Nuclear Waste Services

WASTE MANAGEMENT PLAN

2026 Environmental Safety Case for the LLWR

LLWR/ESC/R(26)10176, May 2026

Conditions of Publication

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 Kingdom[1].

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.

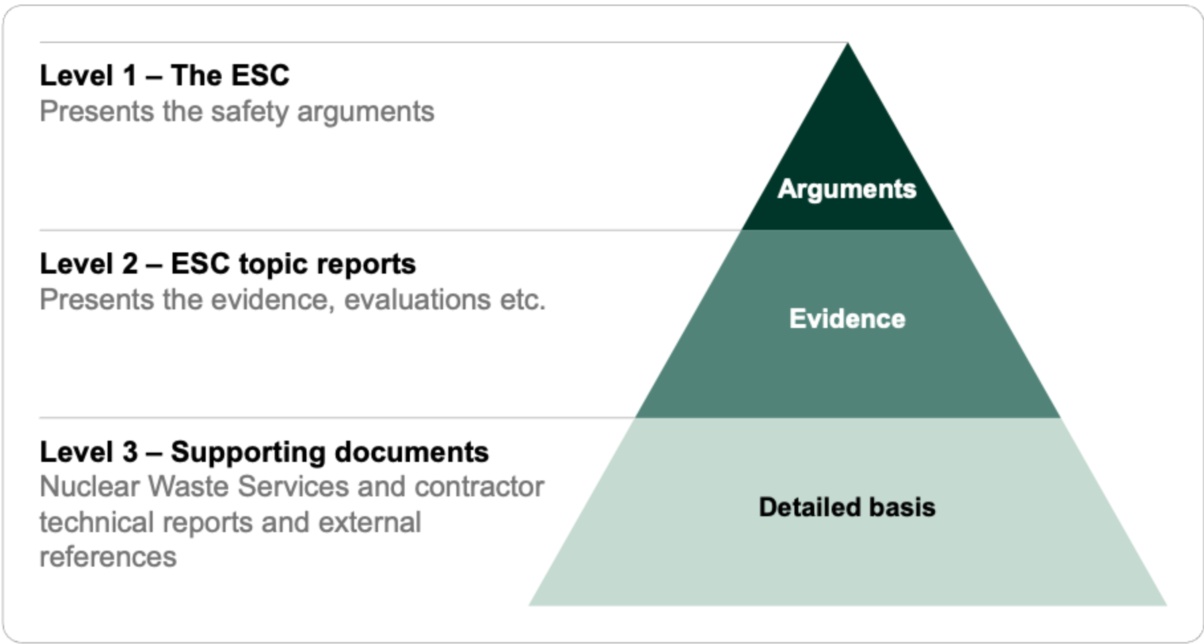
The 2026 ESC consists of documents at two levels:

- 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 '*Waste Management Plan*'. 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 [3]	Provides a history and description of the site
Disposal Facility Inventory [4]	Describes the wastes already disposed and wastes that may be disposed at the facility

Engineering Design [5]	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 [6]	Describes our understanding of the chemical and physical evolution of the engineered disposal system
Hydrogeology [7]	Describes our understanding of the geology and hydrogeology of the site
Site Evolution [8]	Describes our understanding of how the site will evolve, with a focus on coastal erosion
Monitoring [9]	Presents our programme of environmental monitoring supporting the ESC
Optimisation and Site Development Plan	
Optimisation and Site Development Plan [10]	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 (this report)	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

The Low Level Waste Repository (LLWR) is the UK's principal facility for the disposal of solid Low Level Waste. It is a near-surface disposal facility in which waste was disposed of in trenches and is now being disposed of in vaults excavated into the ground surface.

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. Operational and decommissioning wastes have and will continue to arise as a result of these activities. There is also land contamination in areas of the site that are not part of the dedicated disposal facility.

This Waste Management Plan (WMP) sets out how we, the site operator Nuclear Waste Services, will deliver optimised waste management throughout the remainder of the LLWR lifecycle to support the site's eventual release from radioactive substances regulation. The WMP forms part of the overall Site-wide Environmental Safety Case, which is being presented as the 2026 Environmental Safety Case (ESC).

In line with regulatory requirements, the WMP aims to:

- demonstrate that radioactive waste management at the LLWR is optimised;
- identify all current and prospective disposals of radioactive waste arising from the site;
- describe how the site will be brought to a condition that meets the regulatory requirements for release from regulation;
- support the arguments and claims presented in the ESC.

The scope of the WMP includes solid radioactive wastes (both within the dedicated disposal facility and arising from site operations and decommissioning), liquid discharges (including leachate, sewage effluent and minor arisings), gaseous discharges (including permitted stack discharges and releases from the designated disposal facility), and the site's radiological and non-radiological contamination legacy.

The WMP provides a structured account of current waste and contamination issues, the management arrangements in place, and the evidence base used to demonstrate environmental protection and Permit compliance. The WMP is a 'live' product in that it signposts to maintained inventories, registers and monitoring systems that are updated on an ongoing basis.

We have not yet made all the decisions that are needed to finalise our plans for an optimal end state. These decisions will affect our WMP as they will affect the quantity and timing of the generation of site wastes in the future. For example, we do not yet know which infrastructure or land contamination we may apply to leave in situ, assuming it is demonstrably safe and consistent with the site's next use to do so. To arrive at these decisions, we must undertake a programme of site-wide optimisation to develop an integrated view on what will happen to the site and the wastes generated. In some cases, this process of optimisation will require further characterisation of potential site wastes to inform decision-making. The characterisation information and resulting decisions will allow us to progressively improve our WMP to make it more complete.

Although there are gaps in our WMP, we do not consider that there is an urgent need to fill them. The reasons for this are as follows.

- We have characterised our site wastes to an extent that we are confident that they can be dealt with using options for waste management that already exist (e.g. disposal in situ or in our designated disposal facility).
- The site has many years of operation remaining before it is required to be in a condition suitable for its next use. Access to the site will be restricted throughout this period.[2]
- Our environmental monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards, which shows that leaving the contamination in situ for the time being is not having an adverse impact on people or the environment.
- We are satisfied that the procedures and processes that we implement will ensure ongoing environmental safety.

Our timescales for undertaking the necessary programme of site-wide optimisation are linked to our Site Development Plan, which provides a guide as to when those decisions are needed. There is uncertainty in the long-term Site Development Plan because the timing and sequencing of site development and lifecycle decisions are influenced by a range of factors, including external drivers. Given the current point in the facility's lifecycle, this WMP is not intended to support a surrender application or an application for disposal of site wastes. It reflects our current state of knowledge of the site and our current Site Development Plan.

We have developed a Forward Plan that shows how we plan to maintain and update the WMP as uncertainties are progressively reduced and the Site Development Plan evolves. Our established management arrangements will ensure that the WMP is kept live, including maintenance of the underlying evidence base (e.g. inventories, the Building Register, the Land Quality Register and site development records), ongoing site characterisation and environmental monitoring, and formal governance and change control (including assessment of new information and coordination of site development proposals). We will continue to operate in compliance with our Permit and will progress the site towards the Site Reference State and, ultimately, a condition suitable for release from regulation.

[2] An area of the site may be released from regulation before operations are complete. This would only happen if it could be demonstrated that it is safe to do so.

Table of Contents

1 Introduction

The Low Level Waste Repository (LLWR) is the UK's principal facility for the disposal of solid Low Level Waste (LLW). It is a near-surface disposal facility in which waste was disposed of in trenches and is now being disposed of in vaults excavated into the ground surface. Disposal of radioactive waste and radioactive discharges from the site are regulated by the Environment Agency under the Environmental Permitting (England and Wales) Regulations 2016 [19].

The purpose of this Waste Management Plan (WMP) is to describe how we, the site operator, Nuclear Waste Services (NWS), will deliver optimised waste management throughout the LLWR lifecycle, to enable release from regulation once the site's mission is complete. This is the first iteration of a WMP for the LLWR site. It forms part of the overall Site-wide Environmental Safety Case (SWESC), which is being presented as the 2026 Environmental Safety Case (ESC). It summarises and signposts to sources of information that are kept 'live' (Figure 1.1).

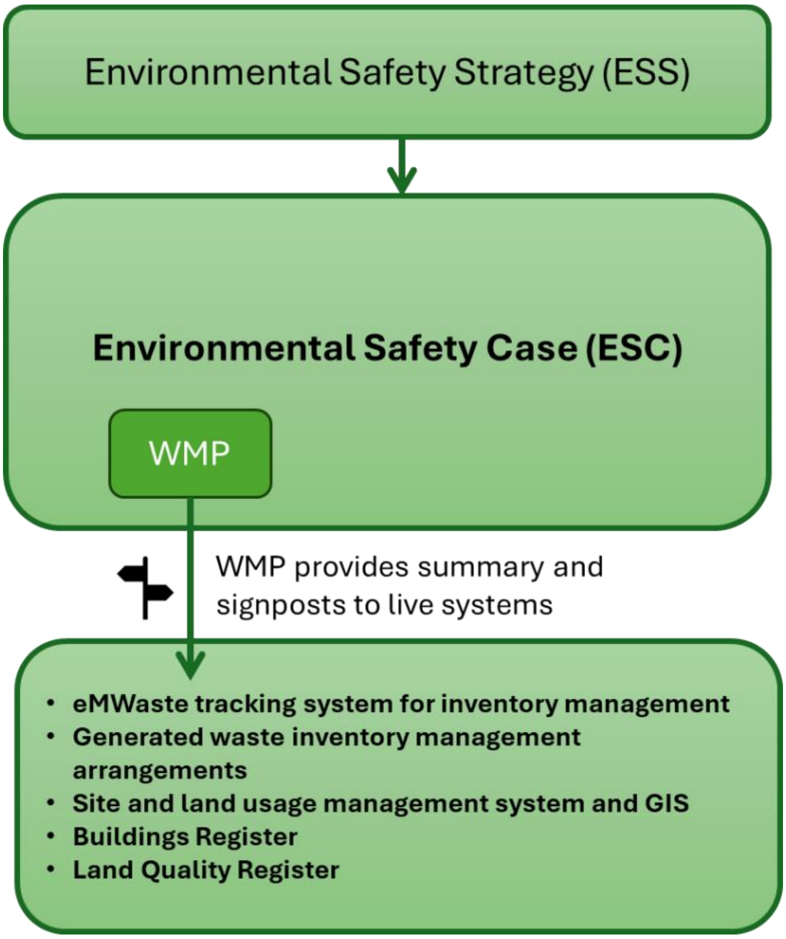


Figure 1.1: Representation of the WMP within the ESC and how it signposts to live systems and data

This WMP has been developed to help address requirements of the *'Management of Radioactive Waste from Decommissioning of Nuclear Sites: Guidance on Requirements for*

Release from Radioactive Substances Regulation' (the GRR) [20]. Our Permit also contains a requirement to develop and maintain a WMP.

Our WMP is supported by and contributes to our Environmental Safety Strategy (Figure 1.1). It forms an important part of the iterative process of progressive development, ongoing throughout the life of the LLWR.

We implement management and control measures [2] to ensure that any impacts that might result from the management of the wastes, including impacts resulting from radionuclides and chemotoxic hazards presented by the waste, are acceptably low [1]. For the wastes associated with operation of the site, we focus on ensuring optimal management of the wastes through application of the waste hierarchy [10]. For the disposal facility, we limit and manage the inventory of wastes, and select appropriate designs and operational practices of the facility [10, 17].

The environmental safety of the LLWR is demonstrated using assessments, which draw upon monitoring data and the results of assessment models [13, 14, 15]. The monitoring data collected are used to understand any impact or change to environmental systems relevant to the LLWR, the interactions between these systems and the performance of engineered systems. The monitoring programme, which will continue to be adapted throughout the lifecycle of the LLWR, provides evidence of compliance with the limits and conditions of the our Permit and assurance of radiological protection of members of the public [7, 9, 13].

WMP Status

This is the first WMP for the LLWR site. It shows that our existing management arrangements for all wastes across the site are robust and ensure environmental safety. They also ensure that the principles of Best Available Technique and the waste hierarchy are applied as appropriate.

We have already carried out significant programmes of decommissioning. For example, we have recently completed the decontamination and decommissioning of the remaining legacy magazine structures. We have used our well-established framework for optimised decision-making to sentence all wastes generated to the most appropriate management routes (see Subsection 5.5). We have also carried out an extensive programme of investigations to understand the extent of the land contamination across the site [7].

We have not yet made all the decisions that are needed to finalise our plans an optimised end state. These decisions will affect our WMP as they will affect the quantity and timing of the generation of site wastes in the future. For example, we do not yet know which infrastructure or land contamination we may apply to leave in situ, assuming it is demonstrably safe and consistent with the site's next use to do so. To arrive at these decisions, we must undertake a programme of site-wide optimisation to develop an integrated view on the site end state and management of the wastes generated. In some cases, this process of optimisation will require further characterisation of potential site wastes to inform decision-making. The characterisation information and resulting decisions will allow us to progressively improve our WMP to make it more complete.

Although there are gaps in our WMP, we do not consider that there is an urgent need to fill them. The reasons for this are as follows.

- We have characterised our site wastes to an extent that we are confident that they can be dealt with using options for waste management that already exist (e.g. disposal in situ or in our designated disposal facility.
- The site has many years of operation remaining before it is required to be in a condition suitable for its next use. Access to the site will be restricted throughout this period.[3]
- Our environmental monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards, which shows that leaving the contamination in situ for the time being is not having an adverse impact on people or the environment (see Subsection 6.3.1).
- We are satisfied that the procedures and processes we implement will ensure ongoing environmental safety.

Our timescales for undertaking the necessary programme of site-wide optimisation are linked to our Site Development Plan, which provides a guide as to when those decisions are needed. There is uncertainty in the long-term Site Development Plan because the timing and sequencing of site development and lifecycle decisions are influenced by a range of factors, including external drivers.

We will undertake our programme of site-wide optimisation during the operational period of the site. We will arrive at an optimal end state that is consistent with the preferred next use and develop our view on the preferred waste management options. We will undertake this work at a point that allows us to iterate these plans with the final detailed engineering plans for the completion of closure engineering. We anticipate this being no later than 2100.

There may be cause to accelerate the process in areas affected by plans for early release from regulation or if our site monitoring indicated that there was a more urgent need for remediation.

Some infrastructure will only become redundant after completion of closure engineering. Previously undiscovered contamination may be revealed as our buildings and facilities progressively become redundant. Our optimised plan may be subject to change at any point in our lifecycle. In line with our management arrangements, we will maintain our WMP as a live product that records our up-to-date position up until an application is made for Permit surrender, and only once we are satisfied that we have achieved the Site Reference State.

[3] An area of the site may be released from regulation before operations are complete (see Subsection 4.4). This would only happen if it could be demonstrated that it is safe to do so.

1.1 Objective

This WMP aims to:

- show that radioactive waste management at the LLWR is optimised;
- identify all current and prospective disposals of radioactive waste arising from the site;
- describe how the site will be brought to a condition that meets regulatory requirements for release from radioactive substances regulation;
- support the arguments and claims presented in the ESC.

This WMP aims to meet Requirement R2 of the GRR (see box below) and the related condition in our Permit [21] together with other 2026 ESC key documents.

> **GRR Requirement R2. Waste management plan**
>
> **A3.16 Operators should prepare a waste management plan (WMP) to manage the programme of disposals of radioactive waste from their nuclear site, and implement the plan to achieve the site reference state.**
>
> A3.17 Operators should develop and maintain a WMP (see glossary for definition), as part of their wider decommissioning plans. The WMP is closely linked to the SWESC and operators should develop them together, and maintain consistency between them.
>
> A3.18 We expect the WMP and SWESC to be 'live' products which should be sufficiently comprehensive for each stage of the lifecycle of a nuclear site.
>
> A3.19 As a minimum the WMP should:
>
> - demonstrate that waste management has been optimised (R1)
> - identify all current and prospective disposals of radioactive waste
> - demonstrate that any proposed on-site disposals of radioactive waste are optimised (R13)
> - demonstrate that the disposals are consistent with the evidence and arguments presented in the SWESC
>
> A3.20 In addition we encourage operators in their WMPs to take an integrated approach to the management of both radioactive waste and directive waste over the lifetime of the facility.
>
> A3.21 The WMP should cover all forms of radioactive waste, including:
>
> - existing waste
> - waste anticipated to arise (including any waste generated from clean-up of ground and/or groundwater contaminated by radioactive substances)

- waste in situ

A3.22 The WMP should cover all forms of radioactive waste disposal such as:

- disposal by transfer off-site
- disposal by emplacement on-site, such as into an on-site radioactive waste disposal facility or for a purpose, such as void filling
- disposal by deliberately leaving radioactive waste in situ
- disposal of liquid and gaseous radioactive waste by discharge to the local environment

A3.23 Operators must apply for, and be granted, authorisation under the permit before making any form of radioactive waste disposal. A WMP and a SWESC, that are comprehensive, credible and mutually consistent, are prerequisites for granting such authorisation.

In addition to meeting GRR Requirement R2, this WMP aims to demonstrate that waste management has been optimised (GRR Requirement R1 'Optimisation of waste management options').

Since there are no proposed on-site disposals of radioactive waste at this time (e.g. no disposals other than those to the dedicated disposal facility), GRR Requirement R13 ('Optimisation of on-site disposals') is not addressed.

As encouraged in the GRR, this WMP aims to take an integrated approach to the management of both radioactive and non-radioactive waste and contamination over the lifetime of the facility.

This WMP is not intended to support a surrender application or a Permit variation application. It reflects our current state of knowledge of the site and our current Site Development Plan [10], and explains how we plan to develop and maintain our WMP. It represents a snapshot in time, but the underlying sources of information will be maintained on an ongoing basis (Figure 1.1).

1.1 Scope

The WMP describes the current intent for dealing with all radioactive substances on or adjacent to the site and to demonstrate how waste management is optimised across the site's lifecycle. It focuses on radioactive substances but aims to take an integrated approach to radioactive and non-radioactive waste and contamination. The scope of this WMP addresses the scope set out in the GRR [20], as illustrated in Figure 1.2.

