LLW Repository Ltd

The 2011 Environmental Safety Case

Non-technical Summary

LLWR/ESC/R(11)10034

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Non-technical Summary of the LLWR's 2011 ESC

This is the '*Non-technical Summary*' of the Low Level Waste Repository's 2011 Environmental Safety Case (ESC). The 2011 ESC will be submitted to the Environment Agency to meet their requirement on us, the LLW Repository Ltd, to submit a revised environmental safety case by the 1st May 2011.

The Low Level Waste Repository

The Low Level Waste Repository (LLWR) is the United Kingdom's principal facility for the disposal of solid low-level radioactive waste (LLW). LLW has been disposed at the LLWR since 1959, initially tipped into trenches and, since the late-1980s, packed in containers and placed in engineered vaults.

The LLWR is owned by the Nuclear Decommissioning Authority (NDA), which is a non-departmental public body created under the Energy Act 2004. The NDA is a strategic authority that owns the 19 civil nuclear sites, and associated nuclear liabilities and assets, previously under the control of the United Kingdom Atomic Energy Agency and British Nuclear Fuels Ltd.

LLW Repository Ltd is the Site Licence Company that operates the LLWR on behalf of the NDA.

Low-level waste

Low-level radioactive wastes form the bulk of all the radioactive wastes in the United Kingdom. About 95 percent of the total physical volume of the radioactive wastes is LLW; however, LLW only contains a small fraction of the total radioactivity in all the wastes, much less than one percent of the total.

LLW contains a wide range of materials, including: paper, tissue, wood, resins, plastic, steels and other metals, graphite, building rubble, and soil. In the future, LLW will contain more secondary wastes, including ash from incineration and slag from metal melting, as more materials are recycled and size-reduced (see below).

The LLWR receives wastes from a range of producers, including nuclear power stations, facilities that manufacture and reprocess nuclear reactor fuel, defence establishments, general industry, radioisotope manufacturing sites, hospitals, universities and from the clean-up of contaminated land and buildings. The largest consignor of waste to the LLWR is the nearby Sellafield nuclear site. Currently, about 30% of the waste we receive originates from Sellafield and waste from other sites is compacted at Sellafield before being sent to the LLWR.

The United Kingdom Radioactive Waste Inventory lists all LLW that will need to be managed in the future. The volume of this waste in its raw state (i.e. before any treatment and packaging) is approximately three million cubic metres. Some of this LLW is called very low-level waste (VLLW). VLLW contains very low concentrations of radioactivity and can be disposed in landfill-type facilities. VLLW does not need to be disposed in the engineered vaults used at LLWR.

National LLW policy and strategy and LLWR's role

The NDA has published a '*UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry*' [1]. The Strategy has been prepared by the NDA for the UK Government and devolved administrations in response to their '*Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom*' [2], published in 2007.

The UK Strategy is to make '*best use of existing LLW management assets*' for the management of LLW. This approach is based on a Strategic Environmental Assessment (SEA), conducted to support the development of the UK Strategy. '*Best use of existing LLW management assets*' means continuing to use the LLWR to dispose of LLW, but only LLW that requires the protection provided by disposal in vaults. It also means minimising the volume of LLW that needs to be disposed at the LLWR, while maximising the capacity of the facility to safely take waste. The UK Strategy recognises that the LLWR can only continue to be used to dispose of LLW if we can demonstrate that the facility is safe.

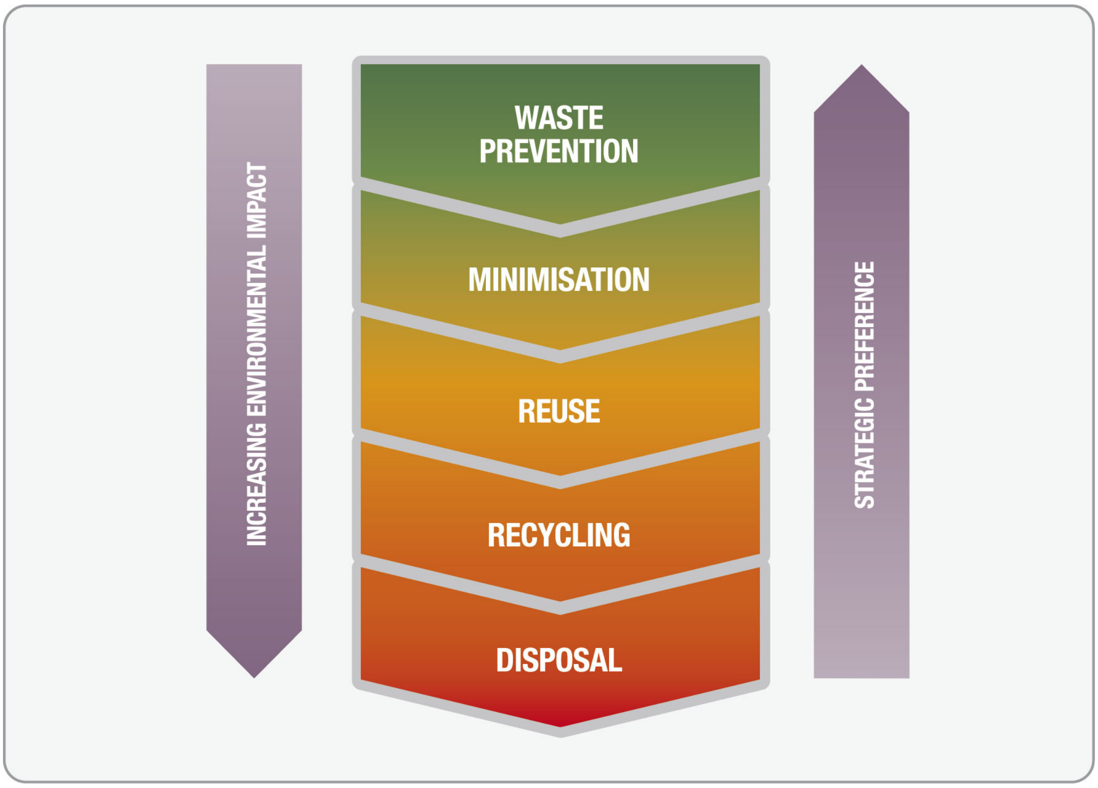

Figure 1 Waste hierarchy

An important part of the UK Strategy is the implementation of the waste hierarchy – see Figure 1. The best ways of reducing the amount of wastes are to prevent or minimise their creation. Where wastes cannot be avoided or already exist, the UK Strategy is to try to reuse or recycle the wastes, or at least reduce their physical volume. The volume of LLW has been reduced by compaction at Sellafield before coming to the LLWR since the mid-1990s. The LLWR has worked as a partner with

