# UK Strategy for the Management of Solid Low Level Waste from the Nuclear Industry

## Strategic Environmental Assessment Environment and Sustainability Report

## Non-Technical Summary

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# Contents

# Introduction

The UK Government and devolved administrations of Scotland, Wales and Northern Ireland have prepared a revised Strategy for the management of solid low level radioactive waste (LLW) produced by the UK nuclear industry. The revised Strategy has been finalised following public consultation in January to April 2015. The Strategy is an update of the previous Strategy for the management of solid LLW from the nuclear industry, which was published in 2010.

The Strategy has been subject to a strategic environmental assessment (SEA), and this document is the Non-Technical Summary (NTS) of the draft Environment and Sustainability Report (ESR) arising from the SEA. A draft of the ESR was included in the public consultation in early 2015.

The overall ESR is bound in three volumes – this NTS, the main text (Volume 1) and the Appendices (Volume 2), which provide baseline and other information to support both the NTS and Volume 1.

### What is solid low level radioactive waste?

Solid radioactive wastes fall into three main categories: low, intermediate and high level wastes. Unlike intermediate and high level waste (ILW and HLW), low level waste (LLW) does not normally require special shielding during handling or transport.

However, low level waste still covers a wide range of radioactivity. In addition, some forms of radioactivity will be quite short-lived and others may last much longer before it decays naturally.

Most low level radioactive waste from the nuclear industry can be divided into waste produced during the operations of nuclear industry sites and waste produced during the decommissioning of nuclear industry sites. Low level radioactive waste is also produced by some non-nuclear industry operations such as hospitals, the pharmaceutical industry, and research establishments. In addition, activities such as mining and processing of minerals concentrate naturally occurring radioactive materials (NORM), producing low level waste.

Operational waste includes such materials as plastic, paper, tissue, clothing, wood and metallic items. Decommissioning waste is mainly building rubble, soil and various metal plant and equipment. All wastes have acquired some radioactivity, or have incorporated some radioactive material, during their use on a nuclear industry site.

The nuclear industry includes former nuclear power stations that are undergoing decommissioning, other nuclear sites licenced to store waste or reprocess fuel (e.g. Sellafield), existing nuclear power stations, some Ministry of Defence sites and research facilities.

### What is strategic environmental assessment?

SEA is a systematic process to ensure that environmental and sustainability considerations are properly and effectively taken into account in the development of strategies, plans and programmes.

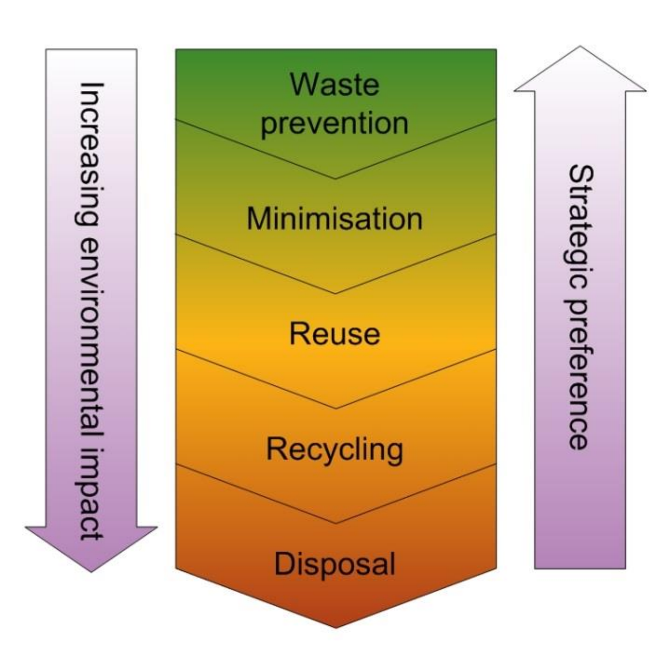
SEA is required under the European SEA Directive (Directive 2001/42/EC ‘on the assessment of the effects of certain plans and programmes on the environment’). The Directive is implemented in the UK through the ‘Environmental Assessment of Plans and Programmes Regulations 2004’.

# Overview of the Strategy

## The first Strategy – published 2010

The first Strategy for the management of solid LLW from the nuclear industry was published in 2010. The requirement for such a strategy was first identified in policy in 2007[1], when it was recognised that the forecast arisings of LLW exceeded the capacity of the LLW Repository, the UK's only disposal facility, and that there were opportunities to manage the waste more flexibly.

The principle behind both the original 2010 Strategy and this revision is to find alternative ways to manage LLW so that some of it can be diverted from disposal. Waste should be managed at the highest practicable level of the 'waste hierarchy' wherever possible.




The waste management hierarchy is a classification of waste management options in declining order of environmental impact.

Waste should be managed at the highest practicable level of the hierarchy.

If the occurrence of waste cannot be prevented, the amount should be minimised, and then reuse or recycling are much preferable to disposal.

**Figure 1 The waste management hierarchy as applied to this Strategy**

In the first five years of implementation of the 2010 Strategy, significant progress has been made in diverting LLW from disposal at the LLW Repository and improving the efficiency of such disposal as continues there.

This has been achieved through making a range of options available for management of the waste further up the waste hierarchy, or more efficiently, and providing a contractual mechanism through which the private sector supply chain is attracted to invest in implementation of these options.

The aim of this revised Strategy is to ensure that it still describes the correct direction of travel for the nuclear industry to manage its solid LLW waste.

[1] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom; Defra, DTI and the Devolved Administrations, March 2007