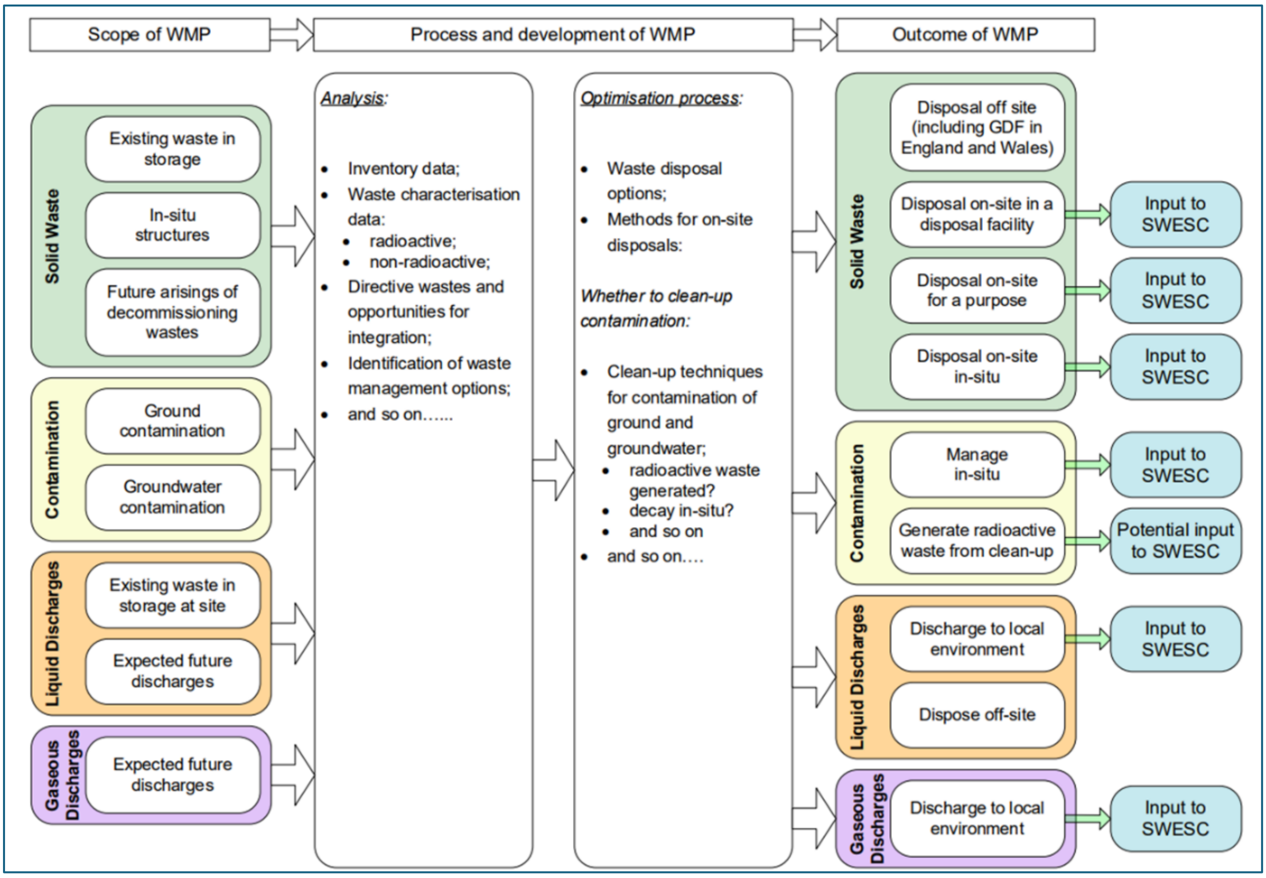


Figure 1.2: Overview of the waste management plan scope, process and outcome (Figure 6 of reference [20])

Within the scope of this WMP, important context for the LLWR site includes the following.

- The LLWR is currently an operational site with a dedicated disposal facility and many more decades of waste disposal operations planned. It reflects our current state of knowledge of the site and our current Site Development Plan [10].
- The WMP will remain live through our established processes and by maintenance of the underlying data (e.g. live inventories and registers). Our ESC is also maintained as a live safety case so new information will be reflected in both, as appropriate, as it becomes available. We will maintain this WMP report in line with the ESC review cycle. We anticipate for this to align with the GRR requirement of comprehensively updating the WMP no less frequently than every 10 years.
- We recognise that partial surrender of our Permit is an option available in the regulations and explained in the GRR [20]. Any application for surrender (be that in full or for part of the permitted site), would require a comprehensive SWESC demonstrating that the criteria for release from Radioactive Substances Regulation (RSR) have been met and the site is performing as expected in the SWESC. For partial surrender, the SWESC would need to show that any decisions taken for the part of site being surrendered, would remain valid when considered together with the whole site and decisions that may be taken for that remaining area.

1.2 Structure

The rest of this document is set out as follows.

- Section 2 sets out the context for this WMP including the site context, support to the WMP from the Environmental Safety Strategy, and how the WMP fits with other waste plans required of NWS.
- Section 3 describes how radioactive waste management at the LLWR is, and continues to be, optimised.
- Section 4 describes our plans to achieve the Site Reference State, the point at which we could apply to surrender our Permit.
- Section 5 documents our current understanding of all current and prospective disposals of solid radioactive waste.
- Section 6 describes our current understanding of both radioactive and non-radioactive contamination on the site, and the processes by which we record, maintain and improve this understanding.
- Section 7 documents our current understanding of all current and prospective disposals of liquid radioactive waste.
- Section 8 documents our current understanding of all current and prospective gaseous discharges.
- Section 9 describes how we approach the management of non-radioactive decommissioning waste.
- Section 10 sets out a forward plan that describes how we will maintain the WMP, ensure we gather all of the required information as the site develops, and how we will continue to learn from experience.
- Section 11 provides a summary of WMP key points.

2 Context

2.1 Background to Site Condition

Key features of the LLWR are shown in Figure 2.1. The site is located on the coastal plain of West Cumbria on the Irish Sea coast. Currently, the closest point of the LLWR vaults lies approximately 350 m inland from the present-day coastline.

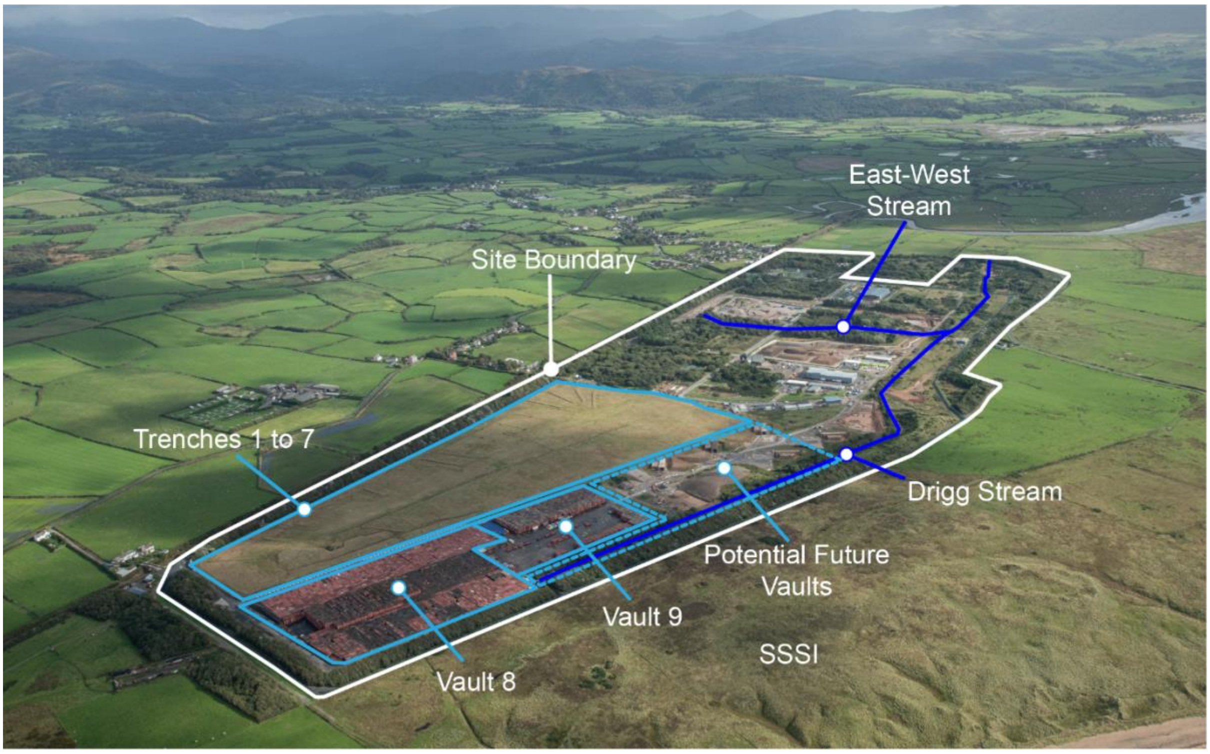


Figure 2.1: Key features of the LLWR (viewed from the north-west to south-east)

The LLWR site has a complex history involving explosives manufacturing, radioactive waste disposal and storage of hazardous materials. Our '*Site History and Description*' report [3] describes how the site was originally developed as a Royal Ordnance Factory (ROF) for the production of TNT during World War II. 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. 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 '*Monitoring*' report [9] 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 (NO_2) 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 require remediation 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 preferred end state (see Subsection 4.4).

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 accidental 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 routes.

The TNT storage magazines were used to store plutonium-contaminated materials. We have undertaken significant programmes of work to remove the hazardous material from the magazines and sentence it appropriately. 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.

2.2 Strategy to Support the WMP

The GRR [20] sets out the need for a clear strategy to support the development of the WMP:

> *'The operator should have a clear strategy to support the development of their WMP and SWESC; a safety strategy. The strategy is a high-level integrated approach comprising an overall management strategy for the various activities required to ensure that WMP and SWESC are properly coordinated and that they address all relevant considerations.'*

This requirement is met through our overall Environmental Safety Strategy, which is set out in our '*Main Report*' [1] and is summarised in the context of the WMP below.

Our Environmental Safety Strategy describes the main objective of the ESC as providing a clear demonstration of the environmental safety of the management of radioactive wastes at the LLWR, where the wastes include those generated and stored at the site and past and planned future disposals of waste. It is designed to satisfy regulatory requirements including the fundamental protection objective set out in the GRR [20]:

> *'Our fundamental protection objective is to ensure that a nuclear site is brought to a condition at which it can be released from RSR, through a process which protects the health and interests of people and the integrity of the environment, both during the period of regulation and afterwards, and which inspires public confidence and takes account of costs.'*

The WMP helps address this fundamental protection objective by providing the vehicle to describe current plans for bringing the site to a condition at which it can be released from regulation, and to ensure future plans iteratively work towards achieving that release.

The ESC, with the WMP now as a component part of it, presents the knowledge and understanding on which our plans for waste management and assessments of environmental safety are based. It also provides a basis for our future consideration of options for the management the facility, including on waste acceptance for disposal. The ESC is implemented as a live safety case and continues to evolve under a formal change control process [2]. How we maintain the WMP and keep it live is addressed in Subsection 10.1.

An important way of achieving environmental safety, particularly radiological safety, is optimisation. Optimisation is central to the GRR and its requirements. This WMP contributes to how we implement optimisation for the site, ensuring optimal management of the wastes through application of the waste hierarchy and Best Available Technique (BAT).

2.3 LLWR Joint Waste Management Plan

The LLWR Joint Waste Management Plan (JWMP) is a 'bottom-up' plan that has been used as an information source in this WMP. It is a proactive management plan that:

- covers the next five years, with a focus on the next twelve months;
- describes the waste that will be sent to our facilities and to those facilities in the supply chain that we access via the Waste Services Contract;
- describes projects that will generate waste, including any key risks that could impact waste generation or export;
- supports forecasting data provided in the associated Waste Forecasting Form, including the confidence in the forecasted quantities;
- discusses services to support higher activity waste management (i.e. Letter of Compliance and Package Assurance submissions);
- describes key ‘opportunity’ projects, that do not form part of 'business as usual' but may lead to improvements in waste management outcomes;
- describes unfunded opportunities.

Waste producers, including the LLWR site, complete the JWMP on an annual basis. The information is used by NWS to support business planning and management activities. The JWMP is used to support the WMP by providing near-term forecasts and keeping these live through the annual JWMP update.

3 Optimisation and Waste Management at the LLWR

The *'Optimisation and Site Development Plan'* [10] presents the approach to optimisation of the LLWR, including existing and future disposal system engineering, and the approach to facility closure. Optimisation is a live process that supports our live ESC. The optimised disposal model that forms the basis of this Major Review of the ESC is our view on the BAT solution at this moment in time based on the information that is available. This view is subject to change as, for example, new understanding of the site, the waste, or the strategic direction of the LLWR arise. Such information is routinely monitored as part of annual and periodic ESC review process [22]. New information is assessed in terms of its implications for the ESC and whether it undermines the positions that have led us to our optimised disposal model. Actions are identified as necessary to re-establish the BAT solution in light of the new information and update the optimised disposal model.

Our Waste Acceptance Criteria (WAC) [23] ensure that waste will only be accepted for disposal at the LLWR when demonstrated as BAT, ensuring optimised waste routing. The WAC also specify that customers shall ensure that BAT has been adopted to segregate constituent parts of waste such that alternative waste treatment and or disposal services can be used to avoid disposal to the LLWR where alternative routes are available. Our '*Implementation*' report [17] describes the WAC, and the process by which we implement it.

For 'site wastes', our optimisation arrangements balance a wide range of factors across the waste lifecycle, working within the constraints of past land use and disposal decisions. This includes consideration of:

- the extent and manner of decommissioning and clean up;
- the timing and sequencing of decommissioning and clean-up activities;
- the resulting management requirements for radioactive and non-radioactive wastes;
- whether wastes are to be disposed of on-site or consigned for disposal elsewhere.

3.1 Arrangements to Optimise Waste Management

The application of the waste hierarchy and of BAT are incorporated as a requirement in our corporate processes for the management of waste arisings on our LLWR site and as part of the requirements of the Permit issued by the Environment Agency. Identification and implementation of BAT for radioactive waste on a specific waste stream basis is a requirement for projects, engineering design, safety case production and implementation, and during modifications to existing processes, and is executed in line with industry good practice. Reviews of BAT assessments are made periodically where there is significant change in local conditions or in the event of improvements to waste management techniques or approaches.

Waste operations on site are supported by our 'Permit Compliance' procedure [24], which includes making use of Radioactive Waste Advisors, as necessary, and ensuring the use of BAT. We adhere to our Good Practice Guide ‘BAT for the Management of the Generation and Disposal of Radioactive Wastes’, which supports the minimisation and optimised management of radioactive waste arisings on or from the LLWR site [25].

Our 'Radioactive Waste Management Process' [26] outlines the process for managing potential and actual radioactive waste arisings, to ensure acceptance to a permitted waste route through application of the waste hierarchy. It stipulates that we:

- use BAT to minimise the activity of radioactive waste produced at LLWR that will require disposal;
- use BAT to minimise the volume of radioactive waste disposed of;
- use BAT to characterise, sort and segregate solid and non-aqueous liquid wastes, to facilitate their disposal by optimised disposal routes;
- minimise the quantity of accumulated radioactive waste and ensure waste management meets the requirements of Site Licence Condition 32 ‘Accumulation of Radioactive Waste';
- ensure application of the waste hierarchy and the consideration of BAT in line with the hierarchy;
- enable effective identification of waste routes for all generated waste;
- ensure compliance with the Waste Acceptance Procedure for our Waste Services Contract;
- ensure sufficient information is recorded at relevant stages of waste generation to enable characterisation.

The inventory of waste generated on the LLWR site is managed according to the 'Generated Waste Inventory Management' procedure [27], which includes:

- tracking the location of generated waste on the LLWR site and maintaining records of waste disposals, including waste characterised as ‘out of scope’;
- maintaining an inventory of all LLW operational and decommissioning radioactive waste in storage and forecast to arise in future at LLWR;
- completing inventory records for the NDA, including the United Kingdom Radioactive Waste Inventory (UKRWI) (every three years);
- completing inventory records as required for the Waste Services Contract − currently the Waste Forecasting Form (every six months) and the Waste Actuals Form (every month).
- tracking the location of interim storage containers consigned to the LLWR site and maintaining records for onward treatment or disposal;

- compliance with Site Licence Condition 4 ‘Restrictions of nuclear matter on the site.’

It does not apply to wastes other than radioactive wastes, or waste consigned to the LLWR for disposal in the vaults. It controls the following five key spreadsheets used as site inventory records and identifies 'Primary Responsible Roles' for individual steps in the process.

- LLWR Waste Inventory, which contains the waste stream information used to produce the Waste Forecasting Form and UKRWI submission (RSIS 24.04_01 within reference [27]).
- LLWR Building Inventory, which contains a high-level inventory of generated waste. Its function is to record the volume of generated radioactive or potentially radioactive waste, stored within buildings (predominantly the building of origin) (RSIS 24.04_02 within reference [27]).
- LLWR Container Tracker, which record the location and content of all generated waste containers on site. This includes temporary stores and containers that will form the final waste packages for the selected waste route. Empty containers purchased for future waste containment are also listed (RSIS 24.04_03 within reference [27]).
- LLWR Temporary Waste Store Inventory, which record all items stored within temporary waste stores (RSIS 24.04_04 within reference [27]).
- LLWR Interim Storage Container Tracker, which records the location and content of all interim storage containers consigned to the LLWR site (RSIS 24.04_05 within reference [27]).

Inventory management is supported by our characterisation guidance [28], which includes the requirement for optimisation and application of the waste hierarchy.

3.2 Ongoing Optimisation

Optimisation is an ongoing process of iterative improvement founded on an increasing knowledge base. Our environmental monitoring programme is modified annually to ensure that the programme continues to meet the needs of the ESC; iteration of the WMP will expose the knowledge gaps that will help to guide future site investigation studies and the coverage of the monitoring programme. New information relevant to the WMP will be routinely assessed using the established reporting mechanisms we use to manage our live ESC, including frequent reports that document the results of characterisation studies and the monitoring programme, and annual and periodic reviews of the ESC, where the implications of this information are assessed. These processes ensure safety by allowing us to:

- promptly identify any exceedances of LLWR screening or assessment levels, or changing trends in contaminant concentrations such that targeted investigations can be launched or remedial measures implemented;

- progressively build optimisation rationale on the basis of empirical data from targeted studies such that the BAT approach to reaching the end state can be adopted;
- determine if new information arising indicates a change of approach is needed within future iterations of the WMP.

