical or biological degradation, e.g. species that might enhance radionuclide mobility following disposal through chemical complex formation; and
 - impacts from any toxic waste constituents.
253. If it is concluded that there are significant issues that may challenge disposability, these issues should be set out together with any assumptions made in arriving at that conclusion (e.g. incompatibility with a specific facility design concept or feature, incompatibility of the transport container with standard designs, or issues that may restrict the future choice of a geological environment for the disposal facility). For each of the issues, the RWMC should discuss the likelihood and the potential impact of the issue and any proposed solutions (e.g. mitigation by modifications to the disposal facility design).

Section 6 Storage

Fundamental requirement for storage

254. The fundamental requirement in the provision of storage for radioactive waste is that there should be arrangements for safe and secure storage for the anticipated storage period that ensures protection of people and the environment.
255. Such arrangements may assume a single store to cover the entire period, or may provide for replacement or refurbishments of stores at appropriate intervals.

There should be arrangements for safe and secure storage for the anticipated storage period that ensures the protection of people and the environment.

Storage of unconditioned waste

256. This section of the guidance is worded in a manner that presupposes that radioactive waste has been conditioned as described in section 5. However, it applies equally to the storage of raw or unconditioned wastes. The following paragraphs briefly outline additional considerations for the storage of such wastes.
257. If raw waste is stored, it should be contained in a manner that avoids deterioration and allows retrieval for processing and eventual disposal, whilst maintaining standards of safety and environmental protection that are as close as is reasonably practicable to those for stored packaged wastes.
258. The physical and chemical state of radioactive wastes accumulated in a raw form that will not be retrieved and packaged until after the plant is shut down, may degrade during accumulation. Periodic inspection, typically achieved through direct sampling and analysis of the accumulated waste, should be undertaken where it is reasonably practicable to do so, to confirm that any such degradation will not affect the ability to retrieve and process the waste as planned.
259. Where wastes are stored in an unconditioned form, this guidance will need to be applied and the storage arrangements should take adequate account of future plans for the waste.

Arrangements for safe and secure storage

260. In all circumstances the following key principles should be applied:
- there will be arrangements for safe and secure storage for the anticipated storage period on the nuclear licensed site concerned that ensures protection of people and the environment; and
 - such arrangements should be applied in the context of a suitable programme for managing such wastes to a point where responsibility for the wastes can be discharged through final disposal or suitable alternative storage on another nuclear licensed site.
261. Arrangements for the safe and secure storage of radioactive waste should have regard to:
- passive safety;
 - multiple barrier containment to ensure protection of people and the environment;
 - the design of storage facilities;

- storage capacity;
 - acceptance criteria;
 - maintenance;
 - inspection and retrieval; and
 - records.
262. These areas are discussed in more detail in the following sections. In addition, the NDA has produced industry guidance⁴⁵ on the interim storage of higher activity waste. The regulators regard this guidance as good practice.

Passive safety

Radioactive waste should be stored in accordance with relevant good engineering practise and the requirements of passive safety.

263. Passive safety requires radioactive wastes to be in a form that is physically and chemically stable and stored in a manner that minimises the need for control and safety systems. Accomplishment of passive safety covers aspects of both the waste package itself (covered in section 5 on conditioning and disposability) and in the storage conditions (covered by this part of the guidance).

As far as is reasonably practicable, passive safety should not be dependent upon active safety systems, maintenance, monitoring or prompt human intervention.

264. With respect to the long-term storage of radioactive waste, it is recognised that it may be necessary or advantageous for some active systems to be in place, for example control of environmental conditions within the store. In such cases, the systems should be designed for minimum maintenance, and, in the event of failure, immediate repair/ replacement should not be necessary in order to ensure continuing safety of the storage facility and its contents. The extent to which passive safety is required will need to be determined by a balance between the various factors discussed in this guidance document, including safety, relevant good practice, protection of the waste, cost and sustainability.
265. This guidance describes the important features of and requirements for passive safe storage. Proposals for the storage of radioactive waste developed by licensees could include most of the requirements for passive safety set out in the following list, but not necessarily every one. Licensees should demonstrate that any shortfall in meeting the full requirements does not result in any significant safety detriment or compromise the overall aim of passive safe storage.
266. To achieve passively safe storage and minimise the risk that a waste package will require intervention prior to final disposal, following requirements should be fulfilled:
- the radioactivity should be immobilised;
 - the waste form (as described in section 5, conditioning and disposability) and its container should be physically and chemically stable;
 - potential energy should be removed from the waste form;
 - a multi-barrier approach should be adopted in ensuring containment;
 - the waste form and its container should be resistant to degradation;
 - the storage environment should optimise the waste package life;
 - the need for active safety systems to ensure safety should be minimised;
 - the need for monitoring and maintenance to ensure safety should be minimised;

- the need for human intervention should be minimised;
 - the storage building should be resistant to foreseeable hazards;
 - the storage arrangements should be amenable to refurbishment as needed;
 - access should be provided for response to accidents;
 - there should be no need for prompt remedial action;
 - the waste packages should be inspectable;
 - the waste packages should be retrievable for inspection, reworking, or disposal; and
 - the lifetime of the storage building should be appropriate for the storage period prior to disposal.
267. Licensees should aim to apply the requirements for passive safe storage within a framework of reasonable practicability and cost-effectiveness. Regulators interpret this to mean that implementing the requirements for passive safety should be carried out where reasonably practicable but in any case, where it constitutes current relevant good practice and complies with good standards of engineering. Exceptions will need to be substantiated by demonstrating that the costs to implement these requirements would be grossly disproportionate to the safety and environmental benefits.
268. The application of good standards of engineering and modern principles for radioactive waste management, including passive safe storage, is an overarching regulatory requirement. As part of a store's safety case, licensees may employ probabilistic safety assessment methods to demonstrate that the risk from the facility is acceptably low. However, probabilistic safety assessments should not be used to defend non-compliance with current relevant good practice or good standards of engineering.

Multiple barrier containment

A multi-barrier approach should be adopted to provide effective containment and protection of the environment.

269. Passive safe storage of radioactive materials and radioactive wastes is most appropriately achieved by providing multiple physical barriers to the release of radioactivity to the environment. The physical barriers include the nature of the waste itself, any material that may be used for encapsulation, the waste container (all covered in section 5 on conditioning and disposability) and the storage building or structure, each of which should be designed to provide effective containment and prevent leakage of radioactive material. The multiple barrier containment provided by the storage building or structure is particularly important in consideration of the storage of unconditioned wastes (e.g. prevention of leakage to ground of raw waste).

Storage building or structure

The storage building is the outer physical barrier to the release of radioactivity to the environment.

270. In aiming to achieve passive safety the most significant barriers are first the wastefrom itself, and secondly the waste container, with the storage facility providing the final outer physical barrier. In some cases, the role of the storage building or structure may be limited to providing suitably protected environmental conditions for storage of waste packages, limited radiation shielding and presenting a secure boundary against unauthorised intrusion or interference and entry of wildlife. Where safety and protection of the environment is dependent on the performance of the storage building or

structure as a barrier, specific design criteria with respect to external hazards, will be relevant (paragraph 289).

271. One of the foreseeable mechanisms for the mobilisation of radioactivity in waste is the ingress and action of water in a store. Potential sources of water ingress are groundwater, rainwater, flooding and condensation. Stores should be located and designed to reduce the potential of water ingress. Factors to be considered in the design of a facility for the storage of radioactive waste are discussed further in paragraphs 272–292.

Radiation shielding

272. Adequate shielding of operators and the public against the radiation hazard from the radioactivity in the waste should be provided by a combination of the waste form, the waste container and the storage building or structure. This should be designed and implemented to meet ALARP requirements, taking account of normal operation, anticipated operational occurrences and design basis accidents.

Prevention and mitigation of releases of radioactivity to the environment

273. Measures for ensuring the optimisation of radiological protection of the workers, public and environment from the release of radioactivity in normal operation, anticipated operational occurrences and design basis accidents should be designed and implemented. If the long-term storage of radioactive waste will involve the discharge of radioactivity to the environment, for example, gaseous discharges may occur via ventilation systems designed to maintain dry and clean conditions in the store, then such discharges will require a permit for disposal from the relevant environment agency.
274. Provision should be made for mitigating the release of radioactivity from the facility in the event of abnormal conditions, for example, by filtration or isolation.

Design of storage facilities

Storage facilities should be designed in accordance with relevant good engineering practice and to enable radioactive waste to be stored in a passively safe condition, taking account of normal and accident conditions.

275. The radioactive waste storage facility should be designed on the basis of assumed conditions for its normal operation and assumed incidents or accidents and should fulfil the following fundamental safety functions:
- acceptable sub-criticality margins, where necessary;
 - containment of radioactive material;
 - optimised radiological protection of operating personnel, the general public and the environment via appropriate shielding and control of the release of any radioactivity;
 - adequate arrangements for handling and stacking of waste packages; and
 - removal of heat, where necessary.
276. The current design basis should be clearly and systematically defined and documented.
277. As far as is reasonably practicable passive safety features should be incorporated into the design.

278. Structures, Systems and Components (SSCs) that act as barriers should be provided, to an extent proportionate to the hazards presented to safety and the environment by the stored waste, to limit the consequences of Postulated Initiating Events (PIEs) and to mitigate accident sequences. The design of the SSCs should take account of a list of PIEs consistent with a proportionate approach.
279. Provisions for maintenance, testing and inspection should be established to address the ageing of SSCs and safety features. Results from this programme should be used to review the adequacy of the design at appropriate intervals. (Note: This may require design provisions to monitor materials whose mechanical properties may change in service owing to such factors as fatigue (cyclic mechanical or thermal loadings), stress corrosion, erosion, chemical corrosion or radiation induced changes).
280. To maintain the waste and the storage facility in a safe state during operation, Operational Limits and Conditions (OLCs) should be established. These defined OLCs should consider:
- environmental conditions within the store (e.g. temperature, humidity, contaminants);
 - the effects of heat generation from waste;
 - potential aspects of gas generation from waste, in particular the hazards of fire ignition, explosion, waste package deformations and radiation protection aspects; and
 - criticality prevention, covering both each individual waste package as well as the whole store (including operational occurrences and accident conditions).
281. Where waste packages that deviate from the acceptance criteria of the store are required to be placed in storage, specific substantiation for the properties of the waste and its suitability for handling and retrieval over the required storage period should be considered prior to consignment in the store (see paragraph 299). In particular, changes that might occur over time in the waste and the packages should be considered.
282. The facility should be designed to prevent a criticality accident, considering the criticality relevant parameters during normal operation and fault/ accident conditions. As far as reasonably practicable, criticality safety should be achieved by the design of the packages used and the store.
283. Means for removing residual heat during normal operation, anticipated operations, operational occurrences and design basis accidents should be provided where identified as necessary by the safety case.
284. The licensee should make design arrangements for fire safety based on a fire safety analysis and implementation of defence in depth (prevention, detection, control and mitigation of a fire).

The design lifetime of the storage facility should align with the expected storage period.