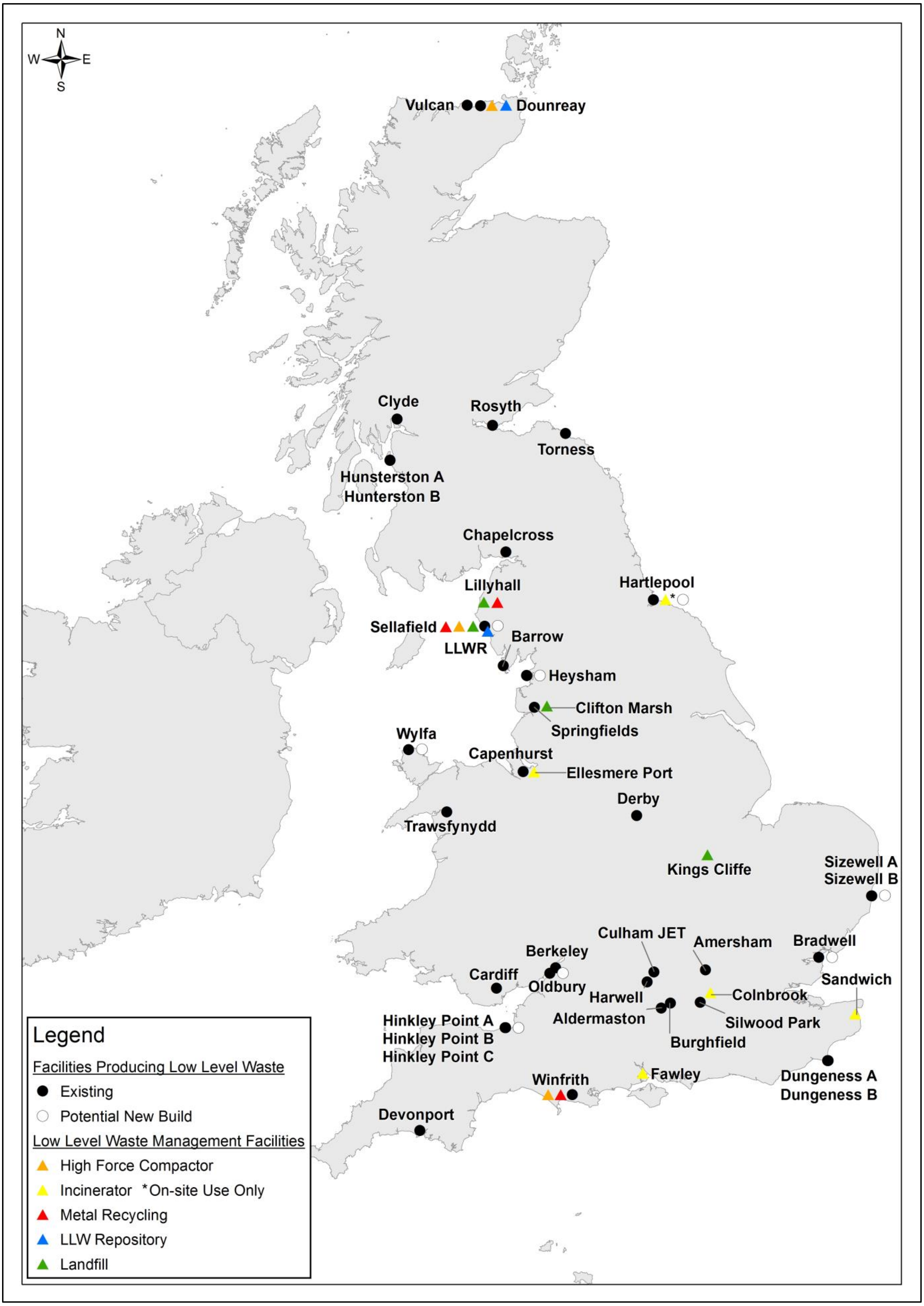



**Figure 2** The UK nuclear industry and LLW management facilities in the UK

# Outline of the revised Strategy for the management of solid LLW

The current revision of the Strategy is intended to be incremental and evolutionary rather than making radical changes from the original 2010 Strategy. It is being developed to address the same ongoing issues, the current status of which is (as of 2015):

- There are two engineered facilities in the UK for the disposal of LLW; at the LLW Repository in West Cumbria, which is open to LLW from throughout the UK, and adjacent to Dounreay in Scotland, for LLW only from the Dounreay and Vulcan sites;
- In addition to these engineered facilities, in recent years three landfill facilities have received permits for the co-disposal of lower activity LLW with other wastes;
- Disposal capacity for LLW is a precious resource that must be carefully managed and used only as a last resort.

The Strategy recognises these issues and aims to address them through three strategic themes:

- Application of the waste management hierarchy.
- Make best use of existing facilities.
- Development and use of new fit-for-purpose management and disposal routes, so waste producers have more choice when determining waste management routes.

## Key environmental issues for the Strategy to address

The following environmental problems are those which are most relevant for this Strategy:

- The total quantity of low level radioactive waste existing in the UK, or forecast to be created in the UK, is greater than the total amount of existing disposal capacity and other management routes are therefore required;
- The construction and operation of new nuclear power stations will add to the total amount of waste and extend the period over which waste is generated;
- Long-term environmental changes, including coastal erosion, climate change, increased flood risk etc., potentially pose a risk to the long-term integrity of disposal facilities;
- Groundwater – the groundwater bodies under some nuclear industry sites are contaminated and ongoing management of LLW must not make the situation worse;
- Transport – waste should be managed as close as possible to its source and with few movements. However, for LLW, the nearest appropriate waste management facility may be at a significant distance from the source of the waste.

## Strategic considerations and options

The identification of strategic options within the overall Strategy and any future implementation depend on the complex interactions of four key considerations:

- Who will manage the waste?
- How will the waste be managed?
- Where will the waste be managed?
- When will any new waste management routes be available?

## Who will manage the waste?

NDA is the key overseeing/coordinating body for the management of LLW in the UK, and the owner of much of the waste that is to be managed. The LLW Repository in West Cumbria is owned by NDA and managed by LLW Repository Ltd.

It is a principle of the Strategy that new waste management routes will emerge through the supply chain, mainly the UK waste management industry. This has been achieved in the first four years of implementation through the establishment of a waste services framework.

## How will the waste be managed?

Options for the method of waste management focus around the waste hierarchy – i.e. can LLW be treated such that a higher proportion of it can be managed at higher levels of the waste hierarchy and a lower proportion sent for disposal?

Options that emerge from the Strategy include:

- Decay storage of LLW – i.e. safe storage of LLW that contains radioactive materials with short half-lives, until the materials have naturally decayed to a lower level of radioactivity and the waste is open to a wider range of options for its management;
- Decontamination – this can open up a wider range of options for management of materials, including recycling;
- Reuse LLW– some materials could be reused in construction, landscaping, shielding etc., where suitable opportunities arise, to avoid the need to consign it as waste;
- Recycling of LLW – some LLW materials are open to recycling either within or outside the UK nuclear industry, often after decontamination;
- Incineration – to reduce the volume of combustible wastes or to recover energy. However, it is unlikely that the quantity of combustible LLW currently co-combusted with hazardous and clinical waste would be enough for energy recovery unless it was burnt together with other, non-radioactive waste;
- Treatment or volume reduction of metallic LLW by melting – melting can be used either to decontaminate metallic LLW or to reduce its volume prior to disposal;
- Volume reduction – other than incineration or melting, volume reduction can be achieved by compaction, either at low pressure in drums or at high pressure into pucks;
- Continued disposal at the LLW Repository – using either existing packaging and disposal practices or alternative, optimised practices to maximise efficiency, minimise resource use and optimise the use of the existing engineered facilities at the Repository;
- Disposal of LLW at landfill sites – lower activity LLW can be disposed of at suitably permitted landfill sites, with other waste. Three such sites have been authorised;
- Disposal of LLW in non-engineered surface facilities – using new non-engineered facilities (e.g. dedicated landfill-style facilities or in situ disposal) for the disposal of LLW to avoid the need for engineered disposal vaults such as those at the LLW Repository;
- Disposal of some LLW in a Geological Disposal Facility – disposal of LLW that contains problematic radioisotopes, such as those with very long half-lives, with intermediate

level waste (ILW) in a deep Geological Disposal Facility (GDF) - covers LLW from England and Wales only as Scottish policy is for near-site near-surface disposal.

### Where will the waste be managed?

Strategic options for where the waste could be managed are described below. The way in which the waste is managed limits the options available for where it is managed. For instance, some options are only available locally, whilst others may be available at a single national site and so on.

- A single national facility near Sellafield – such as the existing LLW Repository in West Cumbria, or a new similar facility built in the same general area;
- A single national facility elsewhere – a new facility outside the area around Sellafield;
- A small number of regional facilities – e.g. manage LLW at several smaller sites on a regional basis, rather than a single national facility;
- Multiple local facilities on, or close to nuclear industry sites – i.e. manage LLW at a number of local sites receiving LLW from one or more nearby nuclear industry sites;
- International facilities – transport LLW overseas for treatment.

### When will any new waste treatment routes be available?

Each option for how or where waste could be treated has implications for when that option may be available. Options that are available now, either in full or in part, include:

- Continued disposal of LLW at the LLW Repository and at Dounreay (when open);
- Decontamination facilities are available now at some UK sites, and internationally;
- Some facilities exist for waste recycling on existing nuclear industry sites;
- One nuclear industry site (Hartlepool) has its own small-scale incinerator. Incinerators are available now at three commercial sites to serve the rest of the nuclear industry;
- Compaction and/or high force compaction is available at some existing sites;
- The potential for reuse of some LLW, exists now;
- Disposal at landfill sites –three landfill sites are now available for disposal of some LLW;
- Disposal in non-engineered surface facilities –in situ disposal could be implemented now, with regulatory approval. Dedicated landfill-style facilities would require new sites and new consents and are not therefore available yet.