1 Nuclear Decommissioning Authority, *UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry*, August 2010.

2 Defra, DTI and the Devolved Administrations, *Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom*, March 2007.

the NDA to set up contracts with companies to treat LLW to allow metals to be recycled after decontamination and organic wastes to be incinerated. These treatments all reduce the volumes of wastes that need to be disposed. The UK Strategy is also seeking to provide options for the disposal of VLLW in fit-for-purpose facilities, where possible near the site of arising, and not in the vaults at the LLWR.

The strategic role of the LLWR is, therefore, to support the NDA in implementing the UK Strategy for managing LLW. This includes maximising the potential of the LLWR to accept LLW that can be safely disposed and which requires disposal in engineered vaults. Our ESC has been developed taking into account this strategic role.

Situation and history of the LLWR

The LLWR is located on the West Cumbrian coastal plain, close to the village of Drigg and approximately five kilometres south-east of Sellafield – see Figure 2. Apart from nearby Sellafield, the area is predominantly rural. The area along the coast adjacent to the site is designated as a Site of Special Scientific Interest (SSSI), known as the Drigg Coast SSSI. Along the north-eastern boundary is the Carlisle to Barrow-in-Furness railway line, a siding from which enters the site for the delivery of waste containers and other items and materials. The main north-south road through West Cumbria, the A595, runs about two kilometres to the east of the site. The Ravenglass Estuary lies to the south. The Cumbrian mountains rise further to the east. The LLWR lies outside the Lake District National Park, which is bounded by the A595 and the Ravenglass Estuary.

Figure 2 The LLWR site and its immediate environs

The LLWR site is about two kilometres long and half a kilometre wide and lies on a northwest-southeast axis. A boundary fence, designed to prevent unauthorised access, encloses the site. The northern half of the site is used for waste disposal. The southwestern boundary of the northern area of the site borders the SSSI. The height of the site above sea level varies from about 5m at its southern end to 20m at its northern end. The Drigg Stream flows through the site roughly parallel with the southwestern site boundary. It leaves the site to the south and discharges into the River Irt, which is tidal at that point. The Irt forms the northern arm of the Ravenglass Estuary.

The site of the LLWR was first developed in 1940 as a Royal Ordnance Factory (ROF) for the production of TNT during the Second World War.

LLW has been disposed at the site since 1959, initially in seven trenches. The drummed, bagged or loose waste was tumble-tipped into the trenches. The trenches were used for disposal up to 1995. The trenches are currently covered by an interim cap of soil, containing a plastic membrane to minimise the infiltration of water into the wastes. The trenches contain about 500,000 m^3 of waste.

From the late 1980s onwards, disposal operations were upgraded to modern standards. A concrete disposal vault was constructed, Vault 8, allowing the disposal of wastes in containers. Waste was first put into Vault 8 in 1988. The first seven years of the operation of Vault 8 overlapped with that of Trench 7, while the space in Trench 7 was utilised. Construction of a second vault, Vault 9, was completed in December 2010. Waste started to be placed in Vault 9, in a prepared area, in 2009 prior to the vault's final completion.

Most wastes are received within steel half-height ISO containers or third-height ISO containers, which are filled with cement grout at the site and then stacked within one of the vaults. Currently, larger items are placed or grouted directly within specific areas of the Vault 8. Vault 8 contains about 200,000 m^3 of waste containers.

It was originally planned that waste containers would be stacked to a height of four half-height ISO containers in Vault 8. Waste in the vault up to this height is disposed – see below. The vault is now almost full to this original design capacity. Some waste containers are now stored in Vault 8 in higher stacks above the disposed waste. Waste is also stored, rather than disposed, in Vault 9 – again, see below.

Water infiltrating through the trenches, known as leachate, and rain water run-off from Vaults 8 and 9, are collected, sampled to check that they are safe, and then discharged down a pipeline into the sea.

Regulation of radioactive waste disposal

The disposal of radioactive waste in England and Wales is regulated by the Environment Agency under the Environmental Permitting (England and Wales) Regulations 2010. The Environment Agency has issued us with a Permit that sets out the conditions under which we may dispose of radioactive wastes. The Permit places conditions on how we manage the facility and the type of waste we can dispose, and tells us the information we must provide to the Environment Agency.

Background to submission of 2011 ESC

Our current Permit is based on the Environment Agency's review of safety cases prepared by the previous site operator and submitted in 2002. The Environment Agency considered that these safety cases, and especially the safety case addressing the safety of the facility in the long term after it closes (the Post-closure Safety Case or PCSC[3]), had failed to make '*an adequate or robust argument for*

[3] British Nuclear Fuels Ltd, '*Drigg Post-closure Safety Case*', September 2002.

continued disposals of LLW'. The Environment Agency decided, therefore, that continued disposal of LLW would be authorised only until Vault 8 was filled to its originally planned capacity, and that any further waste received by the facility could only be stored and not disposed. Hence, the waste we are placing in Vault 9, and the higher stacked waste in Vault 8, is stored and not disposed. The Environment Agency placed a requirement on the site operator to present a revised environmental safety case by the 1st May 2011.