285. The expected lifetime of the storage facility and any associated refurbishment/ replacement strategy needs to be consistent with:
- the associated HAW waste management strategy and strategic endpoint; and
 - the current and planned waste management infrastructure that is available for treatment, storage and disposal of HAW.
286. Where the design life of the storage facility does not meet the required storage time for the waste, consideration should be given to replacement or refurbishment of the store and identification of the appropriate intervals for this to be undertaken.

287. The design of the storage building or structure should be fit for purpose, taking into account the expected time required for storage and the hazards posed by the stored wastes, i.e. the design should be proportionate to the defined purpose of the building and to the risks. If it is proposed that an existing structure, modified in some cases, is used for future long-term storage, it should be demonstrated that, so far as is reasonably practicable, the structure meets current standards, the construction standards and the materials chosen for any modification work are appropriate and the resultant store is safe for the projected period of storage. In some cases a building may be designed for a shorter life with the intention of periodic refurbishment. In these cases, demonstration should be provided that the waste can be stored safely while the refurbishment is carried out.

The storage environment should maximise waste package life.

288. The storage building will need to provide sufficient protection to the stored wastes to maximise the life of the packages and to facilitate safe transfer to the final disposal facility (or to a further storage facility) at the appropriate time. This may necessitate control and monitoring of the environment of the storage building (temperature, relative humidity and constituents of the atmosphere) in order to minimise package corrosion rates. This may be particularly important on sites that are near the coast where chloride levels in the atmosphere are relatively high. It may not be possible to achieve such environmental control by purely passive means and it may be necessary to adopt a forced ventilation system with control of relative humidity and a filtered inlet to remove atmospheric contaminants such as salts. This is an example of where there may be a need for an active system as opposed to a passive system. It would be expected that such systems would be very reliable, simple, long lived and easily maintained.

Appropriate monitoring systems and alarms should be provided but there should be no requirement for continuous human presence or supervision at the store to ensure safety.

289. Monitoring systems and alarms will need to be provided to detect abnormal conditions such as abnormal temperature and relative humidity in the atmosphere of the facility, build-up of flammable gases, water and groundwater ingress, fires and unauthorised intrusions. Where appropriate, alarm systems should be set up to initiate responses at remote locations. A radiation monitoring system would provide the ability to detect radioactivity in liquid or gaseous forms in the event of damaged/ deteriorated packages. Groundwater should also be routinely monitored, particularly adjacent to storage facilities for unconditioned wastes. Wherever possible, the panels and electronics associated with the monitoring system should be situated in a radiologically safe area of the building or externally.
290. Ideally, there should be no requirement for continuous human presence or supervision. Human involvement should be limited to confirmatory surveillance, inspections and responding to incidents on a reasonable timescale. However, it would be good practice to provide periodic surveillance and inspection to confirm that the environment within the building is as intended and that the condition of the waste packages is not deteriorating. The building design should include provision for routine inspection, including access to the packages by remote or manual means depending on the radiation levels and the ability to retrieve packages for inspection and remedial action. The possible use of dummy packages and/ or corrosion test coupons should be considered to minimise the requirement for movement of waste packages.
291. Although one of the aims of passive safety is to minimise the need for surveillance and inspection to ensure safety, it is expected that periodic inspections will be carried out to confirm that the condition of the waste and its storage are not deteriorating significantly, and to confirm its continuing acceptability for safe storage, and ultimately retrieval, transport and disposal. Inspection will not be restricted to the waste packages

but will cover the storage facilities and buildings, and the associated safety arrangements. See paragraphs 308 to 312 on waste package monitoring.

The storage building should be resistant to foreseeable hazards.

292. The storage facilities should be designed to be resistant to the range of foreseeable internal and external hazards. For external hazards, such as seismic events, flooding and high winds, account should be taken of climate change and other long-term trends such as rising sea levels, changes in groundwater levels, extent of flooding, coastal erosion etc. The multiple physical barriers to the release of radioactivity from the waste should provide resistance to dispersal as a result of foreseeable external and internal hazards for example, where appropriate, seismic qualification of the storage facility should be considered. More specific guidance on hazards can be found in the Technical Assessment Guides published by ONR^{46, 47}.
293. Where there is a potential for water and groundwater ingress, storage facilities should include features to monitor for water and groundwater ingress and the means of collecting and removing any water that enters the facility. These features could involve a sloping floor, a collection sump with level alarm and safe facilities to pump out the water and a means of monitoring the water for radioactivity prior to disposal. Any discharge to the environment of water collected from the inside of the store that could have been in contact with radioactive waste will need to be managed in order to minimise radiochemical and chemical contamination, and entrained solids. Appropriate optimisation techniques will need to be employed to identify and implement the most suitable discharge management systems.
294. Any effects, which would cause deterioration of the waste form, container or storage building over the storage period, should be taken into account including, for example, corrosion or microbiological action.

There should be no need for prompt remedial action following abnormal conditions.

295. In line with the passive safety requirements, the design of the storage arrangements should minimise the requirement for prompt remedial action following events and off-normal conditions to mitigate the release of radioactivity. Examples of such provision are filtration and the means to isolate equipment.
296. Where groundwater ingress into a facility could occur any monitoring plan will need to incorporate appropriate trigger and action levels for groundwater elevation and quality.

Storage capacity

Reserve storage capacity should always be available.

297. It may be necessary to move packages within the storage facility, e.g. for inspection, retrieval or maintenance work, and reserve storage capacity should always be available for this.

Waste acceptance criteria

Waste Acceptance Criteria should be set for the storage facility that include consideration of future disposal requirements or planned management strategies, and arrangements put in place to assure compliance.

298. It is important to ensure that any waste package fulfils all relevant design requirements such as:

- compatibility with handling, transport and storage requirements including suitability for retrieval and transport following the anticipated storage periods; and
 - known or likely requirements for subsequent disposal or other management aspects included in the owner's waste management strategy such as the need for further treatment or conditioning of the waste.
299. When establishing Waste Acceptance Criteria, storage conditions and compatibility with the facility safety case should be considered, including the suitability of the waste packages for handling and retrieval and onward waste management prior to disposal.
300. Processes and procedures, involving auditing, inspection and testing, should be designed and implemented to ensure that waste packages meet the acceptance criteria for storage when they are received.
301. Before being placed in storage, waste packages should be monitored and inspected to establish the baseline condition and to confirm the absence of any surface contamination that could initiate or accelerate corrosion of the package. Suitable arrangements should be available for dealing with any surface contamination that is found.
302. The licensee should have arrangements in place, either at the storage facility or other suitable facility to deal safely with waste packages that fail the acceptance criteria of the storage facility
303. If, during or after storage, it is found that the radioactive waste does not meet the criteria for final disposal then any processing required should be undertaken in a proportionate and timely manner.

Contingency plans should be prepared for packages that do not meet the acceptance criteria for the storage facility.

Inspection and maintenance of the storage facilities

Storage facilities should be maintained and inspected,

304. Maintenance, periodic testing and inspection should be undertaken to ensure that Structures, Systems and Components (SSCs) are able to function in accordance with the design intent and safety requirements. This should include both preventative and corrective maintenance.
305. The programme for this maintenance, periodic testing and inspection, which should be based on approved written procedures, should be prepared in advance of storage facility operation. The frequency of maintenance, periodic testing and inspection should be in accordance with the facility safety case. The results of maintenance, testing and inspection should be recorded and assessed.
306. Equipment necessary for on-site emergency plan implementation should be included in the maintenance, periodic testing and inspection programme.
307. Equipment and items used for maintenance, periodic testing and inspection should be identified and controlled to ensure their proper use.
308. Maintenance, periodic testing and inspection programmes should be reviewed at regular intervals to incorporate the lessons learned from experience.
309. The programme of maintenance, periodic testing and inspection should include:
- the monitoring regime for the required environmental conditions within the storage facility;
 - the appropriate programme for monitoring the state of the waste packages, as derived from the facility safety case and the ageing of SSCs; and

- Groundwater control and monitoring boreholes and groundwater control mechanisms should be included in the inspection and maintenance schedule.
310. Handling equipment should be designed to take account of radiation protection aspects, ease of maintenance and minimisation of the probability and consequences of associated incidents and accidents.

Waste packages monitoring programme

A waste package monitoring programme should be developed and implemented.

311. A review of the maintenance, periodic testing and inspection programmes should be undertaken at regular intervals to incorporate the lessons learned from experience.
312. A waste package monitoring programme should be developed and implemented to confirm that waste packages and storage facilities are, and will remain, in an acceptable condition for continuing safe storage, retrieval and final disposal within the limits specified to ensure continued functionality of the safety features on which the safety case is based. The waste package monitoring programme should be adequate to assure the continued compliance of waste packages in line with the safety case requirements.
313. Where it is proposed that only a proportion of the waste packages will be inspected, licensees should demonstrate that the sample is representative or, where appropriate, targeted. A package monitoring programme should be chosen based on the expected rate of degradation and the perceived risk to the integrity of the containers. It should take into account any high risk packages or areas within a store where the conditions present more risk of degradation of the packages. The inspection programme should enable identification of any unexpected deviation from the expected waste package performance.
314. The monitoring and inspection programme should establish the waste package baseline condition and performance criteria against which the condition of the waste can be assessed. Typical performance criteria include:
- Container corrosion (external, internal);
 - Wasteform expansion (indicator of internal corrosion stress, pressure);
 - Loss of package identification;
 - Lifting feature degradation;
 - Loss of mechanical strength;
 - Dose rate change (e.g. indicator of annulus degradation); and
 - Gas generation (indicator of wasteform evolution).
315. These performance criteria should specify and substantiate the method and frequency of inspections. The monitoring frequency should allow time for preventative action or additional protection to be put in place.
316. NDA, through the Letter of Compliance process have produced packaging specifications on the environmental conditions⁴⁸ and monitoring⁴⁹ of higher activity waste.

Remedial action

Remedial action should be implemented for waste packages that show signs of degradation.

317. The licensee should have plans to deal with waste packages that show signs of loss of integrity or degradation including the identification of any appropriate materials or equipment, e.g. additional packaging required, and making it available in due time.

Store design for inspection and retrieval

The storage facility should facilitate the retrieval of all waste packages for inspection, remedial treatment and transfer elsewhere for further storage or final disposal.

318. The storage facility design should include provision for routine inspection, including access to the packages by remote or manual means depending on the radiation levels and the ability to retrieve waste packages within an appropriate time for:
- inspection;
 - safeguards requirements;
 - possible remedial treatment;
 - further storage elsewhere; or
 - for disposal.
319. Waste handling equipment may not be continuously available, but should be capable of being returned to service when needed and should be maintainable within a radiological safe area either inside or outside the building. Depending on the radiation levels associated with the waste packages, remote handling techniques may be required.
320. Appropriate contingency arrangements should be in place to retrieve waste packages if they cannot be retrieved by the normal means, e.g. loss of availability of the normal waste handling equipment.
321. Handling, monitoring and inspection equipment should be designed to minimise the damage (e.g. scratching) and cross contamination (e.g. of stainless steel with carbon steel) of waste packages.