Some options require development of new facilities or capabilities. These options are not available immediately and are subject to a variety of technical, practical and regulatory hurdles.

- Build a new LLW Repository – not likely to be required under current strategic plans;
- Wider availability of decontamination facilities and broader capabilities in the UK;
- There are no metal melting facilities in the UK, although overseas facilities are used;
- The availability of decay storage is subject to the provision of suitable storage capability and is generally considered on a case-by-case basis;

- Energy recovery – incineration capacity for LLW exists now, but at facilities which do not have the capability to make recovering energy economical;
- Deep disposal of long-lived LLW in a Geological Disposal Facility – creation of a GDF is a very long-term project that is in its early stages.

# Approach to strategic environmental assessment

## Outline of the SEA process

SEA is defined on page 1. The approach to SEA adopted here has been developed from that adopted in the original SEA of 2009. Some changes have been made; these are described, along with the reasons for them, in Appendix F, in Volume 2.

The diagram below gives an overview of the five stages of the SEA process, and key SEA outputs, in relation to the ongoing development of the Strategy.

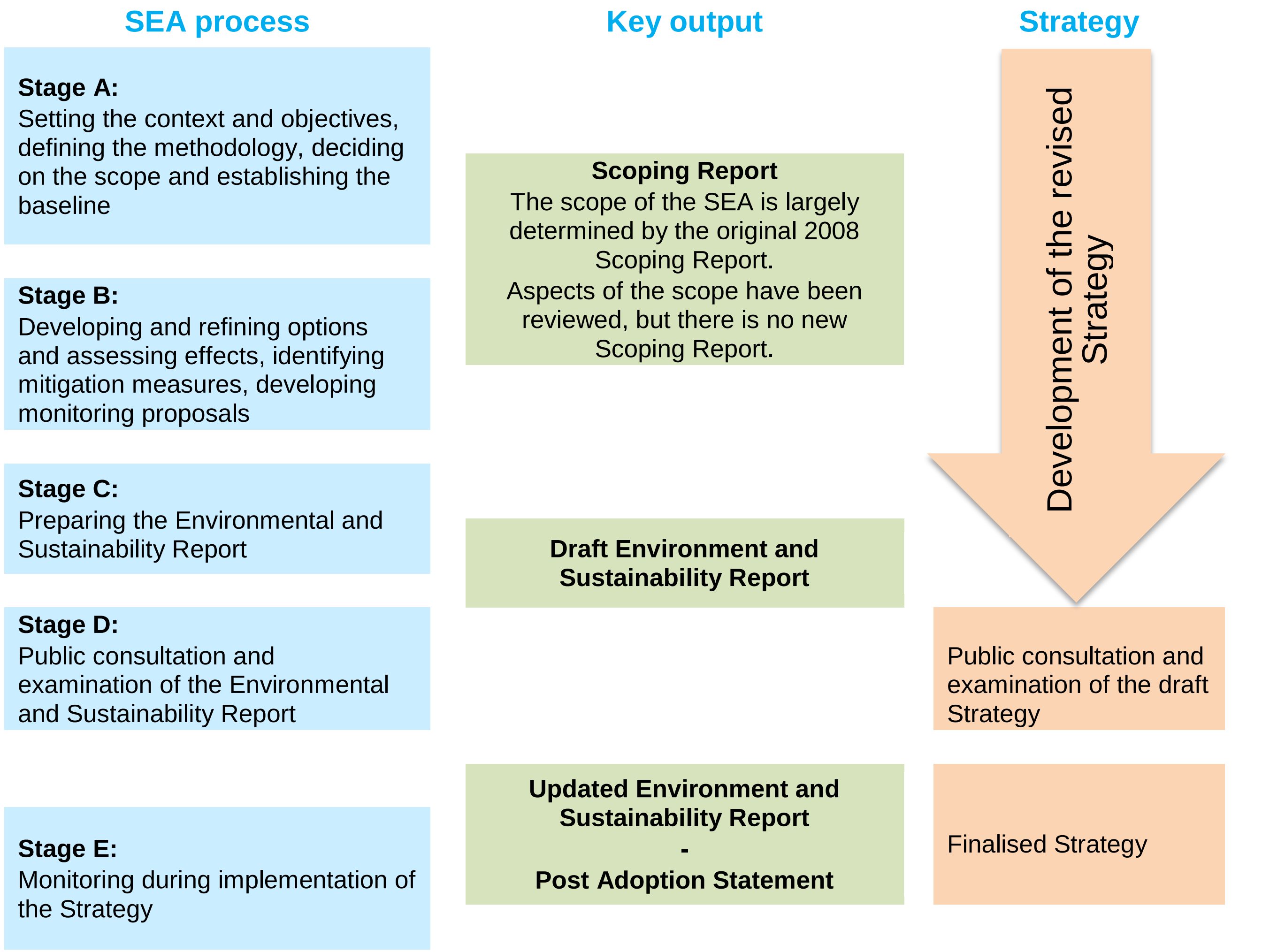



**Figure 3 Outline of the SEA process relative to development of the Strategy**

## Scope of the SEA

The European SEA Directive sets out 12 themes that are to be considered in scoping any SEA. In principle, these themes can be considered individually to determine whether they should be scoped 'in' or 'out' of consideration for a specific SEA. For current purposes, they are all scoped 'in', because in principle the Strategy could have effects relevant to any of them.

To carry out the assessment, more detailed 'objectives' were defined, drawing on the 12 themes identified in the Directive. The table below identifies the objectives that have been identified for this update of the SEA, together with the SEA Directive themes relevant to each objective.

| Sustainability objective | Definition of objective | Relevant SEA Directive themes |
|---|---|---|
| Air quality | Minimise emissions of pollutant gases and particulates to the air and enhance air quality<br>**Geographic scope**: International, national, local/regional | Air; Biodiversity;<br>Human health;<br>Flora; Fauna;<br>Soil; Water |
| Global climate change and energy | Minimise detrimental effects on the climate from greenhouse gases and increase resilience and adaptability to climate change<br>**Geographic scope**: International, national, local/regional | Climatic factors; Material assets |
| Biodiversity, flora and fauna | Protect and enhance habitats and species and promote opportunities to conserve and enhance wildlife (includes terrestrial, freshwater and marine habitats and wildlife)<br>**Geographic scope**: local/regional | Biodiversity;<br>Flora; Fauna |
| Landscape and visual | Protect and enhance landscape character, landscape quality and visual amenity. Includes specific consideration of seascapes.<br>**Geographic scope**: local/regional | Landscape;<br>Cultural heritage |
| Cultural heritage | Protect and, where appropriate, enhance the historic environment including historic buildings, archaeological remains and historic landscapes<br>**Geographic scope**: local/regional | Cultural heritage; Landscape |
| Geology, ground and groundwater quality | Minimise or remove the detrimental impact and maintain, restore and enhance to establish or increase the positive impact on groundwater, soil function and quality and geological features.<br>**Geographic scope**: local/regional | Soils;<br>Human health; Biodiversity;<br>Flora; Fauna; Water |
| Surface water resources and quality | Minimise the consumption of water resources and detrimental impact on surface water quality, enhancing it where appropriate. Protect the quality of near-shore coastal waters.<br>**Geographic scope**: International, national, local/regional | Water;<br>Biodiversity; Human health |
| Economy, society and skills | Contribute to sustainable local economies and social well-being by enhancing the population's skill base and contributing to employment opportunities, recognising workforce needs, thus supporting vibrant local communities<br>**Geographic scope**: local/regional | Population |
| Traffic and transport | Minimise the detrimental impacts of travel and transport on communities and the environment<br>**Geographic scope**: International, national, local/regional | Climatic factors; Material assets; Human health |
| Land use | Contribute to the sustainable use of land within environmental limits.<br>**Geographic scope**: local/regional | Material Assets;<br>Soil |
| Noise and vibration | Minimise disturbance to people and wildlife from noise and vibration.<br>**Geographic scope**: local/regional | Human health;<br>fauna |

## Assessment method

The strategic options described on page 4 of this NTS have been assessed against each of these objectives, to determine whether the option contributes positively or negatively towards achievement of the objective.  The assessment took account of the options for location and timing described on pages 5 and 6.  See Appendix E in Volume 2 for the detailed assessment.