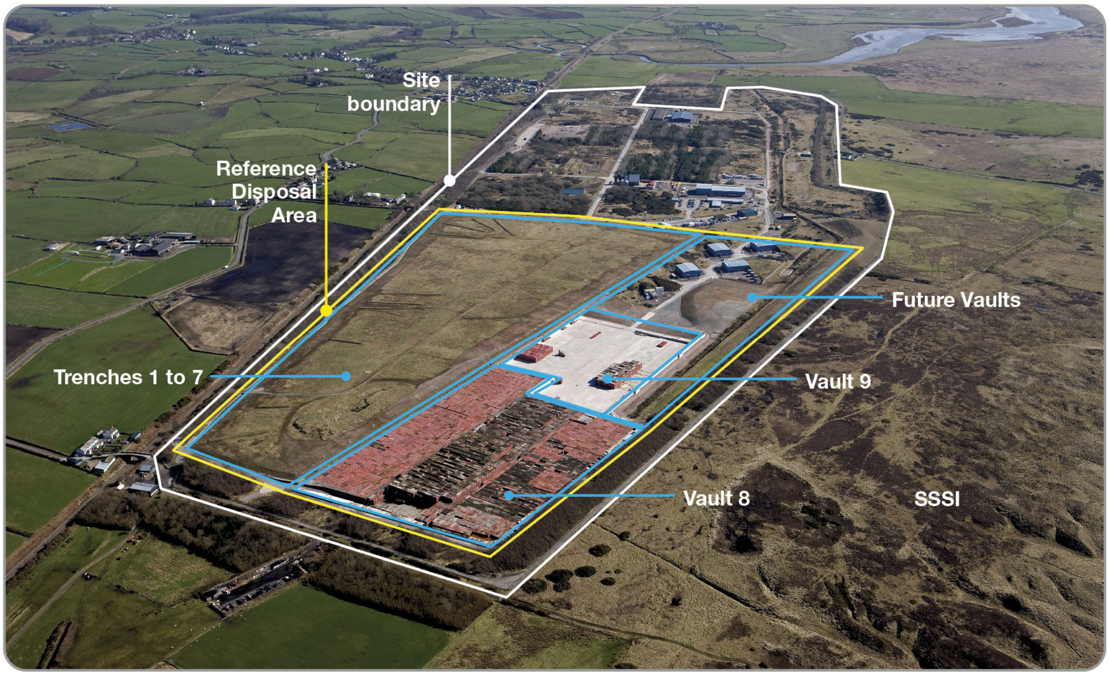

Figure 3 The LLWR site in March 2011

Purpose and objective of the 2011 ESC

The purpose of our 2011 ESC is, therefore, to meet the Environment Agency's requirement to submit a revised environmental safety case.

Our objective has been to develop and present an ESC that demonstrates to the Environment Agency that it is safe to continue to dispose of LLW at the LLWR.

In achieving this objective, the ESC will also provide a sound basis for future management of the site by us and regulation of the site by the Environment Agency.

Nature and scope

The United Kingdom's environment agencies, including the Environment Agency, have provided guidance on the requirements that a near-surface disposal facility must fulfil. These requirements are set out in the '*Guidance on Requirements for Authorisation*' (the GRA)[4]. That a facility meets these requirements must be demonstrated in an environmental safety case. The GRA defines an environmental safety case as:

[4] Environment Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, *Near-surface Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation*, February 2009.

'*a set of claims concerning the environmental safety of disposals of solid radioactive waste, substantiated by a structured collection of arguments and evidence.*'

The GRA sets out the principles that must be followed, and formal requirements that must be met, in developing our ESC. The GRA tells us what environmental safety criteria we must meet and what evidence we must provide in our ESC. The principles and requirements cover environmental safety both during operations at a facility and during and after closure, for however long the wastes will remain a potential hazard.

The ESC is not concerned with conventional safety, including demonstrating protection of workers, or security, which are regulated by the Office for Nuclear Regulation. The ESC is also not concerned with conventional environmental impacts, for example, traffic, noise, and visual amenity. These are important, but are dealt with in submissions to Cumbria County Council under local planning procedures. Although submitted to the Environment Agency to meet their requirements, the ESC is also important for Cumbria County Council because they need to be assured that the site is safe when considering planning applications for developments on the LLWR site.

Key safety arguments

We have chosen to present the 2011 ESC as a set of key safety arguments, following the Environment Agency's definition of an environmental safety case, quoted above. We then show in the 2011 ESC how these arguments meet the individual requirements set out in the GRA.

At a high level, our claim is as follows.

- We work within a sound management framework and firm safety culture.
- We engage in meaningful dialogue with stakeholders.
- Through a programme of scientific and engineering studies, we have gained a sufficient understanding of the LLWR site and facility, and their evolution.
- On the basis of this understanding, we have carried out a comprehensive evaluation of different options for managing and developing the LLWR to arrive at an optimised Site Development Plan for the facility.
- We have assessed the Site Development Plan and demonstrated the environmental safety of the facility under the Plan.
- We have also derived the conditions on wastes that can be safely disposed at the LLWR under the Site Development Plan.

The rest of this document is largely devoted to summarising the key safety arguments set out in the 2011 ESC.

Environmental management

We have a sound Management System, a positive safety culture, and are committed to high standards of environmental safety and quality, as formalised in our Environment, Health, Safety and Quality Policy. The 2011 ESC has been developed within this Management System and culture.

We have set out an Environmental Safety Strategy for achieving and demonstrating environmental safety both now and in the future, including after the facility is finally closed.

Liaison with the Environment Agency

We communicate with the Environment Agency through submissions and reporting required under the terms of our environmental Permit and through regular liaison meetings. During the development of the 2011 ESC, we have held monthly liaison meetings devoted to the ESC and the closely related subject of monitoring. This has allowed us to present our proposed approaches and interim results to the Environment Agency and discuss these with them, with the aim of ensuring our ESC will meet their requirements.

Engagement with stakeholders

We attach a high priority to stakeholder engagement and the views of our stakeholders are sought and taken into account. Through meetings, presentations and site visits we have engaged with our waste consignors, local councillors and council officials, local interest groups and local people. We have discussed a range of issues related to the ESC, including the engineering design of future vaults and the final cap that will need to be built over the facility (see below). We will continue this dialogue, to ensure stakeholders understand the conclusions and implications of the 2011 ESC and that any concerns are identified and considered in planning the future development of the LLWR and its ESC.