Records

322. Detailed guidance on managing information and records relating to radioactive waste can be found in section 7.
323. Licence Condition 32 – Accumulation of radioactive waste requires that records be kept of radioactive waste accumulated on nuclear licensed sites. Licensees are required to make and maintain adequate records of the inventory and management actions associated with the radioactive waste stored. The information contained on these records should include:
- details of packaging;
 - operational history of processes and stores;
 - records of non-compliances with specifications; and
 - records of any relevant incidents.

Information and records that might be required now and in the future for the safe management of radioactive waste should be assembled and preserved.

324. Storage of radioactive waste in a passively safe form may last for at least 100 years. Comprehensive information and records need to be assembled as part of the storage arrangements. Records should be kept in such a way that sufficient information can be

extracted for both current and future needs for each individual waste package. They need to be securely retained and to be accessible when required.

Section 7 Managing information and records relating to radioactive waste

Introduction

325. The safe management and disposal of radioactive waste both now and in the future requires the maintenance of knowledge and adequate records to inform the processes involved. At any point in time the records must be sufficient to address the needs of all stakeholders, including the waste owners/ producers, waste management facility operators, regulators, government, the public and future generations. The licensee needs to work with stakeholders to ensure that this is achieved.
326. The nature of the operations leading to the generation of radioactive waste and the subsequent disposal processes may mean that it will be necessary to transfer knowledge and records from one licensee to another. Sometimes this transfer process will take place over hundreds of years. Knowledge and records must both be managed and transferred in such a way that future licensees are properly equipped to ensure that waste continues to be managed in such a way that prevents or minimises hazards to human health and the environment.
327. Knowledge management is of crucial importance to the continued interpretation of records. Licence Condition 36 requires a licensee to demonstrate continued organisational capability, which includes production of an integrated management prospectus that sets out how management of knowledge is maintained and transferred.
328. This document is focussed on information and records management. Knowledge management is not discussed further.

Nuclear site licensees should establish and implement a system to create, maintain and manage comprehensive, accurate and reliable records.

329. The necessary records must be available to safely manage the waste throughout its lifecycle (including, for example, waste generation, storage, transfer and disposal). Managing records such that they are maintained and ownership transferred appropriately with no loss of authenticity, integrity, availability or confidentiality should be considered as a long term process involving a number of organisations.
330. Traditional records management approaches are unlikely to be sufficiently robust or sustainable to meet the demands over the long timescale involved. This guidance highlights existing national and international standards and practices for managing information that should be considered to address some of the specific issues associated with managing radioactive waste-related information over the long term. Over the long timescales involved, standards and practices will be subject to review and revision. Licensees should be mindful of this through the application of their own procedures to ensure that new standards and practices are identified and implemented as appropriate.
331. Every organisation responsible for managing radioactive waste must establish and implement a system to create, maintain and manage comprehensive, accurate and reliable records. Such systems should be designed with due consideration of all stages of the waste lifecycle including any necessary transfers of records from or to other parties. Licensees should work together, as far as possible, to establish common systems and approaches, or to ensure that records can be transferred without compromise.
332. The ONR's Safety Assessment Principles (SAPs) provide the underlying basis for regulatory judgements made by ONR. RW^d.7 expects that "information that might be

^d RW is radioactive waste management

required now and in the future for the safe management of radioactive waste should be recorded and preserved.”

333. The environment agencies’ Environmental Principles apply in England and Wales. RSMDP14 expects that “sufficient records relating to radioactive substances and associated facilities should be made and managed so as:
- to facilitate the subsequent management of those substances and facilities;
 - to demonstrate whether compliance with requirements and standards has been achieved; and
 - to provide information and continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal.”

Timeframes

An information management system should meet the demands likely to be inherent in the next generation of waste custodians.

The current generation should not impose an approach that might foreclose future opportunities for the effective transfer of information and records.

334. Information relating to radioactive waste management activities will be generated and utilised over a timeframe of hundreds of years. This includes:
- wastes identified at early stages of new build;
 - waste created during operations;
 - waste undergoing treatment and conditioning for disposal; and
 - wastes actively managed throughout storage and disposal including any post-closure management period.
335. Thereafter, information about the waste may need to be retained for a very long time. It is impossible to predict the needs of or the technology available to society over such a timeframe. Hence, attempting to create records with the guarantee that the information it contains will be accessible for the whole timeframe is a challenge. Therefore, an information management system should be designed and implemented to meet the demands expected from the next generation of waste custodians (who will assume responsibility for the records over the next 30–40 years). Care should be taken to ensure that any approach does not foreclose future opportunities for the effective transfer of records to replacement systems.
336. The processes applied to manage and store records will vary depending on usage and long-term value. For example, some records may be used in the short term up to the point that the wastes are placed in a store and again in the longer term when the wastes are transferred to another store or site, or sent for disposal. It is important that such records are managed for the longer term and can be accessed at any time during that term.
337. The licensee should implement a procedure for keeping records under review. This review should take into account the continuing relevance of the information, the suitability of the medium on which it is stored and the needs and expectations of stakeholders.
338. Records produced before the implementation of this guidance should be reviewed and their continuing relevance determined. This may require significant resource, and take considerable time to complete. However, it could be incorporated within the procedures for routine records reviews.

339. Guidance on authorisation of disposal facilities expects that “During the period of authorisation [of a disposal facility], the records will be needed by the organisation exercising control and, potentially, by the regulators. We shall expect the operator to make arrangements at the end of the period of authorisation for the records to be included in the public archive.”

The transfer of waste items from one licensee to another must coincide with the transfer of responsibility for suitable records.

340. Existing controls ensure the safe physical transfer of waste from one licensee to another. Procedures define the various controls (physical and administrative) employed for ensuring the safe transfer of the waste. Transfer of the associated waste records should be equally well controlled and documented. The dispatching and receiving organisations should work closely together to ensure that appropriate records are transferred, and that the handover is properly controlled and recorded. The transfer of the waste record represents the formal transfer of responsibility for the information.
341. Transfer of responsibility for records must coincide with the transfer of the wastes, and the receiving organisation must demonstrate they are satisfied that the records are suitable for the on-going management of the wastes and records. Where only single copies of records exist, duplicate records may need to be created and retained by the dispatching organisation, such that the risk of their loss is minimised. The dispatching organisation may also need to retain some or all of the waste records for their own compliance purposes.

Information and records management policy and strategy

342. The Lord Chancellor’s code⁵⁰ provides a framework for relevant authorities to manage their records expects that:
- Lord Chancellor says: “Authorities should have in place organisational arrangements that support records management.”
 - Original document says: “The records management function should be recognised as a specific corporate programme within an authority and should receive the necessary levels of organisational support to ensure effectiveness.”
And
 - Lord Chancellor says: “Authorities should have in place a records management policy, either as a separate policy or as part of a wider information or knowledge management policy.” “The policy should be endorsed by senior management, for example at board level, and should be readily available to staff at all levels.”
343. Guidance on authorisation of disposal facilities expects that “The developer/ operator will need to set up and maintain a comprehensive system for recording information on all aspects of the project affecting the environmental safety case. The information to be recorded should include:
- decisions taken and the reasons for them, data and results from the site investigation and characterisation programme;
 - design documents, drawings and engineering details of the facility as constructed;
 - records of waste form and characterisation;
 - records of waste emplacements and their location in the facility;
 - other operational information;
 - details of facility closure; and

- results of monitoring and assessment at all stages of the project.”

Organisations should establish and implement a comprehensive policy for managing radioactive waste information and records.

344. Codes and standards which provide advice and guidance on records systems should be consulted and implemented as appropriate. At the time of writing the following British and International standards provide core information for a records system:
- Records Management. General⁵¹;
 - Storage requirements for archive and library materials⁵²;
 - Management system for records. Core concepts and vocabulary⁵³; and
 - Management system for records. Requirements⁵⁴.
345. Organisations should establish and implement a comprehensive policy for managing their radioactive waste information and records. This policy should be endorsed at the highest management level in the organisation. The policy adopted needs to ensure that records are assembled and maintained in a secure form that is readily auditable and accessible to all those persons who may need to consult them. The records should be reliable, comprehensive and cover the full lifecycle of the radioactive waste.
346. The policy should make reference to the procedures and standards applicable to the information and records management function, and to any related policies (e.g. the use of information technology within the organisation). An important function of the policy is to clearly define responsibilities.
347. Having established their policy, the organisation should develop and implement an appropriate strategy that is endorsed at senior management level. The strategy should identify measures to protect records relating to radioactive waste over the long term. Guidance can be found in existing national and international guidance, for example British Standards on Record Management and IAEA guidance^{55,56,57,58}.

Information and records management systems and procedures

348. The regulators will look for evidence that sufficient data and information on each package (and the component raw waste and means of conditioning) are being recorded and stored so that future safety and environmental assessments can be carried out and so that the wastes remain acceptable for disposal or long-term storage.
349. The regulators will also look for evidence that data and information are recorded in a way that allows access and retrieval over the long time periods that may be associated with the storage of radioactive waste.

Information and records management should be regarded as an integral part of the organisation's culture.

Systems

350. Organisations in the nuclear industry should have in place management systems that recognise the importance of maintaining records for a wide range of purposes. These systems should be endorsed at senior management level in the organisation, based on policy, strategy, standards and clear procedures. Good management of information and records needs to be regarded as an integral part of the organisation's culture: an activity to be undertaken and reviewed continually rather than just at the end of a project. All staff need to receive an appropriate level of training, depending on their specific responsibilities for the management of the information and records.

351. Resources for managing information and records should be secured and protected to ensure their continual availability particularly during times when they may be at risk, such as times of national emergency, financial constraint or organisational change.
352. The information and records management system should provide the tools, processes and identify the people that will enable information and records to be managed. Success will be largely measured by the organisation's ability to transfer information and records with no loss of authenticity, integrity, availability or confidentiality.

Managing information requires specific actions beyond just managing records to ensure that the right information is recorded and that it can be accessed, interpreted and understood by an authorised user.

353. Information management is an active process where specific actions (over and above those associated with records management) are undertaken to ensure that the right information is recorded and that it can be interpreted and understood by an authorised user, rather than simply preserving the record itself. These actions may involve, for example, provision of technical glossaries and information providing context, together with indicators of the significance of the information for the safe management of radioactive waste.
354. Elements of an information management system will include, for example:
- identifying the information to be included;
 - how information is collected e.g. format, transmittal, receipt, acceptability;
 - how information is managed e.g. location, retrieval (metadata and inventory of information and records), review and retention schedules, long-term preservation, information transfer; and
 - measures to protect information (short and long-term considerations) e.g. document storage and archive requirements, access control, security and confidentiality requirements, control of modification of records, reproduction or transfer to alternative storage format, national [nuclear] archives requirements.

Procedures

Working practices should comply with documented procedures to provide appropriate quality management.

355. The above sub-section on 'information and records management policy and strategy' highlights the importance of documented procedures in the management of information. Working practices should comply with the documented procedures to provide appropriate quality management. This process is standardised in ISO 9001, the international standard relating to the requirements for quality management systems.
356. The organisational quality policy may be an appropriate place to identify the procedures related to information and records management; section 4.2 of ISO 9001 refers to documentation requirements.