# Summary of baseline information

## Introduction

The appendices set out in Volume 2 provide a body of supporting information including:

- A glossary of technical terms and abbreviations (Appendix A);
- Background information on radionuclides and health risks (Appendix B);
- A review of relevant plans, programmes and policies (Appendix C);
- A body of relevant baseline evidence, arranged thematically (Appendix D);
- The detailed assessment matrices (Appendix E);
- An explanation of how the approach to SEA has changed from the original SEA of 2009 (for the 2010 Strategy) to the current SEA (for the 2014 draft Strategy; Appendix F).

This section briefly summarises the baseline information. For more detail, see the appendices.

## Facilities and sites

The nuclear industry comprises 45 sites, including power generation (22), research (5), defence (7) and industrial medical purposes (2). These facilities are in various stages of operation, with decommissioning and preparation for care and maintenance in progress at 15 sites. Since the focus of the strategy is LLW, facilities for the management of LLW have also been considered (10 sites). These include commercial incinerators, landfills and metal recycling facilities.

More detail, including the individual site names, the owner/operator, status in 2014, any change since 2009 and identification of any waste management facilities are provided in Table D.1 in Appendix D, in Volume 2.

## Air quality

### Radioactive emissions

The public dose limit for radiological discharges to air and water is set at 1millisievert[2] per year, a level at which discharges would not pose a significant health risk to human health or areas of biodiversity. Current aerial discharges from the nuclear industry and waste management facilities are only a small fraction of the public dose limit. Furthermore, only a small proportion of these discharges from nuclear sites derive from LLW management. More information is given in Table D.2 in Appendix D.

### Non-radioactive emissions

Air quality is determined by concentrations of chemical or particulate pollutants in the air. ‘Air Quality Objectives’ (AQO) are defined as concentrations above which pollutants may be

[2] 1 millisievert (mSv) = 1 thousandth of a Sievert, the unit used to measure doses of radiation to living tissue. The average annual dose to a member of the public in the UK from entirely natural sources of radiation is 2.2mSv.

harmful, and 'Air Quality Management Areas' (AQMA) are declared where such AQOs are breached. There are 276 such areas in the UK, nearly all related to pollution from road traffic.

There are no nuclear industry sites within an AQMA in the UK. There are two nuclear industry sites within 2km of AQMAs; these are Rolls Royce Marine Power Operations Ltd in Derby and the AWE site at Burghfield.

In addition to the above, some of the waste facilities are near AQMAs, including Clifton Marsh (landfill; within 2km), Ellesmere Port and Colnbrook (both incinerators, within 5km of AQMAs).

Information on non-radioactive emissions to air is given in Table D.3 in Appendix D.

## Global climate change and energy

In 1990, overall UK greenhouse gas emissions were the equivalent of 779.9 million tonnes of carbon dioxide. Emissions have fallen since, reaching a low of 566.2 million tonnes in 2011. In 2013 (the latest year of available data), emissions were 568.3 million tonnes.

The nuclear industry, including the management of LLW does produce some emissions of greenhouse gases. A summary of sources associated with LLW management is given in Table D.4 in Appendix D.

The location of some nuclear industry sites and LLW management sites within coastal or flooding zones potentially makes them vulnerable to climatic factors. The UK Climate Projections 2009 highlight that the UK will become warmer, particularly during summer while extreme weather events such as severe storms, winds, exceptional rainfall and consequent flooding may become more frequent. These changes may result in an increase in vulnerability of sites susceptible to climatic factors as highlighted in Table D.5 in Appendix D.

## Biodiversity, flora and fauna

Most nuclear sites have biodiversity action plans (BAPs) to manage or enhance the flora and fauna present on site or on surrounding land. As well as working on their own sites, many operators work in the local area to encourage biodiversity. The Winfrith site has Sites of Special Scientific Interest (SSSIs) within its boundary, managed by Magnox Limited as part of its Heathland Management Plan in consultation with Natural England.

Twenty-five nuclear industry sites and five LLW management sites are situated near coastal and marine environments, including estuaries. Some of these habitats are protected by law. Sea water monitoring and monitoring of fished marine life is in place around these sites.

The range of designations applied to sites and species of biodiversity interest in the UK at International, European and National level is defined in Appendix D, while Table D.6 identifies the number of each category of designation within 2km of each relevant nuclear industry site.

## Landscape and visual

Many of the UK's nuclear sites are located in rural locations. The general scale of the buildings associated with a number of the sites makes them relatively noticeable features which have a significant effect on the landscape. One site is located within a National Park, four are visible from within a National Park and six are within or visible from Areas of Outstanding Natural Beauty. Further information is provided in Appendix D.

## Cultural heritage

The UK's historic environment reflects thousands of years of human occupation, settlements and activities. In general terms, it can be divided into three categories – historic buildings, historic landscapes and archaeological remains.

The most important features designated for protection are Scheduled Ancient Monuments (SAM), Listed Buildings, Register of Parks and Gardens and the Register of Historic Battlefields. The numbers of such features within 2km of any nuclear site are listed in Table D.8 in Appendix D. There are no Registered Battlefields within 2km of any nuclear industry sites.

## Geology, ground and groundwater quality

Some nuclear industry sites have no contaminated land; others have small quantities, while a few have millions of cubic metres. All sites are committed to avoiding any future contamination. Where appropriate, sites have developed Land Quality Management Plans, which may involve monitoring programmes, mitigation and clean-up activities. Information on radioactive and non-radioactive contamination is given in Tables D.9 and D.10 in Appendix D.

All Scottish nuclear industry sites overlie rocks that are designated as groundwater bodies and drinking water protected areas. Ten nuclear industry or LLW management sites in England and Wales are located above principal aquifers, while others are located above secondary A or B aquifers. Groundwater contamination is present at five sites and is being managed.

The island of Anglesey, where Wylfa is situated, is a designated UNESCO Geopark. There are several geological SSSIs within 2km of nuclear industry sites.

## Surface water resources and quality

The public dose limit for radiological discharges to water and air is set at 1 millisievert[3] per year, a level at which discharges would not pose a significant health risk to human health or areas of biodiversity. Current discharges from all sites are significantly lower than the public dose limit. Only a small proportion of these discharges from nuclear sites derive from LLW management. More information is given in Table D.11 in Appendix D.

There are limited liquid non-radioactive discharges associated with LLW, including discharges from domestic operations such as drainage. Where there is leachate from disposed or stored LLW, this includes some contaminants whose radioactivity is too low to qualify as 'radioactive'.

Little information is available on the consumption of water resources by activities associated with LLW. Some decontamination activities use water.

There are a number of water abstraction licenses in the vicinity of the nuclear sites. In some cases, for example at Sellafield, these licenses are held by the NDA and used for operations on site. The licences near to other sites are used for agriculture and drinking water. These are monitored under the same regulations as discharges to the water environment.