Site and facility understanding

We have undertaken programmes of site investigation, measurements, research and detailed modelling. This has allowed us to develop a sufficiently detailed and reliable understanding of the waste inventory, engineered facility, how the facility and wastes will change over time, geology and hydrogeology, and coastal and surface environments. This understanding has allowed us to evaluate options for the management and development of the facility, develop our optimised Site Development Plan, and undertake assessments of the Plan's environmental safety.

Monitoring

Much of our understanding of the site and facility comes from the extensive programmes of monitoring that we have undertaken. The results of our monitoring programmes show that the impacts the facility has on people and the environment are very small and that the facility is safe.

We will continue to monitor, to ensure the facility is safe and is behaving as we expect in the future.

Accuracy of information about the wastes

The evaluation of options for the future management and development of the LLWR, and assessments of its safety, require an understanding of the volume and nature of wastes that have already been disposed to the facility and that could be disposed in the future.

The radiological impacts we calculate depend on a small number of radionuclides, which we refer to as ‘key’. Examples of key radionuclides include: carbon-14, chlorine-36, technetium-99, iodine-129, radium-226 and thorium-232. In our collection of information about both past disposals and future wastes, we have focused on a number of waste disposals or waste streams that contain potentially significant amounts of key radionuclides.

We have worked to improve our knowledge of the wastes already disposed. Since 1988, waste characterisation has been effective and good disposal records are available. Prior to this time, waste characterisation and record keeping were less satisfactory. Nevertheless, we have developed a good estimate of the disposals of key radionuclides, based on an examination of available disposal and other records. For other wastes, such as bulk wastes from Sellafield, we have estimated waste stream inventories using volume information from disposal records and the ‘fingerprints’ (data on the concentration of radionuclides in the wastes) of recent analogous waste streams.

A series of interviews was conducted with individuals who had operational experience of waste disposals to the LLWR. These individuals worked at the LLWR site or at Sellafield. This exercise was conducted in part as a response to stakeholder comments that past consignment practices may not have met appropriate standards. The interviews were recorded using the RECALL system, which involved filming and recording information provided by interviewees. A range of issues was identified by the interviewees. Some past practices may not have been fully accounted for in the LLWR's estimated inventory of wastes. On the other hand, our approach to estimating past disposals using modern waste fingerprints will have led to over-estimates of radionuclide inventories because of the amount of non-active waste disposed in the past compared with recent practice. Overall, we have concluded that any departures from accepted practice would not have had a significant effect on the estimated inventory of key radionuclides in the trenches.

We have also considered the accuracy of information about future wastes. This information is important for assessing how safe the facility would be if the wastes were disposed at the LLWR and hence for making plans about the management of these wastes. We will make sure the facility is safe in the future, however, by only accepting wastes that can be safety disposed according to our assessments.

Optimisation and Site Development Plan

Ensuring optimisation is one of the key principles in radiological protection. Optimisation means ensuring that radiological impacts are ‘as low as reasonably achievable’ (ALARA). The need to ensure optimisation is one of the principles and one of the main requirements set out in the GRA. All relevant aspects of developing, managing and closing the facility must be optimised to ensure that radiological impacts are ALARA.

Lack of demonstration of optimisation was one of the main criticisms by the Environment Agency of the 2002 Post-closure Safety Case. This criticism was linked to the high radiological impacts that were calculated for the Safety Case, compared with the regulatory guidance levels.

Ensuring optimisation is therefore an important aspect of our Environmental Safety Strategy.

We have undertaken a range of studies to arrive at an optimised Site Development Plan, which implements our Environmental Safety Strategy and upon which our assessments of the safety of the facility are based. We have presented and discussed the most important of these studies with key stakeholders.

The outcomes of two important optimisation studies, on trench remediation and the design of future vaults the closure engineering, are summarised below.

Trench remediation

The trenches do not provide the same modern standards of protection as the vaults, and wastes were not always disposed to the trenches using the stringent acceptance standards and processes we use today. The impacts calculated in the 2002 PCSC were above regulatory guidance levels. We have, therefore, examined a range of options for the remediation of past waste disposals at the site. We identified feasible options and evaluated their remediation potential, environmental and other impacts from implementation, and the costs of each option. One option we paid particular attention to was the selective retrieval of wastes containing relatively high concentrations of key radionuclides. This was because retrieval of these wastes could result in a significant reduction in the hazard present, rather than just an amelioration of its potential impacts through engineering measures. We found that selective retrieval of wastes might reduce calculated impacts by large factors; however, the reductions would be to impacts now calculated to be lower and consistent with regulatory guidance levels because of the work we have done to reduce uncertainties and improve our assessment methodologies. The financial costs would also be very large. Selective retrieval would costs hundreds of millions of pounds. There would also be other disadvantages, such as disruptions to site operations and additional radiation doses to workers. Hence, in our Site Development Plan, we have proposed no remediation of the trenches.

Future vaults and closure engineering

We will construct a final cap in stages over the trenches and vaults that will be completed once the last disposals are made. The cap will be three metres thick, excluding profiling material, and consist of a number of layers designed to deter intrusion by people, animals and plants, limit infiltration of rainwater into the wastes, and disperse any gas that accumulates. We have selected a single-dome design for the cap, rather than having two domes, one over the trenches and the other over the vaults. The single-dome will be slightly higher than the double-dome design, but will be more resilient to erosion. We do not believe the extra height will lead to a significant increase in visual impact, given the size of the facility and the height of nearby ground. The height of the cap is dictated by the need for the slopes to be steep enough for the cap to shed rainwater. We intend to make use of the volume in the profile of the cap to stack waste containers. We will make the cap as high as it needs to be to shed water, but we will not make the cap any higher than that to fit in more waste. Using the profile volume to dispose of waste will also mean less fill material will need to be procured and transported to the site.

Some water will inevitably infiltrate through the cap, in increasing amounts over time. We intend to continue to collect this leachate, perhaps for up to a hundred years after the cap is completed when disposals finish. We have chosen a vault design that will keep the wastes as dry as possible after we finish collecting leachate, by allowing any water that does infiltrate to drain away. Our investigations show that the water will drain down and mix with groundwater flowing out towards the sea, where it will be diluted. An alternative design approach, which was not selected, would have been to try and keep any infiltrating water contained within the vaults for as long as possible. The disadvantage of this approach would be that there would be a danger of the vaults filling up with water and releasing contaminated water to the surface environment in the immediate vicinity of the LLWR.