Staff should understand their responsibilities and the rationale of the organisation's information and records management policy.

357. Staff should understand their responsibilities and the rationale of the organisation's information and records management policy. Staff will require specific training and guidance to discharge their responsibilities and need to be allocated time to carry out information and record management tasks. Working-level procedures are required for key stages of the information management process. Documented procedures should

be an integral part of the organisation's quality management system. Documented procedures should be provided for such processes as:

- Planning – determining the information that should be made and kept;
- Creation – production of records;
- Registration – providing evidence of the information in the document management system;
- Access and security – assigning rights or restrictions to access;
- Content control – preserving the technical content of records and preventing unauthorised alterations;
- Status – determining where and in what form records are held;
- Determining appropriate retention and review periods;
- Storage and archiving – short and long-term conditions to ensure that records are protected, accessible and managed;
- Use and tracking – identifying when a record was used and / or amended; and
- Record destruction – defining the processes for destruction and the need to create a record of any destruction carried out.

The transfer of information and records from one licensee to another must be planned and controlled. Given the timescales, such a transfer is not just likely, it is inevitable

358. The transfer of records from one licensee to another must be planned and controlled. From the outset, a licensee creating a waste record should consider how the information it provides is to be transferred in the future. This consideration alone may influence things like the storage media, the language and the quality of the metadata and information. Licensees should also ensure that information generated on their behalf (for example, by contractors) is produced in accordance with predefined specifications and that transfer of such information is also planned and controlled.
359. The dispatching organisation is responsible for ensuring the record is complete, in accordance with the requirements determined through dialogue with the recipient and other stakeholders. Records containing supporting information (such as glossaries) should be inextricably linked to the primary record. The record should be in good order, readable, and in a format agreed with the recipient. The inclusion of a glossary of terms might be necessary to explain specialist or unusual terminology.
360. There are different types of record, for example:
- Text, numerical data, maps, drawings on paper or microfilm;
 - Photographic images on film;
 - Digital information on magnetic media (e.g. hard disk drives, tapes, USB media) or on optical storage devices (e.g. CDs, DVDs); and
 - Physical material (such as samples of materials and rock cores).
361. Some records (for example, a photograph) allow direct access to the information, while others (for example, a computer file) require some type of processing. Additional records may need to be created to explain the relevance and use of the primary record.
362. Digital records may, in addition, require a degree of preparation prior to transfer to ensure the information is retrievable in a form that can be 'translated' and understood. Standard formats should be used, wherever possible. The dispatcher will have to liaise closely with the recipient on preferred medium and format for digital media transfers.

363. The dispatcher is responsible for preparing the information for transfer and should bear any reasonable costs. This is a critical activity that carries high risk regarding future understanding of the information and the importance of planning and liaison cannot be over-emphasised.

Risk management

364. There is an inherent threat that the information contained in some records will become inaccessible in the future. For example, this may be as a result of damage to or loss of the record, changes in the technology needed to read the record (particularly relevant to electronic records), or changes in terminology and language. The risks associated with some of these threats may be considered low today, but they will inevitably increase with time.
365. Licensees must establish a risk register which identifies and includes specific threats for the long term, their likelihood of occurring and the potential consequences. The loss of access to a record may be regarded today as merely inconvenient, but some losses may have significant health and safety or environmental relevance in the future and have a cost implication for any future attempt to regenerate the record.

A risk management strategy relating to information and records must be established and actively maintained.

366. The risk register should be reviewed on a regular basis and action taken, as necessary, to reduce risks to an acceptable level.

Back-up procedures

367. A risk management strategy relating to important information and records should be established and actively maintained. A common process employed to reduce the risk of loss is to copy the record onto a second (or back-up) recording medium and to transfer the copy to another location. This process is equally valid for paper or photographic-based and electronic media. Increased assurance can be provided if information back-up is performed on a frequent basis and if the recording medium used is different from that of the primary record.
368. The procedures for backing up information and records should be documented and regularly reviewed for effectiveness and compliance.

Records handling

369. The type and amount of handling to which a physical record is subjected may have a significant effect on its life expectancy. A storage regime should be established that minimises handling and, where necessary, alternative storage formats should be considered'.
370. The environment in which records are to be handled should be considered and potential for damage and contamination controlled (by application of any necessary handling procedures) or eliminated.

A storage regime should be established that minimises handling.

Records management: specific issues relating to managing records for the long-term

General

371. The following sub-sections highlight some of the characteristics of different forms of records and the measures that can be applied to help manage them.
372. Many records linked to the management of radioactive waste are likely to be required for the long-term (>100 years) and will ultimately be transferred to an archive to be managed for the long-term. Licensees should consider the short and long-term role of records under their control and discuss the requirements of the next waste custodian and other stakeholders, in order to select the most appropriate medium.
373. Information contained in a record should be accessible in a form that can be used and understood both now and in the future. Measures should be implemented to ensure that information continues to be accessible, particularly where digital media are used. All records have different characteristics requiring different management approaches (described in the following sub-sections). A sustainable and effective record can be regarded as a combination of four elements, each of which should first be considered individually then as a whole:
- The recording medium – the selected medium should be readily available at reasonable cost and not require sophisticated preservation techniques that rely on unusual technologies or challenging storage environments;
 - The primary data should be in a format that is ‘fit for purpose’, of appropriate quality, and accessible to contemporary and future users;
 - The metadata should comply with the British Standard⁵⁹ and is essential for the long-term preservation and access requirements; and
 - Where information providing context is essential to aid interpretation the explicit links to these sources of information should be maintained.
374. It is government policy to place permanent records for public archive onto digital or electronic media⁶⁰. This may present a challenge to preserving radioactive waste information for a very long time. The NDA should establish standards, procedures and guidance for its national nuclear archive so that early steps can be taken to produce records to the required standard, where practicable. In the meantime licensees should discuss the requirements of the next waste custodian and other stakeholders, in order to select the most appropriate recording media.

Paper records

375. There is extensive experience in preserving paper-based records and clear guidelines are provided in British Standards^{61,62,63,64}. Barring extraordinary events such as fire or flooding, paper records tend to deteriorate quite gradually, providing adequate time for the licensee to migrate the information onto alternative media in a controlled way. To cater for extraordinary events, licensees should give consideration to back-up procedures as described earlier. The following should be considered when working with paper-based records:
- Most of the paper in daily use contains lignin which attacks the wood fibres, and there is increasing use of recycled paper (which has unproven long-term performance). Organisations should consider the need to migrate the information on to archive-grade paper, or ensure that when lower-grade paper is used the record is monitored at suitable intervals to identify when migration is needed. The information management system should specify the approach to be taken;

- Laser printing and photocopying are the most practical and common techniques for transferring text on to paper and should take due regard of British Standards for permanence; and
 - Paper records should be kept under conditions designed to minimise handling, in an environment where temperature and humidity are controlled and exposure to light, gaseous contamination, particulates, vermin and fungal growths are minimised.
376. Specific procedures should be considered and, where appropriate, adopted to maximise long-term performance and minimise potential damage of paper records.
377. Materials that are often filed with paper records (such as staples, paper clips, treasury tags, PVC covers) should be removed during preparation for long-term storage as they can cause or accelerate degradation. Paper itself has a storage life; where long-term storage is required. The use of archival paper may be necessary. Alternately, the creation (by scanning) of an electronic copy of the record may need to be considered.

Digital records

378. Licensees across the UK nuclear industry should strive towards using compatible systems that can enable accurate transfer of digital information without the need to transcribe data.
379. The integrity of reports containing text, diagrams, drawings and images created using a number of file formats will be difficult to protect against changes in technology. Where such records are to be preserved in electronic form, they should be in an appropriate file format that has the greatest potential to be accessible in the future. At the time of writing, the Portable Document Format (PDF) is regarded by records management experts to be the preferred format. British Standards^{65,66,67} provide guidance on the application of the PDF format, which has been specifically developed to address the long-term challenge.
380. Where off-site facilities are used for preserving records, the organisations responsible should implement appropriate security measures to prevent unauthorised access. Records management should involve experts in information security.
381. Generic IAEA guidance on digital records can be found in IAEA safety guides.

Microform records

382. Microform (microfilm, microfiche and aperture cards) is popular for recording large volumes of information and data. There are a number of film types available but for long-term storage silver-halide film should be used as it is less prone to fading when exposed to light.
383. Procedures should be in place to protect the integrity of microform, such as minimising its exposure to dust, dirt, chemicals, fingerprints and light. These procedures need to be considered when handling, packaging, and storing microform records.
384. Further information on the use of microforms can be found in the British Standard⁶⁸.

Records storage facilities

General

385. Regulator guidance for LC6⁶⁹ Documents, records, authorities and certificates expects that “documents and records should be securely stored and maintained in such a way that they are readily retrievable in facilities that provide a suitable environment to minimise deterioration or damage and to prevent loss.”

386. Records with long-term value should be identified and prepared for long-term management as soon as practicable. They should be reviewed to ensure they are complete (for example, that they include information providing context, links to other information sources and explanations of specialist terminology and abbreviations) before they are moved to an archive.
387. Licensees should ensure an 'audit trail' is established and maintained to ensure a record can be traced, in particular when records are transferred.
388. Most licensees keep operational records on site during waste management operations. Licensees should implement arrangements to store operational records safely and have in place procedures to prepare and transfer any records expected to be archived when operations are completed.
389. The minimum standards expected of a records storage facility include:
- Use of appropriate materials for the protection of the records;
 - An appropriately designated building or buildings;
 - Controlled access to the records (whether physical or electronic);
 - Controlled heat, light and humidity (consistent with the needs of the range of record media being stored);
 - Appropriate fire protection and fire fighting equipment;
 - Low risk of flood, damage from inclement weather, subsidence or other natural phenomena; and
 - Appropriate levels of safety for permanent or visiting staff.
390. There are a number of standards and guidance documents relating to minimum standards for record storage facilities. At the time of writing the following standards and guidance provide core information for records storage:
- Storage requirements for archive and library materials
 - Management system for records. Fundamentals and vocabulary; and
 - Regulator guidance for LC6 Documents, records, authorities and certificates.
391. Licensees should use available standards and guidance to judge the suitability of present and proposed storage and archive facilities.

Organisations may choose to transfer records to an off-site archive operated by a third party but cannot transfer responsibility for the records.

392. Licensees may choose to transfer records to an off-site archive operated by a third party. Where this approach is used, the licensee must ensure that the records are managed to a standard appropriate for their long-term preservation and accessibility. The case for using any off-site archive should include an assessment of the ability of the archive to meet the minimum requirements set out in British and international standards. Similarly, the security arrangements must satisfy minimum requirements for the information stored. These arrangements should be regularly checked and assessed.
393. The licensee remains responsible for the records relating to wastes for which they are responsible (even if the records are physically located with a third party) until such a time that they transfer the wastes and associated information and records to another custodian (for example, to the operator of a disposal facility).

National records management facilities: the national nuclear archive

Long-term records should be prepared and maintained such that they can, in future, be transferred to the national nuclear archive with minimal further processing.