Although there is further site characterisation required as we work towards the end state, we are confident that the environmental monitoring programme provides assurance that controlled or uncontrolled discharges from the site do not have an adverse effect on groundwater and surface water at the site [13, 15]. Although the presentation in references [13] and [15] is focussed on the repository, our monitoring programme covers locations up-gradient and down-gradient of the repository [9]. The monitoring data also provide information on the migration of contaminants irrespective of their source. The data therefore provide evidence that contamination left in situ has little effect on groundwater at the site.

4 Plans to Achieve the Site Reference State

Part of the role of the WMP is to demonstrate how the operator plans to achieve the Site Reference State. This indicates the point where the ESC shows that the residual risks presented by radioactive substances remaining on site are, and will continue to be, consistent with the risk and dose guidance levels set out in the GRR, without the need for controls [20] (see Figure 4.1).

This section sets out how we plan, over time, to achieve the Site Reference State at the LLWR. To do this we will use our established land management procedures and, referring to the options set out in the GRR, make optimised decisions in the context of our closure engineering and our planned end state. It sets out high level plans for validation monitoring, long-term records management, and management of uncertainties.

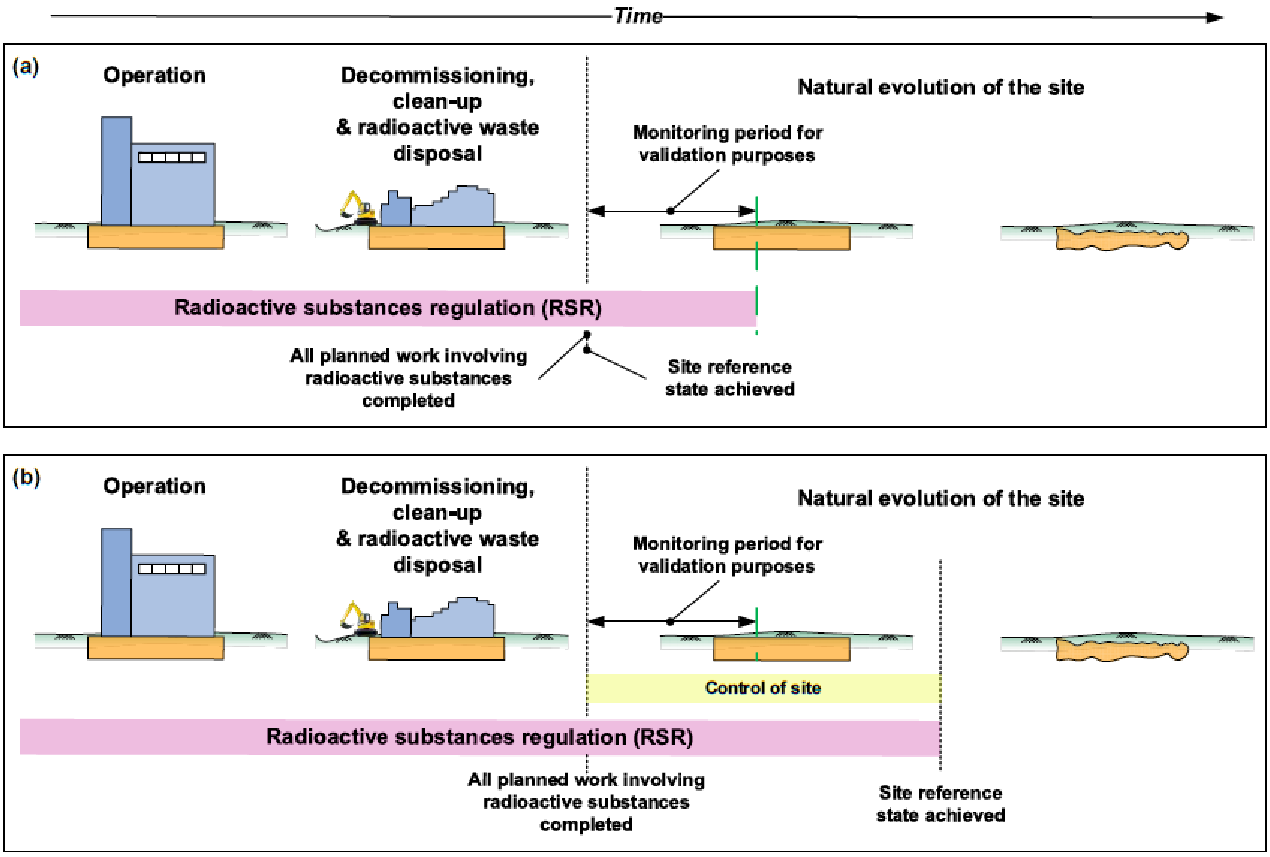


Figure 4.1: Pathways to achieving the site reference state and release from RSR (from reference [20])

4.1 Site and Land Usage Management

We have a formalised procedure for the use and development of land on and around the LLWR site [29]. Under this procedure, the Site Development and Coordination Committee

(SDCC) reviews, evaluates and approves all space management and planning matters for the site and its surrounding area. This is to ensure all future development is coordinated, that impacts are considered, and that any development is aligned with the ESC.

Where there is a need for land or development identified on site, the responsible person will apply to the SDCC with supporting information. This may include drawings and draft Geographic Information System (GIS) LLWR Site Development Mapping, showing proposed updates, amendments and allocations. The SDCC reviews the application in accordance with their Terms of Reference [30].

The SDCC considers:

- alignment or conflict with existing land use;
- alignment or conflict with existing site services and supply capacity;
- alignment with or impact on the ESC and Nuclear Safety Case;
- alignment or conflict with Site Development Strategy;
- alignment or conflict with the existing Site Planning Consents, associated conditions and potential for cumulative impacts;
- optimisation of the proposal;
- impacts on the Permit and discharge authorisations.
- impacts on strategic programmes and projects;
- impacts on requirements for workforce office accommodation;
- contamination impacts from previous land usage;
- interactions with existing known buried structures, voids or holes;
- impacts on the Site Environmental Management Plan;
- alignment with NDA Land Ownership and Land Registry details.

The SDCC is chaired by the NWS Head of Repository Site Enhancement, and membership includes many roles that ensure the needs of the ESC are met, including our:

- Repository Site Development Manager;
- Head of Safety Cases;
- Head of Environmental, Health & Safety;
- Site Characterisation Manager;
- Environmental Advisor – Ecology; and
- Senior Engineering Lead.

The SDCC chair will confirm to the responsible person if the application is rejected, given 'reserved approval', or 'full approval'. The GIS and relevant site registers are then updated as set out in the procedure [29].

This formal land management procedure will ensure that site development is done only in compliance with the ESC and will therefore support the sites eventual achievement of the Site Reference State.

4.2 Management Options for Waste and Contamination

The GRR gives guidance on the range of management options for waste and contamination that an operator may use in decommissioning and clean-up of their site (Figure 4.2). These are important considerations for us as our Site Development Plan evolves over time. The management options are listed below [20].

a) **Disposal by transfer** off site to another permitted facility. We already use this route for diversion to landfill, or for waste treatment.

b) **Disposal to a dedicated radioactive waste disposal facility**, which, for wastes generated on the LLWR site, could include disposal to the LLWR vaults.

c) **Radioactive waste disposed of in situ**, for example by leaving pipes or slabs below ground. This has not yet been carried out on the LLWR site but may be proposed for some infrastructure in future iterations of the WMP (see Subsection 4.4). This would require an application for a permit variation to authorise this activity.

d) **Radioactive waste disposed of in situ with engineered closure**, for example by grouting up redundant below-ground pipework to limit water ingress. This has not yet been carried out on the LLWR site but may be proposed for some infrastructure in future iterations of the WMP. This would require an application for a permit variation to authorise this activity. An example of where this may be proposed in the future is to dispose of the leachate discharge pipeline in situ with engineered closure, once it is redundant.

e) **Radioactive waste disposal for filling an existing structure**.

f) **Radioactive waste disposal for void filling**.

g) **Radioactive waste disposal through use on site such as for a screening bund**.

h) **In situ contamination**. The GRR notes that contamination may be left in situ (if it is optimised and safe to do so) but that this will not become waste unless it is removed or treated. Optimisation assessments for managing contamination should include consideration of waste arisings and these waste arisings should be recorded in the WMP.

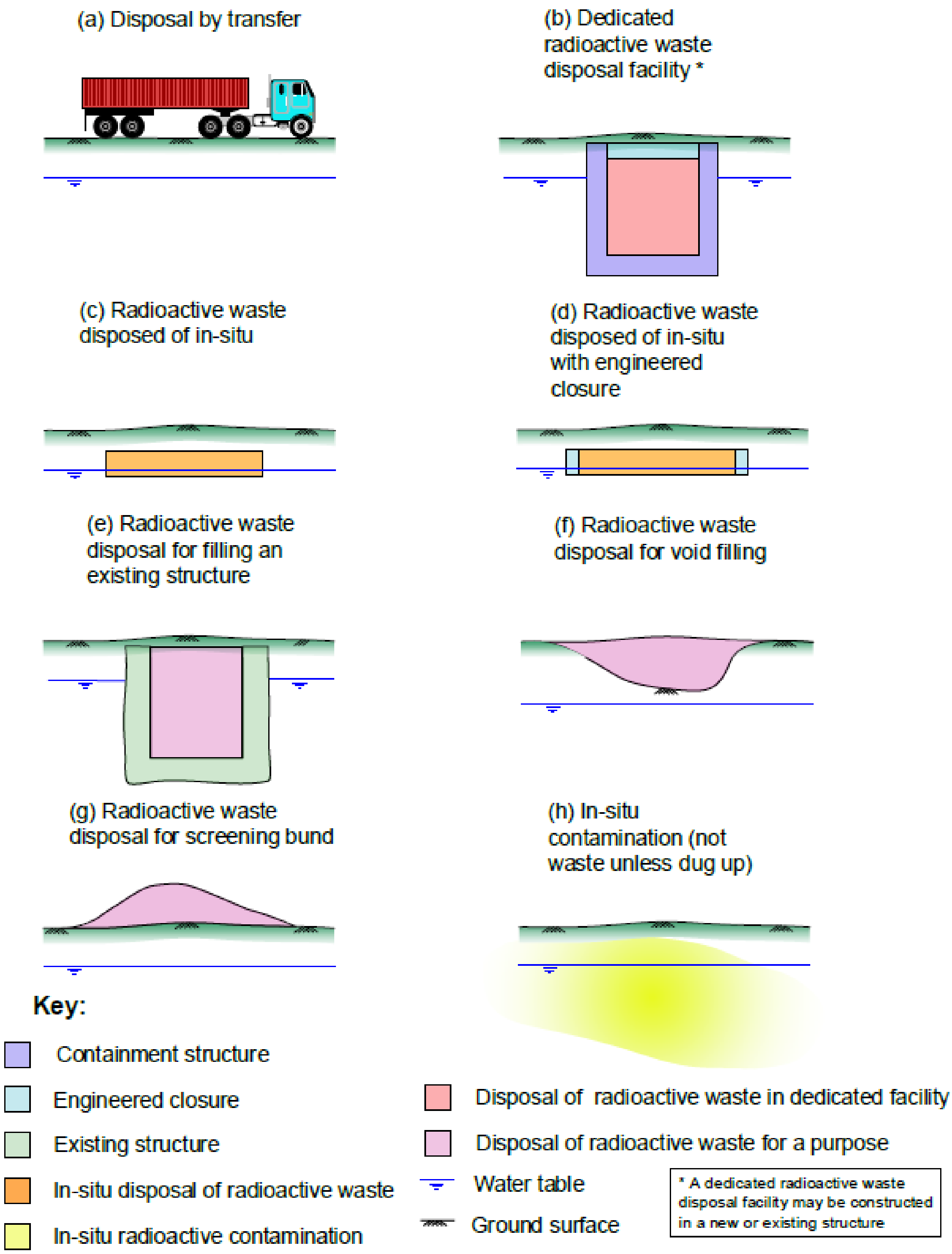


Figure 4.2: Potential management options for radioactive substances from the final stages of decommissioning of nuclear sites (Figure 5 from reference [20])

4.3 Closure Engineering of the Disposal Area

A final cap will be progressively constructed over the vaults and trenches [5]. Eventually, the whole area of trenches and vaults will be covered by a single, gently domed low permeability engineered cap, designed for stability and resistance to erosion and presenting acceptable visual impact. The final cap will be a 3 m thick multi-layered structure. Suitable long-term vegetation cover will be established on the cap area and periphery.

A passive gas venting system will be incorporated into the final cap to provide confidence that differential pressures will not threaten the performance of the cap as a barrier to infiltration. Final decisions on the vent design and whether the vent will be closed before the end of active institutional control will be made later, noting that the venting approach does not need to be part of the construction design for the first strip of the cap.

An underground, low permeability cut-off wall will be constructed, integrated with the final cap, and the existing cut-off wall at the north-east corner of the site. The wall will extend to 2 m below the bases of the vaults. The wall will be of sufficient depth to limit inflow of surface water and shallow groundwater at the level of the vaults and trenches, and outflow of contaminated leachate close to the ground surface near the facility.

Active leachate collection and management will continue during operations and after final disposals for as long as required [31]. The leachate management system will then be decommissioned.

Monitoring will continue during operations and afterwards during the Period of Authorisation. It will provide reassurance that the process of engineering construction is consistent with design requirements for performance and associated Construction Quality Assurance, and after completion, that the repository is performing safely and as expected. It will support the decision on closing the gas vent. Remedial actions, will be taken if required.

More detailed information is presented in the '*Engineering Design*' [5], '*Monitoring*' [9], and '*Optimisation and Site Development Plan*' [10] reports.

4.4 The LLWR Site End State

The term Site End State is used in the nuclear industry in planning for decommissioning and in discussions with stakeholders regarding the next planned use of a site. The NDA defines Site End State as:

> '*The condition of an entire site (including the land, structures and infrastructure) once decommissioning and clean-up activities have ceased. It may be appropriate to define end states for components of the site, which must be brought together and assessed as a whole to determine the site end state.*'

For the LLWR, the site was partitioned into distinct areas (see Figure 4.3). and a structured options assessment considering a range of 'credible options' for the end state of each [32]. The credible options were all designed to be consistent with the designated 'next use' of the site which is 'waste management and recreation or nature conservation'. They were specific to the 'Disposal Area', 'Operational Area', or 'Opportunity Area'[4].

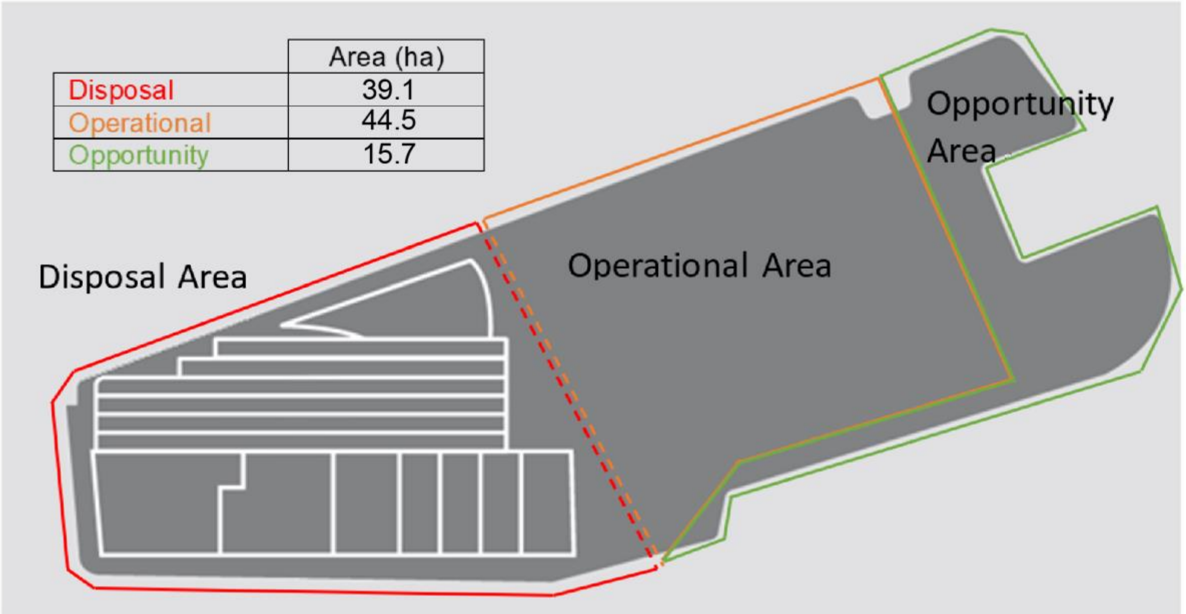


Figure 4.3: LLWR site partitioned into the 'Disposal Area', 'Operational Area', and the 'Opportunity Area' for end state considerations.

Credible end state options for the Disposal Area ranged from leaving waste in situ with closure engineering emplaced to isolate and contain the waste, to targeted remediation or treatment of waste from the trenches and vaults, also with closure engineering emplaced [32].

Credible end state options for the legacy structures, infrastructure, buildings and contamination in the 'Operational' and 'Opportunity Areas' ranged from removing all, to undertaking limited removal, to leaving structures and infrastructure in place.

The credible options were assessed by a multidisciplinary panel [32]. The assessment criteria included:

- environmental impact;
- technical performance and practicability;
- health and safety (during implementation of the option);
- sustainability;
- cost;
- enabling the mission.

[4] The Opportunity Area is named as such because as an opportunity to release that part of the site from regulation was identified on the basis that it is not needed to support ongoing operations.

The preferred end state options for each area were determined and agreed with the NDA [32].

For the Disposal Area, these are:

- operations are assumed to cease in 2135;
- the disposed waste will remain in situ as determined by the ESC;
- the physical state of the repository will reflect the optimised closure engineering described in the ESC;
- access to the site will be managed in accordance with institutional controls;
- the repository will remain subject to institutional controls for as long as required by the relevant regulatory regime to manage risks to people and the environment.