We will also build a ‘cut-off wall’ in the ground round the trenches and vaults under the edge of the cap. This will extend an existing cut-off wall on the north and east sides of the trenches. The cut-off wall will be made of a mixture of clay, cement and blast furnace slag. It will limit the flow of groundwater into the wastes and help prevent contaminated water flowing out near the surface.

Figure 4 shows a cross section across Vault 9 and the trenches. Figure 5 shows a cross section along the vaults assuming seven are built (see below).

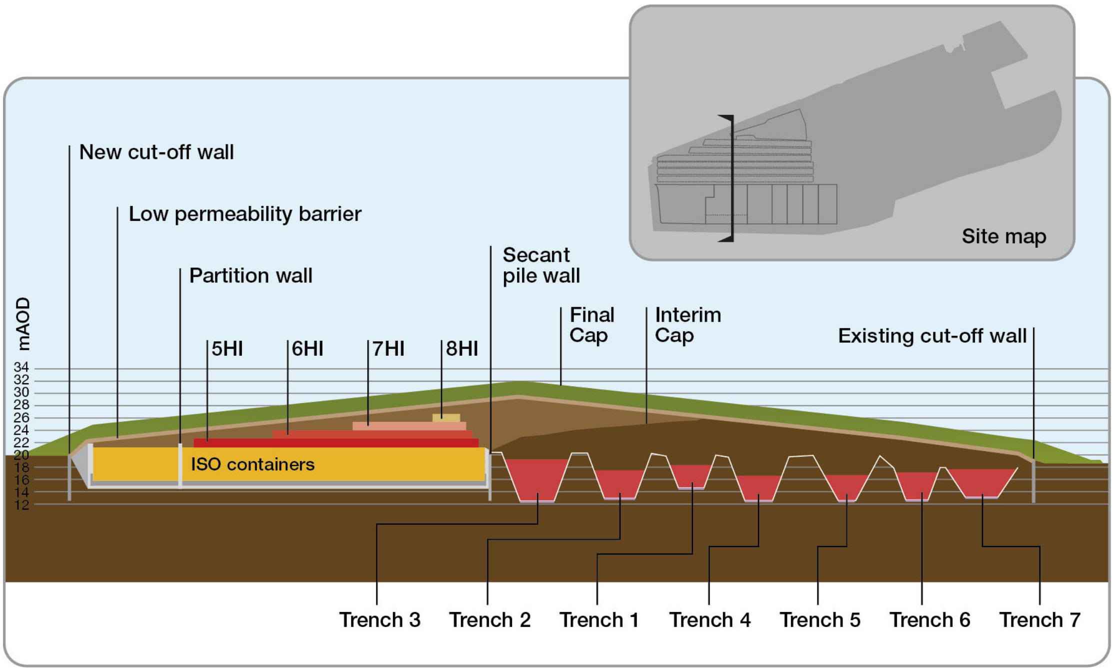

Figure 4 Section across Vault 9 and the trenches

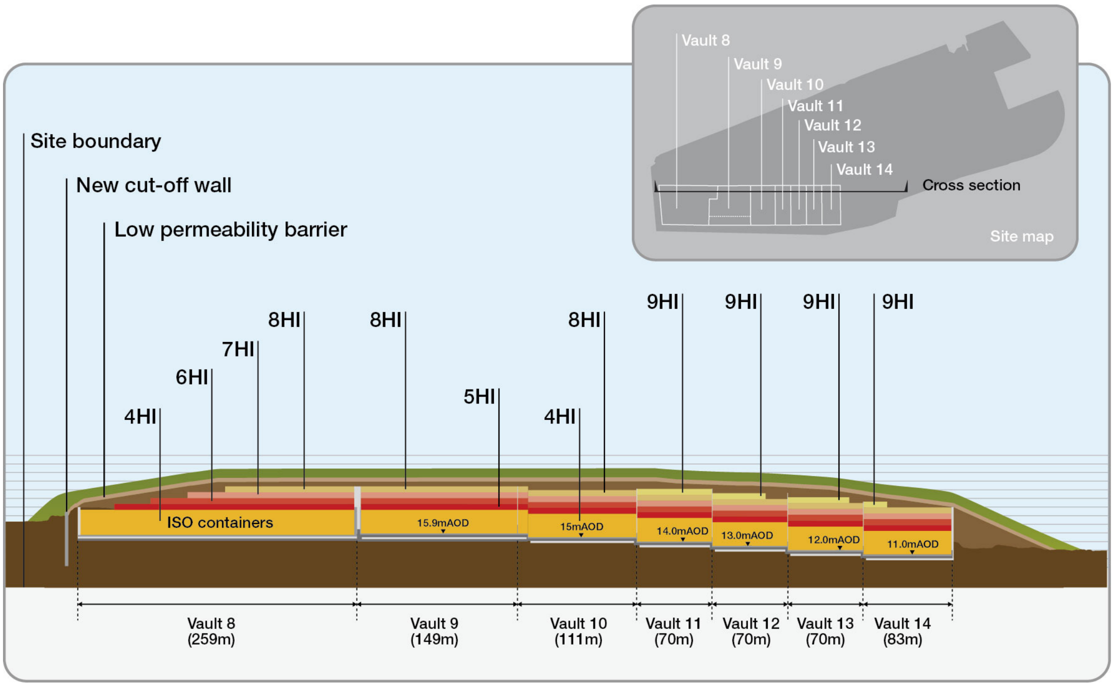

Figure 5 Cross section along the vaults

Ensuring safety in the future

Although the concentrations of long-lived radionuclides in LLW are small, the waste will remain a potential hazard for a long time. It is important, therefore, that we do what we reasonably can to ensure the safety of the disposed wastes in the future. It is one of the principles in the GRA that people in the future must be accorded the same level of protection as people now. There a number of ways of helping to ensure the long-term safety of the facility.