394. Guidance on authorisation of disposal facilities expects the operator to “make arrangements at the end of the period of authorisation for the records to be included in the public archive.”
395. The Nuclear Decommissioning Authority (NDA) has established Nucleus (the Nuclear and Caithness Archives) as a national nuclear archive for the long-term storage of records relating to the UK civil nuclear industry (Reference: <https://www.gov.uk/government/case-studies/nda-archive>) .
396. In the long term (once wastes are disposed of and a disposal facility is no longer subject to permitting or licensing) there will be a national need to maintain information and records relating to the facilities and the wastes they contain. The NDA Archive will be used to archive all waste package records within the NDA estate (including records relating to disposals to the Low Level Waste Repository (LLWR) and a geological disposal facility (GDF), or transfers to interim stores). Records relating to wastes from non-NDA sites destined for disposal to the LLWR and to the geological disposal facility will also, in due course, be transferred to the national nuclear archive. At the time of writing the company charged with operating the national nuclear archive is not responsible for information related to radioactive wastes from non-NDA nuclear sites or wastes from non-nuclear sites that are not disposed at NDA-controlled sites, e.g. controlled on-site burials at non-NDA nuclear sites. The regulators will pursue this issue with the NDA with respect to developing the strategy for operating the national nuclear archive.
397. Records relating to wastes generated from non-NDA nuclear sites and any relevant records from non-nuclear sites will be transferred to the next waste custodian, e.g. when wastes are sent for conditioning, storage or disposal. To this end we recommend early dialogue between all organisations generating and managing radioactive waste to ensure appropriate information and records are collected and that suitable information management systems and procedures are agreed and implemented.

Record review

Every record should be reviewed before it is formally closed, as appropriate points during its period of storage and prior to destruction or transfer for long-term preservation.

398. The licensee should establish a written procedure for closing waste records, which sets out the criteria to be fulfilled before a record can be closed. Every record should be reviewed before it is formally closed, at appropriate points during its period of storage and prior to destruction or transfer for long term preservation. This should take into account factors such as, whether there will potentially be further processing of the waste or whether it has been consigned for disposal. The licensee should also establish a written procedure for destroying waste records, which sets out the criteria to be fulfilled before a record can be destroyed. Any decision to destroy a record should be properly documented and this documentation maintained as part of the continuing records.
399. The licensee should establish a written procedure for reviewing waste records. The review of a waste record will confirm the following:
- the case for preserving the record remains valid and the information contained in the record remains relevant;

- The information is accessible to the reader. This means it should be readable (the data can be recovered from the medium), intelligible (the data are meaningful to the reader) and usable (the data can be correctly interpreted);
 - Unusual or specialist terminology, colloquialisms and abbreviations are explained;
 - Materials that can harm the medium or its content are removed;
 - The record medium remains fit for purpose (i.e. it is not obsolescent and has not been subject to chemical, physical or biological degradation);
 - Information sources referenced in the record and necessary for its interpretation remain accessible; and
 - Security and protective markings are correct (or are amended as appropriate as a result of the review) - see sub-section below on 'Security and the protection of sensitive information'.
400. The nature of the information, recording medium, storage conditions and handling will be factors in determining the review period, which should be defined in the information management strategy document (see sub-section on 'information and records management policy and strategy'). It is understood that the NDA is developing a single Records Retention Schedule (RRS) for use across all NDA-controlled sites (including for those records relating to disposals to the Low Level Waste Repository (LLWR) and a geological disposal facility (GDF)).

Security and the protection of sensitive information and records

Information and records relating to civil nuclear activities

Information and records relating to radioactive waste may contain sensitive information and need to be protected accordingly.

401. Information and records relating to radioactive waste may contain sensitive information and need to be protected accordingly. Licensees should be aware of potential sensitivities and ensure appropriate security arrangements are implemented and followed.
402. Waste records and information providing context may attract differing security classifications. This potential conflict should be highlighted and suitable measures instigated to ensure that necessary linkages between information and records are maintained
403. Information that needs to be protected in the interests of national security requires a protective marking in accordance with the protective security and classification manual. This does not extend to information that has previously been made available to the public anywhere in the world. ONR should be consulted for further guidance.
404. ONR regulates security arrangements within the civil nuclear industry including the protection of sensitive nuclear information. The government's protective marking system applies throughout the civil nuclear industry. Companies operating in the civil nuclear industry are also required to comply with Government IT security policy, with ONR as the accreditation authority.
405. The Anti-terrorism, Crime and Security Act 2001⁷⁰ (ATCTA01) defines sensitive nuclear as "Information relating to activities carried out on or in relation to nuclear sites or other nuclear premises which appears to the Secretary of State to be information which needs to be protected in the interests of national security," whilst information which needs to be protected in the interests of national security is further defined as including "information which requires a protective marking in accordance with the classification policy". It does not include information that has "previously been made

available to the public anywhere in the world” otherwise than in contravention of the law.

406. The unauthorised disclosure of sensitive nuclear information is covered by the ATCTA01, which applies across the UK. The Nuclear Industries Security Regulations 2003⁷¹ (NISR03), as amended, specifically require any person involved in activities on or in relation to a nuclear site or nuclear premises, or who are proposing to become involved, who is in possession or in control of sensitive nuclear information to protect that information in an appropriate manner. These requirements must be borne in mind if it is intended to place records under the day-to-day management of a third party.
407. NISR03 does not apply to nuclear premises operated primarily or exclusively by the MoD or its contractors, or to those holding Category IV nuclear material or radioactive sources outside civil nuclear licensed sites.

Classification of civil nuclear information

408. Organisations subject to regulation by ONR should ensure that their information classification policy is consistent with ONR’s requirements on the use of protective markings. This extends to those categories of sensitive nuclear information that require protection and the level of protective marking to be applied. It includes information held on computer systems relating to nuclear material, other radioactive material (including radioactive sources) and radioactive material designated as waste.
409. Planned reviews of records held should include consideration of the need to retain protectively marked material at its original level. Originators, other specialists and records reviewers should exercise a degree of judgement, according to the sensitivity of the information and any time-dependence this may have, in making decisions to downgrade.

Information and records relating to MOD nuclear activities

410. Information and records relating to MoD nuclear activities, which need to be protected in the interests of national security, require a protective marking in accordance with the security and classification policy issued on behalf of the Secretary of State for Defence.

Disclosure of information

411. The policy relating to protective marking of sensitive nuclear information should not be confused with disclosure policy or the requirement to protect commercial or other official data.

Complying with this guidance

412. We recommend that licensees evaluate their systems in line with this guidance to determine where further work needs to be undertaken and to assess compliance.
413. The National Archives provide guidance⁷² on standards and best practice for records and information managers in all organisations that create or hold public records.

Abbreviations and Glossary

Where possible, the following standard definitions have been taken from:

- IAEA safety glossary
- The UK LLW policy

Archive - A facility specifically identified, equipped and resourced to store records which have been selected for long-term preservation due to their continuing value as evidence of the work of the creating organisation

ALARA (As Low As Reasonably Achievable) - See 'optimisation'

ALARP (As Low As Reasonably Practicable) - See 'optimisation'

Avoidance (waste) - The first step of the waste hierarchy, which states that the production of waste should be avoided, particularly waste that cannot be managed using the using current techniques or techniques under development

BAT (Best Available Techniques) - See 'optimisation'

BPM (Best Practicable Means) - See 'optimisation'

Bq - Becquerel

BRIMS (British Radwaste Information Management System) - A database and client application used to record data and information about unconditioned radioactive waste, waste packages and waste management facilities

Characterisation - Characterisation of radioactive waste involves determining its physical, chemical and radiological properties. It may be carried out in association with several of the other basic steps, such as during segregation. It may be required for record keeping, moving waste between steps and also to determine the best method for managing waste.

Clearance - clearance is where radioactive materials and their management are removed from within a process of regulatory control. It is particularly relevant to the management of wastes produced in decommissioning. The Euratom Basic Safety Standards Directive 2013/59 provides guidance on exemption and clearance criteria.

Conditioning - Conditioning involves transforming radioactive waste into a form suitable for handling, transport, storage and disposal. This may include immobilisation of radioactive waste, placing waste into containers and providing additional packaging. Common immobilisation methods include solidification of LLW and ILW radioactive waste for example in cement, and vitrification of HLW in glass matrix. Immobilised waste may be placed in steel drums or other engineered containers to create a waste package.

Context - The qualitative element of a record that enables a reader to accurately interpret and use 'raw' data. This qualitative element should not be confused with metadata (see below). In general terms, raw data when combined with relevant context can be regarded as information.

Data - Are numbers, words, or images that have yet to be organised or analysed to answer a specific question. Data in their raw form are likely to have little value to uninformed recipients because their unique relevance to an event cannot be determined when viewed in isolation.

Disposal - Disposal is the authorised emplacement of waste in a disposal facility without the primary intention of retrieval; retrieval may be possible but, if intended, the appropriate term is storage. Disposal may also include discharging radioactive wastes such as liquid and gaseous effluent into the environment and transfer from one site to another.

Disposability - This is the compatibility of conditioned waste with the standards necessary for eventual disposal in a specialised land disposal facility. It requires the conditioned waste to maintain its integrity to achieve safe and efficient storage, handling, transport and disposal.

EA - Environment Agency

Exempt (from regulatory control) waste - Radioactive waste can be exempt from specific regulatory control if it satisfies the criteria laid down in the regulations. In England and Wales the levels are described Schedule 23, Part 6 of the Environmental Permitting Regulations 2016. In Scotland, the requirements are set out as general binding rules in Schedule 9 of EASR18.

GDF (Geological disposal facility) - A long-term management option involving the disposal of radioactive waste in an engineered underground facility, where the geology (rock structure) provides a barrier against escape of radioactivity and where the depth, taken in the particular **geological context**, substantially protects the waste from disturbance arising at the surface. Such disturbances **include** those produced by weather, climate change and people. In this context, 'depth' could imply horizontal as well as vertical distance – for example, in the case of a disposal facility sited deep within a mountain.

HAW (Higher activity radioactive waste) - HLW, ILW and such LLW as cannot be disposed of at present. If there is doubt over how to regard a particular waste stream, the owner of that waste stream should consult the regulators.

HLW (High-level radioactive waste or heat generating waste) - waste that is sufficiently radioactive that the decay heat significantly increases its temperature and the temperature of its surroundings. Typical characteristics of high level waste are thermal power above about 2kW/ m³. Sources of high level waste include the radioactive liquid containing most of the fission products and actinides present in spent fuel arising from the first solvent extract cycle in reprocessing, this material following solidification and spent fuel (if it is declared as waste). The heat generated from such waste has to be taken into account when designing storage or disposal facilities.

HSE - Health and Safety Executive

IAEA - International Atomic Energy Agency

Immobilise/d - Conversion of waste into a waste form by solidification, embedding or encapsulation. Immobilisation reduces the potential for migration or dispersion of radionuclides during handling, transport, storage and/ or disposal.

Information - Is produced through processing, manipulating, and organising data to answer questions, adding to the knowledge of the receiver.