For the Operational and Opportunity Areas, these are:

- radiological contamination will be reduced to levels that can be demonstrated safe by our SWESC;
- this may include in-situ disposal of contaminated areas where a case-by-case assessment demonstrates it to be optimal;
- non-radiological contamination will be remediated to meet the requirements for the designated next use;
- safe above-ground structures, such as roads, will be left in situ unless there is a clear disbenefit to doing so;
- in-situ disposal of below-ground structures is preferred if it can be demonstrated to be safe and optimised (this may include filling voids with waste generated from other site remediation works ('disposal for a purpose'));
- opportunities for 'disposal for a purpose' of waste generated from site remediation will be explored.

An interim end state will be reached in the Operational Area at the end of operations that will involve decommissioning and remediation as far as can reasonably be achieved at that point, noting that some apparatus (such as the leachate lines and monitoring boreholes) will still be in use for some or all of the institutional control period (see Subsection 4.5). Controlled public access would be allowed following delivery of the interim end state (e.g. majority infrastructure removed). Some remediation may be accelerated (carried out before the end of operations) if there is an opportunity to do so. The final end state will be delivered at the end of the institutional control period.

Decommissioning and remediation to the final end state of the Opportunity Area will be accelerated where possible so that the area becomes available for its next use. This may be affected by our plans for interim use of some of the land, though the two are not mutually exclusive. We may continue to use the land whilst simultaneously permitting alternative uses and are actively working with the community on plans for interim use.

We are aware that for some of these preferred options, we will need to apply for a Permit variation at the appropriate time. Prior to making those decisions and making an application, further stakeholder engagement, in particular with the Environment Agency, would be undertaken (as per GRR Requirements R3, R4, and R5). Each option being proposed would be fully optimised, recorded in the WMP and consistent with the SWESC at that time. A full demonstration of meeting the GRR technical requirements would also be required to support the application.

The LLWR Site End State will also be reviewed at each major review of the ESC as a minimum, which is expected every ten years.

4.5 LLWR Lifecycle Phases and the WMP

Our '*Optimisation and Site Development Plan*' report [10] and '*Institutional Control Plan for the LLWR*' [31] set out broad lifecycle phases expected for the LLWR site (Figure 4.4). How these phases relate to the requirements of the WMP is set out below.

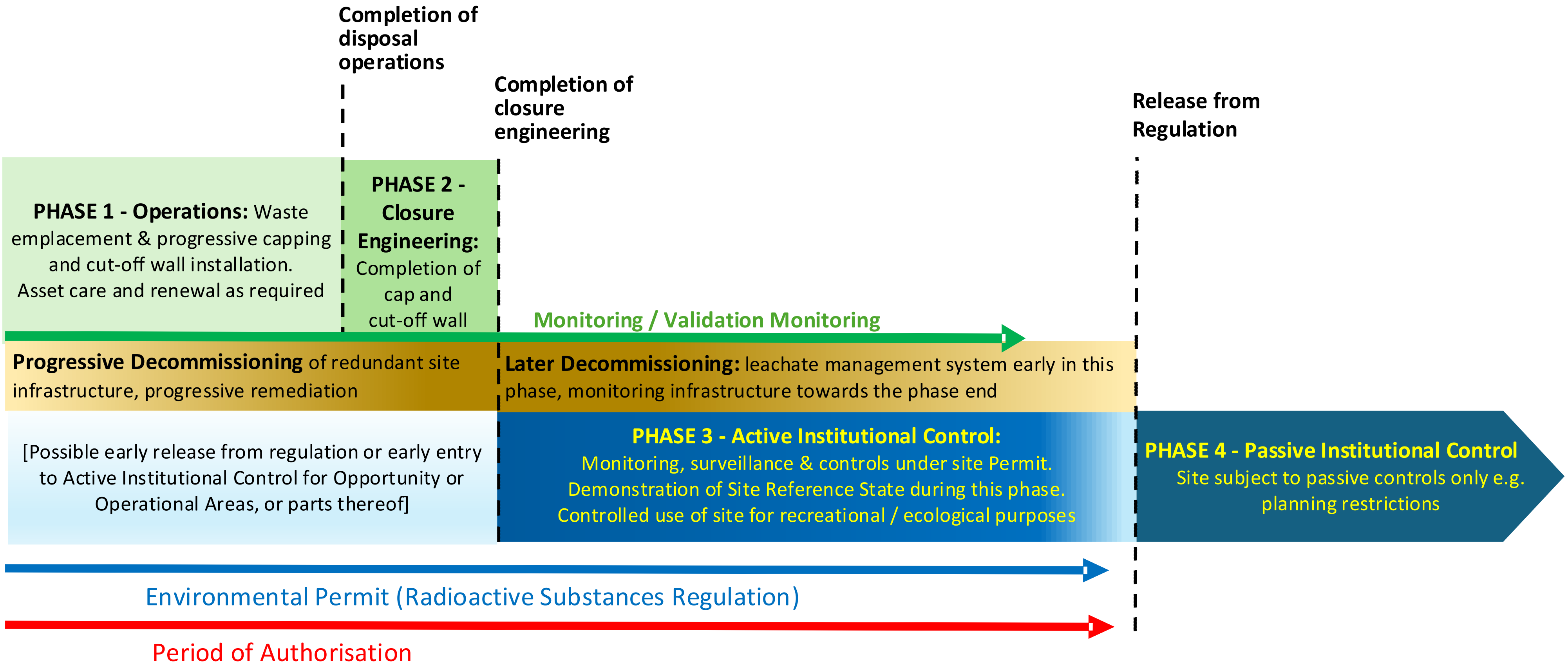


Figure 4.4: **LLWR site lifecycle phases**

Phase 1 − Operations: Waste emplacement, construction of future vaults, progressive capping and installation of the cut-off wall

Ongoing site development such as vault construction requires ongoing site characterisation. Asset care and renewal, as required, is ongoing throughout this phase. Any waste generated by site development activities is captured in the appropriate inventory and managed using our waste optimisation procedures [27, 28, 33]. Identified land contamination is recorded in the Land Quality Register, assessed and managed using our procedures [34]. Monitoring is ongoing throughout this phase to demonstrate environmental safety. Throughout this period, we will maintain the WMP in the light of factors such as developments at the site, new information, changes in legislation and government policy, and will comprehensively review the WMP in line with updates of the ESC.

Phase 2 − Closure Engineering: Completion of the cap and the cut-off wall

This period is anticipated to last approximately seven years, estimated to be from around 2135 to 2142 AD. As with the Operations phase, monitoring will be required throughout the phase. Any waste to be generated will be assessed using our optimisation processes, captured in the WMP, and managed appropriately. Identified land contamination will be recorded in the Land Quality Register [34], and assessed and managed using our procedures [33].

Progressive decommissioning

Progressive decommissioning of redundant site infrastructure will run throughout Phase 1 and Phase 2. Optimised waste management options will be identified for redundant site infrastructure and the results of the optimisation process documented in the WMP and SWESC. Where infrastructure is rendered redundant and it becomes radioactive waste, where a decision is made to leave that waste permanently in situ, a permit application will be made. Likewise, if decommissioning generates radioactive waste that could be disposed 'for a purpose' such as void filling, a permit application will be made prior to that disposal.

Phase 3 − Period of Active Institutional Control: Monitoring, surveillance and controls under the site Permit

We will demonstrate that we have achieved the Site Reference State within this phase. Monitoring will include appropriate validation monitoring which will build on the baseline of information gathered throughout site operations and will be designed to obtain the information needed to confirm the claims in the SWESC. Once the Site Reference State is demonstrated, we will apply for Permit surrender. The WMP will form an important part of the overall SWESC as it will form the record of the optimisation decisions and all waste and contamination remaining on site at that time.

Later decommissioning

Following completion of Phase 2, it is expected that leachate generation will drop off such that the leachate management system infrastructure can be decommissioned. This is expected to happen relatively early in the period of active institutional control (Figure 4.4).

Optimised waste management options will be selected and be recorded in the WMP and SWESC. Where in-situ disposal is selected as the optimised waste management option, then permit variation applications will be made at the appropriate time. Once the Site Reference State has been demonstrated to the satisfaction of the Environment Agency, monitoring infrastructure will be decommissioned (e.g. groundwater monitoring boreholes). A final WMP and SWESC would then be submitted accompanying a surrender application to achieve release from regulation. Monitoring of the site would continue until the point at which the Permit is surrendered.

Phase 4 − Passive Institutional Control

Beyond Phase 3, the WMP forms part of the site records, as part of the final SWESC. The site will be subject to passive controls only, such as planning restrictions.

4.6 Validation Monitoring

The GRR requires the operator to carry out validation monitoring after the end of all planned work with radioactive substances to confirm that the condition and behaviour of the site (and where relevant the surrounding area), is in accordance with the assumptions of the ESC (see Figure 4.1).

Our existing monitoring programme will be adapted throughout the lifecycle of the facility as set out in our '*Monitoring*' report [9] to ensure collection of sufficient validation monitoring to demonstrate the Site Reference State has been reached.

4.7 Long-term Records Management and the WMP

We have a robust records management system, designed to ensure the preservation, accessibility, and long-term retention of all information necessary to support the ESC. We lay out our arrangements in our *'Management and Dialogue'* report [2]. These arrangements also ensure effective handover of all information necessary to safely manage the LLWR throughout its lifecycle.

Our records management arrangements encompass all categories of information specified by the GRR and so include the WMP and its underlying source information. These records include the following.

- **Site investigation data**. These records are stored in the geotechnical database, i.e. borehole records and trial pit logs.
- **Monitoring results**. The Environmental Monitoring Database System is the central repository for all environmental monitoring data at LLWR, including validation monitoring when it applies. It is structured into three core databases:
    - Time Series Data: physical measurements such as dips, levels, and flow rates;
    - Analytical Data: laboratory and field test results;
    - Contaminated Land Data: chemistry data from ground investigations.

- **Design documents, drawings, and engineering details**. These records are stored and maintained, including our Buildings Register [35]. These records will be particularly relevant for future iterations of the WMP, which may propose to leave radioactive waste in situ, for example redundant below-ground infrastructure such as the discharge pipeline.
- **Waste inventory and characterisation**. Site inventory and eMWaste.
- **Optimisation decisions and BAT assessments**.

Our records management arrangements are compliant with both our internal standards and external codes of practice and are designed to be sufficiently flexible to accommodate evolving regulatory expectations and technological developments [2].

4.8 Uncertainties and Assumptions

Given the stage of the site's lifecycle and the remaining planned operating period, there are uncertainties about the exact end state configuration, the final inventory that will be disposed on the site, including if any contamination will be left in situ, and the timing of achieving the Site Reference State. Ongoing site development, characterisation and monitoring will all feed into future optimisation decisions that will need to be made in relation to 'site wastes' and areas of contamination. Therefore, uncertainties will reduce as decisions are made. Uncertainties are collated in Subsection 10.4.

We have developed and maintain an ESC register of significant uncertainties [36]. It collates an evaluation of the significant uncertainties, how they are treated in the ESC, any remaining bias and the planned management. The ESC team also uses a Features, Events and Processes (FEP) list as an audit tool, to help ensure that the ESC addresses all FEPs significant for the LLWR.

Our management system mandates the maintenance of the uncertainty register and define its role in ESC development and review cycles [2]. WMP considerations and related uncertainties are be managed within this established system. As new information is gathered, for example the characterisation of below-ground structures or redundant infrastructure, we will use our established ESC process of 'Assessment of New Information' to assess the impacts on the ESC including determining if the WMP needs to be updated. For example, where an optimisation assessment indicates that in-situ disposal of radioactive waste or leaving contamination in place is the preferred option, this will be assessed in the context of the ESC and documented in the WMP. This process will ensure ongoing alignment between the WMP and ESC.

5 Solid Radioactive Waste

In this section we discuss the following categories of solid radioactive waste:

- wastes disposed of in the repository;
- wastes that arise on the site;
- wastes in long-term storage;
- in-situ structures.[5]

5.1 Dedicated Disposal Facility Inventory

Our reference inventory, and the methodology used to derive it, are presented in our '*Disposal Facility Inventory*' [4] report. As explained in reference [4], we followed a staged approach to inventory derivation. We have used the Stage 2 inventory [37, 38, 39, 40, 41, 42] as an input into the 2026 ESC radiological assessments and the Hydrogeological Risk Assessment [15].

The Stage 3 inventory is our reference inventory and is our best estimate projection of the waste to be disposed of at the LLWR, consisting of:

- the disposed inventory in the trenches;
- the waste received for disposal in the vaults up to 31st March 2022;
- a projected forward vault inventory developed from the 2022 UKRWI, bounded by provisional constraints derived from the ESC and assumptions on waste treatment and diversion.

We operate the eMWaste tracking system, which in 2018 replaced the previous Low-Level Waste Tracking System and provides more detailed data for recent consignments, enhancing the level of detail and the comprehensiveness of the disposed vault inventory. This ensures that our records are kept live. We have also introduced improved Waste Consignment Information forms that allow us to collect more detailed information from consignors and consequently enhance the quality of the inventory. The non-radiological properties of the waste are also recorded.

The reference inventory provides key underpinning data for engineering design and site optimisation.

We lay out our optimised approach to the management of wastes disposed of in the repository in our *'Optimisation and Site Development Plan'* report [10]. Our focus in this report is on other wastes.

---

[5] There are some in-situ structures that are related to the site's previous operation as a ROF. This infrastructure is redundant and there are often land quality issues related to its past use. In the context of the WMP, this infrastructure, often comprising building slabs, is managed as contaminated land (see Section 6).

5.2 Solid Waste Arisings on the LLWR Site

Solid radioactive waste is generated on the LLWR site through operations and ongoing decommissioning activities. These include soft wastes such as Personal Protective Equipment (PPE), silt from desilting of leachate lines, soil from remediation activities, and demolition arisings from decommissioning of equipment and buildings. Characterisation of legacy drums has also resulted in the recategorisation of waste.

Solid waste arisings from the LLWR site over the last three financial years are summarised in Table 5.1. The waste routes used are those available through the Waste Services Contract, namely the:

- metallic treatment route (**M**), where a range of metal types may be sorted, segregated, treated and recycled;
- combustible treatment route (**C**), where thermal treatment in dedicated facilities can treat radioactive waste or co-treat with non-radioactive waste;
- supercompactable waste route (**S**), where waste is volume-reduced prior to disposal;
- alternative treatment route (**A**), which is designed to develop and deploy new or existing solutions for problematic or difficult waste streams;
- Very Low Level Waste route (**V**), where waste with low activities can be disposed of to permitted landfill sites;
- Low Level Waste route (**L**), where waste is disposed of to the LLWR, typically in half-height or third-height ISO containers.

Table 5.1: Solid waste arisings from the LLWR site for financial years 2022/23, 2023/24, and 2024/25

FY	Description	Waste route	Net volume (m^3)	Net weight (kg)
2024/25	15 full-height ISO containers, each containing sixty-six 200 l drums of recategorised VLLW	**V** (VLLW disposal)	211	52,437
2023/24	Two full-height ISO containers, each containing sixty-six 200 l drums of recategorised VLLW	**V** (VLLW disposal)	28	6,689
	Non-hazardous VLLW Smart Lift Bags	**V** (VLLW disposal)	38	18,392

	Bagged combustibles	**C** (incineration)	9.6	967
2022/23	Non-hazardous VLLW	**V** (VLLW disposal)	19.5	7,637
	LLWR bulk metallic waste including large items	**M** (metal Treatment)	60	18,488
	Bulk combustibles	**C** (incineration)	11	1,351

This WMP signposts to the JWMP for near-term forecasts, which is kept live with annual updates (see Subsection 2.3). Forecasts of solid radioactive waste arisings from the LLWR site are low during operations and include the following.

For financial year 2025/26 [43]:

- **Combustible Waste Treatment**: 48 m^3 raw volume waste to be treated off site via the NWS Framework;
- **VLLW / Low Activity LLW[6] Disposal**: 56 m^3 to be disposed of to landfill via the NWS Framework;
- **Supercompactable Waste Treatment**: 56 m^3 to be supercompacted;
- **ILW-LLW Recategorisation**: 112 m^3 estimated to be recategorised as LLW from ILW for disposal as LLW.

Financial year 2026/27 [43]:

- **Combustible Waste Treatment**: 24 m^3 raw volume waste treated off site via the NWS Framework.

There are currently no projections available for further outyears.

5.3 Wastes in Long-term Storage

The magazines were used to store drums of Plutonium Contaminated Materials (PCM). 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. We recommenced removal of PCM material in 1997, which continued up to July 2007 when all bulk PCM material had been removed.

[6] Low Activity LLW refers to LLW that can be sent to an appropriately permitted landfill.

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.

The drums were originally classified as PCM and destined for export to Sellafield for processing and storage prior to disposal at the Geological Disposal Facility. However, many drums were pessimistically classified as PCM solely due to the limited sensitivity of the existing assay system on the LLWR site. Consequently, it was expected that a proportion of these drums could be reclassified as LLW or VLLW.

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. The results of the recharacterisation are reported in reference [44].

A small sub-population of the 1,810 secondary waste drums and some legacy drums remain in storage in B746. We have not yet determined the optimal management route for these drums that remain in storage.

5.4 In-situ Structures

There are in-situ structures, such as the Marine Pipeline, that will eventually become radioactive waste when redundant (discussed in Subsection 5.5).

There are also in-situ structures such as slabs that have become contaminated due to past activities such as storage of radioactive materials (see Subsection 6.2). There are no redundant structures where a decision has been made to leave them permanently in situ. As we develop the site and work towards the Site Reference State, we will undertake optimisation studies for any redundant in-situ structures and ensure that we apply for a Permit variation if a decision is made to leave them permanently in situ.

5.5 Optimisation of the Management of Solid Radioactive Waste

We do not believe that site-wide optimisation of wastes at the LLWR is urgently required. This is because these wastes do not pose a significant hazard (see Subsection 6.3.1). Solid waste arisings on the site include, for example, soil from remediation activities and demolition arisings from decommissioning of redundant buildings and infrastructure. Solid waste arisings are therefore affected by the decisions that we take regarding the optimal management of in-situ structures and land contamination and the timing of such. These decisions will ultimately be reflected in the WMP, ESC and Site Development Plan once we have undertaken the necessary programme of site-wide optimisation. Our management arrangements for solid waste arisings on the site, described in Subsection 5.2, are robust to these plans that will evolve as we progress towards our end state.

