

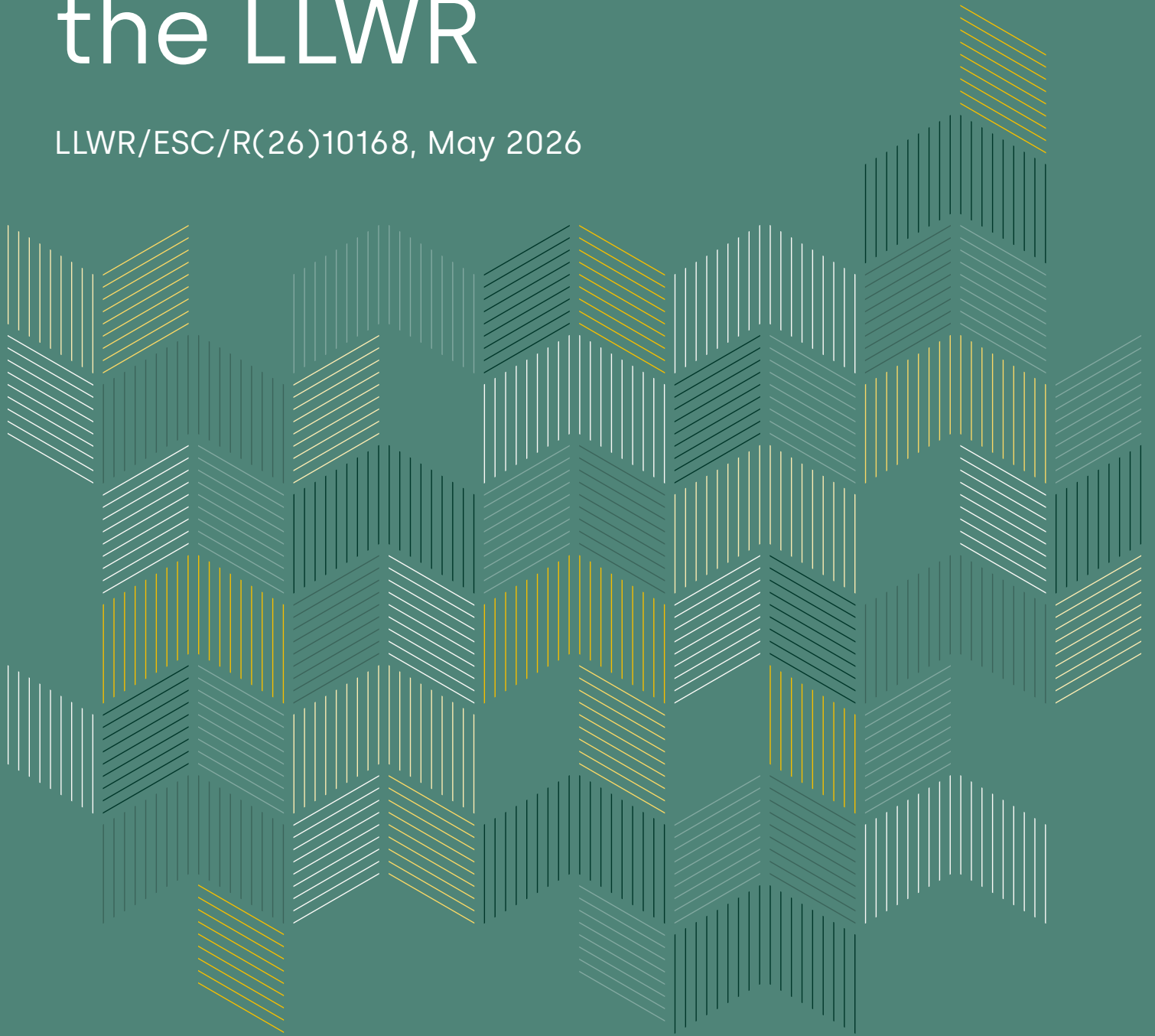


Nuclear Waste
Services

SITE HISTORY AND DESCRIPTION

2026 Environmental Safety Case for the LLWR

LLWR/ESC/R(26)10168, May 2026





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Preface

The Low Level Waste Repository (LLWR) is the United Kingdom's principal facility for the disposal of solid Low Level Waste (LLW). It is a near-surface disposal facility in which waste was disposed in trenches and is now being disposed in vaults excavated into the ground surface. The LLWR is owned by the Nuclear Decommissioning Authority (NDA) and operated on their behalf by a wholly-owned subsidiary division, Nuclear Waste Services Ltd.

We, Nuclear Waste Services, are committed to operating the LLWR as a safe and efficient facility that provides a continuing option for the disposal of LLW in the United Kingdom. This will be achieved consistent with good practice for the near-surface disposal of radioactive waste, in accordance with environmental, health and safety, and security regulation and guidance, and in compliance with the terms of our Nuclear Site Licence and Permit to dispose of radioactive waste. We are also committed to working with the NDA to ensure optimal use is made of the LLWR to support the NDA's mission, in accordance with government policy. This may involve the disposal of a broader range of wastes than just LLW as currently defined in the United Kingdom¹.

One of the means we use to operate the LLWR safely is to maintain and implement an Environmental Safety Case for the site. This is one of the reports presenting the 2026 Environmental Safety Case for the LLWR – the 2026 ESC. The 2026 ESC is a major update based on a comprehensive review of our previous 2011 ESC and subsequent developments. The 2026 ESC addresses both the environmental safety of the disposal facility and the rest of the site. It considers the disposal of both LLW and some less-hazardous Intermediate Level Waste (ILW). Assessing the disposal of some less-hazardous ILW does not imply any decision has been made to dispose of such waste at the LLWR. The work has been undertaken to understand the safety implications if such a decision were made and hence support consideration of the option by the NDA.

The 2026 ESC is issued under the authority of the Nuclear Waste Services' Executive Director of Sites and Operations.

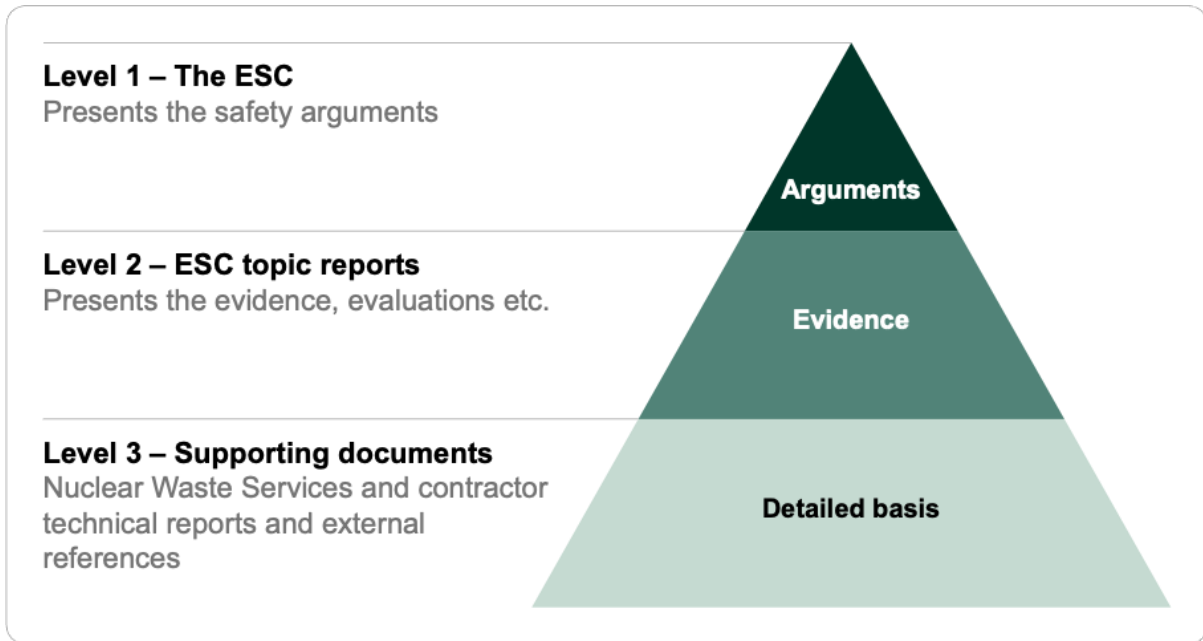
The 2026 ESC consists of documents at two levels:

- A single 'Level 1' report outlines the plan for the development of the LLWR and the main arguments concerning environmental safety and how it is achieved.
- A series of 'Level 2' reports present the evidence that underpins our safety arguments, including descriptions of our management framework, system understanding, design and management choices, assessments and implementation.

This is the Level 2 report '*Site History and Description*'. The ESC Level 1 and 2 reports are listed in the table below, which also shows for the Level 2 reports the set of arguments for

¹ In government policy, LLW is defined as radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq t⁻¹) of alpha or 12 GBq t⁻¹ of beta/gamma activity.

which each report mainly provides evidence. A brief description of the contents of each Level 2 report is also given. The ESC is supported by a large number of technical and scientific reports and references that we refer to as ‘Level 3’ documents. We have also produced a Guide to Key Points of the ESC, to help a wider group of stakeholders understand its nature, conclusions and implications.



Level 1	
Main Report [1]	
Level 2	
Management and dialogue	
Management and Dialogue [2]	Describes our environmental management systems and interactions with regulators and stakeholders
System characterisation and understanding	
Site History and Description (this report)	Provides a history and description of the site
Disposal Facility Inventory [3]	Describes the wastes already disposed and wastes that may be disposed at the facility

Engineering Design [4]	Presents the engineering design of the current facility and proposed changes as further disposal vaults are built and the disposal facility is closed
Near Field [5]	Describes our understanding of the chemical and physical evolution of the engineered disposal system
Hydrogeology [6]	Describes our understanding of the geology and hydrogeology of the site
Site Evolution [7]	Describes our understanding of how the site will evolve, with a focus on coastal erosion
Monitoring [8]	Presents our programme of environmental monitoring supporting the ESC
Optimisation and Site Development Plan	
Optimisation and Site Development Plan [9]	Describes our approach to optimising the design and management of the disposal facility and wider site, and sets out our Site Development Plan
Waste Management Plan [10]	Presents our plans for managing the wastes produced by previous uses and operation of the site
Assessments	
Safety Functions [11]	Presents our understanding of how the different aspects of the repository system and its management contribute to the safety of the facility
Engineering Performance Assessment [12]	Presents our analysis of how the various components of the engineered disposal system will perform, which is an input into our impact assessments
Environmental Safety During the Period of Authorisation [13]	Presents evidence that the LLWR is currently being operated safely and will continue to be so during the period that the facility is permitted
Assessment of Long-term Radiological Impacts [14]	Presents evidence that, if the LLWR is managed in accordance with the Site Development Plan, the site will remain safe in the long term

Hydrogeological Risk Assessment [15]	Presents evidence that the disposal facility protects groundwater from both radiological and non-radiological contaminants in the disposed wastes now and will continue to do so in the future
Assessment of Radiological Impacts on Non-human Biota [16]	Presents evidence that the LLWR does not have adverse consequences for non-human biota populations now and will not in the future
Implementation	
Implementation [17]	Sets out how we use the ESC to manage the site, including setting Waste Acceptance Criteria and other controls on the types and quantities of waste accepted for disposal
Audit	
Addressing Regulatory Requirements and Feedback [18]	Provides a cross-reference between the contents of the ESC and regulatory guidance and feedback

Executive Summary

This report presents background information on the past and current state of the LLWR site as well as information on the geographical and environmental setting of the facility.

The report provides a description of the history of site use and development, initially for industrial purposes during World War II, and then as a low-level waste repository, beginning in 1959 with wastes disposed into trenches. It shows how waste treatment and disposal practices, as well as management processes, have developed and improved over the years, in line with enhanced safety requirements, changes in the types of Low Level Waste (LLW) arising for disposal, and increasing technical knowledge.

Summary details of the engineered features of the site and an overview of LLW disposed – the waste inventory – to the different parts of the site are provided. This highlights the progression in LLW management at the site, from the early disposal of wastes into open trenches excavated into the local strata, to more recent and much more highly engineered emplacement and containment in vaults. It also includes a summary description of the waste; what it consists of, where it comes from, and its radioactive and other hazardous characteristics.

Other sections of the report describe the geographical and environmental setting of the facility and refer to appropriate supporting documents within the Environmental Safety Case (ESC) and elsewhere that provide greater detail. The descriptions include climate, topography, soils and sediments, geology and hydrogeology, surface waters, coastal processes, flora and fauna distributions, human settlement patterns and land use.

In the context of the ESC, the aim has been to summarise information about the development of the LLWR site and to summarise our understanding of the biosphere to provide confidence that it is sufficiently developed to support the performance assessments undertaken (most of the detailed information is compiled in other parts of the ESC, which are signposted to).

In the context of the Site-wide Environmental Safety Case, the report provides background information of the history of operations and site developments that have themselves led to the generation of hazardous operational and decommissioning wastes. Our plans for managing these wastes are documented in our Waste Management Plan.

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1 Introduction

1.1 Objectives

The main objective of this report is to provide an overview of the past and current state of the Low Level Waste Repository (LLWR) site to show how it has been developed for radioactive waste disposal. It describes activities, developments, observations and regulatory decisions that are important to the Environmental Safety Case (ESC).

The report also presents an overview of the environmental setting of the site, which is designed to provide confidence that we, the site operator, Nuclear Waste Services (NWS), have a sufficiently comprehensive understanding of the biosphere to support the assessment calculations that underpin the ESC.

1.2 Relevant Regulatory Guidance

Paragraph 6.4.9 of Requirement 11 of the Guidance on Requirements for Authorisation (GRA) [19] is reproduced in the box below.

Requirement 11: Site investigation

6.4.9 The biosphere is characterised, understood and capable of analysis to the extent necessary to support the environmental safety case. This may involve consideration of, for example, topography, soils, surface water systems, flora and fauna distributions and human settlement patterns and activities.

The investigation and characterisation of the biosphere should be sufficiently comprehensive to support calculations of dose during the period of authorisation and should be proportionate to the assumptions made in the environmental safety case for calculating risks after the period of authorisation.

The report presents information relevant to this GRA requirement, which is generally a summary of the detailed information presented in other Level 2 and Level 3 ESC reports. The report, on its own, does not fulfil Requirement 11 of the GRA. It contributes to our fulfilment of this requirement by providing a relatively high-level summary of the important information and signposting to more detailed information in other parts of the ESC.

The 2026 ESC also serves as a Site-wide Environmental Safety Case (SWESC) that is designed to fulfil the requirements of the Guidance on Requirements for Release from Radioactive Substances Regulation (GRR) [20]. In this regard, the report also provides background information on the activities that have been carried out on the site that have led to the generation of hazardous operational and decommissioning wastes and areas of land contamination.

1.3 Scope

Building on the equivalent report submitted as part of the 2011 ESC [21], this document provides background information describing the site development and the current state of the LLWR and surrounding environment. The inventory of Low Level Waste (LLW) already disposed of and the waste that is planned for future disposal is described briefly, including details of its composition, origin and radiological and other hazardous characteristics. The current and future inventory are reported in detail in the '*Disposal Facility Inventory*' report [3].

Following the recent changes in government policy on the management and disposal of radioactive waste, the 2026 ESC has examined the potential for the LLWR to accept for disposal some less-hazardous Intermediate Level Waste (ILW)². The objective of this work has been to understand the types and quantities of ILW that could be safely disposed at the LLWR and the changes that would be required and hence inform NDA's and others' consideration of the option, in line with the new government policy. This report briefly illustrates the types of ILW that could be safely disposed at the LLWR as part of its discussion of the future inventory of waste. It does not cover any other changes to the optimised engineering design and the safety controls that would be required.

It also provides some supporting information for the justification of biosphere models used in assessments of environmental safety during the Period of Authorisation (PoA), now under the Environmental Permitting (England and Wales) Regulations 2016, and in long-term assessments of impacts at times beyond the PoA. The assessments, reported elsewhere, are of radiological [13, 14] and non-radiological [15] risks to people, and radiological risks to other living organisms [16].

The document begins with a brief description of the setting and main characteristics of the LLWR site, followed by information on the site history, including descriptions of the site use from the industrial development during World War II through to current LLW management using engineered vaults and our progress towards constructing the first strip of the final cap.

The geographical context of the repository and its environs is described. The focus is on the surface environment: the climate, topography, soils and sediments, surface water systems, flora and fauna distributions, human settlement patterns and land use. These are features that we take to correspond to the term 'biosphere', as used in paragraph 6.4.9 of the GRA [19]. The geology and hydrogeology of the site are reported in detail in the '*Hydrogeology*' report [6].

The description is made at the regional scale (including the coastal plain and margins) and the more local scale (the LLWR and its immediate surroundings), as appropriate to support different aspects of the ESC.

² Nuclear Waste Services use the term 'less-hazardous ILW' to describe ILW that can be safely disposed at the LLWR, in-line with regulatory protection criteria – specifically risk and dose guidance levels.

The document does not define or justify assessment models for use in safety analyses; rather it informs the model development process. The focus of the description is the present-day situation, since discussion of past and prospective evolution from a climate and landscape perspective is addressed in the '*Site Evolution*' report [7]. However, important aspects that require consideration of their future development within the ESC are identified, and discussion of present-day climate, soils, sediments and surface waters establishes a reference point for the analysis of site evolution.

The report also provides a context for the discussion of site vulnerability to threats associated with potential inadvertent human intrusion.

1.4 Structure

Section 2 of this report describes the history of site operations and the industrial development of the site over a period of more than 80 years. Section 3 provides a description of the site, including the inventory of waste and the site's environmental setting. The latter includes high-level descriptions of the local climate, local hydrology, geology and hydrogeology, soils and sediments and coastal processes. Section 4 presents the conclusions of the report.

A general glossary for the ESC is appended to the '*Main Report*' [1].

2 Site History

2.1 Site Setting

The LLWR is located on the coastal plain of West Cumbria on the Irish Sea coast. The closest point of the LLWR vaults lies approximately 350 m inland from the present-day coastline (see Figure 2.1). It is about 3 km from the Ravenglass Estuary where the Rivers Irt, Mite and Esk join. The Rivers Irt and Mite flow roughly south-west from the hills inland in the Lake District. The River Esk is separated from the other rivers by the prominent bedrock ridge of Muncaster Fell. To the east, the site is bounded by the Carlisle to Barrow-in-Furness railway line.

The topography surrounding the site varies from about 25 m above current sea level (above Ordnance Datum (OD)) to the north-east and west of the site to less than 5 m OD at the south-eastern site boundary. To the west of the site, the topography gently undulates towards a small cliff line marking the edge of the Drigg beach.

The Drigg Stream flows through the site roughly parallel to the western site boundary. Towards the centre of the site, the Drigg Stream is joined by the East-West Stream, which originates off site to the north-east, draining farmland and taking water from the railway drain. The Drigg Stream leaves the site to the south and discharges into the River Irt, which is tidal at that point. The River Irt forms the northern arm of the estuary complex at Ravenglass that also comprises the rivers Mite and Esk.