Information management - An active process where specific actions (over and above those associated with records management) are undertaken to ensure information can be accessed, interpreted and understood by a user. The principal objective is to ensure meaningful information is communicated rather than simply preserving the recording media.

Institutional control - Control of a radioactive waste site by an authority or institution designated under the laws of the state. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear facility (e.g. near surface repository)

Integrated waste strategy - Is an overview of the approach to the current and future management of all wastes generated on or received by sites. It should integrate and optimise all waste related activities on a site, ranging from operational activities through to decommissioning activities and wastes arising from contaminated land management. This includes demonstration that the waste can be appropriately managed at the time and rate at which it will arise.

ILW (Intermediate- level radioactive waste) - Radioactive waste with radioactive levels exceeding the upper boundaries for low level waste, but which does not require heating to be taken into account for the design of storage or disposal facilities. IAEA guidance is that ILW thermal power is below about 2kW/ m³.

Knowledge - Is what is known by a person or persons. Involves interpreting information received, adding relevance and context to clarify the insights the information contains. Current and future generations of waste custodians will have to acquire and develop their knowledge in order to safely manage radioactive waste.

LoC (Letter of Compliance) - Documentation provided by Radioactive Waste Management Ltd to a licensee (or anyone producing conditioned waste packages) indicating how well the proposed waste package would fit in the anticipated safety case for repository. This information can be used by licensees to demonstrate to the regulators that the proposed packages should be disposable.

LC (Licence condition) - A condition attached to a licence issued under the Nuclear Installations Act 1965

LLW (Low-level radioactive waste) - Radioactive waste having a radioactive content not exceeding 4 gigabecquerels per tonne (GBq/ te) of alpha and 12 GBq/ te of beta/gamma activity.

LLWR (Low Level Waste Repository) - The UK's national low level waste disposal facility

Minimisation - The process of reducing the amount and activity of radioactive waste to a level as low as reasonably practicable (ALARP) at all stages, from the design of a facility or activity to

decommissioning. Waste generated can be reduced by means such as recycling, reuse and treatment, and requires due consideration for secondary as well as primary waste. Minimisation of waste is fundamental good practise in radioactive waste management. Effective methods of minimising the accumulation of radioactive waste include the clearance of waste that is exempt from regulatory control and the reuse or recycling of radioactive material.

Management of radioactive waste - See 'radioactive waste management'

Metadata - Are 'data about data'. Metadata enables a resource to be found by indicating what the resource is about and how it can be assessed with a series of structured descriptions.

NDA (Nuclear Decommissioning Authority) - A non-departmental government body set up, under the Energy Act 2004, by the government in 2005 with a vision to ensure the safe, accelerated and affordable clean-up of the UK's civil nuclear legacy.

Nuclear Matter - Includes radioactive materials and radioactive waste, as defined in section 26 of the Nuclear Installations Act 1965:

- a) any fissile material in the form of uranium metal, alloy or chemical compound (including natural uranium), or of plutonium metal, alloy or chemical compound, and any other fissile material which may be prescribed;
- b) any radioactive material produced in, or made radioactive by exposure to the radiation incidental to, the process of producing or utilising any such fissile material as aforesaid; and
- c) any substance which meets the definition of radioactive waste in the Radioactive Substances Act.

NRW - Natural Resources Wales

OLC - Operational Limits and Conditions

ONR - Office for Nuclear Regulation

Optimisation – is the principle of ensuring that all exposures to ionising radiation of any members of the public and the population as a whole are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account. The term 'optimised' and 'optimal' should be construed accordingly. Best Available Techniques (BAT in England and Wales) and Best Practicable Means (BPM in Scotland) is the means an operator uses in the operation of a facility to deliver an optimised outcome, i.e. to reduce exposures to ALARA. Nuclear licensed site operators must demonstrate to the regulators that the management of radioactive waste is optimised and must ensure that risks to the health and safety of employees and other persons are reduced so far as is reasonably practicable (SFAIRP). , ALARA

Optioneering - An appraisal of a range of possible options for achieving a specified objective.

Overpack - A secondary (or additional) outer container for one or more waste packages, used for handling, transport, storage and/ or disposal.

Passive safety - Providing and maintaining a safety function by minimising the need for active safety systems, monitoring or prompt intervention.

PIE - Postulated Initiating Events

Pre-treatment - Any or all of the operations prior to waste treatment, such as collection, segregation, chemical adjustment and decontamination. This step provides the best opportunity for segregating waste streams according to how they will be managed and to isolate those non-radioactive or recyclable wastes.

Radioactive material - defined in Environmental Permitting Regulations 2016, schedule 23, part 2, paragraph 3(1) 3 as a substance or article which is not waste, and which satisfies the requirements of paragraph 4, 5 or 6 as they apply to such a substance or article;
or article radionuclide or articles -defined in EASR18, schedule 8, paragraph 5 as a substance or article which is not waste, and which satisfies the requirements of any of paragraphs 6, 7 or 8 as the paragraph applies to such a substance or article.

Radioactive waste - defined in Environmental Permitting Regulations 2016, schedule 23, part 2, paragraph 3(1) a substance or article which is waste, and which satisfies the requirements of paragraph 4, 5 or 6.

3 - defined in EASR18, schedule 8, paragraph 5 as a substance or article which is waste, and which satisfies the requirements of any of paragraphs 6, 7 or 8.

Radioactive waste management - The whole process of managing waste from its generation to (but, for the purpose of this guidance not including) its disposal.

RWMC (Radioactive waste management case) - A RWMC comprises document(s) that demonstrate the long term safety and environmental performance of the planned management of specific wastes from its generation to its conditioning into the form in which it will be suitable for storage and (in England and Wales) eventual disposal. It should provide a complete picture of the management of the waste streams.

RWM (Radioactive Waste Management Limited) - A wholly owned subsidiary of the NDA. It is responsible for implementing geological disposal of higher activity radioactive waste, development of the geological disposal concept, defining waste package specifications, conducting disposability assessments and the issue of Letters of Compliance.

Record - In the context of this document a record is the means used to store documented data or information. A record can exist in a number of forms, some of which allow direct access to the information (for example a photograph), while for others some type of processing will be necessary (for example a computer file). Defined as 'Recorded information, regardless of media or format, created or received in the course of individual or organisational activity, which provides evidence of policy, actions and decisions'

Records management - The function of creating, organising and maintaining records to ensure they provide evidence of activity, decision-making and policy. It includes the establishment of links between related records, swift and accurate filing and accessibility when required and scheduled destruction or transfer to an archive as appropriate in a timely manner.

Retrieval - Retrieval is the recovery of waste packages from storage either for inspection purposes, for subsequent disposal or further storage in new facilities. Storage facilities may be designed so the original emplacement equipment may be operated in reverse to retrieve waste packages. Others may require the installation of retrieval equipment at the appropriate time.

Safety cases - A safety case should substantiate the safety of proposals to construct or install new plant, to modify the design of plant under construction, commission plant, or to modify or conduct tests on existing plant. A safety case is a document (or set of documents) that describe the hazards in terms of a facility or site and modes of operation (including potential undesired modes) and the measures that prevent or mitigate against harm being incurred. The safety case should provide a coherent demonstration that relevant standards have been met and that risks to persons have been reduced to as low as reasonably practicable (ALARP).

SAPs - Safety Assessment Principles

SEPA - Scottish Environment Protection Agency

Segregation - An activity where types of waste or material (radioactive or exempt) are separated or are kept separate on the basis of radiological, chemical and/ or physical properties, to facilitate waste management. Mixing together radioactive wastes that have different properties and different methods of future management is avoided. It is most effectively carried out during the early steps of radioactive waste management.

Storage - The holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/ its containment with the intention of retrieval. Storage of radioactive waste may take place at any stage in the radioactive waste management process and aims to isolate the radioactive waste and protect people and the environment from the hazards presented by the waste, while keeping the waste in a controlled state that will ultimately make it amenable to safe disposal. Storage may be used to make the next step in the management process more straightforward, or to act as a buffer between or within steps. Waste might be stored for many years before it undergoes further processing and disposal. Some storage facilities are located with a nuclear power plant or a licensed disposal facility, others are separate facilities.

Treatment - Operations intended to by changing the characteristics of the waste. Basic treatment objectives are: Volume reduction, Removal of radionuclides from the waste, Change of composition. Typical treatment operations include incineration or compaction of dry solid waste or organic liquid wastes (volume reduction), filtration or ion exchange of liquid waste (radionuclide removal) and precipitation or flocculation of chemical species (change of composition).

VLLW (Very Low Level Waste) - A former sub-category of LLW that, due to amendments to legislation in 2011 is now obsolete; VLLW has been replaced by a category of exempt waste.

WAC (Waste Acceptance Criteria) - Quantitative or qualitative criteria specified by the regulatory body, or specified by an operator and approved by the regulatory body, for radioactive waste to be accepted by the operator of a repository for disposal, or by the operator of a storage facility for storage.

Waste container - The vessel into which the waste form is placed for handling, transport, storage and/ or eventual disposal; also the outer barrier protecting the waste from external extrusions. The waste container is a component of the waste package.

Waste form - The physical and chemical form of the waste, in particular used to refer to the waste after treatment and/ or conditioning (resulting in a solid product) prior to packaging. The waste form is a component of the waste package.

Waste generation (waste creation) - Occurs during the operation and decommissioning of nuclear facilities. Waste generation can give rise to solid, liquid and/ or gaseous wastes.

Waste hierarchy - The waste management hierarchy encourages the adoption of options for managing waste in the following order of priority:

Avoid; prepare for reuse; recycle; other recovery (e.g. energy recovery); dispose

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.