Here, we present two examples of instances where we have determined the BAT option for management of demolition rubble from decommissioning of in-situ infrastructure to be disposal in Vault 8. The contribution of such waste to the disposal facility inventory has been included in the Stage 3 Reference Inventory [4]. Assessments of the Stage 3 inventory remain to be undertaken. We are committed to these disposal options, subject to suitable assessment of the final, detailed arrangements, including final characterisation information.

Example: demolition wastes from the magazines

Demolition of the magazines that were used to store Plutonium Contaminated Materials (PCM) is due to generate approximately 10,000 m^3 of rubble waste. Demolition arisings will be lightly contaminated, typically at levels indicative of VLLW (<4 Bq g^{-1} total specific activity) with potentially some limited areas of Low Activity LLW (<200 Bq g^{-1} total specific activity).

A BAT study was undertaken to determine the optimised waste management option for this waste [45] prior to demolition of the magazines. The BAT study was revisited in a 2023 BAT update on the remaining disposal volume in Vault 8 [46].

The proposed BAT option for the management of the material arising from the demolition is to dispose of it in flexi-bags in Vault 8 in spaces where, owing to size and access issues, we cannot dispose of HHISOs. This option will only be undertaken following suitable assessment of the final, detailed arrangements, including final characterisation information and with agreement of the ESC Manager.

The key arguments in favour of this option include maximising the re-use of material and minimising ‘clean’ material import, consistent with the waste hierarchy, the proximity principle, and government policy, which promotes maximising use of the LLWR as an asset. This will also minimise transport impacts and costs and reduce disposal costs, whilst avoiding bulk material purchase and import costs.

Other options considered in the BAT study [45] included consignment of the material to the LLWR vaults, using space that would otherwise be taken by ISO containers (approximate additional disposal cost of £27m and disproportionate use of a national asset) or disposal to an off-site VLLW disposal facility (approximate additional disposal cost of approximately £5m plus potentially significant transport movements through Drigg village). Neither of these options was considered to be consistent with the waste hierarchy.

Example: Legacy Drum Store (B720) demolition rubble as infill for Vault 8

The Legacy Drum Store, building B720 was demolished between 2016 and 2018, generating approximately 925 m^3 of waste comprising breeze blocks and felt or cork expansion joint material. The waste exhibits only low levels of contamination. It was packed in 6 m^3 PACTEC bags and stored within Vault 9 and on the Vault 9 apron.

Work was conducted to determine whether the disposal of Legacy Drum Store waste bags to Vault 8 was acceptable from an ESC and engineering perspective [47]. This work concluded that disposal of the Legacy Drum Store waste in bags is consistent with the ESC and represents an optimised approach. A 2023 BAT update on Vault 8 remaining disposal volume further supported the decision to dispose of the demolition waste in spaces where, owing to size and access issues, we cannot dispose of HHISOs [46].

Emplacement of the B720 rubble into Vault 8 [48] is due to start in June 2026.

5.6 Future Arisings of Solid Radioactive Wastes from Decommissioning

In the future, wastes will arise from decommissioning of site buildings and infrastructure. Decommissioning wastes may arise that comprise radioactive or non-radioactive wastes. This section discusses potential future arisings of radioactive waste. Non-radioactive waste is discussed further in Section 9.

The UKRWI records estimated solid radioactive waste arisings across the site's lifetime, grouped by waste category (Table 5.2). Most waste predicted to arise is in the lowest category, VLLW.

Table 5.2: UKRWI data for the LLWR (2025)

Waste Category	UKRWI Waste Code	Lifetime Total Volume (m^3)
ILW	2N17	35
LLW	2N03, 2N18, 2N04, 2N14, 2N15	244
VLLW	2N06, 2N16	864
Total	1143	

We hold and maintain an official Building Register to provide the definitive list of all LLWR registered facilities, their hazard potential and to indicate responsibility for those facilities where appropriate [35].

The register includes:

- building or infrastructure names, number, purpose and type;
- operations status, and if the infrastructure has been removed or demolished;
- if it has been or still is used for 'active' or 'non-active' purposes;
- construction, operational and planned decommissioning dates;
- planning permission information;
- responsible persons.

The register has fields for building area but is yet to fully collate or collect information on these. As the site develops, we will gather this and further information to determine estimates of decommissioning waste arisings (e.g. material volume etc.).

Radiologically contaminated infrastructure is summarised from the Building Register in Table 5.3, and is marked in Figure 5.1 and Figure 5.2. As each approaches the point it will become waste (i.e. becomes redundant), full characterisation of the radiological and non-radiological properties, material types and volumes will be determined and recorded in the WMP.

Table 5.3: Summary of radiologically contaminated infrastructure from the Building Register

Description	Function	Building Type	Operational Status	Preliminary Views on End State Preferred Option and Assumed Timing
Disposal Area (see Figure 5.1**)**				
Drainage systems including leachate system	Drainage of leachate	See [5]	Operational (or in use)	• In-situ disposal if safe and optimised to do so. • Timing of possible in-situ disposal decision anticipated to be following completion of closure engineering once monitoring confirms leachate generation is minimal.
Trenches 1 to 7	Filled with LLW	See [5]	Care and Maintenance	Disposed waste remains in situ with optimised closure engineering, supported by the ESC.
Vault 8[a]	Radioactive waste disposal	Concrete	Operational (or in use)	
Vault 9[a]	Radioactive waste disposal	Concrete	Operational (or in use)	
Magazine 3	Residual radioactive inventory	Soil, brick and concrete	Final decommissioning	• Above ground material will be used as profile fill or disposal area infill for Vault 8 closure; timing of material usage driven by capping programme.

Description	Function	Building Type	Operational Status	Preliminary Views on End State Preferred Option and Assumed Timing
Magazine 5	Residual radioactive inventory	Soil, brick and concrete	Final Decommissioning	• Below ground slabs are likely to be removed as they are within the footprint of future vaults. The material will be re-used or disposed of as determined by characterisation at that time. Timing linked to Site Development Plan, e.g. when the land is required for future vaults.
Magazine 9	Residual radioactive inventory	Soil, brick and concrete	Final Decommissioning	
Magazine 10	Residual radioactive inventory	Soil, brick and concrete	Final Decommissioning	
Operational Area (see Figure 5.2**)**				
Drigg Grouting Facility	Grouting of LLW containers for disposal in vaults	Steel & concrete blocks	Operational (or in use)	• Assume all surface office or storage buildings and railway infrastructure (e.g. rails, signalling) will be removed. • Safe above-ground structures (e.g. roads, bunded areas, rail sidings) will be left in situ if safe and optimised to do so. • Preferred option for below-ground structures is in-situ disposal if safe and optimised to do so. • Timing to be driven by the Site Development Plan. For the Marine Holding Tanks, the timing of possible in-situ disposal decision
Drum Repacking Facility	Contains drummed PCM waste	Steel frame and cladding	Operational (or in use)	

Description	Function	Building Type	Operational Status	Preliminary Views on End State Preferred Option and Assumed Timing
Marine Holding Tanks (MHT)	For Marine Pipeline	Steel frame and cladding	Operational (or in use)	anticipated to be following completion of closure engineering once monitoring confirms leachate generation is minimal (e.g. during the active institutional control period).
Rail sidings (excluding track)	Unloading waste	Concrete	Operational (or in use)	
Valve station adjacent central monitoring complex	Leachate diverter valve	Glasdon hut	Operational (or in use)	

a Future vaults will be similarly addressed as Vault 8 and Vault 9.

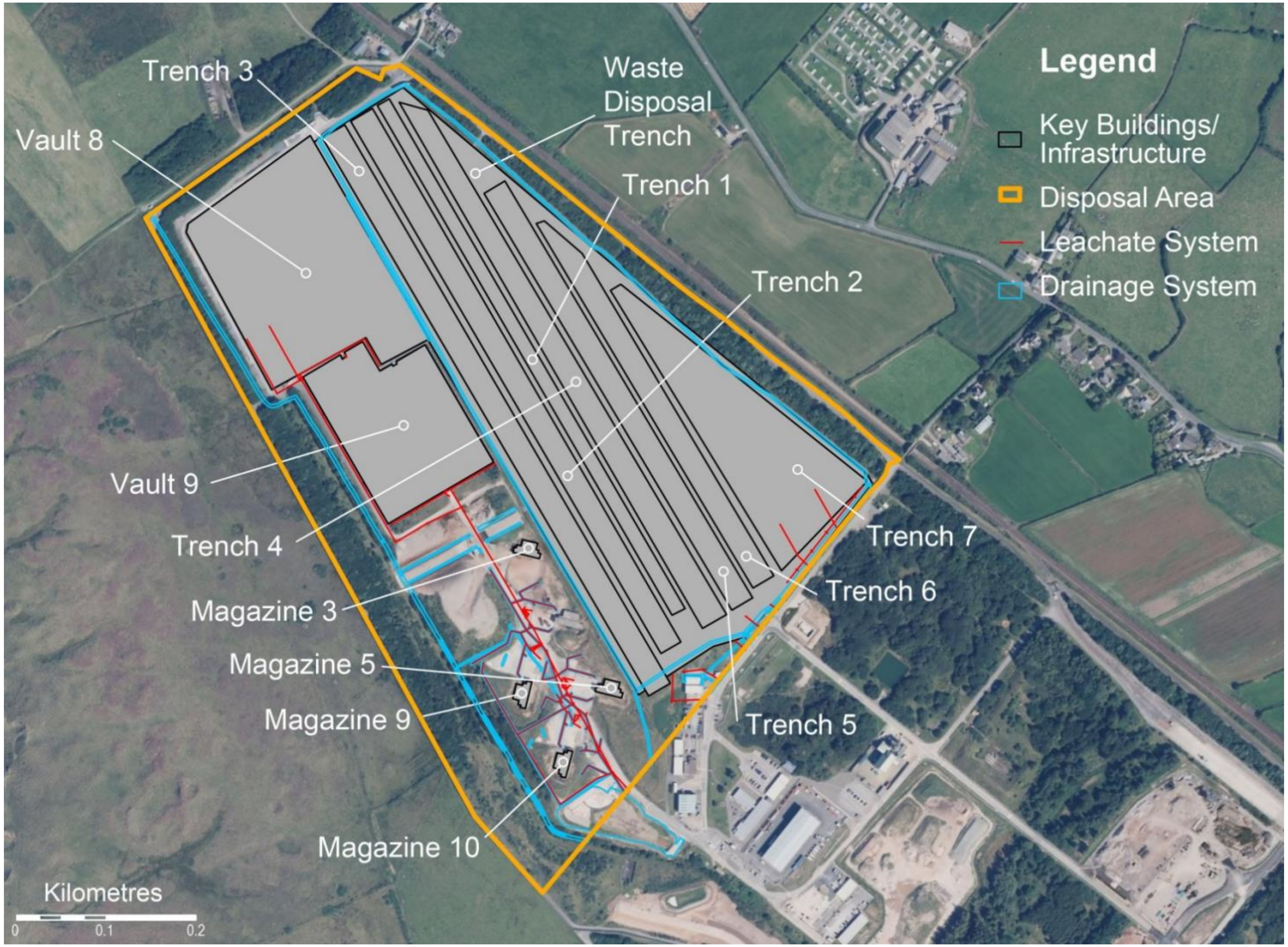


Figure 5.1: LLWR Disposal Area − main infrastructure

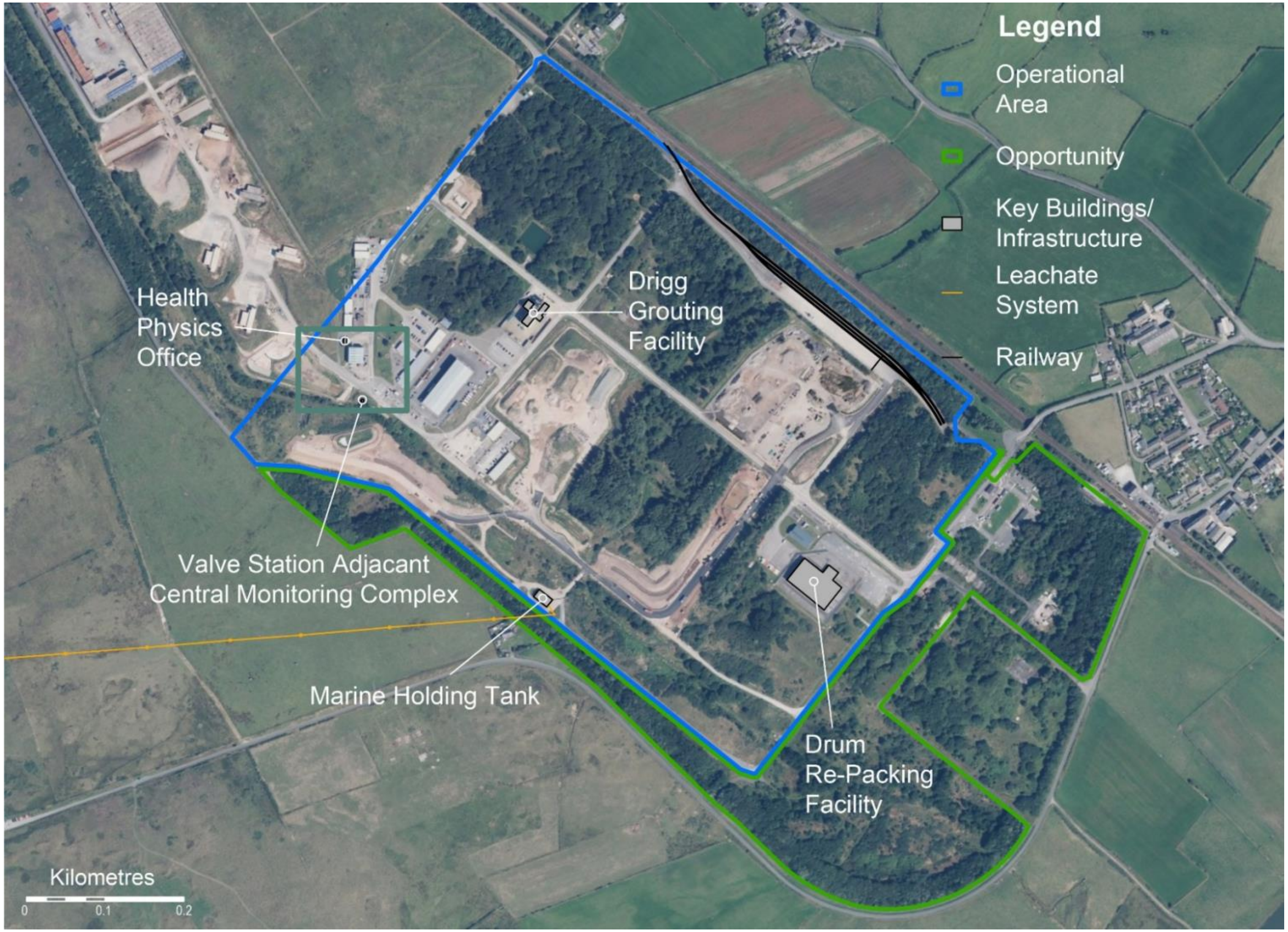


Figure 5.2: LLWR Operational and Opportunity Areas − main infrastructure (the figure does not show the drainage lines of the leachate management system that lead to the MHT − see '*Engineering Design*' report [5])

6 Contamination

6.1 Sources and Types of Contamination

The LLWR site has a complex history involving a range of potentially contaminating activities, including explosives manufacturing, radioactive waste disposal, and the storage of hazardous materials. Assessing the nature, extent, and distribution of contamination is essential to ensure that any risks to human health, site workers, and the surrounding community are properly identified and managed.

We define land contamination as the below-surface accumulation of radioactive and non-radioactive contaminants, excluding authorised disposals within their designated disposal areas or ground contamination that results from an authorised discharge. Land contamination has resulted from the following.

- Contamination from the ROF operations and buildings. Operations on the site involved the storage of raw materials (toluene, sulphur, coal, paraffin, lead, asbestos etc), production of mixing of chemicals (nitric acid, sulphuric acid etc) and ultimately the production and storage of TNT. The majority of these operations were carried out in the southern part of site.
- Ground contamination due to storage of PCM in the magazines (south of Vault 9).
- Contaminant migration from authorised LLW disposal areas (Trenches 1 to 7 and Vaults 8 and 9).
- Migration of contaminants originating from off-site sources such as run-off from agricultural activities.
- Radiologically contaminated concrete slabs (B749, the ROF accommodation building slab adjacent to site entrance, and B741, a former ROF bunded area adjacent to Drigg Grouting Facility) from historic operations.
- Contamination arising from other site operations (vehicle maintenance, cleaning chemicals etc).
- Leakage from the LLWR leachate management system.
- Road and rail (fuel spillage, oil leaks etc).

Wastes disposed of in the repository are permitted for disposal and therefore are not considered to be contaminated land. Leachate generated from water contact with the wastes is collected and discharged to the marine environment via the repository's leachate management system. The collection of leachate from the trenches has not been completely effective [13]. Any leachate released to the geosphere could give rise to contaminated land.

We present our understanding of the historical use of the site in our '*Site History and Description*' report [3].

6.2 Contaminated Land Investigations

A range of data collection and investigation methods have been used to assess the type, extent and location of land contamination on the LLWR site. These investigations are summarised in our '*Hydrogeology*' report [7] and further detail is given in reference [49].

Sources of information include:

- aerial photography;
- recall interviews;
- ROF drawings and records;
- large area gamma surveys;
- borehole investigations;
- surface soil sampling;
- the environmental monitoring programme.

Both radiological and non-radiological contamination from several sources have been identified at the LLWR (see Subsection 6.1). Hazard maps are used to record locations of specific hazards (e.g. radiological contamination, asbestos, unexploded ordnance) and are updated regularly based on investigation findings.

In 2015, a land contamination risk assessment was produced [50] including the development of a conceptual site model and a Tier 1 risk assessment. The conceptual site model was subsequently updated with the results of the risk assessment to include 'areas of concern'. The areas of concern chart the source, type, location and extent of contamination across the site based on our conceptual understanding of the site's historical use and existing site characterisation information, in combination with an interpretation of the level of risk that the contamination presents, in terms of risk criteria that are dictated by the site's interim and final end state. The areas of concern have been used to inform monitoring requirements and to guide a series of site investigations, which were incorporated into an update to the land contamination risk assessment in 2022 [49]. The 2022 assessment revealed five more areas of concern on top of the 15 identified in 2015.