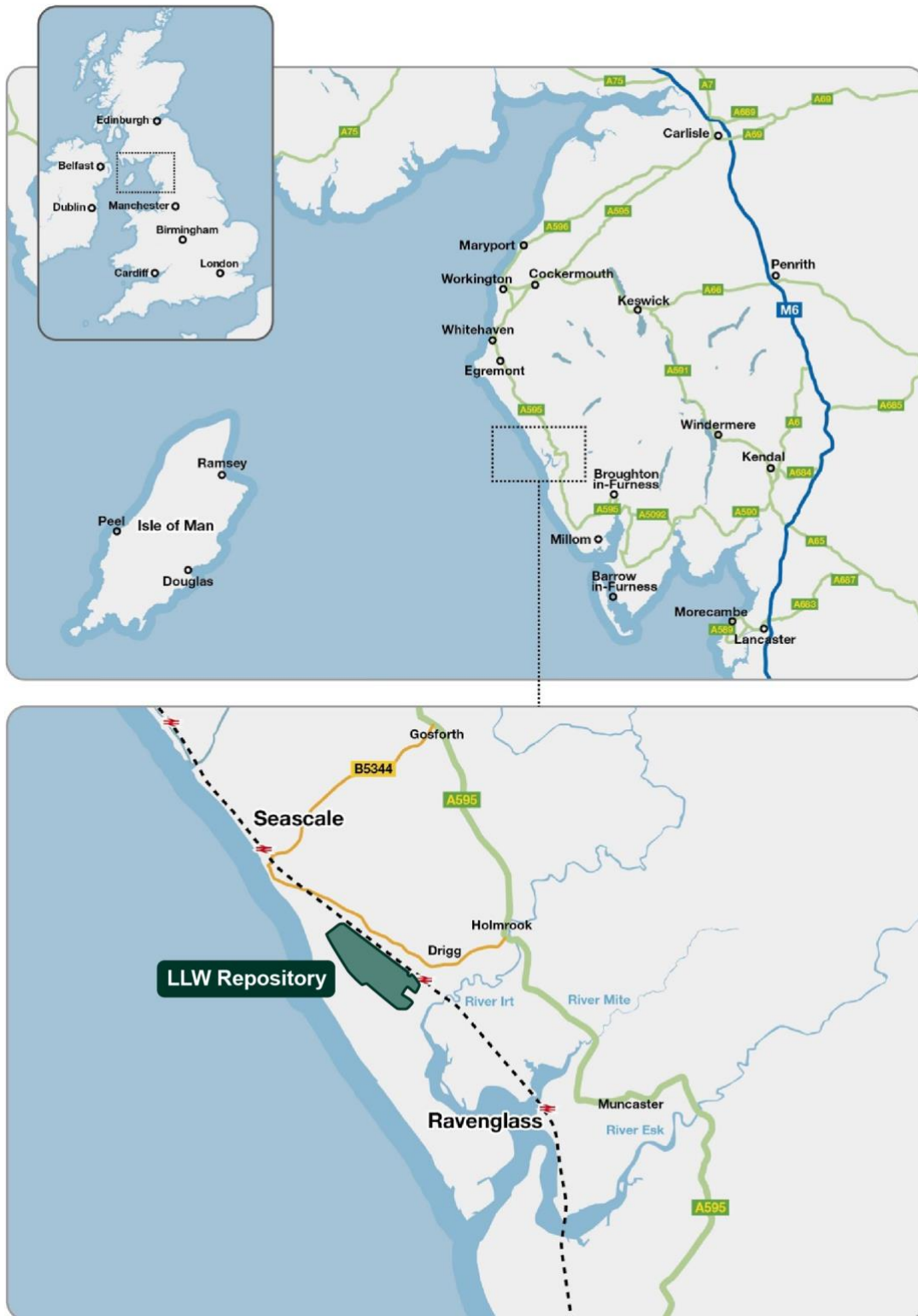


Figure 2.1: Site location

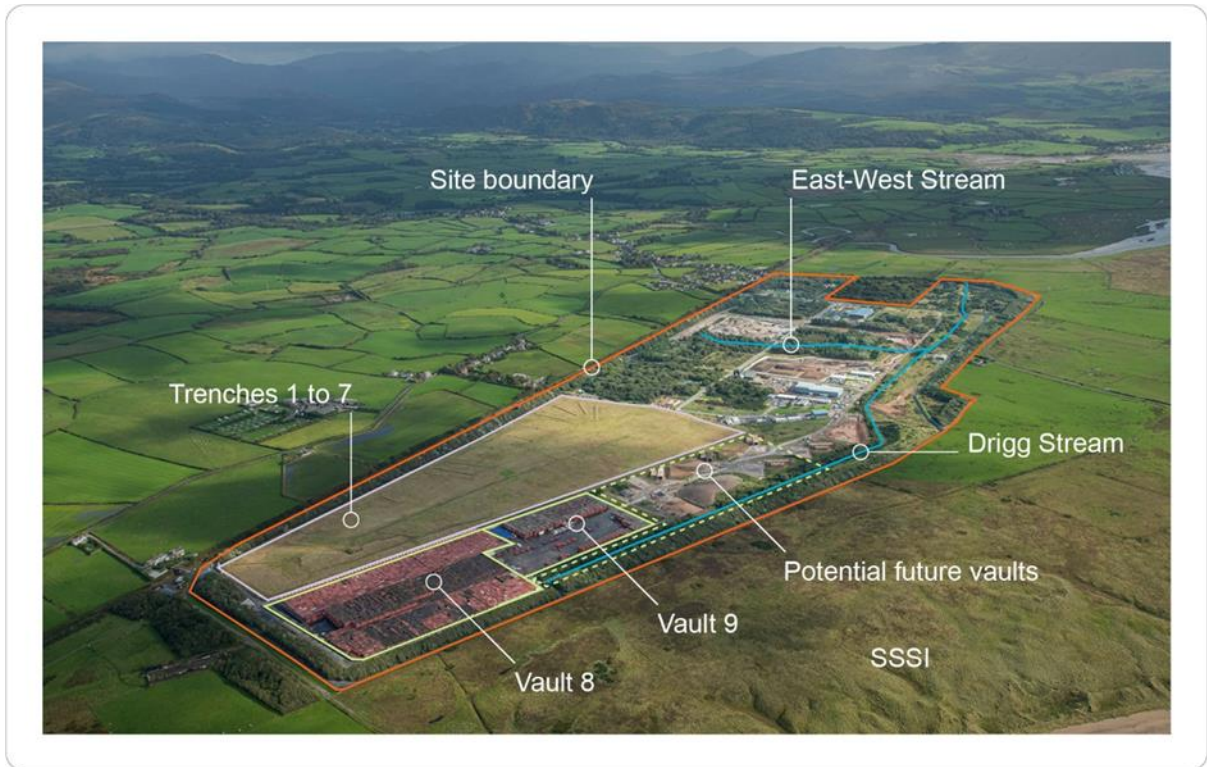


Figure 2.2: Key features of the LLWR (viewed from the north-west to south-east)

2.2 History of Site Operations

The site, now operated by Nuclear Waste Services on behalf of the Nuclear Decommissioning Authority (NDA), was originally developed as a Royal Ordnance Factory (ROF) during World War II. Prior to that, records suggest that the site was agricultural land. Figure 2.3 presents an extract from the enclosure map of 1828 showing the network of fields in the area prior to the construction of the Whitehaven and Furness Junction Railway in 1849.



Figure 2.3: Extract from Drigg Enclosure Award Map of 1828

The ROF was known as ROF Factory No. 35 [22]. Its purpose was to produce trinitrotoluene (TNT) to support the war effort in the 1940s. Construction began in early 1940, with the first TNT produced from March 1941, when the factory was still under construction. An appreciable amount of civil engineering work was carried out in parallel with munitions production because of the great need for TNT. Approximately 4,000 construction workers were employed at ROF Factory No. 35 at this time. Construction of the ROF was essentially complete at the end of 1941, when it achieved its target production of 400 tonnes per week with peak production of 600 tonnes per week in May 1945 [22]. Our '*Hydrogeology*' [6] report documents our understanding of the TNT production process used on the site.

The ROF encompassed the majority of the current site and also extended beyond the current site boundary to the north-west and south-east. Many facilities were constructed for administration, storage, infrastructure, personnel and process buildings. Figure 2.4 shows a photograph of the ROF, which gives an indication of the extent of the facility. Figure 2.5 shows an aerial photograph of the site taken in 1957 showing the extent of the ROF facility and the current site boundary.



Figure 2.4: Oblique view of southern part of ROF No. 35 taken in 1949. Used with permission under license © Historic England – not for further distribution.

Factors affecting the choice of the site as a site for an ROF included its relative isolation from populations, given the hazardous nature of the operations, and to minimise the risk of enemy air attack. During this period, the site was connected to the Carlisle to Barrow-in-Furness railway line by two sidings [22].

Anecdotal evidence suggests that after the end of World War II the site was used for munitions breakdown, including to deactivate German munitions and for safe storage of hydrogen peroxide, the fuel used to power Germany's V2 rockets [23]. TNT recovered from the dismantled ordnance was used in an attempt to manufacture carbon black for use in the manufacture of tyres. Evidence also indicates that fluorescent materials (thought to be fluorescein) were stored in the former TNT washing facility in 1948 prior to use in tidal flow

experiments at Whitehaven. It is unclear how the site was used between 1948 and 1958, but notes from the transfer of the site to the United Kingdom Atomic Energy Authority (UKAEA) indicate that the site was put under care and maintenance [24]. A list of the buildings indicates that the majority of the process plant had been removed but that a large number of the buildings were still in situ along with the boiler plant.



Figure 2.5: Aerial photograph of the site taken in 1957 with the outline of the current site boundary in red

UKAEA was granted planning consent for the disposal of waste in the northern 40 hectares of the site in 1957. The majority of the ROF buildings were demolished, however, most of the below-ground structures such as foundations, sumps and drains were left. Additionally, the storage magazines, earth bunds around the process buildings and toluene tanks remained. The earth bunds are visible as the raised rectangular shapes below the centre of Figure 2.5.

Historical practices during operation and demolition of the ROF facilities have resulted in areas of land contamination (of asbestos, TNT and lead).

An adjacent site on Shore Road was used during the period 1966 to 1974 as a municipal landfill for the disposal of domestic wastes. The site covered an area of 3.9 ha and was operated by Millom Rural District Council. Since 1974, it has been used for inert waste

disposal, comprising small quantities of wastes from highway maintenance and improvement works. Cumbria County Council granted planning permission for continued operation of the site in May 2004 [25]. The landfill is now closed and monitored under an Environment Agency permit. In 2025, an application for temporary planning permission (five years) was submitted by Cumberland Council to Cumbria County Council for change of use of part of the site to be used to grow vegetables in raised beds.

A timeline of the major radioactive waste management operations at the LLWR and related developments is presented in Figure 2.9 and is described in more detail as follows.

1959. Opened as a radioactive waste disposal site

Initial disposals were carried out under an authorisation granted in 1958 (referred to as the 'Authorisation') under the Atomic Energy Act 1954. The disposals were described and reviewed in reference [26], which noted the gross alpha and pure beta activity limits as 20 millicuries per cubic yard and 60 millicuries per cubic yard, respectively (approximately 0.97 GBq m^{-3} and 2.9 GBq m^{-3} , respectively), both values being the averages not to be exceeded for the whole of the wastes being buried in one day. The dose rate at the surface of substantially unshielded beta-gamma waste was not to exceed 0.75 rads per hour (7.5 mGy h^{-1} in SI units).

Trench disposals commenced in July 1959, starting in one of the former ROF railway cuttings that was re-engineered for the purpose (the railway cutting is visible in Figure 2.5, running from the most northerly corner of the site in a south-east direction). The first trench was filled by the end of 1963. In the years that followed, a further six trenches were excavated in the glacial sequence beneath the site. The trenches were designed with drainage systems and the run-off water entered a ditch, which discharged into Drigg Stream. The stream passed through rough pasture for about 400 m and discharged into a tidal section of the River Irt [26].

Figure 2.6 shows a plan of the site drawn in 1985. It shows the layout of the seven trenches and the drainage route from the end of each trench to the Drigg Stream (labelled 'stream' in Figure 2.6, running approximately parallel with the lower site boundary). The plan is part of the engineering documentation that supported our work to demolish the ROF marine outfall. The marine outfall (heading towards the bottom-left corner), and the drainage routes on the site that led to it, are also marked on the plan. The marine outfall was used for surface water drainage up until it was demolished. During operation of the ROF, the on-site drainage routes collected both surface and process water for diversion to the outfall. These routes still exist as surface water drains, which flow into the Drigg Stream via inlets that are known as OF1 and OF2 (at points marked 'A' and 'B' in Figure 2.6). There was no connection between the trench leachate drainage system and the ROF marine outfall.

It is interesting to note that 'Trench 8' is also shown on Figure 2.6. Plans to construct Trench 8 were never realised. As is explained later in this report, the site underwent a major upgrade programme in the years shortly after 1985, which led to the phasing out of the trench disposal model in favour of emplacement of waste in concrete-lined vaults.

Trench disposal began to be phased out in 1988, when Vault 8 commenced operation. An interim cap was placed over Trenches 1 to 6 in 1989. Disposals to Trench 7 were completed in 1995 and the trench was then capped.

Details of the trenches are included in the '*Engineering Design*' report [4] and have been discussed in earlier reports, notably the 2002 PCSC [27, 28].



Figure 2.7: Photograph of trench disposal operations in 1961



Figure 2.8: Photograph of trench disposal operations in the 1980s

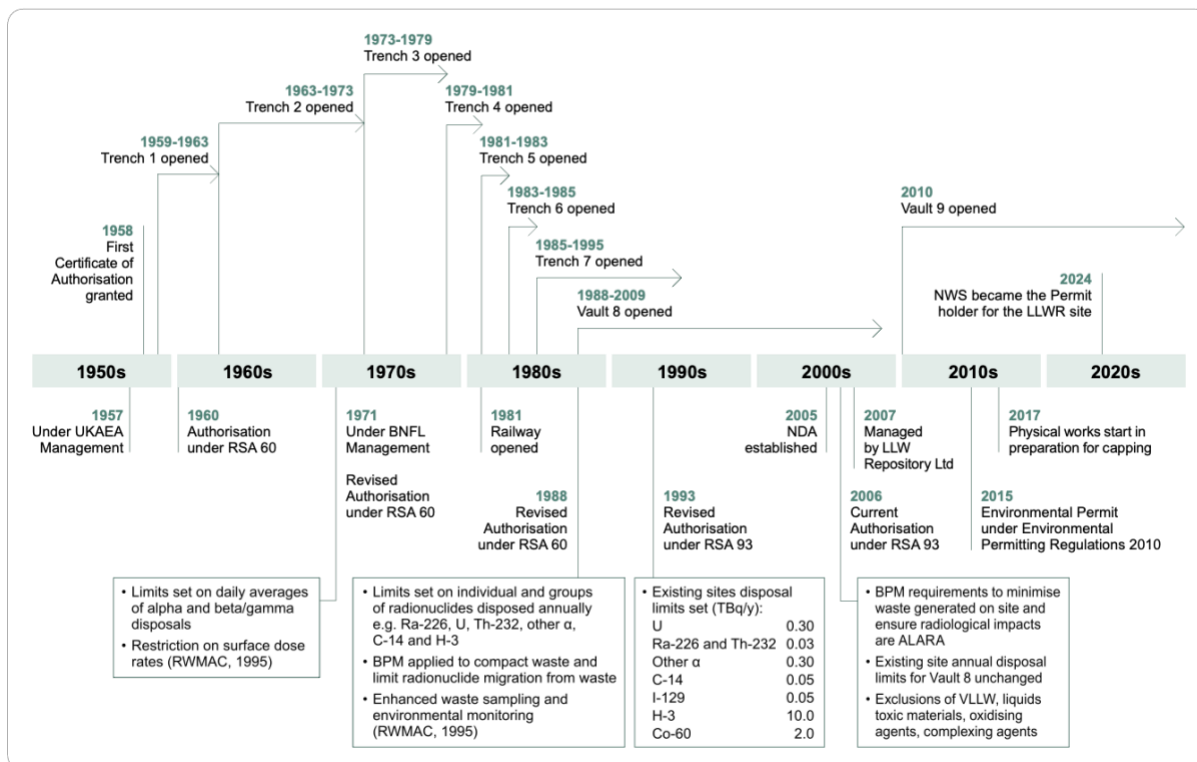


Figure 2.9: Timeline of radioactive waste management operations at the LLWR and related developments

1960s. Storage of Plutonium Contaminated Material

Plutonium Contaminated Material (PCM) was transported to the site between 1959 and 1967 and stored in ten magazines that had been constructed to store TNT when the site operated as a ROF [29]. The storage of the PCM was viewed as a temporary measure, pending the development of a process to recover the plutonium. Removal of some of the PCM was undertaken between 1977 and 1984, when drummed material was removed from five of the magazines. These drums were either transported to Sellafield or placed in a purpose-built store (B720), that was constructed in 1980 in the southern end of the site [30].

1960s. Storage of uranium hexafluoride cylinders

In the 1960s and 1970s, 700 redundant uranium hexafluoride cylinders were stored at the site. The majority were stored in the open in an area adjacent to the magazines and approximately 150 were stored within the magazines. It was considered that many of the vessels were not fully purged and may have contained a few residual kilograms of the material [31]. In 1977, the majority of the cylinders were buried in Trench 3 [32]. The population stored inside the magazines was removed and grouted into Vault 8 [33].

1970s. B741 and B749 ad hoc storage

Some of the base slabs from the demolition of ROF buildings were used for the temporary storage of radioactively contaminated items and other materials [31]. Stainless steel alpha-contaminated vessels were stored in a fenced off area within the B741 earth bund (former

TNT nitration building) [34]. These were disposed of in Trench 7 in 1992. However, contamination from these vessels was found to have penetrated the surface of the base slab.

A second area, B749 (former Shift House) [31], is reported to have been used over an unspecified period of time for the temporary storage of drums containing Cs-137 and Co-60 [35]. Contamination of the concrete surface is believed to have occurred as a result of rainfall washing radionuclides off the containers. Trials were undertaken on two 3 m² areas of the B749 slab to remove surface radioactivity using a proprietary chemical agent. Although trials were initially considered to be effective and to have removed at least 95% of the radioactivity from the trial areas, complete decontamination was not achieved. It was later considered that the treatment process may have caused the radionuclides to migrate deeper into the concrete slab [31].

1971. Revised Authorisation issued under the Radioactive Substances Act 1960

This Authorisation allowed the disposal of solid radioactive waste, including sludges, at the site. Conditions within the Authorisation included:

- requirements for waste to be buried in the ground beneath at least 1 m of soil and for burial excavations not to penetrate through the boulder clay stratum;
- the dose rate at the surface of substantially unshielded waste containing radionuclides emitting either or both beta particles or gamma radiations should not exceed 0.75 rads per hour in air;
- in any cubic metre of buried matter:
 - the number of millicuries of alpha-emitting radionuclides does not exceed 20 averaged over any one day; and
 - the number of millicuries of beta-emitting radionuclides which do not emit gamma radiation does not exceed 60 averaged over any one day.

The Authorisation also contained requirements for appropriate monitoring and sampling and maintaining records of all the wastes buried or deposited, including their location and estimated activity.

1979. Departmental review of control of radioactive wastes

This review [36] was carried out independently from the LLWR operators. It concluded that the LLWR site was fit for purpose and provided a disposal mechanism for waste from Windscale³ and other operations throughout the country. Nevertheless, it identified the following issues to be addressed.

³ Now a part of Sellafield.

- There was a need to investigate how to optimise practices, to achieve a reasonable balance between the need to dispose of waste and the radiological safety of the general public.
- The possibility of lateral movement of contaminated groundwater through deposits of sand and gravel, which lie above the glacial boulder clay, was noted, along with ongoing investigations and tests.
- It was queried whether burial beneath 1 m of cover was sufficient, in view of the risk of subsidence and if the exclusion of the public and surveillance were to cease.

The review also identified that BNFL (now the site operator) believed that it would be unwise to bury drums containing the maximum amount of plutonium permissible under the Authorisation, particularly if all the alpha activity allowed in one day was contained in one drum. BNFL was operating a policy that virtually excluded all wastes known to contain plutonium from the trenches, contributing to a build-up of PCM in storage. The review recommended a change to the Authorisation to include specific limits for plutonium per drum.

Early 1980s. Five PCM storage magazines decommissioned

In the early 1980s, five of the ten magazines used for PCM storage were emptied. The drums were moved to the B720 Drum Store, which was constructed in 1980.

1986. Review by the Environment Committee of the House of Commons

Following a visit in April 1985, the House of Commons Environment Committee delivered a critical review of waste management practices at the LLWR [37]. The report highlighted several shortcomings, including practices relating to leachate management, waste acceptance, capacity management and the rigour and frequency of monitoring. The inadequacy of the approach was highlighted by comparison to other international waste management operations. The report concluded that the then operating trench disposal model was not an acceptable model for any future disposal site and recommended the following.

- The Authorisation should be modified so as to permit the disposal of only short-lived, non-alpha, low activity wastes and to prohibit specified radionuclides.
- All wastes should be properly sorted before arrival to separate inappropriate material and uncontaminated refuse.
- All wastes should be compacted or incinerated where they lend themselves to be so treated.
- All wastes should be put in appropriately labelled containers.
- All wastes should be monitored on arrival to check that they contain only what the new authorisation allows.

1984. Railway drain elevated tritium levels

A trend of increasing tritium activity in the railway drain was observed in the early 1980s. The railway drain is a man-made surface water drain that runs parallel to the north-eastern edge of the trenches, adjacent to the Carlisle to Barrow-in-Furness railway line. It discharges into the East-West Stream, which then joins the Drigg Stream before flowing off site towards the River Irt.

The presence of tritium in the railway drain indicated a pathway from the trenches to the drain, likely via the Upper Groundwater system. A 1984 investigation concluded that perched groundwater was accumulating at the northern end of the trenches to levels that could cause the groundwater to migrate laterally towards the drain [38]. Borehole and in-trench sampling confirmed high levels of tritium activity in Trench 4, thus it was concluded that Trench 4 was the likely source of the tritium observed in the railway drain. In 1985, a small cap was installed at the north-western end of Trench 4 and the adjacent section of Trench 1 [39]. Drainage facilities were installed to remove surface run-off, and leachate was pumped out of the trench to be discharged to the Drigg Stream via a drain.