Further reading

Guidance and documents from the regulators and NDA

- NRW, SEPA, NIEA, EA, Guidance on the Classification and Assessment of Waste, Technical Guidance WM3, 2018 <https://www.gov.uk/government/publications/waste-classification-technical-guidance>
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Figures

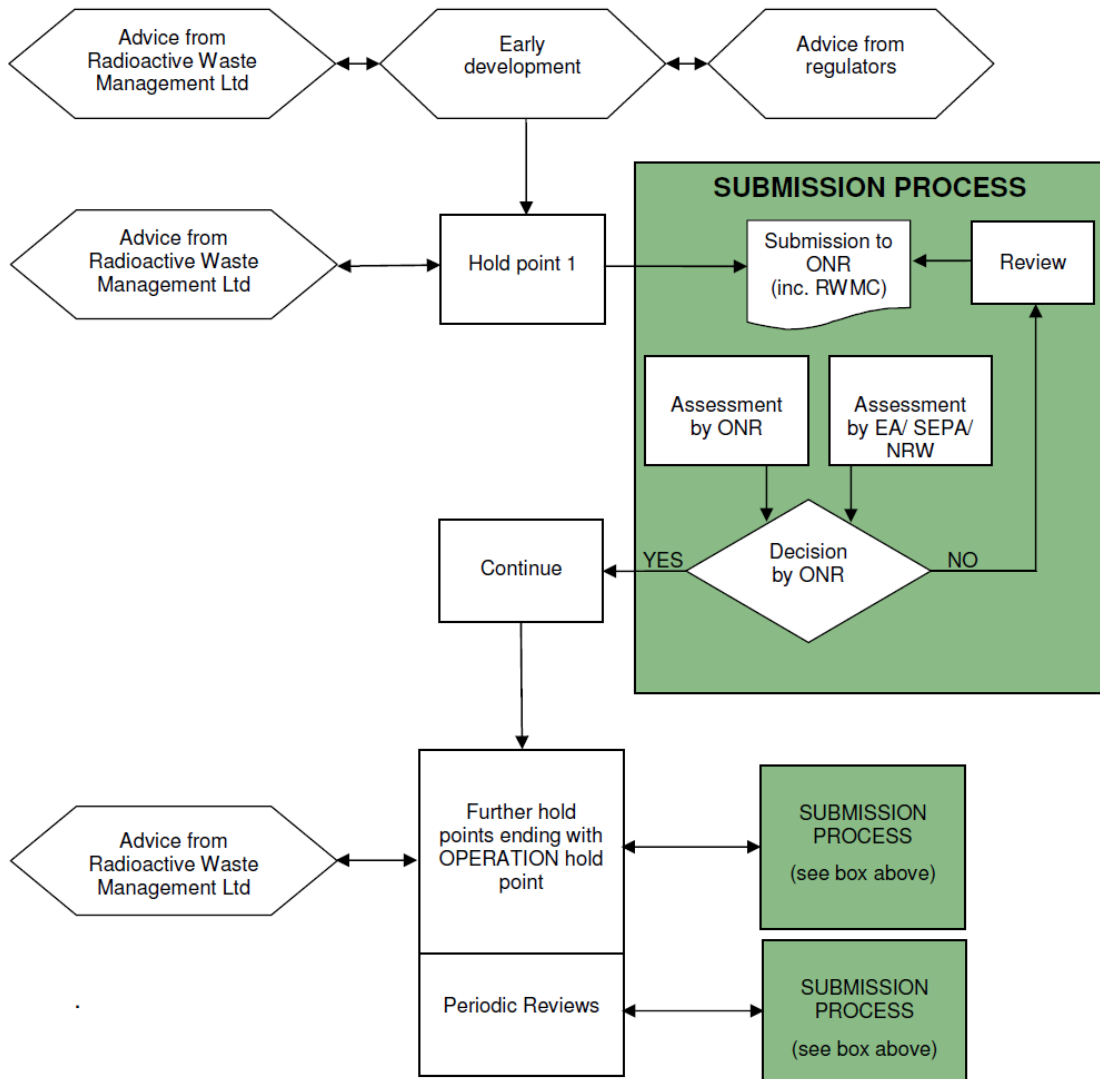


Figure 1: Development of radioactive waste management case and regulatory process

Note: this diagram shows some of the key interactions and is not intended to be comprehensive

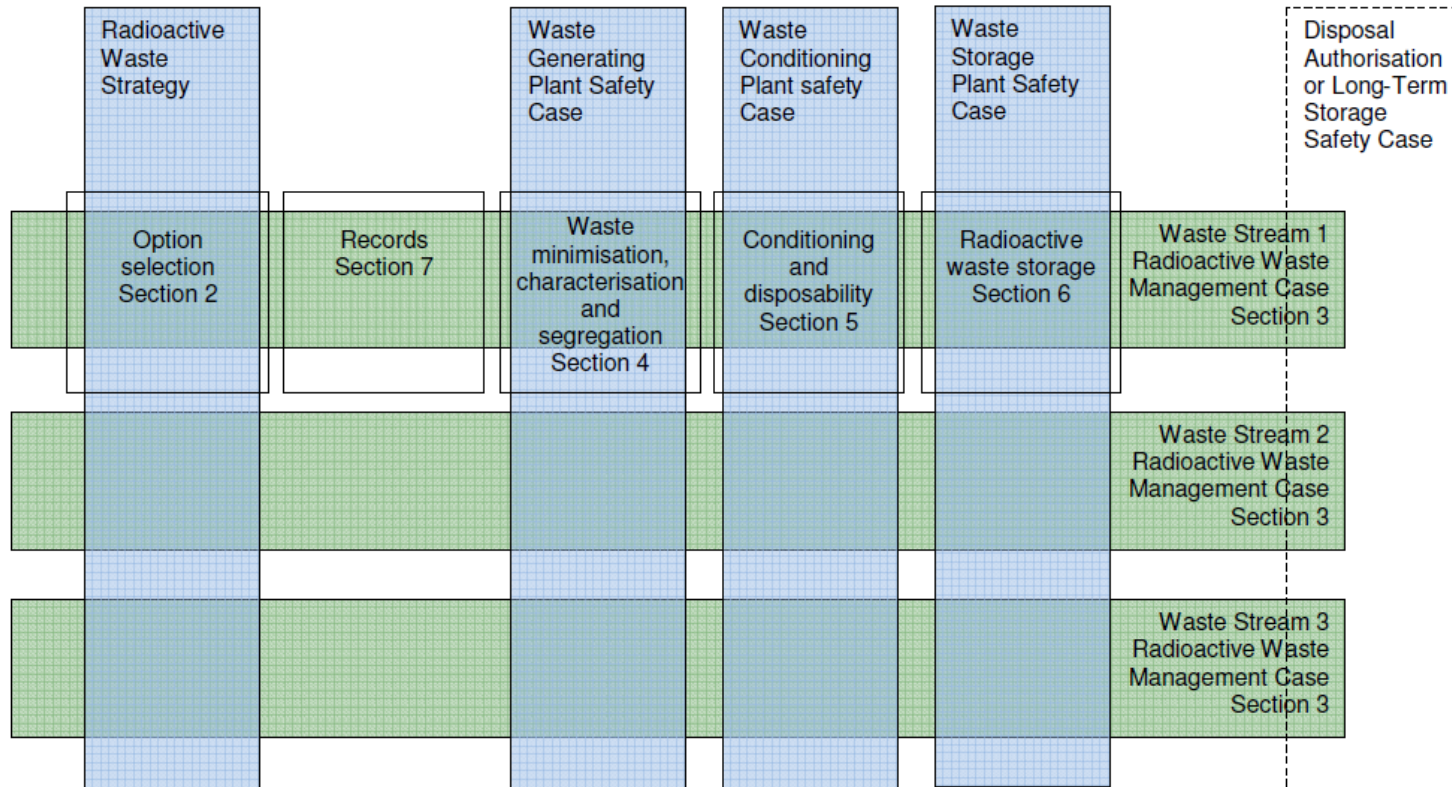


Figure 2: Relationship between specific safety cases and a Radioactive Waste Management Case (RWMC)

Note: Every waste stream should be covered by an RWMC. A single RWMC may deal with a number of similar waste streams.

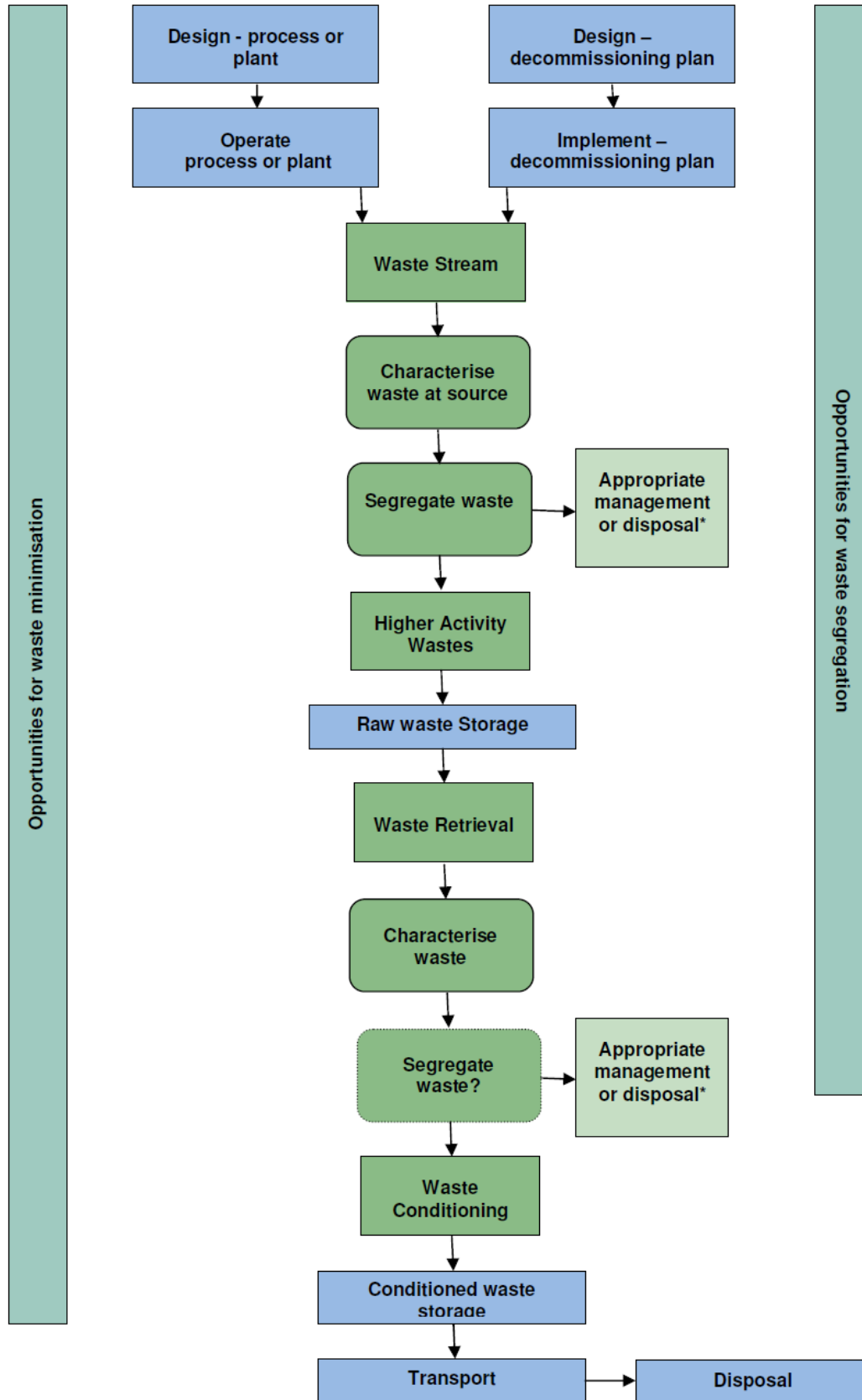


Figure 3: Opportunities for waste minimisation, characterisation and segregation

* Options may exist for the management or disposal of segregated waste.

Appendix 1: Engagement with the regulators

1. This appendix describes the prime interests^e of ONR and the environment agencies for each of the potential stages of a radioactive waste management project. It also explains the anticipated timings of the interactions between the licensees and the regulators. In practice, projects may not be developed or implemented in such discrete stages.
2. The regulators consider it essential that the licensee interacts with us at an early stage to produce a radioactive waste management case, which may be reviewed, revised or refined as the project progresses.