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 [49] 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. The current version documents a total of 32 areas of concern, which are overlaid on the map of the site in Figure 6.1. Further information about each area of concern is provided in Table 6.1. In many locations, one type of contamination is predominant; however, radiological and non-radiological contaminants frequently occur together, therefore, areas of concern are classified along the lines of radiological, non-radiological and mixed.

The screening and assessment levels referred to in Table 6.1 are as follows.

- Non-radiological analysis data are screened against 'suitable for use levels', which are generic assessment criteria denoting suitability for use under the planning regime e.g. suitable for use as a 'public open space'.
- Radiological analysis data are screened against site-specific levels that identify data above the expected background. If a sample value exceeds four standard deviations from the mean (mean +4SD) then it is considered to be above the expected range for the site and requires further investigation.
- For asbestos, decisions and actions are based on relevant legislation e.g. reference [51]. Any visible asbestos is treated as hazardous (with appropriate waste code: 17 06 05). If analysis shows there is less than 0.1% asbestos and none of it is visible, then we do not treat it as hazardous waste [52].

More information on these and other criteria that are used can be found in reference [49]. Where the suitable for use levels or mean +4SD screening levels are exceeded, this acts as a flag for further investigation and informs whether additional risk mitigation is necessary during excavation in the area. Land contamination risks are managed according to our 'Safe Management of Land Contamination' operating procedure [34].

The Land Quality Register will be an important decision-making tool in the options assessment process as we work towards our interim and final end state. Given the legal difference between waste and contamination[7], for the purposes of the WMP, the areas of concern are classified as:

- potential future waste arisings (potential need for future Permit variation); or
- in-situ contamination (not waste unless removed/treated).

This distinction is set out in the 'WMP Status / Future Action' column of Table 6.1. This classification represents our current understanding of each area of concern, and we will update and act upon the classification as necessary as we work towards the Site Reference State. They are based on our understanding from the GRR and the '*On-site disposal of solid radioactive waste on nuclear licenced sites: Joint Regulators Statement of Common Understanding*' [53], which together clarify the following.

- Prior to any specific act of disposal of radioactive waste, which includes the permanent emplacement of radioactive waste into a void or onto land, we must apply for and be granted a Permit variation for that disposal. For waste in situ, where there may be no readily identifiable physical act of emplacement, authorisation is required before operators can leave the waste in situ permanently. Radioactive waste can only be left in situ if safe and optimal to do so. Where decisions are made to leave

[7] Areas of undisturbed ground or groundwater contaminated by radioactivity are not themselves radioactive waste, but their clean-up may produce radioactive waste. Leaving contamination in situ would not be permitted in the same way as leaving radioactive waste in situ. Nevertheless the '*SWESC should demonstrate the safety of all radioactive substances (above RSR out-of-scope values) that the operator proposes to leave on or adjacent to the site, whether radioactive waste or radioactive contamination*' [20].

radioactive waste permanently in situ, we will apply to the Environment Agency for a Permit variation at the appropriate time. We have flagged the need for a future Permit variation in our 'WMP Status / Future Action' classification (Table 6.1) for areas of concern that may represent potential future waste arisings.

- Radioactive contamination in situ is not radioactive waste unless and until it is removed, or if treatment generates waste. Radioactive contamination may be left in situ if it is safe and optimal to do so. Any remediation or treatment of the contamination that generates radioactive waste, needs to be addressed in the WMP and the contamination needs to be considered in the SWESC. Any waste generated would need to be managed under the Permit or a variation sought.

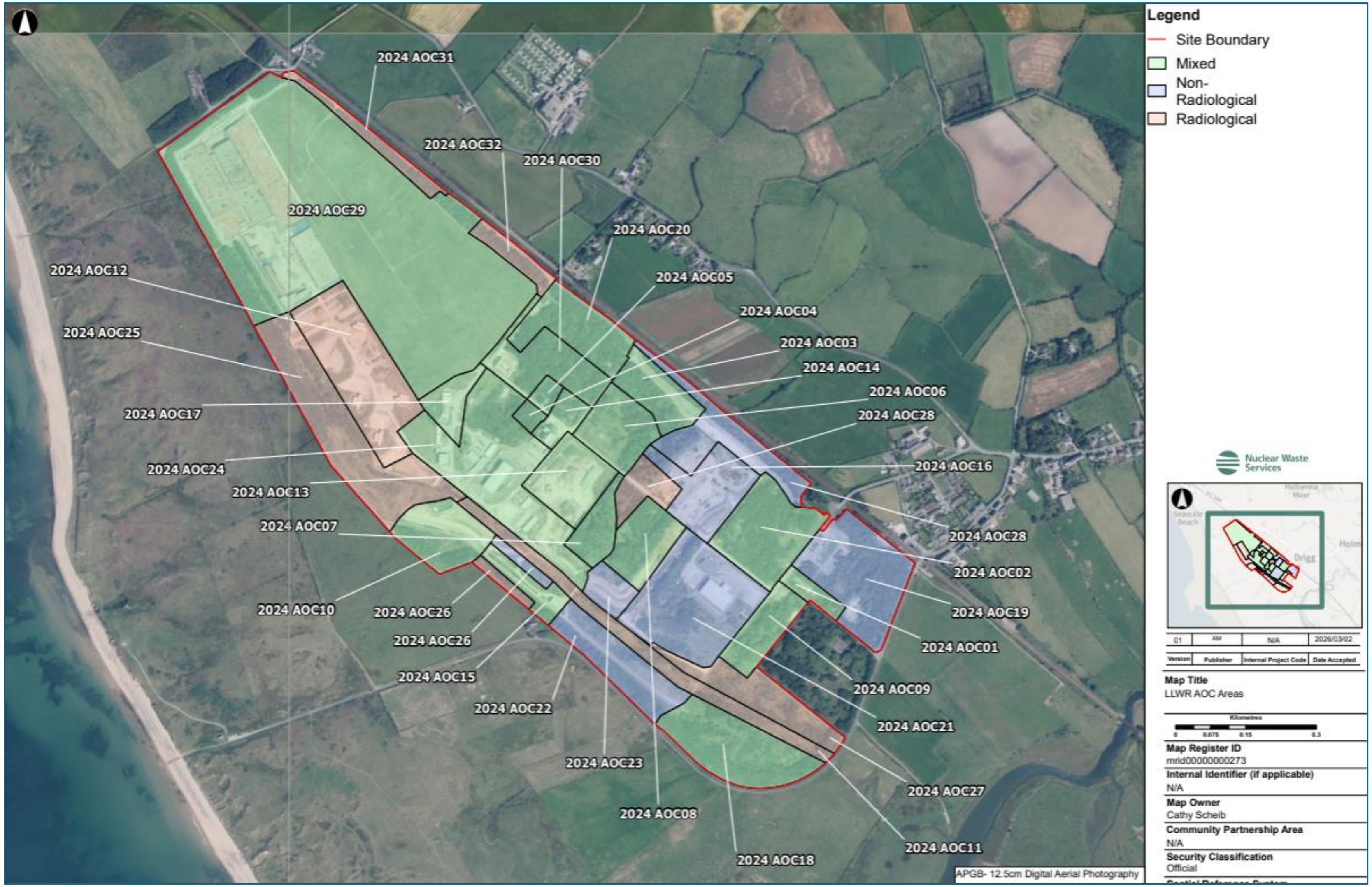


Figure 6.1: LLWR site with areas of concern (AOCs) for radiological, non-radiological and mixed contamination

Table 6.1: Land Quality Register (LQR) summary

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC01 B749 slab and surrounds	Mixed	Radiological and non-radiological contamination identified. Uses: • B749 slab comprises former shop-floor worker wash house; ROF building slabs A10, A10A, A20 and surrounds. No significant contamination is anticipated from this use, though trivial contaminant volumes may be associated with drainage. • The A10 slab is historically known to have been used to store radioactive materials. During this use, contamination is known to have leached and migrated into the A10/A20 slabs and surrounding soils. Known contaminants and levels identified in investigations: • Gross alpha and Cs-137 exceed their mean +4SD levels, with maximum reported levels 4.9 Bq g^{-1} and 1.5 Bq g^{-1}, respectively. • Lead exceeds the LLWR suitable for use levels with a maximum reported value of 2,800 mg kg^{-1}. • Bulk asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	Potential future waste arisings; optimised route to be decided. Further work will be required to identify the optimised route. If we conclude that the optimised approach is in situ disposal or 'disposal for a purpose', then there may need to be a Permit variation. Otherwise, disposal to permitted facility in accordance with Permit.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC02 North of Street 1	Mixed	Radiological and non-radiological contamination identified. Uses: • Producing MNT from precursors toluene, nitric acid, oleum. • Storing spent and mixed acids. • Transporting mixed acids in leaky lead-lined troughs (known lead source and site-wide contamination issue). • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area. • The area is not documented (or known anecdotally) to have been used for any potentially radiologically contaminating uses. However, there have been many bare slabs available throughout the LLWR's operation. Given their known use elsewhere on site, storage of radioactive material cannot be ruled out. As well as the specific precursor manufacturing chemicals associated with the ROF, a variety of associated contaminants and breakdown products may be present in the area. Known contaminants and levels identified in investigations:	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Gross alpha exceeds its mean +4SD levels, with maximum reported level of 3.04 Bq g^{-1}. • Lead exceeds the LLWR suitable for use levels with a maximum reported value of 6,300 mg kg^{-1}. • Suspected contaminants: MNT (and breakdown products), toluene, various acids, cleaning chemicals, oils, fuels, bulk asbestos, metals, polychlorinated biphenyls (PCBs).	
AOC03 Railway sidings	Mixed	Rail sidings are used to bring waste onto the site. Historically skips and containers were not fully enclosed and rainwater that came into contact with waste is reported to have spilt and leached into the area surrounding the rail sidings. Historically a radioactive waste acceptance and TNT production area. AOC03 uses: • Producing TNT from the precursors MNT, toluene, nitric acid, oleum in P21. • Transporting mixed acids in leaky lead-lined troughs (known lead source and site-wide contamination issue). • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		As well as the specific precursor manufacturing chemicals associated with the ROF, a variety of associated contaminants and breakdown products may be present in the area. Known contaminants and levels identified in investigations: • Gross alpha and beta exceed their mean +4SD levels, with maximum respective reported levels of 36.9 Bq g^{-1} and 2.3 Bq g^{-1}, with Am-241 and Pu-isotopes present. • Lead exceeds the LLWR suitable for use levels in one location with a reported value of 4,956 mg kg^{-1}. • Suspected contaminants: TNT (inc. DNT/MNT and breakdown products), toluene, various acids, cleaning chemicals, oils, fuels, bulk asbestos, metals, PCBs.	
AOC04 North of DGF	Mixed	AOC4 includes the site of former Oleum Plant 2 and sulphur storage bins. It is unknown whether underground oleum tanks remain in situ. Known contaminants and levels identified in investigations: • Gross beta exceeds its mean +4SD level, with a maximum reported level of 1.48 Bq g^{-1}. This exceedance is thought to be due to elevated background and is not expected to require radiological remediation.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Suspected contaminants: oleum, sulphur, cleaning chemicals, oils, fuels, bulk asbestos, PCBs.	
AOC05 Fire pond and surrounds	Mixed	AOC5 is only known historically to have been used as a storage pond for clean water and its associated pumping house. There is no documented or anecdotal radiological use known. However, radiological contamination has been identified in the soils in the forebay of the fire pond. Known contaminants and levels identified in investigations: • Gross beta exceeds its mean +4SD level in several locations, with a maximum reported level of 4.47 Bq g^{-1}. • No unusual Pu or U activity in samples and no unusual gamma emitters found. • Further investigation required to find out what isotopes are causing the elevated activity. Suspected contaminants: possible very localised oils associated with the pumping gear, possible bulk asbestos.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC06 B741 and B713 slab and surrounds	Mixed	AOC06 is a former ROF TNT production area that had later use as a radioactive waste store that has led to complicated contamination issues. It retains its ROF-era earth-bunds built to minimise explosion disruptions.	In situ contamination (not waste unless removed/treated) as radiological contamination not associated with the slabs.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		AOC06 uses: • Northern leg of the TNT nitration facilities, P22 (B713) and P23 (B741) producing TNT from precursors MNT, toluene, nitric acid, oleum. • Mixed acids transported in leaky lead-lined troughs (known lead source and site-wide contamination issue) and pumped in P51. • Following demolition of P22 and P23, P23's retained slab was used by BNFL to store PCM, which leaked and leached to contaminate the slabs and surrounds. • P22 (B713) was used as a police firing range. Known contaminants and levels identified in investigations: • Radiological remediation works were undertaken in 2007 to address Pu contamination in P23/B741. This work secondarily identified significant solidified bulk TNT contamination (which was itself contaminated by plutonium) in the soils. Remediation efforts were undertaken, reducing activity in the area and removing some bulk TNT. The project met Pu remedial targets using in-situ measurement equipment. No validation sampling was carried out. As such, actual Pu levels in	Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		the area are unknown and bulk TNT remains. Significant further remediation work is required. • Elevated alpha results have been found throughout the P22/B713 bunded area with some beta exceedances (maximum measured value of 6 Bq g^{-1}). Laboratory analysis could not identify the isotope(s) causing these values and further investigation is required to establish which are causing the elevated activity. • Lead exceeds the LLWR suitable for use levels in several locations with a maximum reported value of 710 mg kg^{-1}. • Almond odours have been observed during borehole drilling suggesting the presence of MNT/TNT. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	
AOC07 South of Stockpile C	Mixed	Uses: • ROF P25 (TNT drying and packing plant) was in this area historically, along with associated roads and infrastructure.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Mixed acids were transported in leaky lead-lined troughs (known lead source and site-wide contamination issue). • The buildings have been demolished and the bund removed. The area is thought have existed as woodland since. Known contaminants and levels identified in investigations: • Suspected contaminants: TNT (inc. DNT, MNT and breakdown products), toluene, various acids, cleaning chemicals, oils, lead fuels, bulk asbestos, PCBs. • No radioactively contaminating processes are known to have taken place in this area, but elevated alpha results have been observed (maximum recorded value of 2.5 Bq g^{-1}).	
AOC08 South of the East-West Stream	Mixed	Radiological and non-radiological contamination identified in this area. Known potentially contaminating uses are exclusively ROF era, comprising: • Southern leg of the TNT washing and drying/packing facilities. • P29 – 'Washing' plant for removing impurities from TNT.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• P62 – TNT drying, flaking and packing plant. • ‘Gearbox’ – unknown paved area, likely a storage facility • Railways, access paths. Mixed acids were transported in leaky lead-lined troughs (known lead source and site-wide contamination issue). • The washing facilities of P29 were used during post-war explosives decommissioning to perform experiments on the production of carbon black. The buildings were demolished with the bunds removed by the 1990s, though foundation slabs and drainage remain. The area is not documented or known anecdotally to have been used for any radiologically contaminating processes during the repository period, however radiological contamination was found in shallow trail pits around the area. In a targeted investigation of ROF P29 triggered by these findings and development works, an area of plutonium contamination in soil was characterised and remediated. Later unrelated excavations in the structure encountered TNT-related ‘red water’ and crystallised material believed to be TNT and derivative products/impurities. Known contaminants and levels identified in investigations:	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Radiological remediation works were undertaken in 2022 to address an area of Pu contamination well-characterised by trial pit works found at P29. Contamination was delineated in the shallow infill material (<1.0 m) in the razed P29 structure, whose main building slab was, unusually, situated below ground level and below the level of an adjacent rail slab. It is postulated waste stored on this rail slab leached to contaminate the infill, though other scenarios are plausible. Remediation efforts excavated and disposed of the material off site. • Later, civils works encountered 'red water' contamination and crystallised TNT, DNT and by-products associated with the P29 drainage and surrounding slabs. The area was made safe and characterisation and remediation works are planned. • Excluding P29, elevated alpha and beta results have been found in various places in shallow trial pits across AOC08 with maximum exceedances of 2.0 Bq g^{-1} and 4.0 Bq g^{-1}, respectively. Further investigation is required of these. • Gamma scans of the 'Gearbox' structure detected elevated readings. Spectral analysis identified Cs-137	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		as a possible contaminant. Further investigation required. • Lead exceeds the LLWR suitable for use levels in several locations with a maximum reported value of 2,740 mg kg^{-1} • Small asbestos finds made in the area associated with drainage and in the demolition infill material of P29. • Elevated alkalinity (pH 12.27) found in waters at P29. Believed to be associated either with TNT 'washing' chemicals (sodium carbonate), or potentially with lime-rich concretes used in P29 construction. Detected elevated metals may be associated with this pH. • Suspected: TNT (inc. DNT/MNT and breakdown products) around P62, various acids cleaning chemicals, oils, lead, fuels, bulk asbestos, PCBs.	
AOC09 North of landfill site	Mixed	Radiological and non-radiological contamination identified. AOC09 not documented or known anecdotally to have been used for any radiologically contaminating processes, however the area was cleared of ROF buildings by the 1960s leaving slabs available for use. Known potentially contaminating uses are exclusively ROF era, comprising:	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• P1 and P2 nitric acid production plants and associated buildings (storage facilities, retort houses, condensers, gas producing plants, gas holders etc.) • Acids were transported in leaky lead-lined troughs (known lead source and site-wide contamination issue). • A demolition-period ROF-material asbestos tip. Known contaminants and levels identified in investigations: • Elevated alpha and beta results have been found in a single location from shallow trial pits across AOC09 with maximum exceedances of 2.1 Bq g^{-1} and 2.4 Bq g^{-1}, respectively. This is adjacent former ROF P69. Further investigation of all slabs is required • Lead exceeds the LLWR suitable for use levels in multiple locations with a maximum reported value of 1,500 mg kg^{-1}. • Asbestos from historical ROF building demolition is known to be present in small amounts in the ground in this area and in larger amounts in what appears to have been an asbestos tip to the west of the zone.	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Suspected: acids, cleaning chemicals, oils, lead, fuels, bulk asbestos, PCBs, coal tar, ammoniacal liquors, tar tanks, other gasworks-related contamination.	
AOC10 West of Drigg Stream	Mixed	AOC10 appears to have been used as a storage area and later a burning ground during operation of the ROF. Slag and partially burned metallic items are evident and several decommissioned ordnance parts have been found at shallow depths. Known contaminants and levels identified in investigations: • Elevated alpha and beta results have been found in several locations in shallow trial pits across AOC10 with maximum exceedances of 1.8 Bq g^{-1} and 5.1 Bq g^{-1}, respectively • No heavy-metal contamination found, but further radiological and non-radiological assessment of the surface slag is required to ensure that the elevated total alpha and total beta results do not indicate significant areas of contamination and to ensure heavy metal concentrations are correctly assessed. As the area has been used as a burning ground, there is the possibility that asbestos is present.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC11 Drigg Stream and Banks	Radiological	Radiological contamination from historical authorised discharges is present from approximately the location of the historical leachate input near GD4 to the site boundary. This was initially limited to the stream cutting, however historical dredging also emplaced some of this material in non-continuous strips parallel to Drigg Stream on the eastern and western banks. Known contaminants and levels identified in investigations: • Investigation has found that contamination on the banks appears to be limited to approximately the top 500 mm of soil. • The maximum reported total alpha, total beta and Cs-137 results from the banks came from a single sample and were 24.1 Bq g^{-1}, 15.0 Bq g^{-1} and 5.4 Bq g^{-1}, respectively. Levels have more typically been found to be an order of magnitude lower than this. Pu-238, Pu-239/240, Pu-241 and Am-241 were detected in the sample at 0.2 Bq g^{-1}, 5.0 Bq g^{-1}, 3.8 Bq g^{-1}, 1.3 Bq g^{-1}, respectively. Further characterisation and delineation of contamination of the banks for the full length of the stream is required.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Gamma scans have been undertaken along large sections of the stream banks alongside physical sampling, which have allowed us to assess contaminant spread and likely risk, though further study is required, particularly regarding differential nuclide transport. • Elevated alpha, beta, gamma levels have historically been detected in Drigg Stream. Further investigation of this is required.	
AOC12 ROF magazines area	Radiological	AOC12 has historical radiological and non-radiological known uses: • During ROF era, ten magazines were constructed for storing dried and packed TNT, eight of these are within AOC12 and two (M1 and M6) were outside AOC12 and are now beneath Vault 9. These were brick/concrete structures within earthen mounds. • Railways (since removed) were built in the area. • During LLWR era, Magazines 1 to 10 were used for storing drummed plutonium contaminated waste. • Magazines 1, 2, 3, 6, 7, 8 were demolished for the construction of Vaults 8 and 9 in the mid-1990s. Limited	Potential future waste arisings. Potential need for future Permit variation for any waste arisings (although unlikely since all material will be removed prior to construction of new vaults).