Wastes with high levels of tritium activity were disposed of in Trench 6 in 1983 and 1984. These consisted of luminised telephone dials or 'Betalights' sent in six consignments from Harwell between December 1983 and April 1984 [40]. The original disposal records for the Betalight drums showed no significant inventory of tritium. However, a review of additional information undertaken after disposal showed that the activity on the disposal records for these dials was underestimated. It was shown that Harwell quoted the activity of a single dial rather than allowing for the number of dials per drum. We consider that the activity of tritium (502 TBq) dominates the total activity of the trenches (566 TBq), and that the majority of the tritium inventory (447 TBq) is derived from the Harwell Betalights. It is possible that tritium from the disposals of Betalights also contributed to the observations of tritium in the railway drain in the 1980s.

In addition to the Betalights, we have identified other discrete disposals of tritium-bearing waste to the trenches, such as those to Trenches 3 and 4 [40]. There is, however, uncertainty in the trench inventory because historic disposal records are limited.

As described in the following subsection, a major upgrade programme was commenced at the site in 1987. An interim cap was constructed over the trenches and a bentonite-cement slurry cut-off wall was constructed initially around the north-eastern and north-western edges of trenches between September 1988 and August 1989. Current and historical monitoring data from the railway drain show that tritium levels significantly reduced in the years following the installation of the cap and cut-off wall to the extent that there is no longer a pathway between the trenches and the railway drain. Figure 2.10 shows how the tritium levels in the railway drain have decreased over time.

We have an extensive environmental monitoring programme, which continues to detect tritium in groundwaters and surface waters around the site. Our '*Monitoring*' report [8] describes these measurements and the reasons why the tritium concentrations are

considered to be of low impact to the environment and pose no significant risk to members of the public. Our '*Hydrogeological Risk Assessment*' report [15] describes how we use the spatial and temporal characterisation of tritium to support the development of the hydrogeological conceptual model of the site, and as evidence that the engineered barriers are performing as expected.

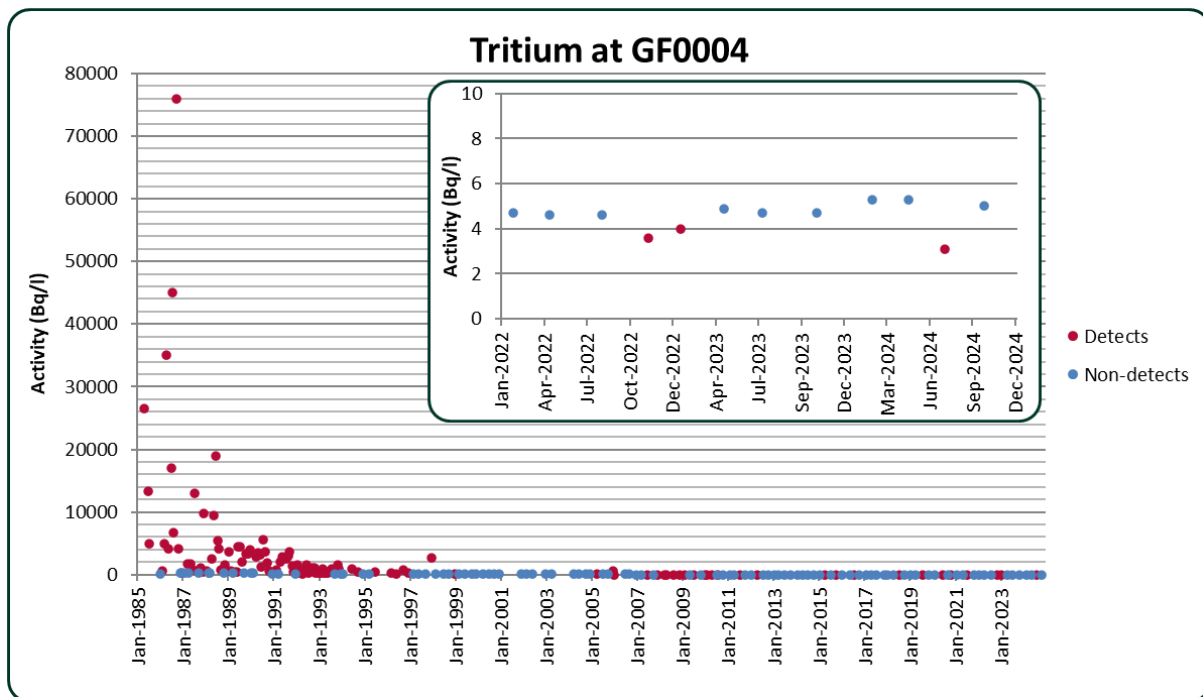


Figure 2.10: Tritium at the GF0004 railway drain monitoring point

1987. Commencement of major upgrade programme and revised Authorisation

In 1987, a major upgrade in disposal operations at the LLWR site was commenced. The work was developed in parallel with a further review by authorising departments of the certificate of authorisation, with the objective, as recorded by the Radioactive Waste Management Advisory Committee (RWMAC), of incorporating the following changes [41]:

- annual activity disposal limits for certain individual radionuclides and groups of radionuclides, and limits on concentrations in individual waste consignments of 4 GBq t⁻¹ alpha emitters and 12 GBq t⁻¹ for other radionuclides;
- a limit on radioactive content of discharges from the LLWR site;
- reference to an agreed environmental monitoring programme.

The main aims of the upgrading activities were to:

- improve management practices;
- utilise the space efficiently; and
- enhance the visual impact of the disposal operations.

The main features of the upgrade were as follows.

- A 450 m long, 1 m wide and 9 m deep (range 7.3 to 9.4 m) cut-off wall was installed around the north-eastern corner of the site in 1988 [42]. The cut-off wall extends from the northern end of Trench 7 to the north-eastern corner of Vault 8. The base of the wall is keyed into the same clay layer that forms the base of the trenches.
- The interim cap and cut-off wall to Trenches 1 to 6 were constructed from September 1988 to August 1989. The details of the interim cap are described in reference [42] and include:
 - 450,000 m³ of fill over 14 ha, average of 3.2 m thickness;
 - a minimum of 450 mm soil cover, typically around 1 m thick;
 - a 1:25 graded earth mound composed of mostly sandy clay;
 - a low-density polyethylene geomembrane at about 1 m depth and 0.375 mm thick;
 - heat fusion 'welded' joints in the geomembrane.
- The leachate drainage system was redesigned and upgraded.
- Trench disposal was phased out in favour of vault disposal.

Material from the bunds around the ROF process plants was used as profile fill for the interim cap.

RWMAC [41] also noted the significance of a detailed analysis of the radiological impact of past and future disposals then being undertaken by the National Radiological Protection Board. This assessment, not published until 1988 [29], took account of a wide range of releases that might occur during the period of site operation and after closure of the site. These included:

- fires in the trenches during the operational period;
- discharges to the River Irt via the drainage system and stream, and separately, assuming that collected leachate would be discharged directly to the sea via a refurbished Marine Pipeline in the future;
- contamination that is not collected in the drainage system and is released via the groundwater pathway;
- release of radioactive gases;
- release due to disturbance of the site by a variety of human intrusion mechanisms.

Consideration was given to past disposals in the trenches and future disposals in engineered vaults and the assessment was designed to address issues raised in the ongoing RWMAC reviews. The results were used to determine disposal limits that would meet the then extant radiological protection objectives.

A revised Authorisation was issued at the end of 1987 and came into effect in February 1988. The key features of this required the operator to:

- limit the total activity of individual and groups of radionuclides disposed annually;
- apply Best Practicable Means to compact waste;
- apply Best Practicable Means to limit radionuclide migration from the waste;
- collect contaminated leachate, measure its radiological content and ensure that it leaves the site only by approved means;
- ensure that the flow of collected leachate into the Drigg Stream is controlled so that concentration limits are not exceeded for as long as the Drigg Stream continues to be used;
- enhance waste sampling and environmental monitoring.

1988. Commencement of vault disposal operations

The design solution adopted for the vault disposal involved the orderly emplacement of containerised, conditioned wastes in reinforced concrete vaults. Vault 8 was constructed in 1986 to 1987 (as shown in Figure 2.11) and commissioned in May 1988. It was designed and constructed according to the best practices of the time. It was founded on a minimum of 1 m of low permeability clay – where the appropriate permeability value was not achieved, bentonite was mixed with local soils.



Figure 2.11: Construction of Vault 8 and capping of Trenches 1 to 6

The base slab was constructed in three bays, with conventional reinforced concrete (250 mm to 300 mm thick). The north and west perimeter walls and southern internal wall

are 350 mm thick reinforced concrete. A secant pile wall provides structural support along the eastern side of the vault, adjacent to the trenches. Engineering details are presented in the '*Engineering Design*' report [4].

1989. Review by the Environment Committee of the House of Commons

The Environment Committee of the House of Commons visited the site again in June 1989 and issued a report in July 1989 [43]. Demonstrating the rapid improvement effected by the 1987 upgrade programme, the Committee was able to record that:

'Sampling equipment had been installed on-site and all waste arriving at [the LLWR] from non-Sellafield sources is placed in an approved container, which is carefully labelled and its ultimate destination recorded. In so far as the old trenches are concerned, these have been isolated by a cut-off wall designed to prevent lateral movement of contaminants from the trenches.'

The full introduction of the revised wasteform and the final phasing out of trench disposals, however, was not completed until 1995 when the operation of new compaction and grouting facilities commenced.

1991. Commissioning of the Marine Holding Tanks and Marine Pipeline

Refurbishment of the leachate drainage system was completed in early 1991 to allow improved leachate monitoring and controlled discharge directly to the Irish Sea, rather than via the Drigg Stream and River Irt.

Leachate from each trench and Vault 8 was routed by gravity flow to a common point and then to the Marine Holding Tanks (MHT) on the western edge of the site, where it was held pending automated discharge. The Marine Pipeline is buried beneath the beach and seabed, discharging to sea through three diffusers (as shown in Figure 2.12) about 1.2 km offshore. It follows the same route as the ROF marine outfall. Discharges via the Marine Pipeline were commenced subject to regulatory review of the assessment of the radiological impacts. This assessment took account of return of activity to shore, including sediment deposition and contamination of the terrestrial environment in the Ravenglass Estuary.

Until mid-1997, discharges from the MHT were controlled to occur around the time of high tide. However, tidal conditions are no longer a determinant of discharge phasing since dispersion tests showed that dilution was not significantly different at low tide.

Surface waters from the cap continued to be discharged into the Drigg Stream.

Provision is included in the Permit to allow for diversion of Vault 8 drainage (and later Vault 9) to the Drigg Stream in the event of extreme rainfall. The valve has not been operated recently with the last confirmed use being prior to the lifting of discharge restrictions in 1997.



Figure 2.12: Photograph of marine diffusers prior to emplacement during the construction of the Marine Pipeline

1993. Revised Authorisation issued under the Radioactive Substances Act 1993

The technical requirements in the 1993 update to the Authorisation were similar to those in the previous Authorisation but took account of the administrative impact of the Radioactive Substances Act 1993.

1995. Completion of Trench 7 cap and extension of cut-off wall

In 1995, the interim cap and cut-off wall (installed in the late 1980s to protect Trenches 1 to 6) were extended to protect Trench 7 after completion of trench disposals. The five empty magazines were demolished at this time and the material used as profile fill over Trench 7.

Mid 1990s. WAMAC and the Drigg Grouting Facility

Two facilities were introduced in the mid-1990s for production of a new wasteform. The Waste Monitoring and Compaction (WAMAC) facility at Sellafield high-force compacts waste and loads the resultant pucks into half-height ISO containers. These were then transferred to the LLWR site for grouting in the Drigg Grouting Facility (DGF) (as shown in Figure 2.13) prior to final emplacement in the vaults.



Figure 2.13: Drigg Grouting Facility

With the progressive introduction of the revised wasteform, the majority of disposals to Vault 8 before 1995 required further treatment to upgrade them to the new wasteform standard. Figure 2.14 shows Vault 8 disposals as well as the backlog facility used to unpack containers that had been filled prior to WAMAC construction between 2003 and 2007.



Figure 2.14: Vault 8 disposals

1997. Management of PCM

Removal of PCM material from LLWR recommenced in 1997 and continued up to July 2007 when all bulk PCM material had been removed.

The major milestones for the PCM retrieval project were as follows.

- 1997 – retrievals began from Magazine 3 and the PCM Drum Store B720.
- 2000 – construction began on new PCM retrieval facilities (B746 and B726).
- 2001 – Magazine 3 emptied.
- 2003 – new PCM retrieval facilities operational.
- 2003 – Magazine 10 emptied.
- 2004 – Magazine 5 emptied.
- 2005 – Magazine 4 emptied.
- 2007 – all bulk PCM retrieved and sentenced to Sellafield.

The drum storage and handling building (B746) and a crate process building (B726) were constructed to provide facilities for the PCM retrieval project. B746 continues to facilitate radiometric assay, buffer storage, containerisation and transport of legacy and secondary PCM waste. Secondary PCM drums are generated from the decontamination of PCM buildings, which began in 2012 as part of the PCM decommissioning project.

A population of 1,810 secondary PCM drums stored in B746 underwent assay using a sensitive assay machine between July 2021 and August 2022 to determine whether they are PCM or LLW. Most of the drums were reclassified as LLW or VLLW, and most have now been removed from the site. A small sub-population of the 1,810 secondary waste drums and some legacy drums remain in storage in B746.

By the end of 2020, the five remaining magazines had been emptied, decontaminated and partially demolished (the covering soil has been removed). The intention is to demolish the remaining concrete and brick constructions and use the material, along with the soil, in the construction of the final cap over the repository.

2002. Safety Case

In September 2002, BNFL submitted an Operational Environmental Safety Case [44] and a Post-closure Safety Case [28] (the 2002 PCSC) to the Environment Agency. The safety cases were submitted in response to a variation to the Authorisation in January 2000 [45], which required BNFL to provide information about the environmental safety of the LLWR.

Although the Environment Agency accepted many of the arguments set out in the 2002 PCSC [46], it was ultimately concluded that it failed to make an adequate or robust argument for continued disposals of LLW because:

- estimates of doses and risks from existing disposals to members of the public in the future significantly exceeded current regulatory targets;
- BNFL indicated that the LLWR is likely to be destroyed by coastal erosion in 500 to 5,000 years and the consequences of erosion were not shown to be acceptably managed;

- the 2002 PCSC included insufficient consideration of optimisation and risk management, to demonstrate that impacts will be as low as reasonably achievable (ALARA).

2006. Revision of the Authorisation

Following the Environment Agency review of the 2002 PCSC [46], and public consultation of the review, the Decision Document issued in February 2006 [47] determined that:

- continued disposal of LLW to the current Vault 8 area using existing annual solid waste disposal limits would be authorised;
- LLW disposals to the proposed Vault 9 would not be authorised until appropriate planning permission from Cumbria County Council had been obtained and the Environment Agency had been provided with adequate information to allow the radiological capacity of the site to be determined;
- when Vault 8 reaches capacity and prior to Vault 9 being authorised, any LLW waste consigned to the LLWR shall be for the purpose of temporary storage;
- construction of the final cap over Vault 8 and trench disposals would not be allowed until the Environment Agency had been provided with the outcome of a wide-ranging risk management study that demonstrates that future impacts will be ALARA.

On that basis, a new Authorisation [48] was issued on 4th April 2006, which came into effect on 1st May 2006. The Authorisation comprised nine Schedules. The 14 requirements⁴ of Schedule 9 included the need for the site operator to update the ESC within five years, i.e. by 1st May 2011.

2006. Planning permission for higher stacking

In 2006, Cumbria County Council granted planning permission for the temporary higher stacking of up to 950 half-height ISO containers above Vault 8 (as shown in Figure 2.15). Higher stacking of containers was necessary to maintain disposal operations at the LLWR in advance of Vault 9 construction in view of the limited remaining volumetric capacity of Vault 8. The permission was conditional upon their progressive removal after 2010 [49]. An extension to this date was sought in 2010 and granted to allow these operations up to 2015.

⁴ Schedule 9 was amended to include its 14th requirement by a variation notice issued 11th August 2006 and effective from 1st September 2006.

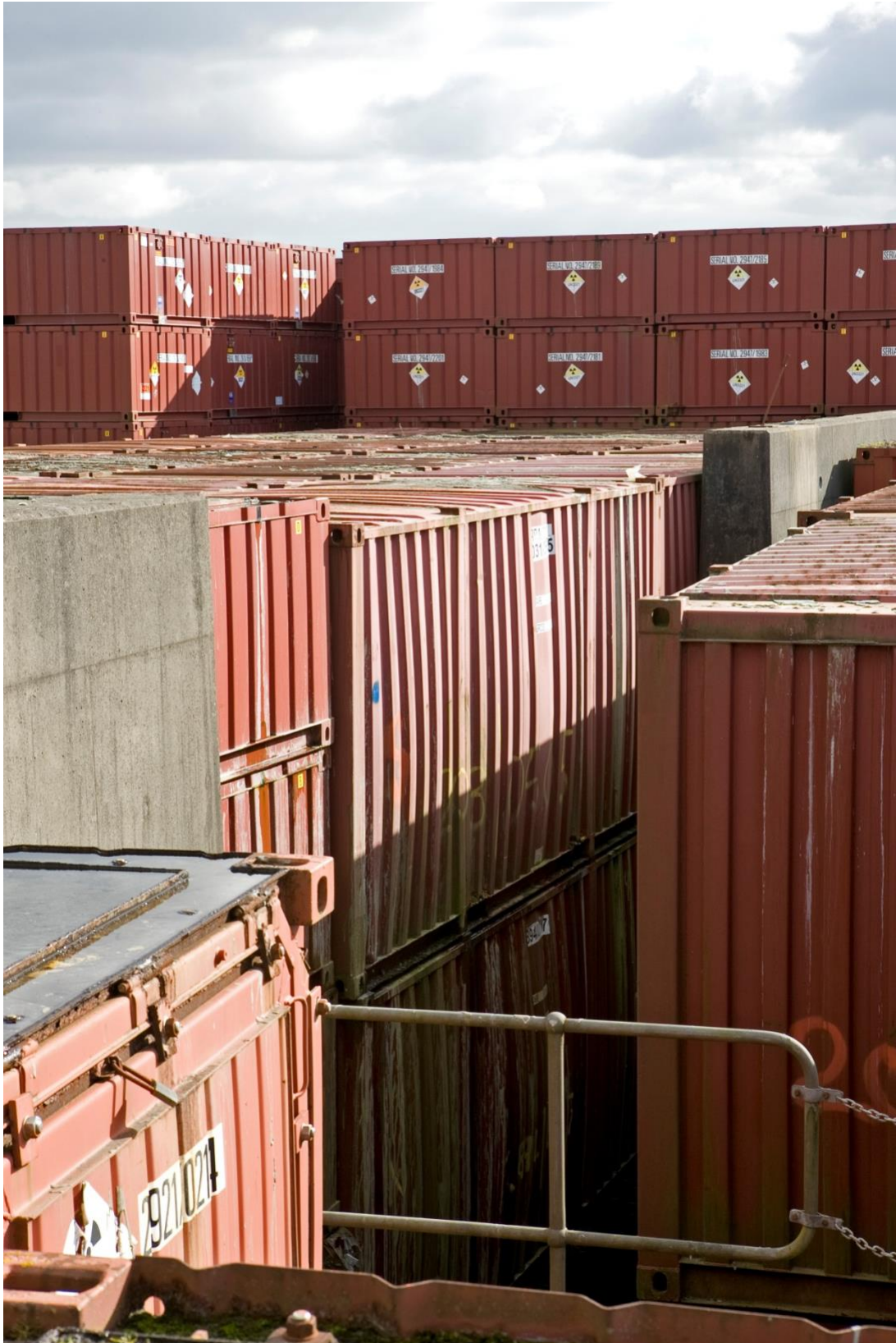


Figure 2.15: Higher stacking in Vault 8

2007. Transfer to LLW Repository Ltd

On 19th July 2007, the Environment Agency issued a transfer of the Authorisation from Sellafield Ltd to LLW Repository Ltd that came into effect on 29th July 2007. The site was removed from the Sellafield authorisation to allow for a competition for a Parent Body Organisation to manage the site separately. An international consortium, UK Nuclear Waste Management, won the 17-year contract in 2008.

2008. Vault 9

On 22nd January 2008, planning permission was granted by Cumbria County Council's Development Control and Regulatory Committee for Vault 9, subject to a range of conditions. The report submitted by the Head of Environment to the Development Control and Regulation Committee [49] noted that:

'There is no doubt that additional capacity is needed urgently for managing the low level radioactive wastes (LLW) that arise within the county and elsewhere within the UK. Such waste is inevitably produced by hospitals, the healthcare industry and others and will increase as nuclear facilities are decommissioned.'