## Waste

Approximately one million cubic metres of radioactive waste has already been disposed of. The total predicted volume of existing waste and waste forecast to arise over the next 100 years or so is approximately 4.5 million cubic metres, of which 94% is LLW (including 'very low level waste', or VLLW). Most LLW is building rubble, soil and steel items such as framework,

[3] 1 millisievert (mSv) = 1 thousandth of a Sievert, the unit used to measure doses of radiation to living tissue. The average annual dose to a member of the public in the UK from entirely natural sources of radiation is 2.2mSv.

pipework and reinforcement from dismantling and demolishing of nuclear reactors and facilities, plus paper, plastics and scrap metal. There is considerable uncertainty in the estimation of the quantities of LLW, particularly given the potential development of new nuclear power stations in the UK and other factors. More information is given in Appendix D, including Table D.12.

Throughout the decommissioning process various non-radioactive wastes will be generated, for example asbestos from the demolition of facilities. Non-radioactive waste generated through activities associated specifically with the management and disposal of LLW, as opposed to the wider decommissioning process, will generally be limited to that arising from the domestic operations of the waste management works (e.g. canteen waste, office waste, etc.).

## Economy, society and skills

In 2013, the nuclear industry sites employed over 27,000 people across the UK (not including those working at Rolls Royce Marine Power Operations Ltd or on the naval bases). Jobs associated with LLW make up a small proportion of this workforce.

Nuclear industry sites are often located in relatively remote areas. Consequently some sites are a dominant local employer, and are strongly linked to the area's social and economic wellbeing.

The AWE facilities have been noted in the West Berkshire Core Strategy as employment sites which are strategically important for the district's economy. As several of the LLW management facilities are found in more urban areas and the facilities are smaller in scale, their influence on employment structure is less clear.

Further information covering skills and skills development programmes is given in Appendix D.

## Traffic and transport

Most nuclear sector workers travel to work by car, mainly because of the rural location of most nuclear industry sites.

In recent years, the number of waste movements to and from the LLW Repository has significantly reduced, due in part to implementation of the 2010 Strategy and diversion of LLW elsewhere. The majority of waste movements to the LLW Repository are by rail. Most of these rail journeys are from Sellafield (approximately 8 miles), having come to Sellafield by road from locations that are often much more distant. In 2013 the number of containers received was less than 300. Additional information is given in Appendix D.

## Land use

At the majority of nuclear industry facilities surrounding land use is dominated by agriculture. In a few cases nuclear facilities occur in groups or in more industrial/business-park type settings or in dockyards. Waste management facilities can be found in a variety of settings, including urban/industrial, rural or within existing nuclear sites.

Intended site end states after decommissioning vary, and in many cases are defined in the NDA Strategy 2011. For some sites, the end state depends on surrounding land uses (for instance, Winfrith is intended to be returned to heathland, while Harwell will become part of a science, technology and innovation park). Further information is provided in Appendix D.

## Noise and vibration

Potential sources of noise associated with LLW management include transportation, use of heavy machinery, ventilation equipment, grouting and decontamination activities. Potential receptors include residential properties, schools, care homes and wildlife areas etc. Further information is given in Appendix D.

# Summary of the assessment of effects

## Introduction

This section summarises the overall assessment of the potential environmental effects of the strategic options described on page 4. The full detailed assessment is described in the assessment matrices set out in Appendix E.

The detailed assessment has been made using a methodology that is described in detail in Chapter 3 of the main report. This methodology includes the application of a qualitative scoring system, which is reproduced in the table below.

The scores awarded to each option against each environmental topic have been brought together in the assessment summary tables on the following pages. Not all options for LLW management are available at all geographic scales, and the tables are subdivided geographically as follows:

- The table on page 17 summarises the assessment of those strategic options available at a single national facility near Sellafield or a single national facility not near Sellafield;
- The table on page 18 summarises the assessment of those strategic options available at a small number of regional facilities or through use of international facilities;
- The table on page 19 summarises the assessment of those strategic options available at multiple local sites.

Some strategic options appear in more than one of these tables, but the assessment is not always the same, depending on the geographic context. The rationale for which options appear in which tables is given in the bullet points under paragraph 2.26 in the main report.

The tables are followed by a summary of key issues arising on a strategic option-by-option basis. The main report also includes a summary on an objective-by-objective basis.

| Description | Symbol |
|---|---|
| The proposed option contributes significantly to the achievement of the objective | ++ |
| The proposed option contributes to the achievement of the objective but not significantly | + |
| Any positive or negative effect on the achievement of the objective is negligible | 0 |
| The proposed option detracts from the achievement of the objective but not significantly | - |
| The proposed option detracts significantly from the achievement of the objective | - - |
| There is no clear relationship between the proposed option and the achievement of the objective, or the relationship is negligible | ~ |
| There is too much uncertainty, or too little information, to enable an assessment | ? |

**Table 1 Qualitative scoring system**

| | Single national facility near Sellafield<br>Only available options are shown | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment or volume reduction of metallic LLW by melting | | | Disposal at LLW Repository | | | Deep disposal at a GDF | | |
| Timescale (short/medium/long) | S | M | L | S | M | L | S | M | L |
| Air quality | ? | ? | ? | 0 | 0 | ? | 0 | 0 | 0 |
| Global climate change and energy | - - | - - | - - | ? | ? | ? | 0 | 0 | + |
| Biodiversity, flora and fauna | ? | ? | ? | 0 | 0 | -- | ~ | + | + |
| Landscape and visual | - - | - - | - - | 0 | 0 | 0 | ~ | ~ | ~ |
| Cultural heritage | ? | ? | ? | ~ | ~ | ~ | ~ | ~ | ~ |
| Geology, ground and groundwater | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | 0 |
| Surface water quality and resources | ? | ? | ? | 0 | 0 | ? | ~ | ~ | ~ |
| Economy, society and skills | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | 0 |
| Traffic and transport | - | 0 | 0 | ? | ? | 0 | ~ | 0 | 0 |
| Land use | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | 0 |
| Noise and vibration | ? | ? | ? | 0 | 0 | 0 | ~ | 0 | 0 |

| | Single national facility not near Sellafield<br>Only available options are shown | | | | | |
|---|---|---|---|---|---|---|
| | Treatment or volume reduction of metallic LLW by melting | | | Deep disposal at a GDF | | |
| Timescale (short/medium/long) | S | M | L | S | M | L |
| Air quality | ? | ? | ? | 0 | 0 | 0 |
| Global climate change and energy | - - | - - | - - | 0 | 0 | + |
| Biodiversity, flora and fauna | ? | ? | ? | ~ | + | + |
| Landscape and visual | - - | - - | - - | ~ | ~ | ~ |
| Cultural heritage | ? | ? | ? | ~ | ~ | ~ |
| Geology, ground and groundwater | ? | ? | ? | 0 | 0 | 0 |
| Surface water quality and resources | ? | ? | ? | ~ | ~ | ~ |
| Economy, society and skills | ? | ? | ? | 0 | 0 | 0 |
| Traffic and transport | - | 0 | 0 | ~ | 0 | 0 |
| Land use | ? | ? | ? | 0 | 0 | 0 |
| Noise and vibration | ? | ? | ? | ~ | 0 | 0 |