Site waste management strategies and plans

3. The regulators expect interaction with licensees to discuss site waste management strategies and plans as they develop or change, in order to:
 - understand the intent of these strategies and plans;
 - identify issues at an early stage;
 - understand the implications for licensees' work planning.
4. For civil nuclear sites, the regulators expect a licensee's site waste management strategy and plan to be consistent with the national waste management strategy developed by NDA. The regulators expect the options for any radioactive waste management project to be consistent with the site waste management plans and strategy.

Options assessment process

5. It is expected that licensees will maintain a dialogue with the regulators during the options assessment process, with the aim of identifying the most appropriate waste management strategy to adopt.
6. The regulators expect that licensees will undertake BPEO/ BAT/ BPM studies for any significant proposals. These studies should reflect all relevant issues, including the requirement to reduce health and safety consequences to levels that are as low as reasonably practicable, and to minimise the short- and long-term environmental impacts. These studies should be made available to the regulators, together with any supporting arguments that substantiate the choice of option (or options) that the licensee is taking forward for further development or implementation. The regulators will wish to be satisfied that appropriate studies have been carried out, and will express a view on their adequacy in relation to each regulator's responsibilities.
7. The interests of the environment agencies will include the disposability of the final waste form and the type and quantity of secondary wastes, including discharges to the environment. ONR's interests will be concentrated on safety, radiological and on-site radioactive waste management aspects, with particular interest in any conditioning processes, stores and other plant involved, and minimisation of the volume and activity of the waste to be disposed of.

^e For the purposes of this document, only those regulatory interests of direct relevance to waste conditioning and storage are covered. In particular, ONR will have wider interests in respect of nuclear safety that will be regulated under the nuclear site licence conditions. Any discharges to the environment will be regulated by the environment agencies under the Environmental Permitting Regulations 2016 (EA and NRW) or the Environmental Authorisations (Scotland) Regulations 2018 .

Joint guidance from the Office for Nuclear Regulation, the Environment Agency, the Scottish Environment Protection Agency, and Natural Resources Wales.

Conceptual design

8. The licensee should inform the regulators about proposals for significant changes to HAW management strategy. At this stage, the regulators will form an initial view as to the level of regulatory scrutiny required and prioritise their efforts on more difficult and/or contentious proposals.
9. Proposals should be sufficiently substantiated to demonstrate that the selection and implementation of the proposed waste management approach has been suitably optimised, such that the risks from the implementation of the proposal throughout the lifetime of the HAW packages are ALARA/ ALARP. The regulators do not expect full substantiation when the licensee first engages, however evidence that the licensee's plans for developing the revised strategy includes this substantiation is required.

Detailed design and construction of relevant waste management plant

10. The regulators' interests are likely to involve a watching brief on progress and emerging problems, plus an interest in ensuring that the issues or concerns identified during the earlier phases of work are being addressed and closed out. The licensee should complete the majority of the RWMC before construction of relevant waste management plant commences. The start of construction is likely to be one of the hold points in the regulatory process beyond which the licensee may not proceed without ONR's permission.

Commissioning of packaging plant

11. The regulators' main interest will be confirming that the plant produces waste packages to the specification agreed at the detailed design and construction stage.

Operation of packaging plant

12. The regulators' interest will be confirming that the plant continues to produce waste packages to specification and understanding the fate of any non-complying packages that are produced.

Storage

13. The regulator will be interested in the state of the packages and the integrity of the store throughout its lifetime until removal of the waste to a final disposal facility or further store. This will include commissioning of waste stores, their operation and the monitoring of packages within them.
14. Figure 1 shows the formal procedural stages that are envisaged. Early dialogue with the regulators is a key component of the regulatory arrangements but is not represented in the figure for simplicity. The arrangements are designed to be flexible and efficient to avoid undue delay. In practice, continual dialogue between all the parties concerned will ensure that actions are carried out in parallel, as far as possible.

Appendix 2: Technical contents of a Radioactive Waste Management Case

1. Much of the information required for an RWMC should already be available in other documents, such as the integrated waste strategy and relevant plant safety cases. The RWMC should not aim to duplicate such information which can be incorporated through brief summaries and referencing. The added value of an RWMC is a demonstration of how the various components interact together with a description of any necessary arrangements for managing such interactions. In developing an RWMC it may be that gaps are found between the components and these can be addressed either in the RWMC or in the safety cases or other supporting documentation as appropriate. Where there is not, at the time of writing, sufficient knowledge to provide the necessary information, or where the need to make improvements is identified, then this should be recorded in the RWMC together with a description of how the matter will be taken forward.
2. The RWMC should describe and substantiate, in a proportionate way (see section 'Proportionate approach in the production of RWMCs') and as appropriate (noting that not all the contents listed will be relevant to all waste streams), the matters described in the following sections.

General contents

3. General contents of an RWMC should include, in summary form:
 - the waste streams (including their source of arising, characteristics, inventory and quantities);
 - the current ownership of the waste streams;
 - the management strategy for the waste streams;
 - the proposed waste management processes;
 - the relevant buildings and plant involved (e.g. for conditioning or storage) and their physical state;
 - relevant aspects of the facility organisation and the management of radioactive waste (e.g. the overall waste strategy for the site);
 - interdependencies among all steps in generation and management of radioactive waste management;
 - how the generation of radioactive waste is minimised;
 - how the radioactive waste is adequately controlled and contained;
 - how any safeguards and security issues will be addressed;
 - how the radioactive waste meets the relevant requirements to enable its transport;
 - the quality assurance arrangements; and
 - the information and records management arrangements.
4. The RWMC should refer where appropriate to relevant safety and environmental cases or other supporting documentation for detailed information and assessments.
5. The following topics should be summarised, as appropriate, in an RWMC with reference to more detailed supporting documentation. These are the subject of further guidance in this series.

Radioactive waste management strategies

6. The RWMC should summarise how the management of the relevant waste stream(s) fits into the overall waste strategy for the site and, by referencing the integrated waste strategy as appropriate, include:
- any subsidiary or secondary waste streams produced;
 - identification of the ultimate destination for all parts of the waste streams, be it
 - immediate disposal (e.g. to LLWR or other LLW disposal facility);
 - decay storage followed by disposal as LLW;
 - interim storage prior to disposal in a GDF;
 - (in Scotland) long-term storage, or
 - any other disposal solution identified subsequent to the publication of this guidance;
 - the options and processes considered to convert the raw waste into a product that is suitable for long-term interim storage and/ or disposal (including any necessary pre-treatment stages);
 - the reasons and assumptions used to reject options;
 - the reasons, assumptions, uncertainties, calculations and conclusions for selecting the preferred option(s), including comparison of the safety and environmental performance of the preferred option(s) with the options that were not selected;
 - how the preferred option is consistent with the integrated waste strategy;
 - how the preferred option is consistent with existing and reasonably foreseeable provisions for transport, storage and (in England and Wales) disposal;
 - how the preferred option is consistent with relevant government policies
 - details of any stakeholder or public consultation, if appropriate; and
 - the use of, and implications for, existing waste disposal routes if the preferred option is selected.

Waste minimisation, characterisation and segregation

See section 4 for further guidance on waste minimisation, characterisation and segregation

7. The RWMC should summarise how the management of the relevant waste stream(s) applies the requirements for minimisation, characterisation and segregation, details of which may include:
- a description of the techniques to be adopted to prevent or minimise arisings (including how any secondary wastes generated during conditioning will be prevented or minimised);
 - the details of the methods to be used for the segregation and characterisation of wastes and the steps to be taken to avoid dilution; and
 - the evidence that the (segregated) waste streams can be characterised to the level necessary to ensure compliance with the specifications for waste packaging (e.g. with respect to potential variability or heterogeneity).

Conditioning and disposability

See section 5 for further guidance on waste conditioning and disposability

8. The RWMC should summarise how conditioning is applied in management of the relevant waste stream(s), in particular how disposability is ensured, details of which may cover:
- how passive safety will be achieved;
 - the evidence that the waste package produced will be consistent with existing and reasonably foreseeable provisions for transport, storage and (in England and Wales) disposal. For most HAW this will include a disposability assessment undertaken by Radioactive Waste Management Limited, resulting in a Letter of Compliance (LoC). Where other options are considered, e.g. decay storage, then this evidence will need to be derived by the licensees themselves;
 - identification of any significant issues that may challenge disposability. These issues should be set out in detail together with any assumptions made in arriving at that conclusion (e.g. incompatibility with a specific facility design concept or feature thereof, incompatibility of the transport container with standard designs, or issues that may restrict the future choice of a geological environment for the disposal facility);
 - the intended specification for the waste package (presented in a format suitable for external audit to ensure compliant packages have been produced);
 - how the inventory of individual packages will be controlled and measured, including demonstration that any heterogeneity or variability in the waste stream can be accommodated within the specifications for the final waste form;
 - a demonstration that the proposed packaging and conditioning strategy uses best practicable means (BPM)/ best available techniques (BAT) to minimise the long-term environmental impact and to ensure associated doses are ALARP;
 - a demonstration that the proposed strategy will not lead to significant increases in the possibility of criticality in a disposal facility;
 - an assessment of the long-term performance and degradation of the waste containers;
 - identification of any potential package failure mechanisms;
 - an evaluation of any reactions that may take place between the waste and the conditioning matrix;
 - an evaluation of the long-term performance of the waste form, e.g. assessment of the potential for cracking and chemical degradation;
 - an assessment of the potential for gas generation from the wastes in the long term;
 - consideration of the impact of toxic materials as a result of release from a disposal facility and environmental impacts that might arise during, or as a result of, operations;
 - an assessment of the potential impact from any detrimental effects due to chemical species that may be present in the wastes or might reasonably be expected to form, e.g. enhancement of radionuclide solubility through chemical complex formation;
 - how conditioned waste that does not meet specifications will be managed;
 - the arrangements for quality assurance and records;

- how developments in disposal facility requirements will be taken into account.

Storage of radioactive waste

See section 6 for further guidance on the storage of radioactive waste

9. The RWMC should summarise how radioactive waste is stored, details of which may include:
- details of the storage capacity requirements;
 - estimates of package lifetime and the proposed timescale for storage;
 - demonstration that the conditioned wastes will remain within the agreed specification for final disposal throughout the storage period;
 - how passive safety will be achieved;
 - the integrity of the storage arrangements;
 - arrangements for leak detection;
 - the details of ventilation requirements and the filtration of airborne releases;
 - the environmental monitoring arrangements;
 - how the stored waste will be inspected and retrieved; and
 - how packages that show evidence of deviating from specification during storage will be managed.

Control, accountancy and records

See section 7 for further guidance on record keeping

10. The RWMC should summarise how control, accountancy and records of the relevant waste stream(s) are to be applied, details of which may include:
- the arrangements for the identification of information and records that may be required in the future to facilitate the subsequent management of radioactive substances and facilities;
 - the on-going measures to demonstrate whether compliance with requirements and standards has been achieved;
 - the timescales over which such information and records should be collected and retained; and
 - the environmental conditions for storage and long-term preservation of records.

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