Construction of Vault 9 was fully complete in December 2010, although interim storage commenced in July 2009. Vault 9 was designed with similar objectives to Vault 8. Engineering details are presented in the '*Engineering Design*' report [4]. In accordance with the Environment Agency's 2006 Decision Document [47], consignments held within Vault 9 at this time were for the purpose of storage only. This remained to be the case until a new Permit was granted in 2015 and planning permission was granted subsequently in 2016. Storage of waste in Vault 9 in 2011 is illustrated in Figure 2.16 and Figure 2.17.



Figure 2.16: Vault 9 in 2011



Figure 2.17: Vault 9 operations

2009. The GRA

In 2009, the environment agencies issued new guidance [19] in relation to near-surface disposal, the GRA. While the basic radiation protection objectives for human populations remain similar to those in the previous version, the new guidance suggested explicit

consideration of protection of the environment (as opposed to only humans). This aspect is addressed in the '*Assessment of Impacts on Non-human Biota*' report [16].

2010. Environmental Permitting Regulations 2010

In 2010, changes were made to the regulation of radioactive waste management in England and Wales, with the introduction of the Environmental Permitting (England and Wales) Regulations 2010. Under these regulations, the Permit for the LLWR site became effective on 1st January 2011 [50].

2010. UK Strategy for the Management of LLW

The '*UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry*' was published in 2010 [51]. The strategy set out plans to apply the waste hierarchy more effectively to the management of LLW, with a preference for managing LLW at higher levels of the hierarchy, meaning a move away from the past focus on disposal. It was envisaged that this would ensure optimal use of the LLWR and the UK's capacity for the management of LLW.

The development of the 2011 ESC was framed by the role of the LLWR within this strategy: to maximise its potential to accept for disposal LLW, requiring vault disposal and treated to minimise its volume, in a safe and optimal way, while supporting the implementation of the waste hierarchy in the UK [52].

Since 2011, we have developed a Waste Services function within our organisation that delivers safe and effective options to waste producers to reduce and recycle their wastes. These routes are provided by commercial organisations and include facilities for the treatment and recycling of metallic waste, incineration of suitable waste, the diversion of Very Low Level Waste (VLLW) to suitably licensed landfill sites and supercompaction of waste to minimise volumes sent to the LLWR.

Since the strategy was implemented, the volume of waste received at the site has decreased as illustrated by Figure 2.18.

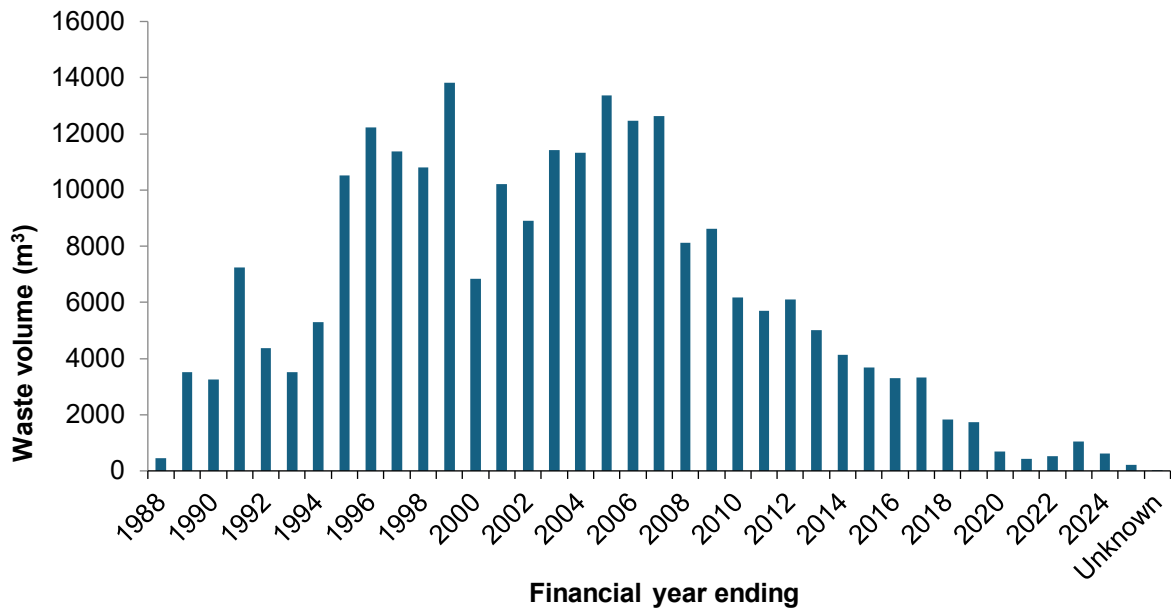


Figure 2.18: Volumes of waste received since 1988

2011 ESC

The 2011 ESC was submitted to the Environment Agency on 1st May 2011 [52]. It was a complete revision of the case submitted in 2002, although it made use of the research and development undertaken for the previous safety case.

In conducting its review, the Environment Agency considered the ESC as submitted in 2011 alongside additional technical work submitted in 2013 [53] that was, in part, undertaken in response to queries and requests for information set out by the Environment Agency during its initial review of the 2011 submission. A request to vary the existing Permit was also submitted in 2013 alongside the additional technical work [54].

The Environment Agency’s review of the 2011 ESC was issued on 15th May 2015 [55] and states the following:

‘Overall, we consider that LLW Repository Ltd has met the requirements of the GRA and its current environmental permit through the 2011 ESC and supporting documents. The evidence is of a suitable standard and quality to support an environmental permit decision on future disposals at the site. We are satisfied that the 2011 ESC and supporting documents demonstrate that further disposal of radioactive waste at the facility will be safe for people and the environment both now and in the long-term.’

The Environment Agency accepted the 2011 ESC as a sound basis to support our application to vary the Permit to allow continued disposal of LLW at the site. A variation to the Permit was issued on 28th October 2015 and came into effect on 1st November 2015 [56]. The revised Permit included seven Improvement Conditions (IC1 to IC7). IC7 required us to submit a Major Review of the ESC by 3rd May 2021.

2015. New perimeter fence constructed

Construction of a new welded mesh security fence to establish a single, secure zone within the confines of the site boundary began in 2015 and ended in 2018. Wildlife access gates, namely for reptiles and badgers, were incorporated within the fence line at designated locations.

2016. Planning permission

In July 2016, LLWR received planning permission from Cumbria County Council for installation of a final cap over Trenches 1 to 7, existing Vaults 8 and 9 and future Vaults 9a, 10 and 11. Incorporated in the planning consent were ancillary works to support construction activities, higher stacking of containers and conversion of Vault 9 from storage to disposal. The planning consent is time-bound to 2055.

2016. Demolition of B720 Drum Store

Demolition of the B720 Drum Store commenced in late 2016 and was completed in mid-2018, generating approximately 925 m³ of demolition rubble. The waste is packed in 6 m³ PACTEC bags and stored within Vault 9 and on the Vault 9 apron. There are plans to use the rubble as infill of the remaining disposal volume of Vault 8 that is not suitable for ISO containers, including the access ramp [57]. This is due to be completed before 31st March 2026, at which point Vault 8 will be filled completely.

2017. Commencement of the capping operations programme

Our capping operations programme began in 2017 under what was then titled the Repository Development Programme. The aim of the programme is to install the closure engineering required to protect the environment from the wastes in Vault 8 and the adjacent area of the trenches, including optimisation of the closure engineering design.

The final engineering design of the cap is complete. Full details of the cap design and the optimisation process can be found in our '*Optimisation and Site Development Plan*' [9] and '*Engineering Design*' [4] reports. In summary, the final cap is a 3 m thick highly engineered multi-layered structure. It will be constructed atop a layer of profile fill that provides a stable base and desired gradients. The area where the first strip of cap is to be constructed will be surcharged prior to addition of the profile fill. The most important layers that act to limit water infiltration are a geomembrane composed of 2 mm thick high-density polyethylene and an immediately underlying bentonite-enriched sand layer.

Recent physical developments on site have been mostly in preparation for capping, for example:

- construction sites were cleared between March 2019 and August 2020;
- construction of an acoustic fence to reduce the noise and visual impact of other construction activities was completed in September 2020;
- a minor civils contract, completed in January 2023, saw us complete construction of the initial material stockpile areas for management of the vast quantities of aggregate

needed for construction of the cap, the first sections of haul road, and temporary drainage infrastructure, including several lagoons.

2020. Variation of the Permit to include requirement for SWESC and WMP

Effective from 9th March 2020, the Permit was revised to include IC8, which requires us to produce a SWESC and WMP [58].

2021. Variation of the Permit to delay the submission of the ESC

In early 2021, we wrote to the Environment Agency to request a delay to the completion of IC7 beyond the 3rd May 2021. At the time, we were undertaking a programme of design optimisation within the RDP to address difficulties encountered in the closure of Vault 8 and were undertaking a separate programme of optimisation work to consider the potential for enhanced or new types of disposal facility that could be developed on the site. We considered that it was not timely to undertake a Major Review of the ESC in 2021 as such a review would not be based on a fully optimised repository design and would, therefore, not fully meet the requirements set out in the GRA.

We agreed to produce an interim submission by 1st May 2021. The submission was titled our Enhanced Periodic Review (EPR) [59]. Based on the submission, we proposed that the next Major Review of the ESC should be submitted by 1st May 2026. We also proposed that the SWESC and the WMP should be part of that submission.

The Environment Agency issued a revised permit for the LLWR site effective 1st April 2021 [60]. The new Permit:

- amended the due date of IC7 (submission of a Major Review of the ESC) to 1st May 2026;
- amended the due date of IC8 to 1st May 2026, to align with the ESC submission;
- introduced a new improvement condition, IC9, which required us to report on the outcome of our work to optimise the disposal model by

The scope of the 2026 ESC has been broadened to meet the requirements of submitting a SWESC and WMP.

2021. LLW Repository Ltd becomes direct subsidiary of the NDA

On 12th July 2021, the Parent Body Organisation contract for the management of LLW Repository was terminated and the company became a direct subsidiary of the NDA.

2022. Formation of Nuclear Waste Services

NWS was formed on 31st January 2022, creating an integrated waste management organisation consisting of Radioactive Waste Management Ltd, responsible for delivering the UK's Geological Disposal Facility (GDF), and LLW Repository Ltd. At this point, NWS was not a legal entity and did not hold the Permit for the site, which remained the responsibility of LLW Repository Ltd. NWS provided strategic oversight of the operation and development of LLW Repository Ltd through a management-board governance structure.

2022. Site Emergency Control Centre

The Site Emergency Control Centre was officially opened in March 2022 as part of an on-site security enhancement programme. It significantly improves our ability to respond to safety or security incidents and is considered a cornerstone of LLWR's emergency preparedness infrastructure.

2024. TRS Drums

The Treated Radwaste Store (TRS) at Winfrith held 1,068 500 litre drums of encapsulated sludge. The drums were originally being held awaiting transfer to interim storage pending disposal in a GDF. However, due to a period of radioactive decay, they were reclassified from ILW to LLW meaning they could be disposed of at the LLWR. Disposal took place in otherwise unusable space in Vault 8, as shown in Figure 2.19. Emplacement of the drums was completed in February 2024.

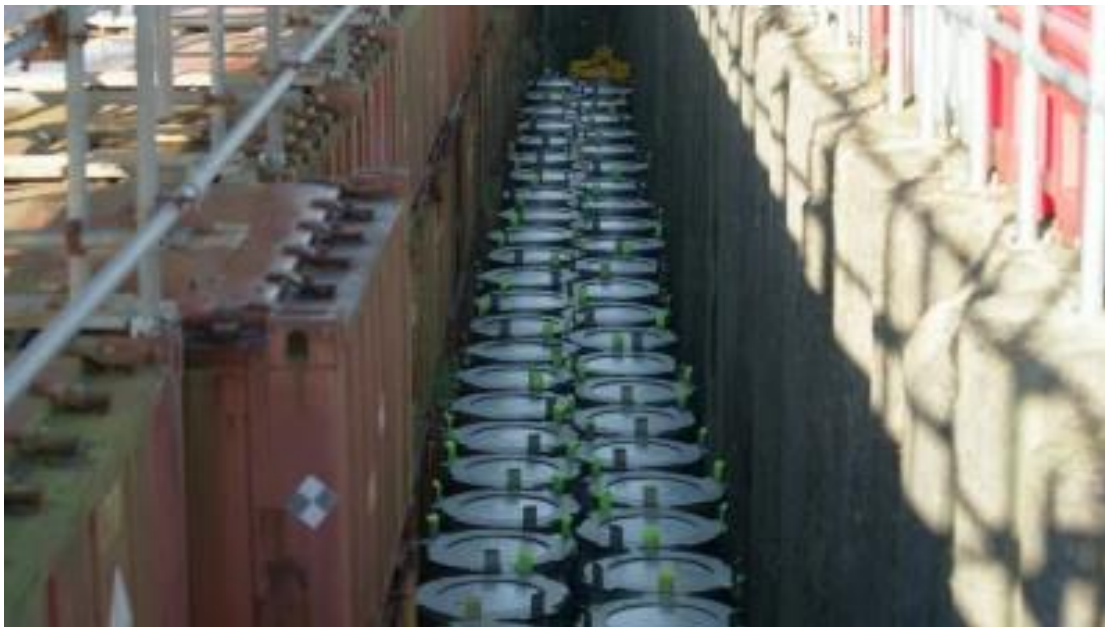


Figure 2.19: Emplacement of TRS drums in Vault 8

2024. Transfer to Nuclear Waste Services

NWS became a legal entity and the Permit holder for the LLWR site on 27th March 2024.

Recent safety case and regulatory developments

We submitted our response to IC9 on 28th June 2024 [61]. The report synthesises the results of our programme of optimisation and outlines the high-level disposal model for the LLWR. It shows how and why the design has developed since the baseline provided by the 2011 ESC, including where optimisation studies were prompted by new information on engineering performance gained since the 2011 ESC, and outlines a forward programme, including key priorities for continuing optimisation and design.

The main areas of development since the 2011 ESC design are:

- an extra metre of profile fill added to maximise confidence in cap performance;

- the interim trench cap will be replaced in areas not covered by the first strip of cap;
- existing and committed containers will be surcharged prior to capping;
- strengthened containers (via a relatively minor update to the half-height ISO container design) will be used for future LLW disposals;
- reinforced concrete ‘container protection units’ (CPUs) spanning the tops of stacks will be used to protect against damage to the lids during closure;
- containers will be protected from environmental effects by a temporary seal at the leading edge of the cap and the use of interim protection warehouses in future vaults;
- a modular approach to vault operations will be adopted, with different areas of the vaults being used for different disposal and closure approaches;
- ILW may be disposed to the vaults in future, on a risk-informed basis.

Delivery of the IC9 response was an important milestone as it provides the design basis upon which the current ESC submission is built.

Recent engineering developments

Construction of the final cap is being carried out in phases. The first phase is the replacement of the interim membrane over the southern part of the trenches. This will be followed by construction of the final cap over Vault 8 and the northern part of the trenches as illustrated by Figure 2.20.

Water balance data suggest that the interim cap over the trenches is not performing as intended and a larger fraction of annual precipitation than originally expected is entering the trenches [62]. In 2012, a BAT study [63] was commissioned to examine options for the trenches in light of the strip capping approach planned for the whole repository. The installation of the final cap in sequential sections over part of the trenches and the adjacent vault following completion of operations in that vault would mean the southern trenches would not be finally capped until after 2100 [4]. Over the period between 2012 and 2018 the initial BAT study was reviewed and updated following investigations that uncovered damage to the interim cap membrane. The damage to the cap uncovered during investigations included quite extensive tears and holes in the membrane [64]. The final outcomes of the BAT process were reported in 2019 [65], which includes the decision to replace the interim membrane over the southern part of the trenches.

We recently carried out preparatory work on the interim trench cap to facilitate its reprofiling and replacement. This involved installing a herringbone drainage system across areas of the trench cap where standing water is regularly observed. The construction work began in June 2023 and was completed in November 2023.

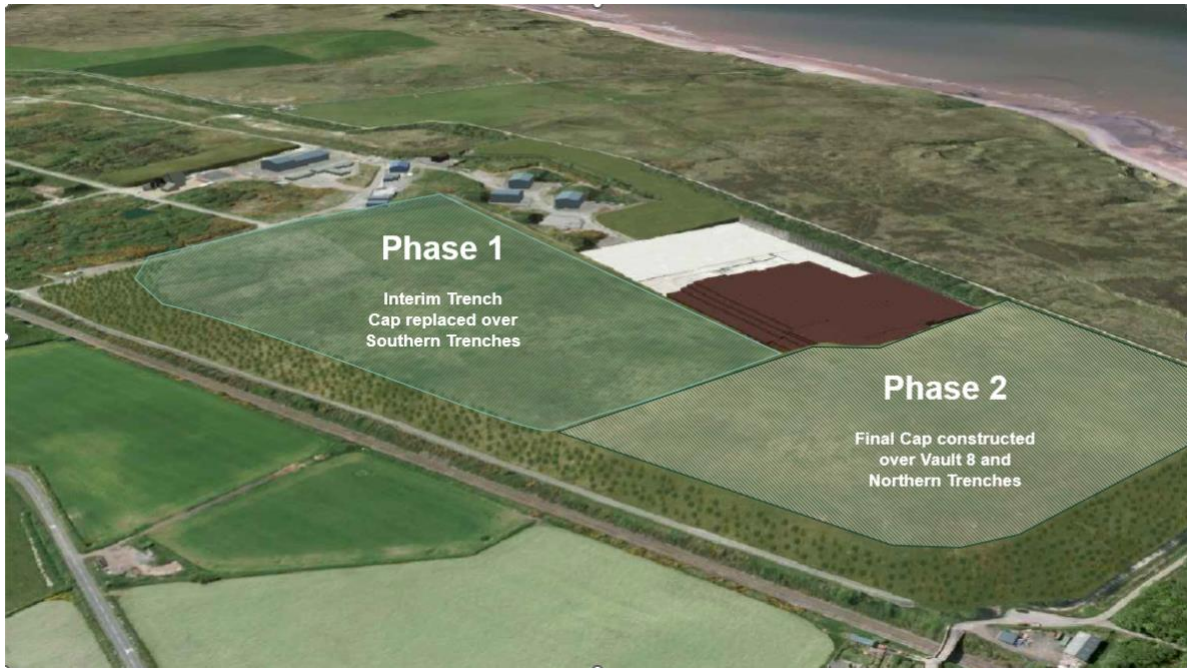


Figure 2.20: Phase 1 and 2 of capping

A geosynthetic clay liner and geotextile composite drainage layer will be installed to form a continuous low permeability layer, which will be laid on top of a new layer of profile fill that will have appropriate gradients to direct surface run-off towards the existing drainage. Figure 2.21 shows the current work trialling placement of the geosynthetic liner.



Figure 2.21: Aerial photograph from July 2025 showing work on the trench cap

3 Site Description

3.1 Disposal Facility Inventory

Solid radioactive wastes have been produced, stored and disposed by various industries in the UK for many decades. The main sources of waste generation since the 1950s onwards have been nuclear energy development, nuclear power generation and the weapons industry. In addition, many non-nuclear industry users of radioactive materials produce radioactive wastes, for example, universities, hospitals, the pharmaceutical industry, research establishments and the oil and gas industry [51].

In the UK, solid radioactive wastes are defined according to three main categories: high-, intermediate- and low-level wastes. High Level Waste is waste in which the temperature may rise significantly as a result of their radioactivity, so this factor must be taken into account in the design of storage or disposal facilities. ILW is waste exceeding the upper boundaries for LLW, but which does not require heating to be taken into account in the design of storage or disposal facilities.

LLW represents a broad category spanning a range of five orders of magnitude of specific activity, which is measured in Bq kg^{-1} . LLW is defined as radioactive waste having a radioactive content not exceeding 4 GBq t^{-1} of alpha or 12 GBq t^{-1} of beta/gamma activity. There is also a definition of VLLW, a sub-category of LLW, and a legal definition of LLW [66].

The majority of UK LLW and ILW (by volume) arises at nuclear sites that are undertaking, or have previously undertaken, the following activities: fuel fabrication and uranium enrichment; nuclear power generation; spent fuel reprocessing; decommissioning; nuclear energy research and development; Ministry of Defence activities; manufacture of radioactive medical products; and waste treatment facilities.

LLW can be sub-divided into operational- and decommissioning-related material. Operational LLW typically arises from routine monitoring and maintenance activities, and includes plastic, paper, tissue, clothing, wood and metallic items. Decommissioning LLW mostly comprises building rubble, soil and various metal plant, equipment and items.

LLW does not normally require special shielding during handling or transport to protect workers or members of the public. Waste consigned to the LLWR arrives primarily by rail, but also by road. Most waste is transported in a range of specially constructed containers mainly based on ISO shipping containers. Shielding is used, where necessary, to meet radiation dose rate transport requirements.