We will control the overall level of radioactivity in the wastes, by only disposing of LLW, and set specific limits on the quantities of particular radionucides that can be disposed. This is an important means of ensuring long-term safety.

We are planning to keep the repository under active control for one hundred years after the last wastes are disposed. After one hundred years, much of the radioactivity in the wastes will have decayed away and the hazard will be much less. At least for some of this active control period, we will continue to collect leachate, limiting its infiltration into the ground. During this period we will be able to stop the cap being damaged by people, for example, by them constructing a building, or the cap being used for farming, activities that might lead to radiological impacts. We will also take measurements to monitor the facility to make sure it is behaving how we expect, and take action if any unexpected problems arise.

After the end of the active control when we have finally closed the facility, we envisage that use of the land will be controlled by land covenants and ownership of the land will pass to the local community for a sustainable use, such as a nature reserve. Through these means, we can reduce, for a considerable period, the likelihood of people damaging or farming on the cap.

In our demonstration of the safety of the repository, we are only allowed by the Environment Agency to assume a limited period of active control after the end of disposal of wastes. We must show that the repository will remain safe even if its existence is forgotten about. The designs for future vaults and the cap and cut-off wall described above use passive measures to achieve their aims for the long-term; that is, they do not require people to, for example, continue to collect and dispose of leachate from the repository, or repair any damage to the cap.

Inevitably, there are uncertainties about what will happen in future, but we do our best to identify these and take account of them when we estimate the impacts from the facility. We do not try to predict what people will do in the future, although we do need to make reasonable and cautious assumptions about what activities people will undertake locally.

Size of the repository

In our analysis of environmental safety, we have considered two, different-sized, repositories. The first we refer to as the 'Reference Disposal Area' repository, see Figure 3. For this repository, we would build new vaults up to number 14 (i.e. seven in all) down to the end of the trenches, in what used to be known as the 'consented area' (the area originally consented for disposal in the late 1950s). A repository of this size could take all the United Kingdom's LLW arising up to about 2080, depending on a number of assumptions, for example, about how the volume of the wastes will be reduced by VLLW being disposed elsewhere and waste treatments. The second repository we refer to as the 'Extended Disposal Area' repository. It would include six extra vaults built on the south side of the trenches and vaults in the Reference Disposal Area, see Figure 6. The Extended Disposal Area repository could take all the LLW in the United Kingdom Radioactive Waste Inventory, which includes waste arising up to 2127, again depending on assumptions about where VLLW is disposed and how wastes are treated.

Our analyses show that either repository would be safe, meeting the requirements of the Environment Agency set out in the GRA.

Radiological impacts during operations

In order for the radioactivity in the wastes to cause potential harm to people (other than workers on site), either the radiation from the radioactive materials must reach people off the site, or the radioactive materials themselves, the radionuclides, must leave the site.

There will be some radiation when the waste containers are uncovered. LLW, however, only produces small amounts of radiation and is considered safe by the regulatory authorities to transport round the country without extra shielding beyond that provided by the ISO containers. Even when the waste containers are all stacked together in a vault, our measurements show radiation levels are safe. The grout we put into the containers helps reduce radiation. Once the facility is capped, the cap will provide sufficient shielding to prevent radiation from the wastes in the facility reaching people.

There are a number of 'pathways' along which (small amounts of) radionuclides can leave the facility during operations. The leachate collected from the trenches and run-off from the vaults is disposed to the sea. Some leachate will escape from the trenches, infiltrate down and mix with groundwater and be carried out towards the sea. The degradation of organic materials in the wastes may lead to gas containing carbon-14 being released. Radium in the wastes will release the radioactive gas radon. Tritium, a radioactive form of hydrogen, might also be released as gas or vapour.