**Table 2 Assessment summary table – single national facility near Sellafield or not near Sellafield**

| | **Small number of regional facilities** Only available options are shown | | | | | | | | | | | | | | | | | | | | | | **International facilities** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Decay storage | | | Recycle | | | De-contamination | | | Incineration to recover energy or reduce volume | | | Treatment or volume reduction of metallic LLW by melting | | | Volume reduction by compaction | | | Disposal at landfill sites | | | Treatment or volume reduction of metallic LLW by melting | | |
| Timescale (short/medium/long) | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L |
| Air quality | 0 | 0 | + | ? | ? | ? | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | - | ? | ? | ? |
| Global climate change and energy | 0 | 0 | + | + | ++ | ++ | - | - | 0 | - - | - - | - - | - - | - - | - - | - | - | - | + | + | + | - - | - - | - - |
| Biodiversity, flora and fauna | 0 | 0 | ~ | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | ? | ? | ? | ? |
| Landscape and visual | 0 | 0 | ~ | ~ | ~ | ~ | ? | ? | ? | - - | - - | - - | - - | - - | - - | - | - | - | 0 | 0 | 0 | - - | - - | - - |
| Cultural heritage | 0 | 0 | ~ | ~ | ~ | ~ | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | 0 | ? | ? | ? |
| Geology, ground and groundwater | 0 | 0 | ? | 0 | 0 | 0 | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | - | - | - | 0 | 0 | 0 | ? | ? | ? |
| Surface water quality and resources | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | ? | ? | ? | ? |
| Economy, society and skills | ~ | ~ | ~ | + | + | + | + | + | 0 | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | + | + | + | ? | ? | ? |
| Traffic and transport | ~ | ~ | ~ | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | - | 0 | 0 | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | 0 | 0 | ? | 0 | 0 | 0 | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | 0 | 0 | 0 | ? | ? | ? |
| Noise and vibration | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0 | 0 | 0 | ? | ? | ? | ? | ? | ? |

**Table 3 Assessment summary – small number of regional facilities and international facilities**

| | **Multiple local facilities** Only available options are shown | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Decay storage | | | De-contamination | | | Reuse | | | Recycle | | | Volume reduction by compaction | | | Disposal at landfill sites | | | Disposal at non-engineered facilities | | |
| Timescale (short/medium/long) | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L |
| Air quality | **0** | **0** | **+** | **0** | **0** | **0** | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **0** | **0** | **-** | **0** | **0** | **-** |
| Global climate change and energy | **0** | **0** | **+** | **-** | **-** | **0** | **+** | **++** | **++** | **+** | **++** | **++** | **-** | **-** | **-** | **+** | **+** | **+** | **+** | **+** | **+** |
| Biodiversity, flora and fauna | **0** | **0** | **~** | **?** | **?** | **?** | **?** | **?** | **?** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **?** | **?** | **?** | **?** |
| Landscape and visual | **0** | **0** | **~** | **?** | **?** | **?** | **~** | **~** | **~** | **~** | **~** | **~** | **0** | **0** | **0** | **0** | **0** | **0** | **-** | **-** | **-** |
| Cultural heritage | **0** | **0** | **~** | **?** | **?** | **?** | **~** | **~** | **~** | **~** | **~** | **~** | **0** | **0** | **0** | **0** | **0** | **0** | **-** | **-** | **-** |
| Geology, ground and groundwater | **0** | **0** | **?** | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **-** | **-** | **-** | **0** | **0** | **0** | **?** | **?** | **?** |
| Surface water quality and resources | **0** | **0** | **+** | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **?** | **?** | **?** | **?** |
| Economy, society and skills | **~** | **~** | **~** | **+** | **+** | **0** | **+** | **+** | **+** | **+** | **+** | **+** | **0** | **0** | **0** | **+** | **+** | **+** | **?** | **?** | **?** |
| Traffic and transport | **~** | **~** | **~** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **+** | **+** | **+** | **0** | **0** | **0** | **0** | **0** | **0** |
| Land use | **0** | **0** | **?** | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **?** | **?** | **?** |
| Noise and vibration | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **?** | **?** | **?** | **0** | **0** | **0** | **?** | **?** | **?** | **?** | **?** | **?** |

**Table 4 Assessment summary – multiple local facilities**

## Summary of assessment by strategic option

### Decay storage prior to further treatment or disposal

In the short to medium term, with appropriate packaging and management, decay storage is a low-risk waste management method.

In the long term, decay storage reduces the level of radioactivity in the LLW. Therefore, when it is released from decay storage, there would be greater potential to manage more of the LLW higher up the waste hierarchy and for less of the LLW to go to disposal. Any remaining radioactive components of the LLW will pose a lower risk to air quality and surface water, and there may be benefits for other environmental objectives. Climate change may benefit through avoiding the use of high-energy decontamination techniques or through opening up opportunities for greater use of recycling.

### Decontamination of facilities, materials and equipment before consignment as waste

Decontamination covers a variety of physical and chemical processes for removing radioactive material from LLW.

Some decontamination processes are energy-intensive, which implies a high rate of carbon emissions and therefore negative effects on climate change. Other emissions to air from decontamination processes are assumed to be insignificant due to stringent regulatory controls.

Development of any new facilities for decontamination could affect a number of environmental objectives in uncertain ways, and thorough site-specific assessment would be essential.

Relative to most other options decontamination is likely to require a larger workforce with a broad range of skill levels. In the short to medium term it is likely to make a positive contribution to the economy of local communities.

Some decontamination activities have the potential to create relatively high noise levels. However, whether this leads to a significant effect depends on site-specific factors, including the proximity of sensitive receptors.

### Reuse LLW to avoid consigning it as waste

Reuse of manufactured items offers potentially significant savings in carbon emissions compared to disposal of the material and replacing it with items newly manufactured from virgin materials. Wider savings can also be recognised, taking into account the avoidance of depletion of non-renewable resources.

Minor additional benefits are likely to arise in relation to employment, but would not significantly affect communities.

Reuse of bulk materials such as soils and rubble in void filling and landscaping poses potential risks to achievement of a number of other environmental objectives. This is because of the potential for contaminants in the reused material to leach out. Such effects would be dependent on site-specific conditions and could only be confirmed by site-specific assessment.

### Recycle LLW after consignment as waste

Recycling is essentially a catch-all term for the reuse of materials after they have been processed to make reuse possible; it would therefore include reuse after decontamination or decay storage, or after a range of other conventional processes for sorting or processing of waste for recycling that are applicable irrespective of their radioactive status.

Some recycling processes are energy-intensive and could cause air pollution and create noise. The confirmation of any impact would be subject to site-specific assessment, depending on the process involved and a range of site-specific factors. These potential adverse impacts would have to be set against the potential impacts of manufacturing virgin materials.

There are significant benefits to climate change through recycling due to the savings in energy consumption from recycling materials compared to manufacturing virgin materials. Recycling steel for example, can save up to 75% of the energy used to make virgin steel.

### Incineration of LLW to recover energy or reduce volume

Incineration is currently provided at three commercial sites. Any future expansion of incineration would entail increased use of these existing sites or licensing of additional commercial incinerators.

Incineration has the potential to release a range of gaseous, particulate and radioactive pollutants to air. It reduces volume by, in effect, burning most of the waste, leaving only a non-combustible residue in the form of ash for disposal.

The only capacity for energy recovery through incineration is at Sandwich, where steam is recovered for distribution in the local area heating system.

All incinerator operations are subject to very strict regulatory oversight and licencing conditions, including monitoring and measures to clean up emissions before they reach the air. Nevertheless, effects on air quality are uncertain and would be subject to specific assessment. Any significant emission of pollutants has potential knock-on effects for several other environmental objectives.

There are wider potential effects for a number of objectives if new facilities are to be developed. These effects remain very uncertain and subject to confirmation during site selection and site-specific Environmental Impact Assessment.

Finally, while in general, incineration of waste has the potential to contribute to greenhouse gas emissions, the quantities of relevance to LLW would not lead to significant effects on a national scale.