The 2026 ESC has examined the potential for the LLWR to accept some less-hazardous ILW for disposal. The objective of this work has been to understand the types and quantities of ILW that could be safely disposed at the LLWR and the changes that would be required and

hence inform NDA's and others' consideration of the option, in line with the new government policy.

The major components of ILW in the UK are steels, graphite, concrete, cement and sand, sludges, ion exchange resins and flocculants. Some ILW will not be suitable for disposal in the near-surface environment and will require disposal in a GDF. Any ILW considered for disposal at the LLWR would be assessed against WAC in place at the time to determine whether it could be accepted.

We would dispose of all ILW in containers sufficiently strong to withstand the loads imposed during and after installation of the final cap. If the ILW were to have external dose rates comparable to those from LLW, the containers would be stacked in the vaults alongside LLW (although stacked separately). ILW that gives rise to dose rates necessitating additional shielding would be disposed of in shielded modules, which would be constructed as required in Vaults 10, 11 and 12. See our '*Optimisation and Site Development Plan*' report [9] for more details.

The volume of LLW that the site receives has decreased dramatically over the last 20 years. In 2010, the '*UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry*' [51] set out plans to apply the waste hierarchy more effectively to the management of LLW, with a preference for managing LLW at higher levels of the hierarchy, meaning a move away from the past focus on disposal. It was envisaged that this would ensure optimal use of the LLWR and the UK's capacity for the management of LLW.

As can be observed in Figure 2.18, implementation of the strategy has been successful. The volume of waste received to the site has steadily decreased over time and the current volume of annual waste arisings is very low. It is noted that the rate of container receipt is expected to fluctuate in accordance with the schedule profile of decommissioning activities across the estate, so the current rate of receipt is not necessarily representative of the rate of receipt at all times in the future. Our most recent inventory projections indicate that vaults up to Vault 12 will be required to accommodate the UKRWI arisings of LLW up to 2135.⁵

A total of 566 TBq of activity has been disposed to the trenches, a further 122 TBq had been disposed to the vaults as of 31st March 2022, and a further 1,820 TBq of LLW is expected to be disposed to the vaults after this date. Thus, a total inventory of 2,510 TBq is anticipated to be disposed to the LLWR. This value does not account for any radioactive decay after the point of disposal. If ILW was accepted for disposal, a further 15,000 TBq could be disposed to the vaults, bringing the total inventory plus ILW disposals to 17,600 TBq.

Inventory information used in the current ESC is described in the '*Disposal Facility Inventory*' report [3] and is summarised here in terms of trench, vault and future disposals.

⁵ These inventory projections also include a portion of the ILW inventory that can be safely disposed of in at-surface vaults.

3.1.1 Trenches

In the period between 1959 and 1995, LLW was disposed of in a series of seven trenches at the LLWR. Figure 3.1 shows the operational dates for each trench and the volume of waste disposed of.

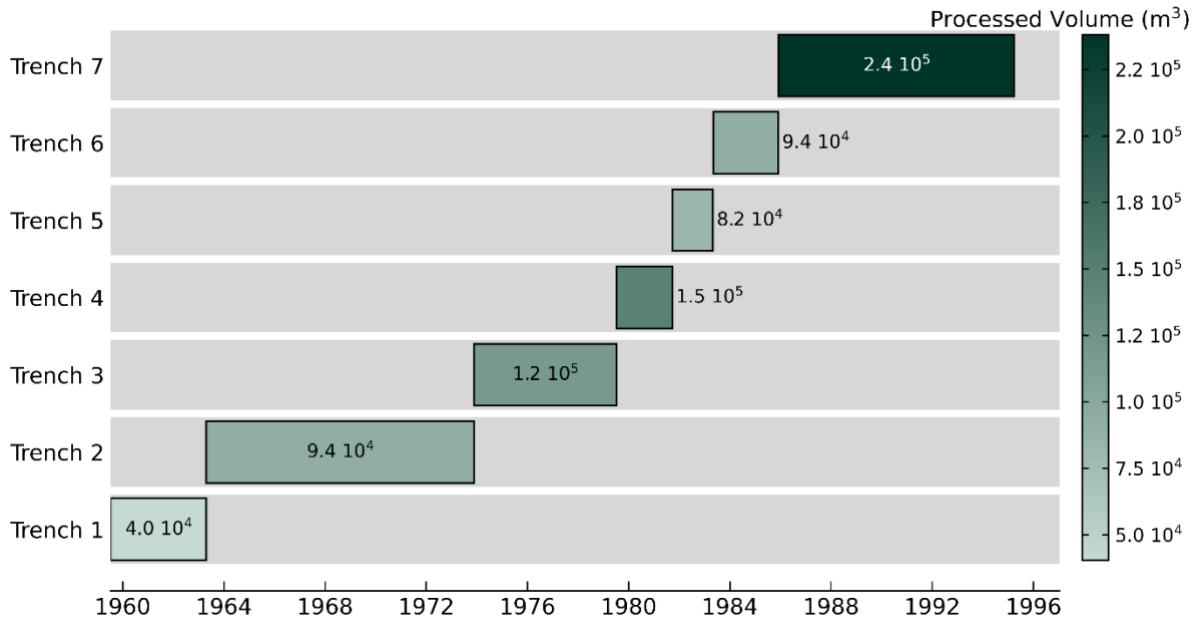


Figure 3.1: Trench operational dates and processed waste volumes. The boxes for each trench are labelled with the processed waste volume (in m³). The colour of the box provides a visual representation of the volume using the right-hand side bar. The width of the boxes represents the operating period in line with the y-axis.

In terms of material types, metals (mainly ferrous metals and stainless steels) dominate the inventory, accounting for 32% of the total volume. Figure 3.2 illustrates the distribution of the material types within the trench inventory.

Total Volume of Materials in the Trenches 815,000 m³

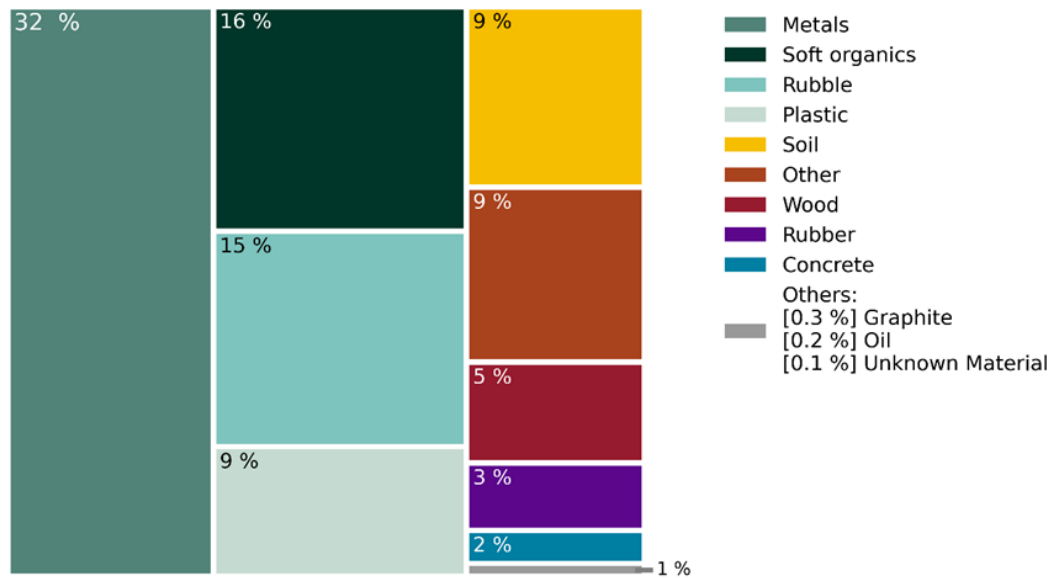


Figure 3.2: Distribution of the material types in the trench inventory

The total activity of the derived trench inventory is 566 TBq. The activity of tritium dominates the trench inventory at 502 TBq of the total (89%). The majority of the tritium (447 TBq) is in Trench 6, with the source being Harwell Betalights.

Of the potentially important radionuclides identified in the ESC that have already been disposed of at the LLWR, the trenches hold the majority of the inventory of Ra-226, Th-232, U-238, Pu-239, Pu-240 and tritium [3].

It should be noted that due to more limited record-keeping in the earlier operating years of the LLWR, there is more uncertainty over the trench inventory. More details on the volumes, types and activities of wastes in the trenches, and the associated uncertainties are given in 'Disposal Facility Inventory' report [3].

3.1.2 Vaults

Disposal operations to the first engineered disposal vault, Vault 8, began in 1988. Between 1988 and 1995, disposal to the trenches and Vault 8 occurred concurrently. The Low Level Waste Tracking System was introduced with Vault 8 and allowed us to maintain detailed records of the inventory of vault disposals.

There are 8,844 half-height ISO containers in Vault 8, 908 other ISO container variants (mainly third height and full height), 318 other containers or non-standard items, 74 Windscale Advanced Gas Reactor (WAGR) boxes and 1,068 TRS Drums.

The vault was mostly filled in 2009, although some consignments have been emplaced in Vault 8 in the period since then to fill the remaining space. Four WAGR boxes were received to the site in 2018 and emplaced in the vault in early 2019. Between March 2022 and January 2024, 1,068 stainless steel drums containing encapsulated sludge were received on

site for emplacement in gaps at the eastern edge of the Vault 8 disposal area, with emplacement of the drums completed in February 2024 (see Figure 2.19).

More recently, a small area at the north end of the of the central bay of Vault 8, which was left unfilled to allow vehicular access to the vault via a ramp and to allow disposal of any overweight or containerised waste, was filled with 171 ISO containers that were transferred from Vault 9. The emplacement of the containers was completed in January 2025. There are plans to use demolition rubble from one of the waste stores on site (B720) for infill of the remaining disposal volume of Vault 8 that is not suitable for ISO containers, including the access ramp [57]. This work is due to begin in June 2026; once done, Vault 8 will be completely filled.

Vault 8 is soon to be permanently sealed beneath the final cap. Our '*Engineering Design*' report [4] describes our plans for the pre- and post-closure engineering. Our '*Optimisation and Site Development Plan*' report [9] describes how we have arrived at these plans. The optimisation of pre- and post-closure engineering takes account of the history of operations in the vaults, which are also described in greater detail in the report [9].

Construction of Vault 9 began in 2008 and was completed in December 2010, although interim storage of containers commenced in July 2009. Following the 2015 Permit revision and subsequent planning permission in 2016, Vault 9 can now be used for disposal. The full history of the regulatory and permitting decisions affecting Vault 9 is outlined in our '*Optimisation and Site Development Plan*' report [9], along with the future development plans for the vault.

Vault 9 contains approximately 2,000 disposal containers, most of which are half-height or third-height ISO containers. Figure 3.3 illustrates the volumes of wastes disposed of in Vault 8 and Vault 9 and the remaining capacity of Vault 9 (and Vault 9a). The containers in Vault 9 have not been placed in their final disposal positions. Our intention is to move the containers to the northern end of the vault and extend the final cap over them at the appropriate time. These plans are outlined in our '*Optimisation and Site Development Plan*' report [9].

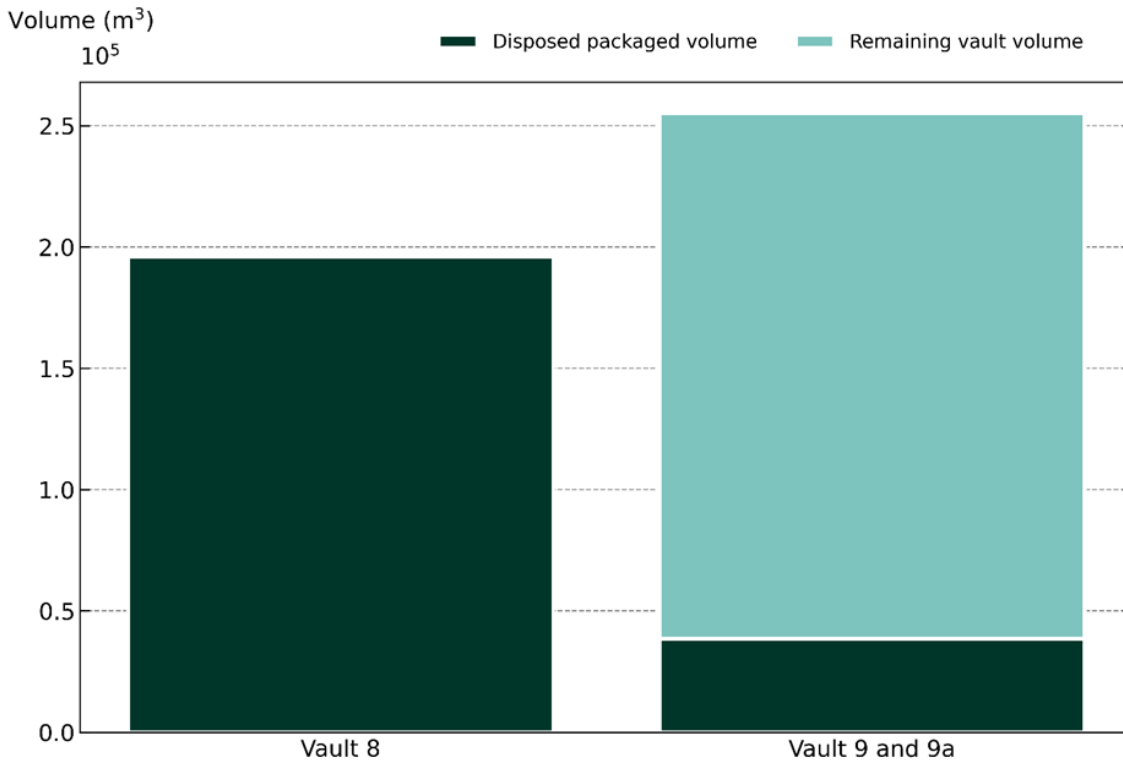


Figure 3.3: Packaged volume disposed and remaining vault volume per vault

The total mass of processed waste in the disposed vault inventory (as presented in Figure 3.4) forms some 42% of the total packaged mass of 407,000 t, with grout contributing 49% of the total packaged waste mass and the mass of container material contributing the remaining 9%.

The total disposed activity in the vaults is 122 TBq. Currently, of this total, 101 TBq of this radioactivity is in Vault 8, and 20.5 TBq is in Vault 9. Of the potentially important radionuclides already disposed to the LLWR, the vaults hold the majority of the inventory of C-14, Cl-36, Nb-94, Tc-99, I-129, Co-60 and Cs-137 [3].

We upgraded our waste tracking system in April 2018. The new waste tracking system, eMWaste, records more detailed data than the previous system, therefore, enhances the quality of the inventory. This change has principally enhanced our ability to record the types and quantities of non-radiological components of the inventory at a greater level of detail.

Figure 3.4 illustrates the relative quantities of the material types within the vault waste inventory. In terms of material types, metals (mainly ferrous metals and stainless steels) are the largest group, accounting for 38% of the total mass of processed waste. The material distribution is comparable to that of the trenches (Figure 3.2), although metals dominate to a lesser extent (note that Figure 3.2 presents the material composition of the trench inventory in terms of volume and metals are usually dense).

Disposed material composition [Total mass: $1.69 \cdot 10^5$ te]

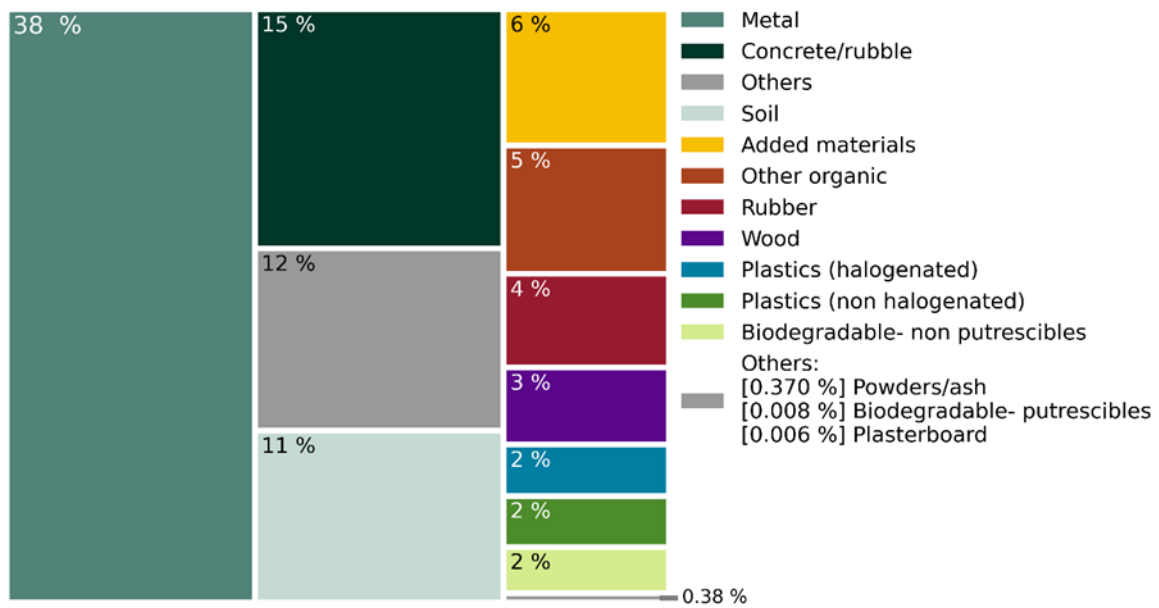


Figure 3.4: Disposed vault material composition for processed waste by mass

The volume of wastes received in recent years has greatly diminished due to the introduction of the waste hierarchy into the management of LLW and the consequent diversion of wastes to other waste management routes. The trend of decreasing waste receipts is shown in Figure 2.18.

The composition of the waste being received to Vault 9 may have been affected by diversion, although to a lesser extent than the overall volume of waste received. The composition of waste may be affected by diversion as certain materials are compliant with the different waste management routes, for example, some metals are sent for recycling, certain combustible materials are sent for incineration, and VLLW (often soil and rubble) is sent to permitted landfill. Figure 3.5 plots the proportions, by mass, of eight material groups in waste received since 2009 and primarily disposed of in Vault 9. The data are presented as a moving average of waste receipts over the five years prior to the year plotted. The data treatment is necessary because the low number of container receipts in recent years mean that the per annum data are highly variable, which obfuscates the trends.

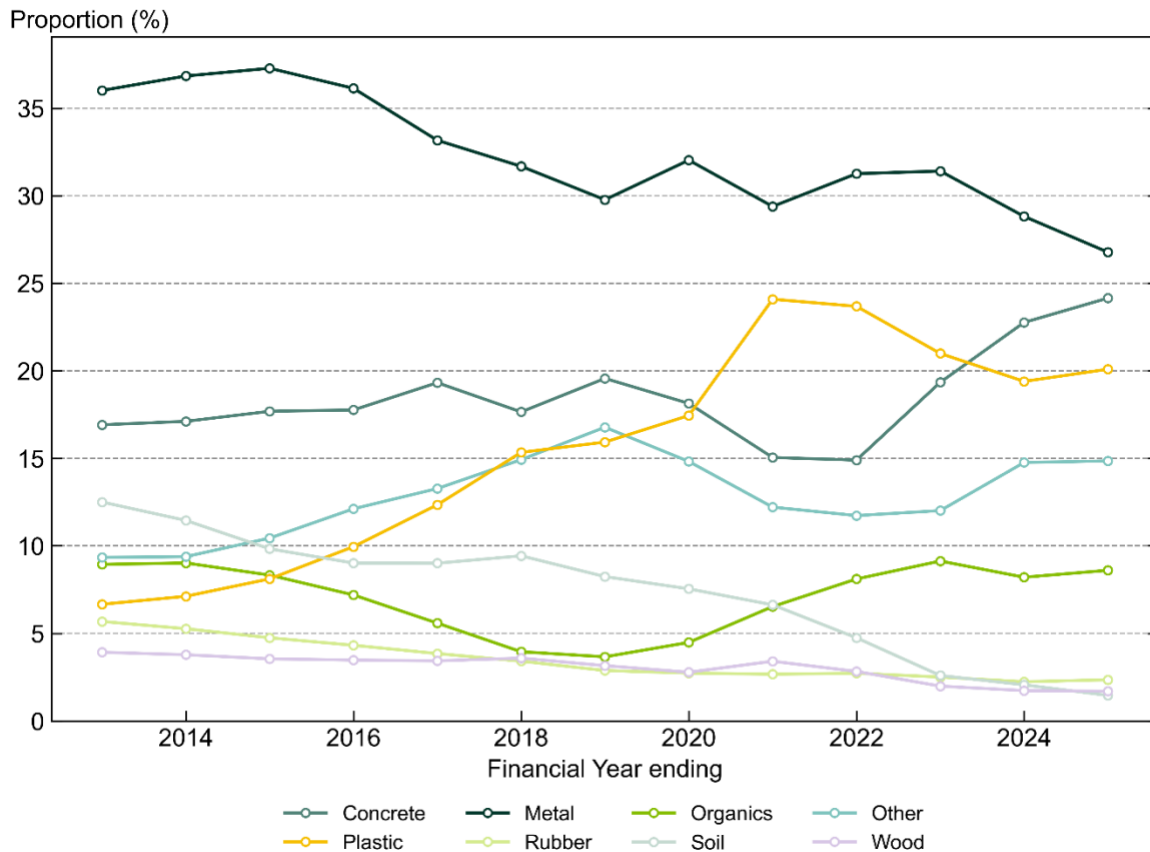


Figure 3.5: Proportions, by mass, of eight material groups in waste received since 2009

The five-year average of metallic waste and soil has decreased by approximately ten percent over the period, most likely attributed to metals recycling and diversion of VLLW, respectively. Decreasing trends are also observed for rubber and wood, which are often candidates for incineration.