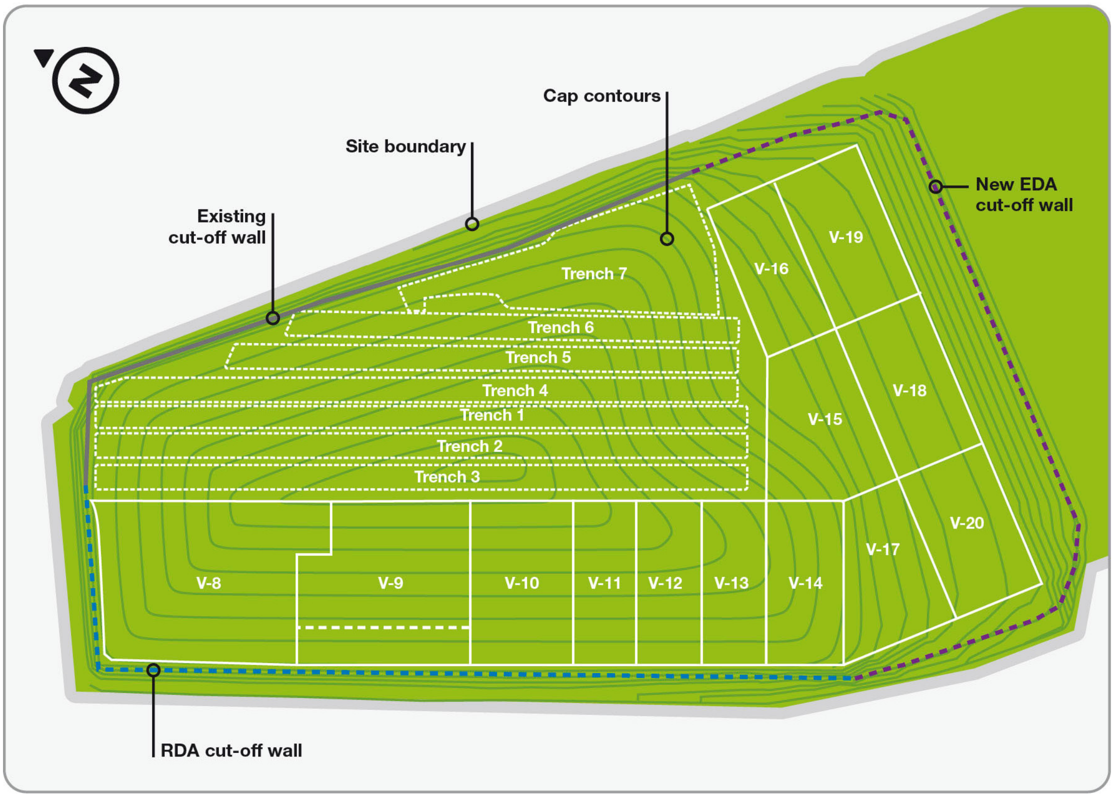

Figure 6 Disposal area of Extended Disposal Area repository

Radiological impacts after capping

Some of the 'pathways' along which radionuclides might be released from the facility after final capping are different from those before. Once we stop collecting leachate from the trenches and vaults and discharging it to the sea via the Marine Pipeline, leachate will at some stage start to infiltrate down into the groundwater from the vaults. The amounts of leachate from both the trenches and vaults will be very low because of the final cap. If someone sank a well between the site and the coast, they might drink contaminated water, or use it for irrigation or for animals to drink, leading to the contamination of foodstuffs. This is not likely to happen in the near future because most of the area between the site and coast is a SSSI. After many hundreds of years, and as the coast recedes towards the facility because of sea-level rise and erosion (see below), water levels might rise sufficiently in the facility, and the barriers to release of radionuclides degrade sufficiently, for radioactivity to be released to the surface immediately around the facility. Carbon-14 in gas might still be released. Radon could only be released if the repository cap was damaged because it decays away very quickly once produced. Wastes might also be dispersed because of erosion of the facility as sea levels rise and the coast recedes.

We are also required by the Environment Agency to consider 'human intrusion', that is, someone intruding into the wastes inadvertently, not knowing that wastes were buried under the cap. We consider the potential impacts of activities such as building a house, drilling a borehole, or retrieving materials from the cliff as the facility erodes. The cap over the wastes will be at least four metres thick including the profiling material, so considerable effort would be required to uncover wastes.

We estimate the impacts from all these possible pathways using computer models.

Radiological impacts

Radioactive wastes are potentially harmful because they release radiation. A radiation 'dose' is the energy absorbed by a person subject to radiation. This energy can damage cells and lead to cancer or cause genetic damage.

The Environment Agency provides guidance in the GRA on levels of radiation dose and corresponding annual risk that it considers a radioactive waste disposal facility should meet. Different guidance is given for the period during which the Agency regulates the site and issues a permit, and for the period after, assumed in the ESC to be the period after the facility is finally closed, a hundred years after the last wastes are disposed.

The GRA specifies a general 'constraint' on the maximum radiation dose that a person can receive from the facility during the time a permit is held. The general constraint in the GRA is a radiation dose of 0.3 mSv (millisieverts) per year. Recently, for this period, a new (draft) 'guidance level' of radiation dose received via contaminated groundwater has been added to the GRA of 20 µSv (microsieverts) per year. Our calculations, partly based on our measurements of radiation now and releases of radioactivity in the past, show that the LLWR meets these regulatory requirements now and will continue to do so up to its final closure.

For the period after a permit is relinquished, the Environment Agency recognises that there are uncertainties about how the facility and site will evolve. The Agency requires us to demonstrate 'consistency' with 'guidance levels' of dose and risk. Generally, we must show consistency with a risk guidance level is one in a million per year of fatal cancer or severe hereditary defect. For events that are certain to occur, this corresponds to a radiation dose of about 20 µSv per year. For human intrusion, which is only expected to occur infrequently, the radiation dose guidance level is given as a range from 3 to 20 mSv per year, depending on the length of time the radiation exposure might last.

Our assessments of the radiological impacts both now and in the future show that the facility meets the regulatory requirements on radiological dose and risk. This is provided we control the site for a hundred years after the last waste is disposed and make arrangements to prevent the cap being used for subsistence farming for a period beyond one hundred years.

The radiation dose levels specified in the GRA can be compared with the average annual radiation dose to people in the United Kingdom of 2.7 mSv[5]. This annual dose mostly comes from natural sources, such as radon released from the ground, the natural radioactivity in people's bodies, and cosmic radiation. Some comes from medical treatments. This radiation dose is more than 100 times higher than the dose corresponding to the Environment Agency's risk guidance level, for events that are certain to occur. A radiation dose of 2.7 mSv gives a risk of cancer or severe hereditary defect of about one in six thousand. The average risk of dying of cancer from all causes in the United Kingdom is about one in four. At these low dose levels, radiation accounts for only a very small fraction of the risk of dying of cancer.

5 Watson SJ, Jones AL, Oatway WB and Hughes JS, '*Ionising Radiation Exposure of the UK Population: 2005 Review*', HPA-RPD-001, ISBN: 0-85951-558-3, May 2005.

Non-radiological impacts

Some of our wastes are hazardous because of their chemical nature as well as because they are radioactive. We also dispose of radioactive asbestos. Hence, we also assess 'non-radiological' impacts. We are required by the Environment Agency in the GRA to show that the protection the facility provides is '*no less stringent*' than is provided by facilities for the disposal of non-radioactive hazardous wastes. We have achieved this through appropriate design measures, including disposing of wastes in ISO containers. We will ensure we only dispose of hazardous materials, including asbestos, in amounts and forms that are safe.

Impacts on other living things

We are also required by the Environment Agency to consider the impacts of the facility on living things other than humans, 'non-human species', or through more general environmental effects such as damaging habitat quality. Unlike for people, where we assess impacts on individuals, we assess the impacts on populations of non-human species. There are currently no internationally established criteria for determining radiological protection of the environment. We have taken advice from the Environment Agency on sufficient levels of protection and found the impacts we calculate, using a methodology recommended by the Agency, meet these levels.

Climate change, flooding and coastal erosion

At its north-west corner, the LLWR site is only about 400 m from the sea (mean high-water mark). We have, therefore, considered whether or not the site and facility might be flooded or eroded by the sea. Our studies suggest that the disposal vaults will begin to be eroded on a timescale of a few hundred to a few thousand years, with erosion of the vaults and trenches being complete within one to a few thousand years. It is most likely that the vaults will be undercut, rather than directly eroded. The vaults and wastes will gradually break up and fall on to the beach, where the materials will further break up and disperse into the sea to be mixed with coastal sediments.