### Treatment or volume reduction of metallic LLW by melting

Melting of metallic wastes is a high-temperature thermal process, currently carried out using international facilities, and can be used as a form of treatment/decontamination prior to recycling of metallic LLW or to reduce the volume of metallic wastes prior to disposal. Any expansion of the practice could entail building new facilities in the UK, although there are no such plans at present; it is assumed this would be on a national or regional basis.

Although the range of pollutants potentially generated would be narrower, in other respects the environmental risks associated with melting and particularly with the provision of any capacity for melting in the UK, would be very similar to those described above for incineration. Potential impacts relevant to a wide range of environment and sustainability objectives remain very uncertain and would require site-specific assessment.

Where the technique is applied for volume reduction before disposal, there would be adverse effects in relation to climate change due to the high energy usage involved in melting, though not assessed as being of a significant level relative to other sources of emissions nationally. Where it is applied as a form of treatment to enable recycling of the metals, these effects would be offset by the savings in energy usage in making ‘virgin’ metals from ores.

## Volume reduction by compaction

Compaction includes two processes both designed to reduce the volume of LLW to maximise the efficiency of use of the available volume for disposal at the LLW Repository, or other disposal facility. Low-force compaction is a relatively low-technology process carried out at some nuclear industry facilities, while high-force compaction is carried out at three regional centres (Sellafield, Winfrith and Dounreay).

High-force compaction, which is currently used to a greater extent than low-force compaction, is a relatively energy intensive process (although much less so than melting) due to the operation of high-force hydraulic systems and ventilation systems etc., so there would be minor effects on climate change due to emissions of greenhouse gases. In addition, there is the potential for construction of any new high-force compaction plant to have visual impacts, although this is likely to be limited by its probable location within an existing nuclear industry site. The process would also increase the efficiency of use of transport, potentially reducing the total number of vehicle movements involved in the management of LLW.

## Disposal of LLW at the LLW repository

In most respects, disposal of LLW at the existing Repository in West Cumbria would represent a continuation of existing practices. Increased use of this method of disposal would represent a reversal of the intention of the Strategy.

The LLW Repository is designed to be permeable in the long term, and overlies a groundwater body designated as a primary aquifer. However, there are very substantial engineering and packaging containment measures in place to ensure that contamination does not occur even in the long term. These have been very thoroughly assessed through an Environmental Safety Case process and are subject to stringent regulatory requirements and oversight.

In the very long term (on a timescale of many hundreds of years), coastal erosion could compromise the integrity of the LLW Repository, leading to the re-exposure of waste that had been intended to be buried in perpetuity. Radioactive decay would have significantly reduced the activity levels in the waste by this stage, but some radionuclides would remain and other non-radioactive contaminants will also be present. There is therefore a risk that such radionuclides and other contaminants could be released into the environment at an unknown date in the distant future, with potential knock-on effects for air quality, biodiversity, soils, surface water and land use, and in particular for coastal waters and marine habitats. The Environment Agency has given a formal view that providing the requirements are met, the potential for disruption of the site by coastal erosion is an acceptable risk.

## Disposal of LLW at landfill sites

In general, the use of landfill sites for disposal of LLW is a low-risk option, with little potential for significant environmental impact. This is because the impacts associated with establishment and operation of the landfill itself would already be in place and not directly attributable to LLW.

Disposal at landfill sites requires a much lower level of engineering and materials, and therefore much less energy expenditure and embodied carbon, than disposal at the LLW Repository.

In order to obtain Environmental Permits to receive LLW, landfill sites must complete an Environmental Safety Case process that will demonstrate no long-term effects from receiving LLW, to the same standards as the LLW Repository.

However, in the very long term landfill sites may be vulnerable to erosive forces, again in a similar way to the LLW Repository (albeit none of the current sites are coastal) and therefore the effects of long-term environmental change, increasing the risk that buried LLW may be released into the environment in the distant future. This risk is subject to site specific factors (e.g. geological conditions, proximity to the coast or rivers, susceptibility to flooding).

### Disposal of LLW at non-engineered surface facilities

This option includes disposal in dedicated landfill-style facilities and disposal in situ.

Disposal of LLW in dedicated landfill-style facilities could use existing voids, newly excavated voids or land-raising techniques. Disposal in situ does not require the LLW to be moved or disturbed from its present position. Instead, minor works are carried out to secure and contain the waste in place.

The creation of new dedicated landfill-style facilities, particularly if they are outside the boundaries of existing nuclear industry sites, could affect a range of environmental objectives, and would require detailed site-specific assessment.

Disposal in situ has the potential to cause leaching of contaminants into groundwater or surface water, with knock-on effects on biodiversity and land use. These effects remain uncertain, due to their dependence on site-specific factors.

Both types of disposal are open to similar long-term risks of erosion to those described for landfill sites.

Both variants use much lower levels of engineering and materials than the LLW Repository, resulting in potential savings in carbon emissions and embodied carbon.

### Deep disposal of LLW in a Geological Disposal Facility (GDF)

Disposal of LLW in a GDF is a very low-risk option for all environmental objectives. A GDF would be built principally for disposal of higher activity wastes, and its secondary use for disposal of LLW would not significantly add to its impacts. While this use would entail an increase in the size of the underground excavations, the increase would be negligible compared to the overall scale of a GDF.

There are potential benefits arising from the very high resilience of a GDF in the face of long-term environmental change, in that the LLW would be placed as far as is practicably possible outside the reach of erosive forces, flooding, extreme weather events, etc. In addition, it would be placed beyond any reasonable possibility of interaction with the biosphere, maximising the protection of biodiversity from the effects of radioactive or other contamination.

## Cumulative effects

### Introduction – definition and approach to cumulative effects

It is a principle of the Strategy that there is no preferred option, and that multiple options are likely to be implemented simultaneously. This section considers whether the simultaneous implementation of more than one option could result in cumulative or combined effects.

Cumulative or combined effects could occur in one of four main sets of circumstances:

- Where more than one option is implemented at a single location, and both options have effects relevant to the same objective or objectives that act in a cumulative manner to increase the significance of the combined effect;
- Where a single option is implemented at more than one location, and the combined impact in multiple locations acts in a cumulative manner to increase the significance of the overall effect;

- Where more than one option, implemented in separate locations, have effects relevant to the same objective or objectives that act in a cumulative manner to increase the significance of the combined effect;
- In addition to the above, the implementation of any option or options could have effects that act cumulatively with the effects of other developments unrelated to the management of LLW but taking place in the same area.

The simple occurrence of several impacts of a similar kind, especially if they are at separate locations, does not necessarily represent a cumulative impact, particularly if the individual impacts are felt solely or primarily at a local level.

So, for instance, noise effects at several different locations might occur, but would not act together because they would each be felt only at the local level. However, if several different noise sources are created on one site, they might have a combined effect on an individual receptor. Similarly, greenhouse gas emissions from several different sites would act together to have a combined effect on the global climate.

## Cumulative effects

Volume 1 contains a detailed account of potential cumulative effects, organised by environmental objective. A brief summary of the principal issues identified is provided below.

**Air Quality**

- Incineration and melting could occur in proximity to other industrial activities or emissions from busy roads, with consequent cumulative air quality effects. Assumed to be minimised or avoided through initial assessment/consenting process.

**Global Climate Change and Energy**

- Several options, but particularly incineration and melting, would produce excess greenhouse gas emissions, contributing to climate change. Because the climate is global, these effects would act cumulatively wherever the options are implemented; and
- Other options create net savings in greenhouse gas emissions through recycling and reuse of materials, which uses far less carbon than manufacture of virgin materials/items.

**Biodiversity, Flora and Fauna**

- In relation to biodiversity, due to the relative similarity of the locations of many nuclear industry sites, there is a high potential for the presence of similar habitats. The development of any options that affect habitats at these sites, particularly if designated or priority habitats are present, could disproportionately affect particular habitat types and wildlife species in a cumulative manner.