The clearest increasing trend is associated with plastic wastes, which is of interest because there are diversion routes available for incineration of plastic. Trends in the composition of waste are affected by factors other than diversion, such as the extent and nature of decommissioning being undertaken across the estate at any given time. Plastic is often used for contamination control as a lightweight construction material; as the focus of the nuclear industry has shifted from operations to decommissioning, it is likely that a larger amount of plastic waste has been generated in the first instance.

Furthermore, peaks and troughs are created by specific disposal activities. For example, the recent uptick in concrete wastes is likely attributed to the receipt of 1,068 stainless steel TRS drums containing cement-encapsulated sludge from Winfrith, of which the weight fraction for each consignment was approximately 50% concrete. These drums were employed in Vault 8.

There is a trend towards higher specific activities in wastes received from 2017 onwards, which coincides with a reduction in the average number of containers received (see Figure

2.18). This reflects that the site has received consignments with higher activity concentrations, including some longer-lived radionuclides (notable wastes are the reclassified ILW to LLW in WAGR boxes and TRS drums), whilst diversion of lower activity wastes and treatment options have resulted in lower volumes of waste.

3.1.3 Future Disposals

Two principal data sources are used to derive the forward inventory: the 2022 UKRWI [67] and information on waste streams associated with the UK's nuclear new build programme that were not included in the 2022 UKRWI.

The Reference Inventory has been produced over three stages, with the final Reference Inventory being the output of Stage 3. At each stage, we have developed the inventory through iteration with the ESC assessments. The Stage 1 Inventory was used in the Phase 1 assessments. The Stage 2 inventory was used in the Phase 2 assessments. The Stage 3 Inventory has been used to test the viability and practicality of the proposed capacities and emplacement criteria discussed in our '*Implementation*' report [17].⁶

Whilst every effort has been made to ensure that the presented inventories are robust, the forward inventory is subject to considerable uncertainty, not least due to currently irreducible uncertainties in the quantity and radioactivity of wastes on consignor sites and uncertainty related to future strategic, regulatory and legislative changes. This uncertainty will be resolved when the future wastes reported in the UKRWI are characterised for onward treatment and management. The uncertainty of the forward inventory is discussed in greater detail in our '*Disposal Facility Inventory*' report [3], along with a presentation of the derivation methodology and results.

The total packaged volume of waste in the forward inventory is approximately 467,000 m³. This includes 376,000 m³ of LLW, and 92,000 m³ of ILW. Figure 3.6 shows the expected cumulative arisings of the total Reference Inventory, and when the transitions between vaults occur based on the projected waste arisings. It will take longer to fill the vaults with LLW alone if ILW is not included.

⁶ The Reference Inventory includes the waste already disposed of at the LLWR. There is greater opportunity to refine and optimise the future inventory, hence, the iterative, staged approach to inventory development is most relevant to the forward inventory.

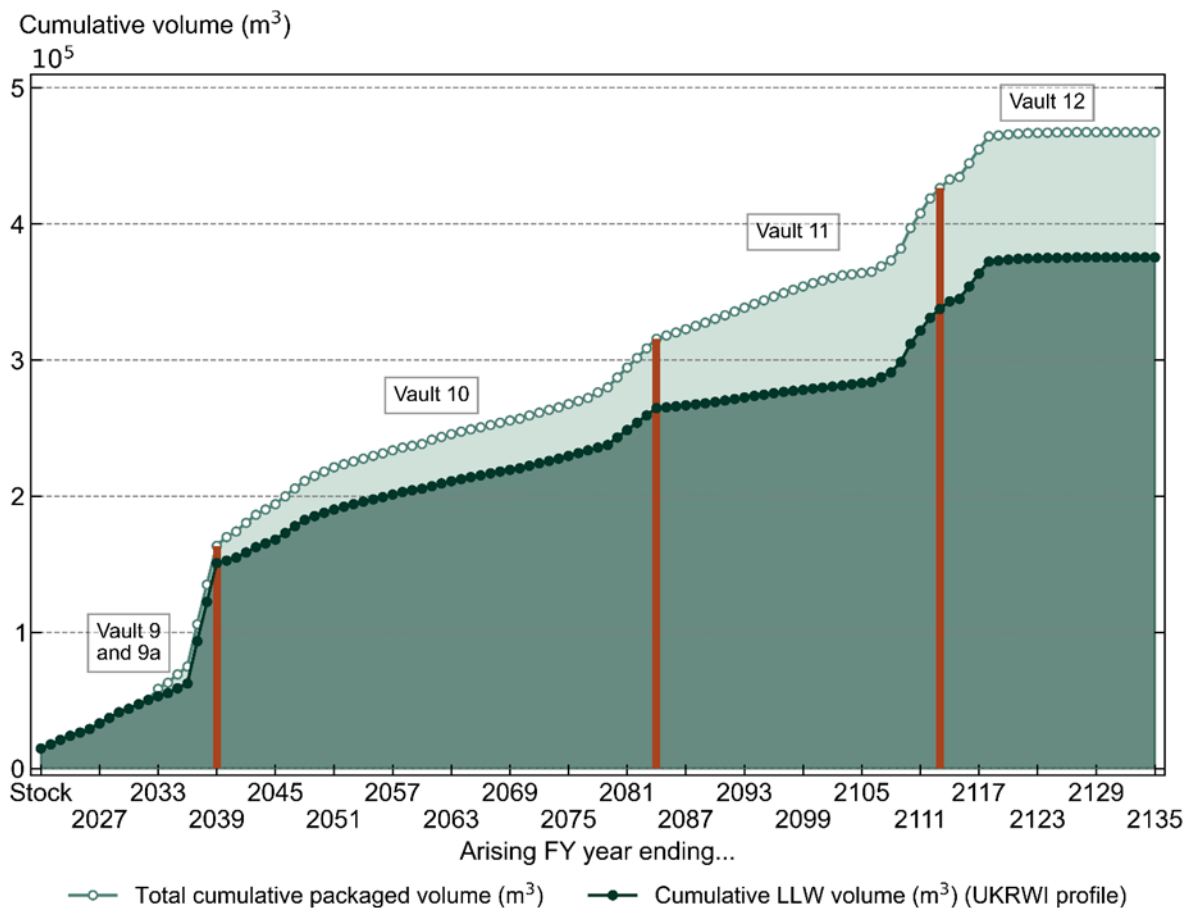


Figure 3.6: Cumulative packaged volume per year showing when vaults will be used if a decision is taken to accept ILW, using the full 2022 UKRWI profile

We expect the year of final waste emplacement to be 2135. If a decision is taken to accept ILW for disposal, this would require construction of future vaults up to Vault 12. Only Vaults 9a, 10 and 11 are required for the LLW inventory alone.

One of the significant improvements since 2011 is the increase in diversion of waste to treatment and other disposal routes, decreasing the volume of waste expected to be disposed to the LLWR. In 2011, it was expected that a total volume of 850,000 m^3 LLW could be disposed to the LLWR vaults, which would fill the vaults planned at the time, up to Vault 14, by 2080.

Radionuclide content

The packaged volumes and activities associated with the trenches, the vault LLW and vault ILW are compared in Figure 3.7. If a decision was made to accept ILW, it can be seen that a relatively small volume of waste would be added to the vaults, but it would constitute the greatest proportion of the total activity.

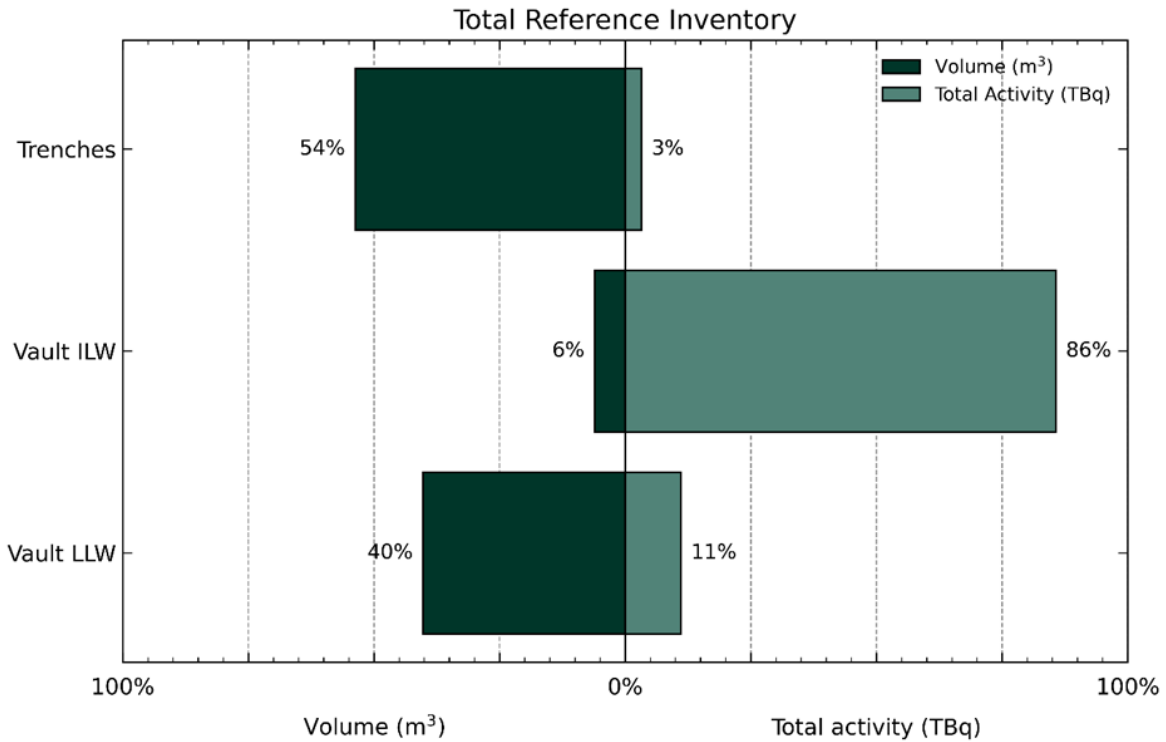


Figure 3.7: Comparison of the total activity and volume of the trench wastes, vault LLW and vault ILW

The potentially important radionuclides have been selected on the findings of the assessment work detailed in ‘*Environmental Safety During the Period of Authorisation*’ [13] and ‘*Assessment of Long-term Radiological Impacts*’ [14] reports.

The key radionuclides for assessments are similar to those identified in the 2011 ESC, with Co-60, Cs-137 and Nb-94 identified as additional key radionuclides. The largest amounts of C-14, Cl-36, I-129, Pu-239 and Pu-240 are still expected to arise in the forward inventory, with a slightly smaller total inventory. Our ‘*Disposal Facility Inventory*’ report [3] describes the anticipated distribution of these potentially important radionuclides across the LLWR disposal facilities, and the waste streams with which they are associated.

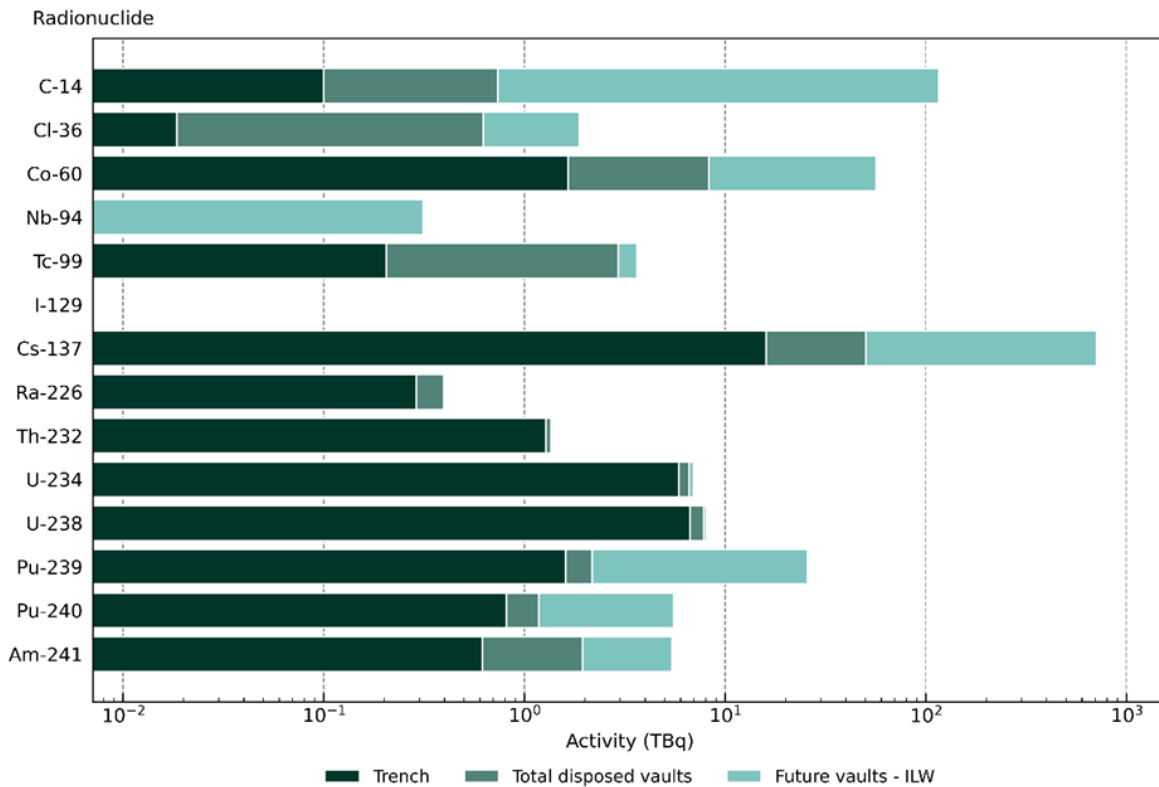


Figure 3.8: Activities of the potentially important radionuclides in the Reference Inventory

There is much less Tc-99, Ra-226 and Th-232 expected in the forward LLW inventory now than in 2011, despite the disposed activity being relatively unchanged. It was expected in the 2011 ESC that each of these had high levels of uncertainty in the fingerprints used for the estimates and that the actual amounts could be reduced by two to three orders of magnitude. U-234 and U-238 also have significantly less activity in the forward LLW inventory than in 2011, which were noted at the time as cautious upper estimates.

3.1.4 Non-radiological Contaminants

In accordance with the GRA [19], we are required to provide 'adequate protection' against the non-radiological hazards presented by the waste. The GRA provides further guidance on how this adequate protection may be demonstrated, noting that 'nationally acceptable standards' for disposing of hazardous waste 'need not necessarily be applied' in the case of waste that presents both a radiological and a non-radiological hazard. Nevertheless, there is a requirement that the level of protection be 'no less stringent' than if such standards were applied.

The relevant standards to consider when demonstrating that disposals of solid radioactive waste at the LLWR address the GRA are the European Union (EU) Water Framework Directive 2000/60/EC and its daughter directive, the Groundwater Daughter Directive 2006/118/EC. Both directives are concerned with the protection of groundwater against pollution, the prevention and limitation of inputs of pollutants to groundwater and the

prevention of deterioration of status of groundwater bodies. In England, the Water Framework Directive and the Groundwater Daughter Directive are implemented by:

- the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017;
- the groundwater provisions in Schedule 22 of the Environmental Permitting (England and Wales) Regulations 2016.

These are the standards for disposal of waste that presents a non-radiological hazard but not a radiological hazard (i.e. these are what would be applied to a landfill). We consider them to be an appropriate means by which to demonstrate compliance with the GRA.

Our '*Hydrogeological Risk Assessment*' report [15] demonstrates that the engineered system will ensure that the impacts from radiological and non-radiological contaminants present in wastes disposed of, or planned to be disposed of, at the LLWR comply with the requirements of the relevant regulations.

We undertook work after the 2011 ESC to develop our approach to managing non-radiological contaminants, which formed the basis of our WAC. In our WAC, we considered three categories of non-radiological contaminants:

- Category 1 – materials for which we record the masses, but do not manage against a numerical capacity;
- Category 2 – materials for which we record the contaminant masses, and manage disposals against a numerical capacity derived from our groundwater assessment model;
- Category 3 – materials which would be categorised as hazardous waste if they were not radioactive, hazardous substances, or non-hazardous pollutants, and which would only be accepted for disposal after receipt of a variation and completion of an assessment to demonstrate that disposal at the LLWR is consistent with the ESC.

The classification of materials to the three categories was based on the degree of impact that the material would have on the natural environment, as indicated in the then-current Joint Agency Groundwater Directive Advisory Group guidance [68]. The classification takes into consideration whether it is appropriate and proportionate to manage disposal of a given contaminant against a capacity limit. The categorisation of non-radiological contaminants in our current WAC is shown in Table 3.1.

Table 3.1: Category 1 and 2 non-radiological contaminants in our current WAC [69]

Category 1	Category 2
Aluminium metal/alloy	Arsenic all forms
Asphalt or tarmac not containing coal tar (generally that laid down post-1980)	Asphalt or tarmac containing coal tar (generally that laid down pre-1980)
Bitumen	Beryllium all forms
Chromium metal/alloy	Boron all forms
Cobalt metal/alloy	Cadmium metal/alloy
Copper metal/alloy	Cyanide
Fluoride (inorganic)	Lead metal/alloy
Iron metal/alloy	Mercury metal/alloy
Magnesium metal/alloy	Selenium all forms
Mild steel	Tributyl phosphate (TBP)
Molybdenum metal/alloy	Electrical and electronic equipment Type 1 (equipment with printed circuit boards)
Nickel metal/alloy	Electrical and electronic equipment Type 2 (plant items)
Phenol	Electrical and electronic equipment Type 3 (electrical and electronic tools)
Phosphate	Electrical and electronic equipment Type 4 (mercury-containing items)
Plastics (halogenated)	Electrical and electronic equipment Type 5 (rechargeable batteries)
Plastics (non-halogenated)	
Stainless steel	
Tin metal/alloy	

Titanium metal/alloy	
Vanadium metal/alloy	
Vinyl chloride (un-polymerised)	
Zinc metal/alloy	

We updated our quantitative assessment of the impacts of non-radiological contaminants in 2018 [70] and have updated it again as part of the assessments that underpin the 2026 ESC – see our *'Hydrogeological Risk Assessment'* report [15]. The assessment results help us to determine which contaminants should be classified as Category 1 and 2 materials, and the capacities that should be applied to Category 2 materials.

The non-radiological contaminants considered in the Hydrogeological Risk Assessment have been chosen on the basis that they:

- are explicitly declared in historical or future waste streams; or,
- are considered to be present in declared bulk materials; or,
- are known to be present in grout.

We have determined capacities by calculating, for each non-radiological contaminant, concentrations in the groundwater at compliance points that are consistent with landfill guidance. Our assessment [15], along with calculated capacities [71], indicates that the impacts to groundwater from all contaminants currently managed as Category 1 contaminants will be very low. We consider it remains appropriate, therefore, for all these contaminants to remain assigned to Category 1.

For all contaminants except cyanide and selenium, calculated concentrations at the compliance points never exceed the relevant regulatory values. This means that, for these contaminants, there is no limit (from a groundwater perspective) to the quantity that could be disposed of. Even for very large vault loadings, calculated impacts would remain lower than relevant assessment criteria. Based on these results, all Category 2 non-radiological contaminants, with the exception of cyanide and selenium, will be re-categorised as Category 1.

Environment Agency guidance for disposal of non-radioactive asbestos waste [72] focuses on preventing the waste being disturbed and preventing asbestos dust being generated. We take measures to minimise the potential for generation of asbestos dust during the PoA, which are described in our *'Implementation'* report [17]. We have also considered the post-closure safety risks to members of the public from exposure to disposed asbestos following inadvertent human intrusion and coastal erosion [73]. The conclusions of this study informed our current WAC limits on the mass of asbestos permitted in a consignment [74].