The timing of erosion is uncertain for a number of reasons. It will depend to a large extent on how much greenhouse gases are released into the earth's atmosphere by people and how quickly the Greenland and West Antarctic ice sheets will break up and melt. This, in turn, will affect how quickly and by how much sea level rises. It is predicted that sea levels will increase in our locality by about one to twenty metres over the next thousand years. Sea level rises on this scale will have a huge impact on humanity.

Before the disposal area is eroded, the southern end of the site is likely to suffer flooding from the Ravenglass Estuary, but there are no plans to dispose of wastes down at this end of the site.

Like all surface waste disposal facilities, whether for radioactive or other wastes, the LLWR is vulnerable to erosion and the exposure of wastes on a timescale of thousands of years. In the case of the LLWR, we believe it will be eroded by the sea. Our regulator tells us that the acceptability of the facility should be judged against the risk guidance level (and other requirements) specified in the GRA. By the time the LLWR is eroded, radioactive decay will mean that the risks will be acceptably low and consistent with the regulatory risk guidance level.

Waste acceptance and repository capacity

Our assessments of the environmental safety of the LLWR have made assumptions about the properties of the wastes that will be disposed to the facility in the future. To ensure safety, we must make sure that we only accept wastes with properties consistent with the assumptions we made in undertaking our safety assessments. We will do this by checking that wastes that organisations want to dispose at the facility meet our Waste Acceptance Criteria, which we have derived from our safety assessments.

Our assessments suggest that we should introduce some rules about how we emplace particular waste packages in the vaults. For example, we intend to place any packages containing relatively large amounts of radium away from the top of the waste stacks. This will make it less likely that radon gas that is generated from disposed radium will be released from the repository if the cap were to be damaged in the future.

Our assessments also show how much radioactivity it will be safe to dispose of in the facility – the site's 'safe radiological capacity'. We will monitor the quantities of wastes we dispose to make sure that we will not exceed the safe radiological capacity of the site.

Implementing the 2011 ESC

We are required by our environmental Permit from the Environment Agency to operate the facility in accordance with our current ESC. We will, therefore, start to manage the site in accordance with the 2011 ESC. There will be an implementation phase. We expect it to take about a year to introduce the necessary procedures and processes to implement the Waste Acceptance Criteria, waste emplacement strategies and capacity monitoring derived from the 2011 ESC.

It will not be possible to make some of the changes to waste acceptance we believe should be made unless the Environment Agency issue us with a revised or new permit. We will continue to operate the site in accordance with our current Permit until such time as we receive a revised or new permit.

2011 ESC documentation

The detailed, technical exposition of the 2011 ESC is given in the full set of ESC documentation, which includes a main, or 'Level 1', report and sixteen underpinning 'Level 2' reports. The Level 2 reports provide summaries of the evidence supporting the safety arguments. The ESC documents reference many supporting 'Level 3' technical documents. Our document structure is shown in Figure 7.

The Level 1 report describes:

- our Environmental Safety Strategy and Site Development Plan;
- our environmental safety arguments;
- a future work programme aimed at further developing the ESC and reducing remaining uncertainties;
- how the 2011 ESC has improved on the Safety Cases presented in 2002;
- how we have met the Environment Agency's requirements set out in the 'Guidance on Requirements for Authorisation'.

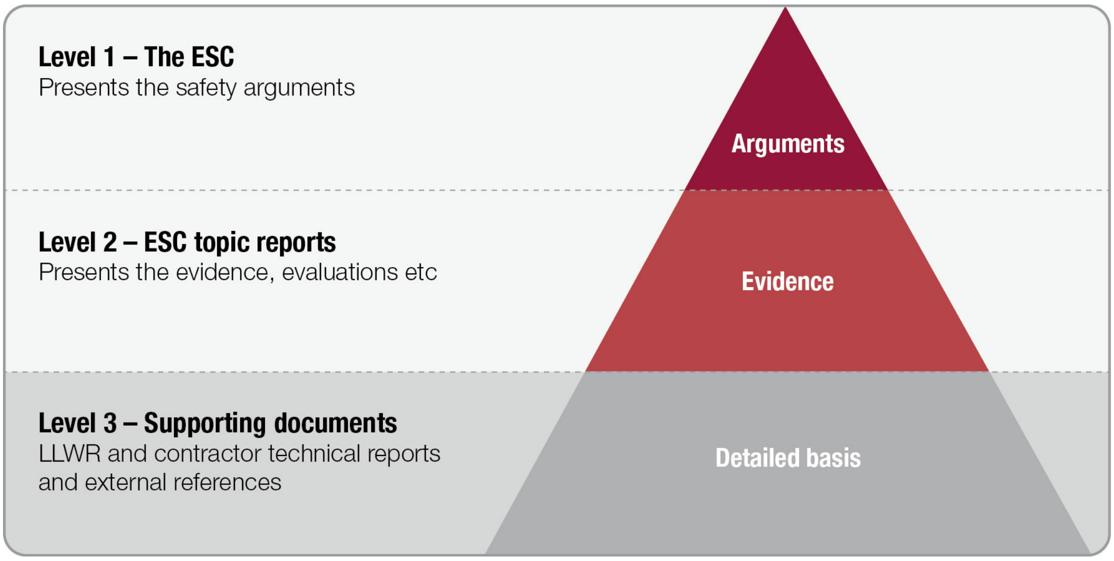

Figure 7 Documentation structure for the 2011 ESC

Conclusions

Our conclusions are as follows:

- our 2011 ESC meets the requirements of the Environment Agency set out in their relevant guidance;
- it is safe to continue to dispose of LLW at the site, both now and in the future.

Our aim is to support the Environment Agency's review of the 2011 ESC and their subsequent consideration of our application for a new permit to continue to dispose of LLW at the site.

We will continue to engage with our stakeholders to make sure we take account of their views as our management plans evolve in the future.