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		documentation or anecdotal evidence is available for this work. Their structures and footings are believed to have been entirely removed. • Land drainage linked to the leachate management system was constructed to address flooding at Magazines 9 and 10, which remains in situ but is scheduled for decommissioning in 2026. No radiological impact is associated with this infrastructure. • Magazines 3, 4, 5, 9, 10 were decontaminated using purpose-built material recovery facilities and have since been fully excavated/exposed and cleared for demolition. Known contaminants and levels identified in investigations: • Whilst PCM has been removed from site and the magazines have been decontaminated, it is expected that historical waste storage in the area may have led to plutonium contamination within the ground. • Magazines 9 and 10 previously flooded, leaching contaminants to the forebays and leading to installation of a surrounding French drain and remedial excavation work undertaken in the early 1990s. Further intrusive	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		ground investigation has recently (2025) been undertaken adjacent to them, which has identified significant alpha contamination in one location close to Magazine 9 at 12.5 Bq g^{-1} gross alpha. All other samples in this extensive investigation found no evidence of gross contamination, though no samples were available from directly below the structures. Further sampling will be required during demolition. • Magazines 3, 4 and 5 require intrusive investigation. • Significant radiological contamination has recently (2025) been detected between Magazines 2 and 3 adjacent to the new haul road access to the trench cap. Initial impact characterisation is ongoing, but preliminary results suggest levels of Am-241 of 176 Bq g^{-1}, which is strongly suspected to be a PCM-related. No anecdotal or documentary evidence for the provenance of this material is available. Further work is required.	
AOC13 Stockpile C	Mixed	Radiological and non-radiological contamination has been identified in AOC13. Known potentially contaminating uses are: • Northern leg of the TNT washing and drying/packing facilities.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• P24 – 'Washing' plant for removing impurities from TNT. • P60 and P61 – TNT drying, flaking and packing plant. • Unknown building (likely shelter/latrine). • The washing facilities of P24 were used during post-war explosives decommissioning to perform experiments on the production of carbon black. Also used for mixing powdered fluorescein dye into solution for Sellafield tidal tests. • TNT process water trunk-drain from TNT nitration facilities later used for PCM storage. • Railways, access paths. Mixed acids were transported in leaky lead-lined troughs (known lead source and site-wide contamination issue). Buildings were demolished and bunds removed by the 1990s. Recent (2022) works entirely removed residual P66 and P61 structures. P24 was only partially excavated following discovery of fluorescein dye contaminants, and TNT issues at the sister P29 plant − foundation slabs and drainage remain. AOC13 not documented to have been used for any radiologically contaminating processes during repository use,	required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		however it is possible the slabs were used for storage. There is anecdotal hearsay radium dials were kept in this area, though surveys in 2022 did not encounter any evidence of this. Known contaminants and levels identified in investigations: • Minor civils works encountered fluorescein dye at P24. Due to its non-toxic nature, no remediation was undertaken, however coupled with TNT findings at the very similar P29, it was decided further disturbance was best avoided until potential contamination issues were better understood. The area was made safe and remaining structures reburied under Stockpile C running surface. Further investigation is required on change of land use to investigate for TNT (inc. DNT/MNT and breakdown products), various acids cleaning chemicals, fluorescein, oils, lead, fuels, bulk asbestos, PCBs etc. • Elevated alpha and beta results have been found in various places in shallow trial pits across AOC13 with maximum exceedances of 2.5 Bq g^{-1} and 5.8 Bq g^{-1}, respectively. Further investigation may be required. • No contamination was encountered on demolition of P60 and P61.	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC14 DGF and area south of the fire pond	Mixed	Potential radiological and non-radiological hazards. Uses: • Small buildings in AOC14 during ROF operation comprising water treatment facility and an air compressor house. • Not known to have been used for any potentially radiological uses until construction of Drigg Grouting Facility (DGF) in the 1990s. ISO containers are stored and grouted within the DGF forecourt. An underground suspect active tank taking effluent from the DGF is also located here. • Bare slabs at P34 and P35 available throughout the LLWR's operation. Given their known use elsewhere on site, storage of radioactive material cannot be ruled out. • Boreholes and trial pits in the area suggest there may be slag/ashy infill and asbestos in some locations under and around the DGF. Known contaminants and levels identified in investigations, historical works: • Suspected contaminants: possible slag/ashy backfill, cleaning chemicals, oils, fuels, PCBs etc. Radiological	Potential future waste arisings; optimised route to be decided. Further work will be required to identify the optimised route. If we conclude that the optimised approach is in situ disposal or 'disposal for a purpose', then there may need to be a Permit variation. Otherwise, disposal to permitted facility in accordance with Permit.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		contaminants may be present under the DGF, sampling of which is not practicable at this time. • Bulk asbestos is known to be located to the north of the DGF car park and it is possible more bulk finds may be made in the area.	
AOC15 North of the MHT	Mixed	Potential radiological and non-radiological hazards. Uses: • No specific known ROF use, though aerial photographs show tracks in the area. • Known LLWR uses are limited to the construction of the Marine Holding Tanks and leachate management system. No further potentially radiologically contaminating processes known to have been undertaken. Known contaminants and levels identified in investigations: • Elevated alpha and beta results have been found in various places in shallow trial pits across AOC15 with maximum exceedances of 6.1 Bq g^{-1} and 2.9 Bq g^{-1}, respectively. Further investigation may be required.	Potential future waste arisings; optimised route to be decided. Further work will be required to identify the optimised route. If we conclude that the optimised approach is in situ disposal or 'disposal for a purpose', then there may need to be a Permit variation. Otherwise, disposal to permitted facility in accordance with Permit.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Evidence of heavy-end hydrocarbon contamination was found in boreholes in 2021 in the upper 4 m. Further investigation required. • The Marine Holding Tanks and Marina Pipeline are located within this area and may be a source of contamination through leaks, though no leaks are currently known.	
AOC16 ROF nitration plants	Non-radiological	Former ROF TNT production area. It is now an aggregate stockpile. Uses were: • Southern leg of the TNT nitration facilities (P26, P27, P28), producing TNT from precursors MNT, toluene, nitric acid, oleum. • Mixed acids transported in leaky lead-lined troughs (known lead source and site-wide contamination issue) and pumped in P52. • Cluster of largely unknown, but likely administrative ROF buildings north of the nitration plants (A4A, A16C, A79, A83, S11, S18). A79 is known to have been an office. Buildings are believed to have been cleared to slab level around the 1970s. Drains and slabs remain in situ today. Earth	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		bunds excavated for trench cap fill, shallow land drains (above slab/drainage level) installed, and the area planted with cash-crop conifers through the 1980s. In 2020, AOC16 was cleared and redeveloped as a stockpile, again above slab level. Known contaminants and levels identified in investigations: • Almond odours were detected during construction of the stockpile in some deeper sections consistent with evidence of TNT contamination. This requires significant further investigation on development. • No elevated radiation has been detected in AOC16. • Lead exceeds the LLWR suitable for use levels in several locations with a maximum reported value of 7,683 mg kg^{-1} likely related to the acid lines. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in AOC16.	
AOC17 Workshop and southern trench boundary	Mixed	Potential radiological and non-radiological hazards. Uses: • In ROF use, area held A13 complex, which were empty box stores and a joiner's shop. • In LLWR use this has largely been a workshop, roads, or grassed areas, though a track is known to have existed between the offices and the trench cap. Area	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		contains the western trench leachate chambers and stretch of pipeline. Known contaminants and levels identified in investigations: • Elevated alpha results found in various places in shallow trial pits across AOC17 with maximum exceedances of 5.2 Bq g^{-1}. Gamma surveys have identified several hotspots, one of which coincides with the existing 5.2 Bq g^{-1} alpha level. These require further investigation. • Operations and materials storage could have led to historical non-radiological ground contamination, such as oils, fuels, metals, cleaning chemicals etc. requiring investigation on redevelopment. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	
AOC18 Toluene tanks	Mixed	Potential radiological and non-radiological hazards. Uses: • ROF storage and pumping facilities ('toluene tanks') for liquid production-feedstock in earthen bunds known to have contained toluene and 'Borneo Spirit' (believed to have been a fuel oil similar to kerosene).	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• A tributary to Drigg Stream bisects AOC18 and may have been contaminated by sediments from Drigg Stream transported upstream due to being within the tidal reach. The ROF toluene tanks, which are documented to have been emptied and cleaned on site handover, remain in situ and are accessible through concrete tunnels. The area has no documentary or anecdotal evidence of other radiological or non-radiological uses. Known contaminants and levels identified in investigations: • Elevated alpha and beta results found in various places in shallow trial pits across AOC17 with maximum exceedances of 1.9 Bq g^{-1} and 2.4 Bq g^{-1}, respectively. Further investigation is required to determine if this is background activity and there is no obvious spatial association of these results to current or former infrastructure. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	
AOC19	Non-radiological	Potential radiological and non-radiological hazards. Uses:	In situ contamination (not waste unless removed/treated).

LQR Reference	Contamination Type	Description	WMP Status / Future Action
South-east corner		• In the ROF, this was an administrative area containing several buildings, though it also included a laboratory for TNT testing (A9). • Bare slabs were available throughout the LLWR's operation, particularly at the neighbouring A10/B749 slab. Given their known use elsewhere on site, storage of radioactive material cannot be ruled out in AOC19. It has otherwise been used for administrative purposes. Known contaminants and levels identified in investigations: • Lead exceeds the LLWR suitable for use levels in several locations with a maximum reported value of 770 mg kg^{-1}. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area. • Possible TNT and precursor chemicals around A9. Further investigation is required. • Potential radiological materials associated with waste storage. Further investigation is required.	Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC20	Mixed	Potential radiological and non-radiological hazards. Area uses:	In situ contamination (not waste unless removed/treated).

LQR Reference	Contamination Type	Description	WMP Status / Future Action
Trench cap haul road		• AOC20 is historically known to have been used as a haul road for LLW from the rail sidings to the trenches. • No significant ROF use known. Known contaminants and levels identified in investigations: • Elevated alpha and beta results found in various places in shallow trial pits across AOC20 with maximum exceedances of 6.2 Bq g^{-1} and 3.6 Bq g^{-1}, respectively. This requires further investigation. • Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC21 Site Emergency Control Centre	Mixed	Potentially contaminating radiological and non-radiological land uses relevant from ROF period: • P30 – TNT drying and packing plant. • P63 – TNT drying and flaking plant. • P3/3A – sulphuric acid plant. • P5 – gasworks/producer to P3. • P8/P9 – de-nitration vat house, de-nitration slabs/plant. • P4 – sulphuric acid storage.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• A16/A16A – machine shops. • A17 – plumber's shop. • A37 – diesel paint and oil store. • A36 – sample store. • A62 – de-superheater house. • P19 – oleum. • Various unknown buildings/sheds associated with the rail lines. • Rail lines. • Area of 'clear' ground currently covered in light grassland may have undergone significant infilling based on historical logs. It is unknown where such infill material originated. Known contaminants and levels identified in investigations: • Elevated alpha result found in a single location out of over 30 shallow trial pits across AOC21 with a maximum exceedance of 2.8 Bq g^{-1}.	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Asbestos from historical ROF building demolition may be present in small or large amounts in the ground in this area. • Operations and materials storage could have led to historical radiological and non-radiological ground contamination at and around a variety of former ROF slabs with contaminants including radionuclides, oils, fuels, explosives, metals, cleaning chemicals, asbestos, acids, sulphur, gasworks contamination etc. requiring investigation on redevelopment. • Lead has been found to exceed the LLWR suitable for use levels in several locations with a maximum reported value of 2,800 mg kg^{-1}. • Bare slabs were available throughout the LLWR's operation covering most of the buildings listed above. Given their known use elsewhere onsite, storage of radioactive material cannot be ruled out in AOC21.	
AOC22 Nitre cake and coke dump	Non-radiological	Potential radiological and non-radiological hazards. Uses: • In the ROF, the area was used as a nitre cake dump, saltpetre store and reserve coke dump. • No significant LLWR use known.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		Known contaminants and levels identified in investigations: • Asbestos from historical ROF building demolition may be present in small or large amounts in the ground in this area. • Lead has been found to exceed the LLWR suitable for use levels in several locations with a maximum reported value of 960 mg kg^{-1}, these may be related to historical road networks. • Suspected contamination associated with ROF uses.	required to identify the optimised route.
AOC23 Duck Pond	Non-radiological	Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area. No other known significant ROF or LLWR uses in the area. The pre-ROF 'Old Shore Road' passed through this area and is known to have been capped with 'blacktop' containing coal tar. Sections of this have been unearthed and remediated locally, but more may remain in situ. Known contaminants and levels identified in investigations: • Elevated alpha and beta results found in a single location with respective maximum exceedances of 1.8 Bq g^{-1} and 1.5 Bq g^{-1} – possibly background values.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC24 B728 and surrounds	Mixed I	Potential radiological and non-radiological hazards. Uses: • Relevant from ROF period: o Oleum Plant 1, sulphur bins and P81 (sulphite store). o A47 and A72 – substation, vehicle decontamination. o Rails and sidings. o Unknown storage uses (netted covered stores). • Relevant from LLWR period: o Edge of DGF. o Vehicle wash building. o Area contains a stretch of the trenches leachate pipeline. Known contaminants and levels identified in investigations: • Elevated alpha and beta results found in two separate locations out of over 30 shallow trial pits across AOC24 at 1.6 Bq g^{-1} and 7.1 Bq g^{-1}. • Multiple unexploded ordnance (mostly small arms) finds across the area. Possibly related to covered/netted stores.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		• Asbestos from historical ROF building demolition is known to be present in significant amounts in the ground underlying the DGF car park and surrounds. There may be more asbestos across AOC24. • Possible trace TNT and precursor chemicals in soakaway associated with A72. Unlikely to be a significant hazard. • Defined hotspot identified in gamma surveys near A72 (Th-232 nuclide identified at dose rate of 1.5 μS h^{-1}). • Diffuse hotspot identified in gamma surveys near ROF A13. • Suspected range of contaminants associated with ROF usage include acids, cleaning chemicals, oils, lead, fuels, bulk asbestos, PCBs.	
AOC25 Lagoon F and surrounds	Radiological	No significant ROF use known. Gamma scans have identified presence of a radiological hotspot in the south-east of the area associated with Drigg Stream sediments. This has been extensively investigated with sampling detecting elevated gross alpha (8.7 Bq g^{-1}), gross beta (4.9 Bq kg^{-1}), Pu239/240 (1.4 Bq kg^{-1}), Cs-137 (2.8 Bq g^{-1})	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		and the extents of contamination delineated. This is scheduled for remediation in 2026.	
AOC26 Burning Grounds	Non-radiological	Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area. Small risk of radiological contamination at above background activity. Evidence of ROF ordnance burning pits have been identified here. Potential for metal and unexploded ordnance contamination.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC27 Boiler Room 1	Mixed	Potentially contaminating radiological and non-radiological land uses: • A24 – Boiler Plant No. 1. • P80 – anhydrous ammonia storage. • Route of toluene duct to toluene tanks passes through area. A product pumping station was also likely located here. • Rail and sidings with contaminants associated with nearby facilities. • Bare slabs were available throughout the LLWR's operation from the buildings listed above. Given their	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		known use elsewhere onsite, storage of radioactive material cannot be ruled out in AOC27. • AOC27 currently covers part of land known to be impacted with Drigg Stream dredging contamination. Known contaminants and levels identified in investigations: • Elevated alpha result found in several locations associated with Drigg Stream contamination with a maximum exceedance of 1.9 Bq g^{-1}. • Lead has been found to exceed the LLWR suitable for use levels in several locations with a maximum reported value of 1,700 mg kg^{-1}, these may be related to the historical road/ rail networks. • Elevated gamma associated with Drigg Stream contamination has been located associated during gamma scans. • Asbestos from historical ROF building demolition may be present in small or large amounts in the ground in this area. • Suspected non-radiological contamination from ROF A24 and P80 and rail use: oils, fuels, metals, cleaning	

LQR Reference	Contamination Type	Description	WMP Status / Future Action
		chemicals, asbestos, product (toluene, paraffin, ammonia), gasworks contamination, waste coke coal.	
AOC28 East-West Stream	Non-radiological	No radiological or non-radiological contamination known. No significant historical land uses in AOC28, however near to nitration facilities and East-West Stream, so there is a possibility of TNT production contamination in surface waters. Asbestos from historical ROF building demolition may be present in small or large amounts in the ground in this area.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC29 Trenches and vaults	Mixed	AOC29 has largely been completely remodelled and engineered as the trenches and the vaults, both of which are beyond the scope of the LQR as authorised disposals documented elsewhere. Dispersed alpha and beta contamination have been identified in soils in one area in AOC29 on the eastern boundary believed to be associated with historical trench capping activity. Maximum gross alpha and beta were 62.1 Bq g^{-1} and 14.4 Bq g^{-1}, respectively. This is currently pending further investigation and remediation scheduled for 2027.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

LQR Reference	Contamination Type	Description	WMP Status / Future Action
AOC30 Mireside	Mixed	No known significant ROF uses in the area. Area incorporates some sections of the leachate management system. Asbestos from historical ROF building demolition may be present in small amounts in the ground in this area.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC31 Trench north-east	Radiological	Possibility of radiological contamination from historical spillages during waste processing and disposal operations.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.
AOC32 Trench south-east	Radiological	Possibility of radiological contamination from historical spillages during waste processing and disposal operations.	In situ contamination (not waste unless removed/treated). Future optimised management to be decided. Further work will be required to identify the optimised route.