The controls that we implement on non-radiological contaminants, including asbestos, and the discussion that supports our proposals for updated WAC that reflect the understanding documented in the 2026 ESC are described in full in our '*Implementation*' report [17].

We implement an extensive environmental monitoring programme, as detailed in our '*Monitoring*' report [8], appropriate to the LLWR that is reviewed on a regular basis to ensure that any changes to regulatory requirements or environmental standards are reflected in the programme.

The results of this programme validate our conceptual understanding of the site and its evolution. Moreover, the monitoring programme demonstrates that there are no significant impacts on groundwater and surface water bodies from present operations at the LLWR.

3.2 Site Wastes and Land Contamination

As described in Section 2, the LLWR site has a complex history involving explosives manufacturing, radioactive waste disposal and storage of radioactive materials. Activities associated with these purposes have been carried out across the site. They have led to, and continue to lead to, operational and decommissioning wastes. There are also areas of land contamination in regions of the site that are not part of the dedicated disposal facility.

The 2026 ESC is designed to fulfil the requirements of the GRR [20]. It is a Site-wide Environmental Safety Case that takes account of the hazardous wastes on the site that are not necessarily associated with the dedicated disposal facility. An objective of this report is to document background information on the history of operations and site developments that have themselves led to the generation of hazardous operational and decommissioning wastes and areas of land contamination. This objective is principally met by the historical information provided in Section 2, however, this subsection aims to link that historical information with the site wastes and land contamination that we are responsible for managing.

More information on the operational and decommissioning wastes, and our processes for managing such wastes, is found in our '*Waste Management Plan*' (WMP) report [10]. Our efforts to characterise the areas of land contamination across the site are documented in our '*Hydrogeology*' report [6] and reference [31]. Our plans for managing the land contamination in a way that is optimised and ensures that the site achieves its desired end state are documented in our WMP [10].

Through day-to-day operation of the nuclear site, we generate a certain amount of solid, liquid and gaseous wastes. The wastes are managed through routes that we have determined to be optimal. For example:

- Personal Protective Equipment (PPE) and other soft materials are often sent for incineration through the NWS framework for combustible waste treatment;
- minor arisings of contaminated liquids from e.g. the DGF or groundwater samples are permitted for discharge via the leachate management system;

- gases from B746 and the DGF are permitted for discharge to the atmosphere via HEPA-filtered stacks.

Our WMP describes the full range of solid, liquid and gaseous wastes that we produce on site and how they are managed.

Our operations today also leave behind a legacy of infrastructure that will ultimately need to be decommissioned and will become radioactive waste. For example, at some point during the period of active institutional control, the active leachate management system will be decommissioned. The Marine Pipeline, Marine Holding Tanks and leachate drainage system will need to be managed accordingly as radioactive waste. We have not yet developed the plans for this, but future iterations of our WMP will be progressively optimised according to the framework set out in our '*Optimisation and Site Development Plan*' report [9], which will ensure that the BAT solution to management of wastes on the site is adopted as we prepare to achieve our end state.

As discussed in Section 2, the LLWR site was originally developed as a ROF for the manufacture of TNT. The site was home to a vast array of buildings, plant and other infrastructure. Operations on the site involved the storage of raw materials, mixing of chemicals and ultimately the production and storage of TNT. Historical practices during operation and demolition of the ROF facilities resulted in areas of land contamination. Our '*Hydrogeology*' report [6] gives a detailed description of the activities on the ROF that may have led to land contamination, some of which is summarised below.

Although definitive process information is not available, it is thought that trinitration of toluene occurred in a three-stage process. Nitric acid and oleum were used to add progressively more nitro (NO₂) groups to the initial toluene ring. Toluene was nitrated to mononitrotoluene (MNT), MNT was then nitrated to dinitrotoluene (DNT) and then DNT was nitrated further to TNT. After completion, remaining acids and other impurities were washed out using alkaline sulphites or carbonates for reuse or disposal and the pure TNT piped to packing facilities prior to storage at the magazines.

Traces of TNT, and its precursors and breakdown products, have been detected in various regions of the site that may need to be remediated as the site is developed.

Prior to being washed and combined with soda ash to neutralise the pH, the TNT produced from the trinitration plants was acidic. The acidic TNT was run by gravity in lead-lined heated troughs in overhead gantries (situated about 6 m above the ground). Anecdotal evidence suggests that the acid content of the TNT corroded the lead-lined troughs and they were prone to leakage and needed frequent replacement.

Lead contamination is detected in near-surface soils across the site and is thought to be associated with leakages from the lead-lined acid troughs that crossed the site between process plants. Along with asbestos, lead is thought to be the non-radiological contaminant of greatest concern, in terms of the effort required to remediate the site, as it is detected in several areas in concentrations that exceed the exemption levels for non-radiological contamination relevant to the site's intended end state.

Asbestos is detected in near-surface soils across the site, which is thought to have resulted from the demolition of the ROF buildings. We control excavations to minimise the potential mobilisation of asbestos fibres and other particulates. Areas of the site affected by asbestos contamination may need to be remediated in order for the site to achieve its end state.

Former ROF infrastructure has been used to store radioactive materials over the course of the site's history. For example, it is known that the B749 slab was used to store radioactive materials and contamination has migrated from the materials to the slab and surrounding soils. Additional control measures are enforced for works carried out on or around B749 slab to prevent unrestricted access to the area or accident disturbance of materials on and around the slab area. Remediation of the slab and the surrounding area is likely to generate additional decommissioning wastes that will need to be managed through appropriate channels.

The TNT storage magazines were used to store PCM. We have undertaken significant programmes of work to remove the hazardous material from the magazines and sentence it appropriately. As discussed in Subsection 2.1, the five remaining magazines were emptied, decontaminated and partially demolished (the covering soil was removed) by the end of 2020. The intention is to demolish the remaining concrete and brick constructions and use the material, along with the soil, in the construction of the final cap over the repository. The land around the magazines may require further remediation as hazardous materials have migrated from the materials in storage to the surrounding ground.

We have recently produced a Land Quality Register that sits within our management system. The Land Quality Register was first issued in 2026. It supersedes reference [31] as the principal method of recording our latest understanding of contaminated land. It will be maintained as a live database, hosting the information relevant to each 'area of concern'. Areas of concern are defined as areas of the site for which there may be a land contamination issue and therefore require some additional investigation, some of which are alluded to in the discussion above. The current version of the Land Quality Register documents a total of 32 areas of concern. The areas of concern are described in full in our WMP [10].

Our '*Environmental Safety During the Period of Authorisation*' report [13], with reference to our '*Hydrogeological Risk Assessment*' report [15], shows that the contaminated land is not having an adverse impact on people or the environment whilst left in situ at present.

3.3 Environmental Setting

3.3.1 Climate

Climate is taken to mean the seasonal and longer-timescale variation in meteorological parameters, as well as during extreme events, particularly temperature and precipitation, to establish hydrological and meteorological boundary conditions and physical constraints on soil development and vegetation.

The present-day climate at the LLWR is classified as cool temperate. The prevailing wind is from a south-westerly direction. The mean annual temperature over the last several decades has been measured at 9.7 °C for the west Cumbrian coast and average annual precipitation from 1999 to 2024 was 1150 mm. The mean monthly temperature and rainfall are presented in Table 3.2. Temperature and precipitation are the key climate drivers for much of the ESC modelling of the surface environment at the LLWR.

Table 3.2: Mean monthly rainfall and temperature

Month	Mean monthly temperature (°C)	Mean monthly rainfall (mm)
January	4.73	105
February	4.90	86.0
March	6.05	71.5
April	8.24	57.4
May	11.3	68.2
June	13.7	74.4
July	15.4	94.7
August	15.4	110
September	13.6	106
October	10.8	130
November	7.6	123
December	5.20	123

We carry out extensive monitoring at and around the site [8]. The automatic weather station at the site provides details of precipitation, temperature, wind direction and speed, etc. In conjunction with stream flow data, the information is used to evaluate the effective rainfall for the site and aid in the quantification of the site water balance.

3.3.2 Topography

Topography is taken to mean the configuration of the land surface (including, as appropriate, the seabed) taking account of relief and the relative positions of natural and man-made features in the landscape.

The LLWR site is located near the coast in West Cumbria as illustrated in Figure 3.9. It is situated on a coastal plain from which the Cumbrian fells rise to the east. There are a number of streams and rivers that drain the coastal plain and enter the nearby Irish Sea.

The broader coastline is characterised by a beach and inter-tidal zone with sand dunes and low cliffs inland. Most of the coastal plain consists of grassy fields with only a small amount of land dedicated to woodland and the growing of crops. Roads and minor tracks allow access to the coastal plain and to settlements that are located there.

The coastal study area at and around LLWR is characterised by a coastal plain comprising low undulating hills, dunes and the Esk Estuary. The northern limit of the study area (see Figure 3.9) is at Whitriggs Scar, a prominent headland formed of till (glacially-deposited sediment) cliffs up to 15 m high subject to erosion and instability. An embayment extends to the south of Whitriggs Scar to Barn Scar. The bay is backed by low till cliffs, between 10 m and 15 m high, and capped by blown sand or dune slacks. The bay has a mixture of sand and gravel beach deposits. Barn Scar is a prominent headland formed of till cliffs capped with blown sand up to 10 m high, subject to erosion and instability [75].

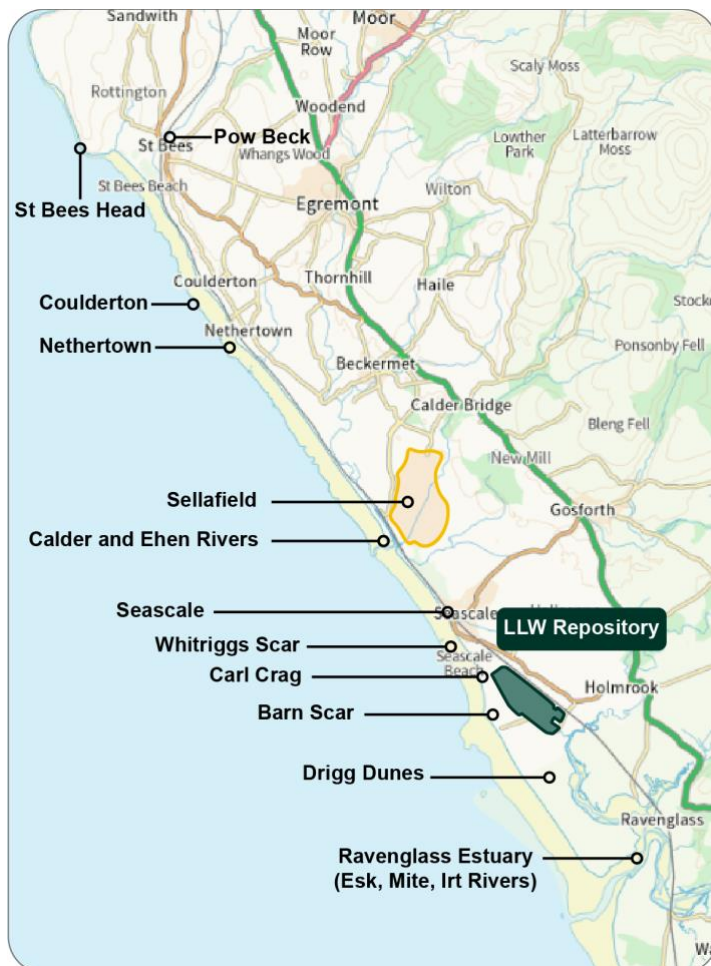


Figure 3.9: The coastal study area at and around LLWR

In one area, the cliffs and overlying dune slacks have been re-profiled in connection with construction of the Marine Pipeline from the LLWR site in 1991. The headland is fronted by a

mixed sand and gravel beach and shore platform. The foreshore is cut in glacial till deposits, with a residue of superficial boulders, which provide a degree of armouring against erosion. The shore platform has also undergone much bioturbation through burrowing of worms forming a reef with a characteristic domed appearance.

From south of Barn Scar to Drigg Point the coastline is characterised by a dune spit that has formed across the mouth (north side) of the Esk Estuary. The dunes vary in height up to 7 m and form a near continuous grass-topped ridge behind an extensive beach formed of sand and localised boulder beds. Field observations indicate new foredune ridges are forming. Blowout features are also evident further inland. Evidence from aerial photographs shows that a well-developed parabolic dune form has developed that is orientated in the direction of the predominant wind direction from the south-west.

The morphology and composition of the shore platform is strongly related to the distribution of coastal landforms. Detailed mapping conducted as part of the shoreline characterisation work supporting the 2011 ESC [76] identified shore platforms cut in poorly-sorted glacially-derived sediments and others formed of well-sorted outwash fan gravels. This understanding is part of the underpinning for our current coastal evolution projections [77] and is described in full in our '*Site Evolution*' report [7].

3.3.3 Geology

The LLWR site and its surrounding area have been the subject of extensive surface and sub-surface investigation for decades (particularly since the 1990s). The sub-surface in the region consists of thick (up to 70m) Quaternary age (last 2.6 million years) deposits overlying bedrock. The Quaternary deposits are particularly important for the hydrogeology because the LLWR is a near-surface facility. A detailed review of the geology of the area and the development of the geological conceptual model is provided in our '*Hydrogeology*' report [6]. Recent investigations have contributed substantially to the current geological understanding of the formation of bedrock and Quaternary deposits in the region. A new geological conceptual model of the Quaternary deposits has been derived using an integrated stratigraphic methodology, applying multiple approaches, including an event stratigraphy and lithostratigraphy [78]. This allows better understanding of the geological complexity, processes and the connectivity of different units in areas where there are little data

The LLWR site has been subject to glacial processes during the Quaternary period, which have given rise to a complex sequence of sedimentary deposits. The deposits consist, for the most part, of interbedded deposits of clayey diamicton, sandy diamicton, glacio-fluvial sands and gravels and glacio-lacustrine silts and clays. At the LLWR, the Quaternary deposits overlie Triassic sandstone of the Ormskirk Formation (around 240 million years old). The complexity of the Quaternary sediments has been revealed through the extensive investigations that have been undertaken at the LLWR site

Made ground occurs across the majority of the LLWR as a result of site development. The thickness of the made ground is variable across the site and may, in some locations, be over 2.5 m. Made ground typically comprises a mixture of sand and clay with some gravel,

representing reworked natural materials originating from within the LLWR, with occasional construction waste such as brick and concrete fragments.

3.3.4 Hydrogeology

A detailed summary of the hydrogeology of the LLWR site is provided in the '*Hydrogeology*' report [6].

In the vicinity of the LLWR, groundwater generally flows sub-horizontally from the Lakeland fells towards the coast. Groundwater flow occurs within the Quaternary drift deposits and in the underlying Ormskirk Sandstone. Figure 3.10 show a schematic representation of the hydrogeological conceptual model.

The Regional Groundwater occurs within the deeper Quaternary deposits and the underlying bedrock. It is distinguished from the Upper Groundwater by differences in the characteristics of the groundwater head. In the Regional Groundwater, there is not a significant vertical head gradient in the measured heads. Instead, there is a weak horizontal gradient that is generally perpendicular to the coastline. Flow is roughly from north-east to south-west, driven by the weak horizontal gradient. In areas where the upper part of the bedrock is sandstone, flow in the upper part of the bedrock makes a significant contribution to the Regional Groundwater flow. The Regional Groundwater zone is made up of hydrogeological unit B3 (and lower units in the Quaternary deposits) and bedrock.

Although the data suggest that it is possible to distinguish between the Upper Groundwater and the Regional Groundwater, they are not separate systems. Groundwater flows between them.

The flow is generally downwards in the Upper Groundwater, although, in places, the flow has a significant horizontal component. In discharge areas, which onshore are generally near streams, the flow has an upwards component. The flow in the regional groundwater is roughly horizontal, ultimately discharging into the sea.

There are localised discharges from the groundwater to the streams near the LLWR: the Drigg Stream and the East-West Stream. A component of the Regional Groundwater passing under the south-eastern part of the site discharges to the River Irt and the Ravenglass Estuary.

Several engineered structures – including the northern section of the Drigg Stream, a railway line and associated drain (running in a cutting along the north-eastern site boundary), trench and vault engineering and a historical surface and sub-surface drainage system – all affect groundwater flow to a greater or lesser extent.

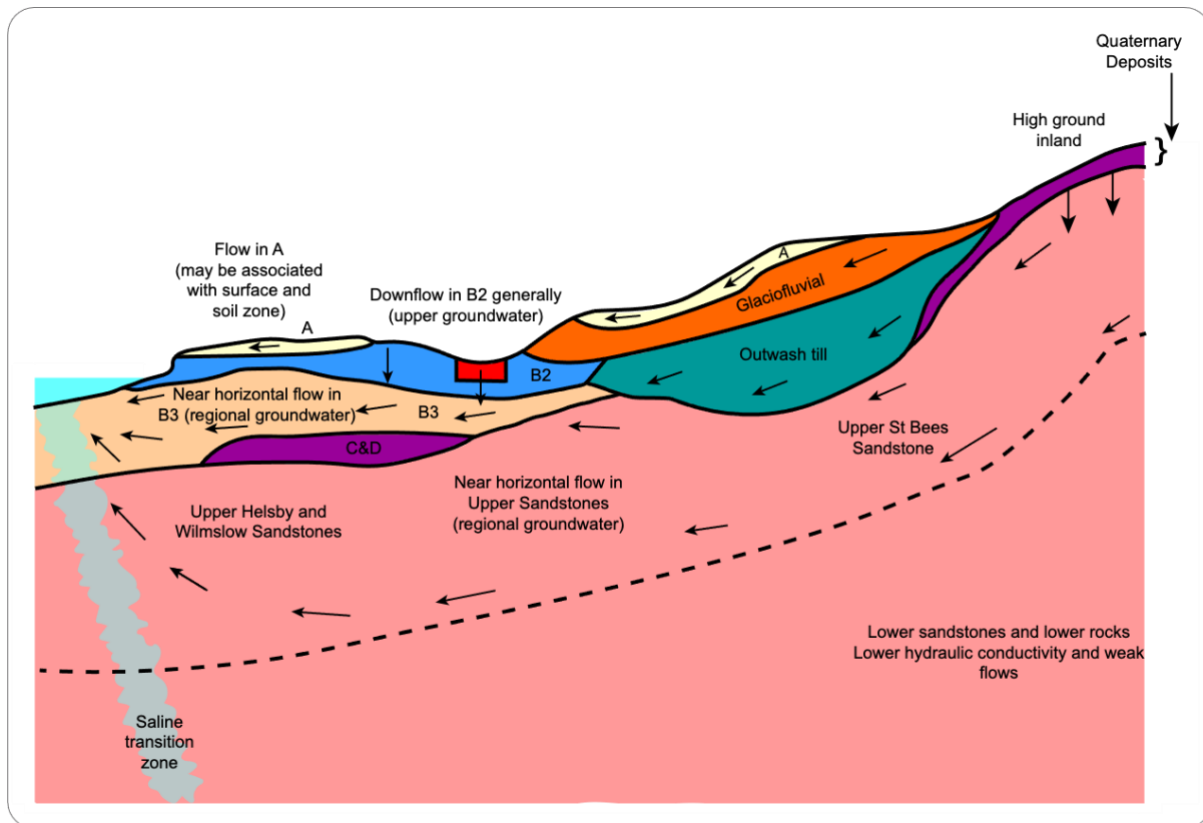


Figure 3.10: Hydrogeological conceptual model

3.3.5 Surface Waters

The LLWR site is located in a small surface water catchment area, as shown in Figure 3.11. The catchment is drained by the Drigg Stream, which rises immediately to the south of Vault 8, and the East-West Stream, which rises to the north-east of the site in farmland and is a tributary to the Drigg Stream on the site. Across the LLWR site, these streams are fed by numerous drains, for example, the railway drain, which is located parallel to the north-eastern edge of the trenches. The Drigg Stream discharges into the tidal section of the River Irt. The River Irt is located about 500 m to the south-east of the south-eastern boundary of the LLWR site and flows to the south-east for about 2.5 km before entering the Ravenglass Estuary. This estuary includes the confluence of the Irt, Mite and Esk Rivers. The confluence with the Drigg Stream is about 500 m downstream of the railway viaduct across the River Irt. Waters within the Ravenglass Estuary interact with the Irish Sea. We carry out regular monitoring of stream flows and surface water quality [8].

As part of the cap construction work a new sustainable urban drainage system, including multiple lagoons to aid sediment removal, has been installed across the site to support surface water management relating to this work. The details of these arrangements are included in our '*Engineering Design*' report [4].