**Landscape and Visual**

- Impacts on the landscape (including seascape and townscape) are only likely to act cumulatively if several options are developed in close proximity, effectively within the same landscape setting. In practice, the same principle applies to cumulative effects on cultural heritage.

**Geology, Ground and Groundwater Quality**

- Soils may be vulnerable to multiple impacts from the development of several options in close proximity; and
- Groundwater is a particularly vulnerable receptor, and could experience cumulative effects if more than one source of contamination is present within the area of a single groundwater body such as an aquifer. Any contamination of groundwater could have knock-on effects for surface water, biodiversity and land use, and indirectly on human health if it leads to relevant dose limits being exceeded.

**Economy, Society and Skills**

- In relation to economy, society and skills, few significant effects were identified due to the generally small levels of employment generated by waste management. However, if several options were to be implemented in close proximity, then there may be sufficient employment and a sufficient range of skills created to significantly benefit the local communities.

**Noise and Vibration**

- Wherever more than one option is implemented in close proximity, there is the potential for its noise impacts to act in combination to create more significant effects. In all cases, this is dependent on the proximity of receptors to experience such effects.

# Conclusions

## Introduction

These conclusions are structured around the three strategic themes that form the core of the Strategy:

- Application of the waste management hierarchy;
- Make best use of existing facilities;
- Development and use of new fit-for-purpose management and disposal routes, so waste producers have more choice in determining waste management routes.

## Application of the waste management hierarchy

The main methods examined in this SEA for managing LLW at the higher levels of the waste hierarchy are reuse and recycling, facilitated by decontamination. Decay storage could also be considered as a method for enabling the management of LLW further up the hierarchy.

### Decontamination

Decontamination could help to divert significant quantities of LLW from disposal to recycling, although it would also generate a smaller quantity of secondary waste, which would require separate management.

Decontamination also carries the potential for adverse effects in relation to several aspects of the environment, particularly if new facilities are required, although in most cases these effects are uncertain and subject to the need for site-specific assessment. The scope of any such assessment would be determined on a case-by-case basis, but would always include:

- Biodiversity, flora and fauna;
- Landscape and visual (including seascape and townscape, where relevant);
- Cultural heritage; and
- Noise and vibration.

### Reuse

Once waste has been generated, reuse is the highest/most desirable available level on the waste hierarchy still. It has significant potential benefits, including:

- It defers the need to dispose of the material as waste for a substantial period, possibly indefinitely, during which time its radioactivity is likely to reduce due to decay;
- It avoids the need for the use of new materials, which could themselves become contaminated and then need to be managed as radioactive waste.

However, the circumstances under which materials can be reused are limited, in order to avoid the risk of human or environmental exposure to radiation. In particular, the reuse of soils or rubble in void-filling or landscaping could divert large bulk materials from disposal. However, this practice would carry a risk of contaminants affecting surrounding environmental receptors.

Any consideration of the potential for reuse therefore needs to be subject to rigorous assessment and site-selection processes. Key issues to be considered would include:

- The nature of the LLW concerned and the circumstances of reuse;
- The prevailing ground and groundwater conditions;
- Local environmental conditions, including biodiversity, surface water and land use.

### Recycling

Recycling of LLW, often after decontamination or other treatment, can significantly reduce the amount of LLW sent for disposal. There are some potential but uncertain adverse effects, but in general recycling is relatively low-risk for the environment.

### Decay storage

Like decontamination, decay storage can be considered a form of treatment of LLW to prepare it for other forms of management.

The assessment has identified no significant adverse effects in the short to medium term. In the long term, there may be knock-on benefits to air, climate change and surface water, with the possibility of benefits for ground and groundwater and for land use.

In circumstances where it is applicable, decay storage is a low-risk option with potentially significant benefits.

## Make best use of existing facilities

### The LLW Repository

Continued use of the Repository as it is at present, to house LLW that cannot be managed elsewhere, is a necessity. Any differences between packaging options are not significant in environmental terms, although they may have cost implications.

Continued minimisation of the waste sent to the LLW Repository is given extra value by the very long-term risk that coastal erosion could lead to the re-exposure of LLW that had been thought permanently buried, resulting in its release into the environment.

### Volume reduction

Compaction of LLW to reduce its volume before disposal is a low-risk activity in environmental terms (with appropriate containment for the high-force compaction facilities), and achieves significant benefits in terms of efficient use of disposal space. It would be equally applicable to waste destined for other disposal routes than the LLW Repository, such as landfill.

Melting of metallic wastes and incineration both require industrial-scale plant carrying out high-temperature thermal processes. There are potentially significant environmental impacts associated with their construction and operation, although they are subject to very strict environmental regulation.

While these options have a valuable role to play, the assessment also indicates that they carry the greatest potential environmental risks of all the options considered. Any decision to apply these options would be subject to a demonstration that the long-term environmental and sustainability benefits outweigh the potential risks.

The potential range of effects associated with these methods is such that any proposal to expand their use, and in particular any proposal to establish new plant in the UK, requires very careful assessment through its site selection and Environmental Impact Assessment (EIA) process. A broad range of environmental issues, including all of those covered in this report, would need to be taken into account.

## Develop and use new fit-for-purpose management and disposal routes

Some LLW has such low levels of radioactivity that it does not require the high levels of containment provided at the LLW Repository, while in some cases the radioactivity is very short-lived due to the short half-lives of the relevant radionuclides.

For such lower activity LLW, alternative forms of disposal are appropriate once it is demonstrated that disposal will meet all required regulatory risk targets and any other requirements. The methods considered here include disposal at landfill sites and disposal at non-engineered facilities. A third route, disposal at a Geological Disposal Facility (GDF), is appropriate for LLW at the opposite end of the spectrum – waste that contains such long-lived or otherwise problematic radionuclides that it cannot be accepted at the LLW Repository.

All of these routes except disposal at a GDF carry a risk that, in the very long term, they could be affected by erosion that could re-expose waste that has been disposed of there. This means that the selection of suitable sites needs to include careful consideration of factors potentially affecting very long-term stability and resilience, such as proximity to a river or the coast, geological conditions, vulnerability to flooding, etc.

### Disposal at landfill sites

This option implies co-disposal of LLW with other waste at established landfill sites. Any environmental impacts associated with the establishment and management of the landfill site as such are therefore separately accounted for as part of the original consenting and licencing process for the landfill site itself.

In principle, use of landfill void is not desirable. However, it is preferable to disposal at the LLW Repository because there is only one LLW Repository; capacity there is much more limited than available landfill capacity, and disposal at the LLW Repository uses much more resources than disposal in landfill. Disposal of LLW will not significantly deplete available landfill void – the total of all LLW expected to arise over more than 100 years is well under 1% of the total volume of landfill space available and only a proportion of the total LLW is likely to be sent to landfill.

### Disposal at non-engineered facilities

The use of dedicated landfill-style facilities would be broadly similar to the use of landfill sites, with the addition of any environmental effects associated with the initial establishment and management of the site. A broader assessment at site selection stage is therefore required.

In situ disposal has advantages in that the waste does not need to be disturbed from its existing position. However, without substantial engineering works it would be difficult to prevent contact with ground and groundwater, which could lead to a risk of damage to environmental receptors on adjacent land. This could limit the long-term applicability of this method on sites where it would otherwise be desirable. The key factor influencing decisions on this would be local ground and groundwater conditions.

### Disposal at a GDF

Disposal of LLW at a GDF is seen as a low-impact, low-risk option. However, it will only ever be applicable to a small proportion of LLW, including problematic categories of LLW that are not suitable for other management routes. It is not likely to be available in the short term.

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