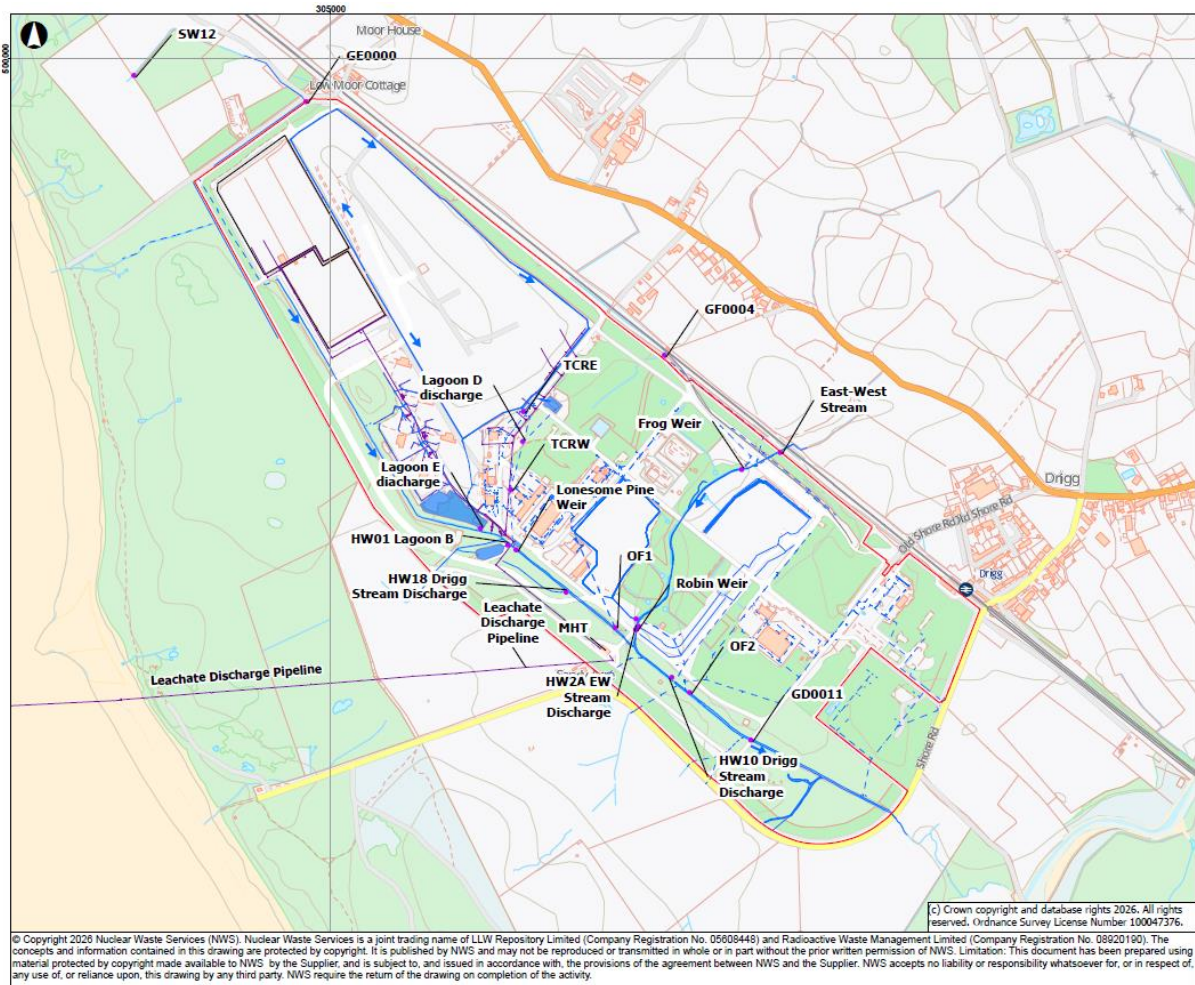


Figure 3.11 Streams and drains near the LLWR and the surface water catchments (reproduced from reference [79])

3.3.6 Soils and Sediments

Soil parent materials at the LLWR and its environs consist of complex Quaternary sediments comprising glacial, fluvio-glacial and lacustrine deposits overlain by recent deposits including marine deposits, peats and wind-blown sand. The development of peat and cover sands has profoundly affected the soils and dominates their character. Peat formation ceased some time ago and, where this land is under cultivation, the peat has become amorphous and is subject to oxidation and degradation. Where the peat is thin, it has become mixed with the underlying mineral soil by ploughing. There are therefore gradations across the area from raw peat to amorphous peat and from pure peat to humic mineral soils [28].

The development of wind-blown cover sands is continuing in the lee of the dune belt. Blown sand covers the peats to the north and west of the site and encroaches onto the site where the sand thins out. The cover sands have a low capacity to retain moisture. The marine alluvium of the River Irt floodplain and estuary is rich in both clay and organic matter and the soil structure is well developed [80]. The water table is at, or near, the surface for much of the time with flooding occurring frequently [81].

The National Soil Resources Institute at Cranfield University describes the soils in the area of the LLWR as generally loamy and free draining [82], although this is most relevant to the agricultural soils, rather than surface peat and till outcrops. A description of the presence and extent of soil types in the wider region is given in reference [83].

Relevant sediments include those associated with streams and rivers, estuary, beach, inter-tidal zones and off-shore sediments. Areas of silt and clay (as river and marine alluvium) are prevalent on the lower lying flood and tidal plain areas, on which salt marshes have developed [80].

Recession of the hinterland, such as a cliff, is caused by a combination of marine erosion at the cliff base and surface erosion of the cliff face. As the cliff erodes it supplies material to the beach. The eroded materials provide the main source of beach sand and shingle. Other sediments eroded from the cliffs are rapidly broken down and carried away in suspension [50].

The superficial deposits of the East Irish Sea Basin consist predominantly of sand and muddy sand with sediment size increasing offshore [84]. Reworking of glacial debris on the floor of the Irish Sea can account for the origin of these superficial sediments. The bottom sediments are being actively reworked by tidal currents [85] and their fine constituents are transported to the north and north-east in the direction of the strongest tidal currents.

Immediately offshore of the LLWR, the seabed sediments are sandy and to the south there is a narrow zone of gravelly sand. The seabed is devoid of sand waves, but to the south-west and north-west there are sand wave fields of generally low amplitude [86].

Detailed information on the implications of sedimentological and hydrological processes for the distribution of radionuclides in the saltmarsh near Sellafield is presented in reference [87]. This report focuses on the Esk Estuary and provides useful information on accretion and erosion rates, and tidal processes in the area, relevant to evaluation of future evolution of the site.

3.3.7 Coastal Processes

Since 2012, we have undertaken an annual coastal monitoring survey from St Bees Head to the Drigg Spit to identify any significant changes to the coast. The results of this survey are assessed alongside an annual review of weather data to identify the number, frequency and impact of storms. Baseline surveys of the nearby coastline were carried out in 2002 [88] and 2009 [89]. The data were used to generate an understanding of the recent evolution of the coastline and as input to the development of a conceptual understanding of coastline evolution [77].

The '*Site Evolution*' report [7], presents work that has been undertaken to understand the implications of climate change for coastal changes in the vicinity of the LLWR site. It identifies coastal features closest to the LLWR site, including Barn Scar, the Drigg Coast, Whitriggs and the Carl Craggs embayment (see Figure 3.9). These represent variations in the

fundamental type of this coast, essentially a shore profile being carved through Quaternary deposits by coastal hydrodynamics, with varying depositional characteristics.

Current sediment transport processes on the nearby beaches are mainly due to wave action, and sand has been shown to be mobile under wave action in the vicinity of the LLWR. However, the coastal system at Drigg is described as 'inherently robust' thanks to its local sediment source and the coarse grade of sediment on the shore which acts to dissipate waves and is not very mobile.

The dune spit is subject to accretion and erosion in places. The sand dune complex in the area forms an important unit. As the dunes are formed of non-cohesive material, they adapt to changing hydrodynamic conditions over very short timescales and therefore need to be understood as part of the long-term management of the LLWR site [88]. The shoreline management plan [90] for the area shows no active intervention planned for up to 100 years allowing natural erosion of cliffs and evolution of dunes to continue.

Analyses carried out to assess future changes due to coastal erosion and sea-level rise have identified the following likely impacts.

- Disruption will primarily occur through cliff recession rather than site inundation.
- Scenarios relating to sea-level rise and associated estimates of cliff recession and sea level change have indicated that undercutting is likely to be the main mechanism of site disruption rather than direct wave loading and erosion.
- Disruption to the site is likely to commence between several hundred to a few thousand years after present. The range reflects uncertainties associated with anthropogenically derived greenhouse gas emissions and sea-level rise scenarios, and erosion mechanisms and related processes.
- Significant disruption of the wastes will not occur immediately upon contact with the site boundary – site loss will be gradual, and likely to be over a period of around 700 to 900 years after first exposure.

It is understood that a survey was conducted by the Environment Agency during 2022 to 2023 but was not publicly available at the time when our coastal evolution projections were undertaken for the 2026 ESC. These data will be useful, but, based on the evidence from LiDAR data collected since 2009, are not expected to fundamentally change understanding.

3.3.8 Flora and Fauna

At the present day, widespread agricultural land use in West Cumbria largely determines the flora and fauna present. Most of the agricultural land around the LLWR site is used as pasture for sheep and cattle (dairy and some beef), and for silage production. Some fields are used for root crops and some cereals. The farms in the area are typically of a 40 to 80 ha size with stocking densities of about 1.2 dairy cattle per hectare. Up to 35 beef cows are kept and around 300 sheep are over-wintered on these farms. Pigs, goats or chickens are not commonly kept on the farms. Most farms can provide a large part of their own fodder for

their cows and sheep and also grow cereal crops such as barley and maize. The farmers do not tend to have kitchen gardens or grow green/root vegetables and fruit.

Closer to the coast the soils are of even lower agricultural value, being adversely affected by poor drainage, the encroachment of blown sand and exposure to salt laden winds. The land to the south and west of the site affords poor grazing and is mainly used for sheep (see Figure 3.12), while the land to the north and east is more fertile, and is mainly used for dairy cattle [59].



Figure 3.12: Sheep grazing on land to the south-west of the LLWR

The LLWR site is ecologically rich with several protected species present. There are three sites of Special Scientific Interest (SSSI) within a few kilometres of the LLWR site, referred to as Hallsenna Moor, Drigg Holme and the Drigg Coast SSSI, as shown in Figure 3.13. The Drigg Coast SSSI is also a Special Area of Conservation (SAC) under the European Habitats Directive, which was transposed into UK legislation under the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019. The coastline near the site is designated as a Marine Conservation Zone (MCZ), known as the Cumbria Coast MCZ.

The LLWR site is comprised of a variety of habitat types including:

- open dry grassland, comprising extensive areas of unimproved acid and neutral grassland, where the acid grasslands are associated with heath vegetation or are remnant dune communities;
- a small fragment of relict dune heath;
- two areas of marshy grassland and swamp adjacent to the fire pond, which both support a diverse ecology;
- several, less diverse areas of swampy grassland scattered over the site;

- several semi-natural and man-made seasonal and permanent ponds throughout the site;
- brownfield habitats such as areas of bare ground;
- the Drigg Stream, which runs the length of the southeast side of the site, has steep banks (about 50° to 60°) that are up to 2 m high, is 2 to 3 m wide and 0.2 to 0.3 m deep, and for much of its length is choked by weeds;
- the East-West Stream, which supports diverse vegetation;
- coniferous plantations, broadleaved and mixed woodlands and scrub (trees are predominantly aspen, willow pines and white poplar).

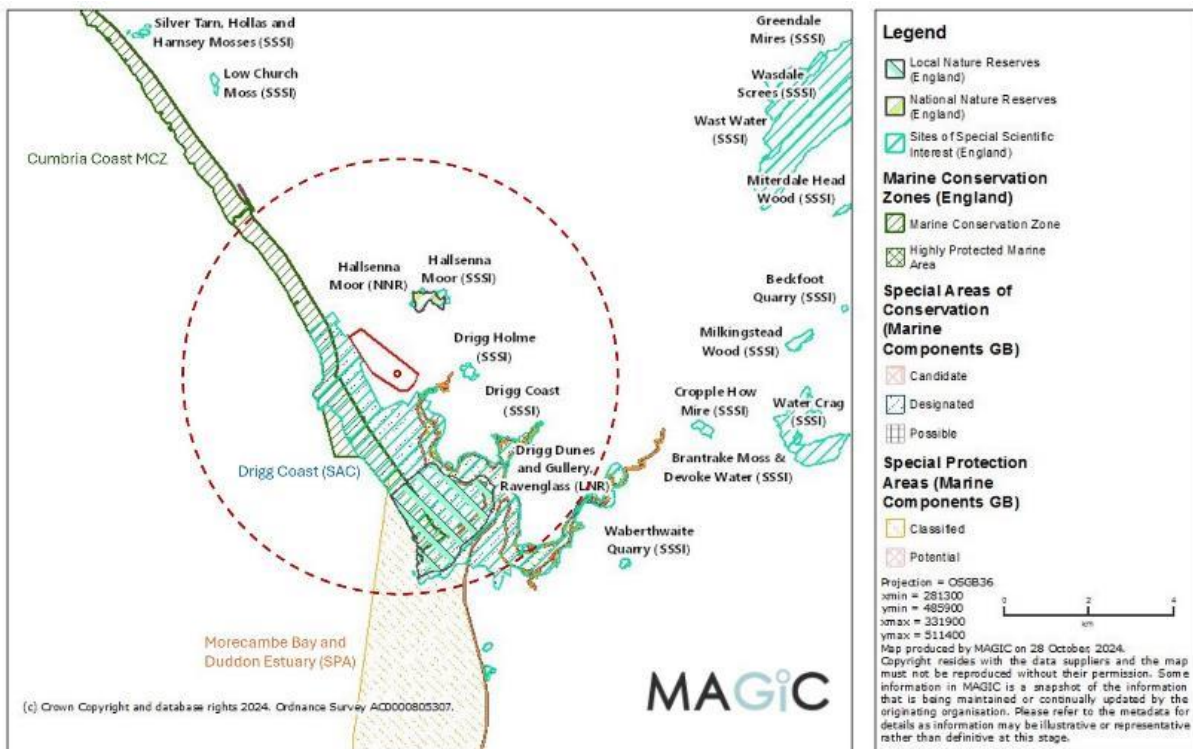


Figure 3.13: LLWR site with conservation areas marked. The red dashed circle indicates a 5 km radius circle centred on the LLWR site. (MAGIC used with permission from Natural England) [91]

The range of habitats is diverse and reflects the fact that the site was once part of the adjacent Drigg Coast dune system as well as being affected by man-made influences. These habitats support a diverse range of flora and fauna, including a number of legally protected species and species listed on Section 41 of the Natural Environment and Rural Communities Act 2006 as species of principal importance for nature conservation.

Legally protected species recorded on site are [92]:

- great crested newt;
- badger;

- common pipistrelle bats (roosting) and other foraging bat species;
- adder;
- slow-worm;
- common lizard;
- pennyroyal;
- barn owl;
- otter.

3.3.9 Human Settlement and Land Use

Consideration of the local population and land use is included as part of the system description in order to ensure that phenomena related to human impact on the environment are taken into account in detailed model development. This means that processes responsible for contaminant migration linked to management of the biosphere (including livestock) are implicitly represented as transfer processes between system components. In addition, consideration of the human community also supports the ESC by identifying potentially suitable data for the definition of Representative Persons as part of the overall conceptual model for radiation exposure, especially for the near term, as described in reference [93].

LLWR is situated within the administrative district of Copeland. Most of the population of the area is concentrated in a number of small towns, of which the most significant are Whitehaven (20 km from the LLWR site) and Egremont (15 km). Drigg village is the most populated place near the site. A small percentage of the population is dispersed throughout the district on farms and in isolated cottages. The economy of a wide area of West Cumbria is dominated by the role of the Sellafield works, which, in 2017, was estimated to sustain 58.7% of local jobs in Copeland alone [94]. Most of the other working population is employed in the small towns and villages. Other groups of people are engaged in farming, leisure, tourism and small business group enterprises throughout the region. In terms of agriculture, which is important to the community immediately around the LLWR site, at present there are several dairy farms. These farms are family run, with the farmers heavily engaged in their livelihood, which tends to be their only source of income [95].

In the recent past, extraction of resources in the vicinity of the site was limited to small-scale water abstraction, primarily for agricultural purposes [29] and, in the nineteenth century, use of spring water for medicinal purposes [96]. No water abstractions are carried out in the downstream region between the LLWR and the coast, where any contaminants that are released to groundwater are expected to migrate. A water features survey carried out in 2023 [97], combined with information on private water supplies in the area was provided by Cumberland Council [98], indicate that there were no private water supplies and licensed abstractions in the vicinity of the site, as shown in Figure 3.14, and that the site does not lie within a source protection zone. We have recently been granted a water abstraction licence

to allow the use of one of the on-site boreholes to supply water for dust suppression as part of cap construction.

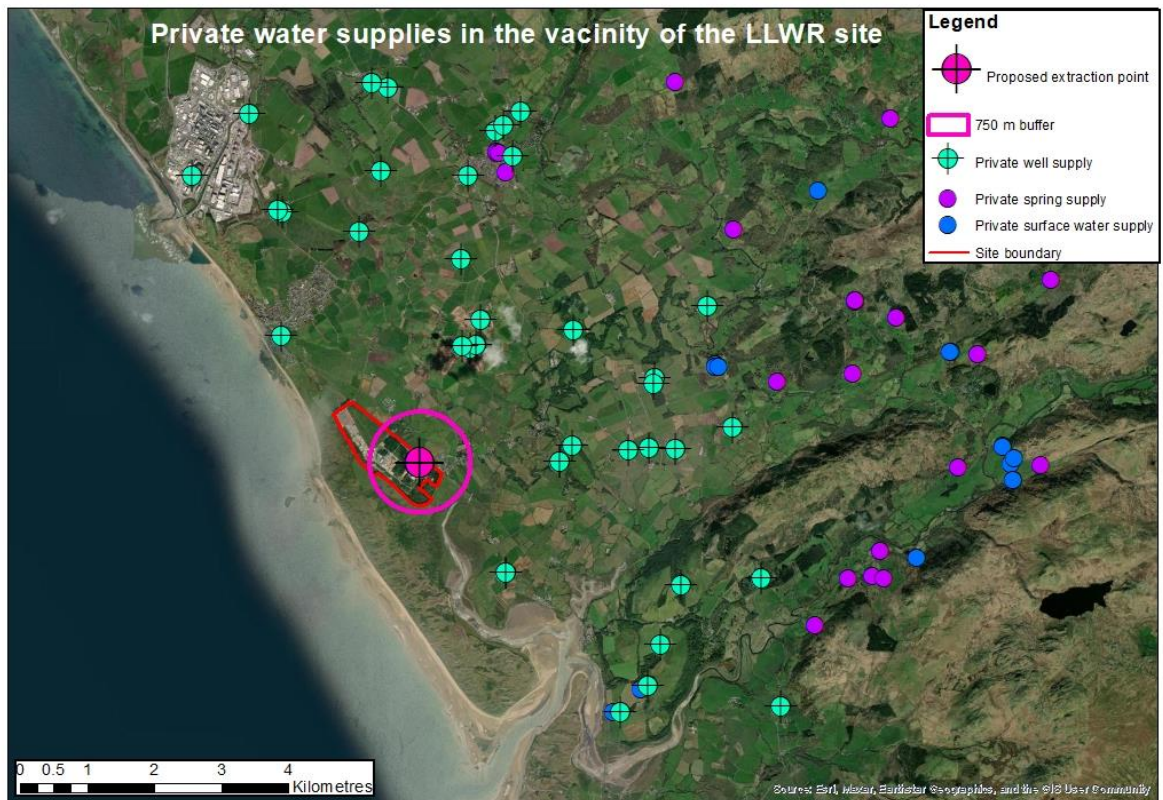


Figure 3.14 Private water supplies in the vicinity of the LLWR site

4 Conclusions

This report presents background information on the past and current state of the LLWR site as well as information on the geographical and environmental setting of the facility.

The report provides a description of the history of site use and development, initially for industrial purposes during World War II producing 400 tonnes of TNT a week, and then, beginning in 1959, as a radioactive waste repository.

Over the period of operation, waste management has evolved from the loose tipping of untreated wastes into open trenches, to disposal of treated and contained wastes in highly engineered vaults. The LLWR disposal facilities and management processes have been progressively improved to meet the developing needs and changing requirements for safe disposal.

The report provides a summary description of the waste, what it consists of, where it comes from, and its radioactive and other hazardous characteristics.

The document has also presented a summary of the local environmental setting of the LLWR, including geology, hydrology, hydrogeology, and coastal processes.

Within the context of the ESC, the aim has been to summarise information about the development of the LLWR site and provide confidence that we have a sufficiently comprehensive understanding of the biosphere to support the assessment calculations that underpin the ESC.

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