6.3 Optimisation of the Management of Contaminated Land

We have undertaken a significant amount of work in recent years to better understand the contaminated land on the site, which has allowed us to produce the Land Quality Register.

Although we have a reasonably good understanding of the extent of the land contamination and legacy in-situ structures across the site, we have not yet undertaken the full process of site-wide optimisation that is required to determine the preferred management options needed to bring the site to a condition that is suitable for its next use. The Land Quality Register will be an important tool in this decision-making process.

The optimisation of the management of the contaminated land may require further targeted characterisation, plans for which will be considered on a case-by-case basis and be proportionate to the hazard. This will be guided by our current understanding of the areas of concern identified in Table 6.1.

We will undertake our programme of site-wide optimisation during the operational period of the site. We will arrive at an optimal end state that is consistent with the preferred next use and develop our view on the preferred waste management options. We will undertake this work at a point that allows us to iterate these plans with the final detailed engineering plans for the completion of closure engineering. We anticipate this being no later than 2100.

6.3.1 Environmental Safety of Contaminated Land

Our land contamination risk assessments [49] show that the risks are low given the current land use and management procedures that are applied.

Measured quantities of non-radiological contaminants (excluding asbestos) in soil samples are screened against two sets of assessment criteria relevant to the site’s current use (Commercial) and its end use (Public Open Space). The criteria are derived from the planning regime and are therefore generic and may be cautious [49].

Only lead is detected at concentrations that exceed the screening criteria. The screening criteria for lead are 1,100 mg kg^{-1} and 580 mg kg^{-1} for the Commercial and Public Open Space land uses, respectively. Exceedances for lead are generally detected in the south-east area of the site (Figure 6.2). The maximum measured concentration of lead is 6,400 mg kg^{-1}. The risk associated with the lead contamination is principally mitigated by controlling access to the affected areas prior to any necessary remediation being carried out.

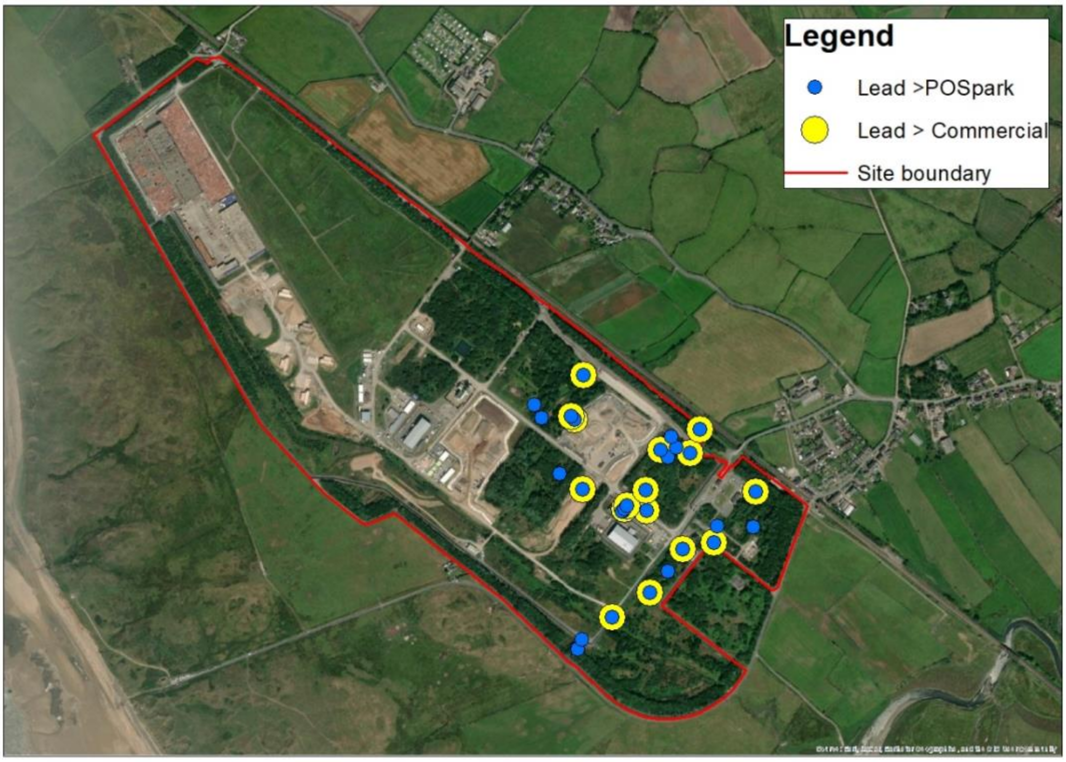


Figure 6.2: Detections of lead on the site

Radiologically contaminated land is assessed by considering the doses associated with the disturbance of a volume of soil that is radiologically contaminated to the maximum extent measured in a single soil sample from the site (0.041 GBq t^{-1} alpha, 1.6 GBq t^{-1} beta). Our assessment [49] shows that over 18,500 m^3 of soil would need to be disturbed to exceed a dose to the public of 1 µSv and 142,000 m^3 would need to be disturbed to exceed the dose threshold to workers (2 mSv).

The uncontrolled movement of this quantity of soil is not credible. We have procedures in place for material re-use that require the material to be screened, assessed and tested prior to use [54]. Furthermore, the dose to the public considered in this assessment (1 µSv) is much lower than the dose constraint in Requirement 9 of the GRR of 0.3 mSv from any source from which radioactive discharges are made [20].

Our assessments show that the concentrations of radiological and non-radiological contaminants in the contaminated land are generally low. Their contribution to the overall risk presented by the facility is negligible. Public access to the site will remain restricted throughout the Period of Authorisation. Any interim end state that allowed for public access prior to permit surrender would involve remediation of the site to the extent that any accessible areas are demonstrably safe.

We further control access within the site perimeter to specific areas of concern so that workers do not come into contact with or cause accidental disturbances to contaminated land. We maintain a Land Quality Register (see Subsection 6.2) that documents our current and evolving understanding of land contamination. Plans for site development are informed by the Land Quality Register, such that appropriate precautions are in place if any works are undertaken in the affected areas.

The controls and procedures that we implement are effective in limiting the exposure pathways to contaminated land, rendering the site safe in its current use. These controls and procedures are:

- NWSSOP 02.06.01 − Safe Management of Land Contamination [54], which defines our framework for the safe management of land contamination, requiring contaminated land to be identified, risk-assessed, controlled and recorded using a proportionate, risk-based approach that supports controlled excavation, asbestos management, and environmental protection across the LLWR site;
- NWSSOP 47.04 − Management and Control of Asbestos [52], which sets out our requirements for managing asbestos as a form of non-radiological land contamination, ensuring asbestos present in soils, made ground or structures is identified, risk-assessed and controlled, with disturbance prevented or managed through defined working methods, competent personnel, designated areas, appropriate waste handling and formal records to protect people and the environment;
- NWSSOP 56.05_01 − Control of Excavation Activities (Permit to Dig) [55], which establishes the controlled excavation and Permit to Dig process at LLWR, requiring all excavations to be authorised, hazard-screened, depth-limited and supported by formal excavation information and declarations, thereby preventing uncontrolled disturbance of buried services and contaminated land, including asbestos.

We implement an extensive environmental monitoring programme [9]. The monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards. The evidence for this is presented in our:

- '*Hydrogeological Risk Assessment*' report [15], which presents monitoring data in support of the argument that the LLWR is not having an adverse impact either on groundwater or on surface water;
- '*Environmental Safety During the Period of Authorisation*' report [13], which presents monitoring data relevant to discharges to air, surface water and groundwater, and radiation dose measurements at the site boundary in support of its assessment of the site's environmental impact.

These reports are principally concerned with the risk associated with the designated disposal facility and our permitted discharges. However, the analyses presented are in many cases applicable to the potential impacts of the wider site wastes and land contamination. For example:

- Reference [15] presents groundwater and surface water quality data measured from samples taken from monitoring locations that are designed to provide full coverage of the site, including up- and downgradient locations beyond the site boundary. This extensive dataset would allow us to identify any significant levels of contamination migrating from the wider site wastes or contaminated land into the groundwater or surface water systems should they arise.

- We calculate doses that would be incurred by a hypothetical adult with continuous occupancy inhaling dust at the concentration measured by our high-volume air sampler located at the site main gate in our retrospective dose assessments [13, 56]. The assessments provide confidence that if dust or airborne particulates have been released from the site, doses received would be very low.
- Radiation dose rate measurements are made at a range of locations around the site boundary to determine any contribution to a person's exposure from external irradiation by the radioactive materials on the site [13]. External dose rate data are reported annually in retrospective dose assessments (see for example reference [56]).

Our site monitoring suggests that none of the wastes on the site or the land contamination left in situ for the time being are having an adverse impact on people or the environment. The hazard associated with the wider site wastes and land contamination is very low and will decrease in the future as we progressively enact our plans for remediation.

We do not consider that a numerical prospective assessment is proportionate. Our monitoring programme will continue to provide assurance for this conclusion. The monitoring programme is designed to be responsive, allowing it to adapt to new information and promptly characterise any developing trends. This information will allow us to take appropriate actions to mitigate any risks to the environment should they arise.

7 Liquid Discharges

Our Permit requires us to manage aqueous effluent discharges using BAT. This includes minimising the activity and volume of radioactive waste released, ensuring disposal methods reduce radiological impact, and excluding solids, gases, and non-aqueous liquids before discharge.

We make permitted discharges via the Marine Pipeline of:

- trench and vault leachate;
- sewage effluent;
- various minor arisings;
- surface water from land drains in the area of the magazines.

This section summarises the nature of the discharges and the steps that we take to fulfil our Permit obligations. It also considers how we have optimised our liquid waste arisings and how we expect future discharges to evolve.

This section also considers the steps that we take to ensure that surface water and groundwater on site are not significantly impacted by operation of the disposal facility or legacy activities that have caused land contamination.

7.1 Sources of Liquid Waste Arisings

7.1.1 Leachate

Rainwater that falls on the disposal area can interact with the waste contained therein to generate radiologically and non-radiologically contaminated leachate.

The vaults have an active leachate management system that collects and pumps leachate to the Marine Holding Tanks (MHT). We monitor the quality and quantity of vault leachate − see details of our environmental monitoring programme in our '*Monitoring*' report [9]. These data show that vault leachate is generally subject to very low levels of contamination. This is because the vast majority of leachate that enters the vault drainage points is uncontaminated rainwater that has not interacted with the waste. The vault wastes are restricted from contact with rainwater by the physical protection afforded by the grout and container. The cement grout also provides a chemical barrier to contaminant release. Vault leachate may also be termed vault 'run-off' because it is predominantly composed of uncontaminated rainwater.

The clay-lined bases of the trenches generally fall from north to south and direct leachate to drainage sumps. These historically discharged to the Drigg Stream (see Subsection 6.2 on land contamination), but the system was refurbished in 1991, since when they have discharged to the MHT. Leachate from the trenches is routinely monitored and assessed − see details of our environmental monitoring programme in our '*Monitoring*' report [9]. The trenches produce lower volumes of leachate than the vaults as rainwater is prevented from freely entering the system by the interim trench cap. However, the interim trench cap is not performing as intended and allows some water ingress, which percolates through the trench pore space, interacting with the waste, before being discharged to the leachate management system. Trench leachate is generally subject to a higher loading of contamination than vault leachate.

Leachate in the MHT is discharged via the Marine Pipeline approximately 1.2 km offshore in the Irish Sea through three marine diffusers. The MHT system has a discharge consent of 6,500 m^3 per day. When effluent levels reach a pre-set limit, the effluent is automatically pumped to the sea. Flow rate and discharge volume are automatically recorded and calculated for each discharge to sea. Under normal operating conditions, the flow rate does not come close to exceeding this volume, and the system can comfortably manage heavy storms.

Provision is made for extreme rainfall: the site is authorised, under emergency conditions, to discharge leachate directly to the Drigg Stream. In this event, leachate from the vault collection system would be diverted into the Drigg Stream, whilst the trench leachates would continue to be discharged into the Irish Sea via the Marine Pipeline in accordance with two Environmental Permits (NPSWQD002191 and EPR/YP3293SA). The valve has not been operated since discharge became unrestricted in the mid-1990s.

In addition to leachate from Vault 8, Vault 9 and the disposal trenches, the MHT also collects effluent from Sewage Treatment Plants 1 and 2, and surface water from the drains around the magazines. Our leachate lines are regularly de-silted to remove the solid material that accumulates in the underground pipework, silt traps, manholes, chambers, and the MHT. Silt is removed, dewatered, and the solid and liquid wastes that are generated are disposed of through appropriate channels.

Samples for radiological analysis are taken from the MHT during each discharge. The results are used to calculate the radiological activity of aqueous discharges to the Irish Sea. There are no set limits for radiological content or non-consented parameters in the leachate. Using our monitoring data and a projection of future discharges, we assess the radiological impact of the permitted discharges via the Marine Pipeline to the sea in our '*Environmental Safety During the Period of Authorisation*' [13] and '*Assessment of Impacts on Non-human Biota*' [16] reports.

We also carry out an annual radiological risk assessment for aqueous discharges and discharge to air. The results of the MHT radiological sample analysis and risk assessment are presented annually in our '*Liquid and Gaseous Effluent Discharge Summary*' report. The 2024 analysis [57] showed that the population group dose is significantly lower than 20 μSv. The Environment Agency has published an initial radiological assessment methodology [58] for prospective assessment of the radiological consequences of discharges of radioactive waste to the environment. The Environment Agency advises that assessed doses of less than 20 μSv do not require further assessment. We conclude, therefore that radiological discharges do not present a significant risk to human health or the environment.

Monthly spot samples are collected from the MHT for non-radiological analysis to ensure compliance with the conditions of our consent to discharge (NPSWQD002191). An annual risk assessment of non-radiological components in aqueous discharges is carried out using the methodology required in the Environment Agency's '*Surface Water Pollution Risk Assessment for your Environmental Permit*' [59]. The 2024 assessment [57] resulted in all of the non-radiological analytes being screened out as insignificant discharges and, therefore, the discharges do not present a significant risk to human health or the environment.

The data generated in the previous year's environmental monitoring programme are considered in our Annual Review of the ESC. Covering the period from 1st April 2015 to 31st March 2025, the monitoring results for vault leachate consistently show low levels of radiological and non-radiological contamination that do not exceed the LLWR Assessment Standards. It is shown that trench leachates are the predominant contributor to contamination that reaches the MHT. Only one significant trend pertaining to vault leachate has been observed over the period, documented in the previous two annual reviews in 2023 [60] and 2024 [61], relating to an increasing trend in Cs-137 activity at Vault 9 leachate sampling points (maximum activity concentration of 15.9 Bq l^{-1}). The levels of Cs-137 are very low and are contained within the leachate management system of Vault 9. They pose no significant risk to the environment as they are safely discharged.

7.1.2 Sewage Effluent

The LLWR is permitted to discharge treated sewage from two sewage treatment plants (STP1 and STP2). We are required to correctly manage and maintain the plants so that stated discharge volumes are not exceeded, and no visible oil or grease is present. Discharge to STP1 and STP2 is routed to the MHT for discharge to the Irish Sea.

A third sewage treatment plant (STP3) was installed in the site reception area in October 2017 and a fourth (STP4), adjacent to B789, in July 2020. The discharges from these plants are released into the site surface water drainage system, and ultimately the Drigg Stream, and are less than 5 m^3 per day. Due to the low daily discharge volumes, the plants comply with the General Binding Rules and do not require a permit.

All four sewage treatment plants are subject to the same monitoring regime. The effluent is from each plant is subject to analysis of biochemical oxygen demand, total suspended solids, and visible solvents. Effluent from STP1 and STP2 is routed to the MHT and is therefore subject to further non-radiological analysis as part of the monthly spot samples collected from the MHT to ensure compliance with the conditions of our consent to discharge (NPSWQD002191).

Through our programme of monitoring and regular inspection, we ensure that our sewage plants are operating as intended and that the discharge is of appropriate quality. The results of this programme are presented annually in the '*Liquid and Gaseous Effluent Discharge*

Summary' report [57]. The series of reports also document the remedial and mitigative actions that we have taken when performance of the sewage treatment plants has been observed to be below the expected standard.

7.1.3 Minor Arisings

Our consent to discharge (NPSWQD002191) permits discharge of minor arisings, which are defined as groundwaters from borehole sampling operations and environmental monitoring operations and waters from waste storage and recovery operations.

We report on our minor arisings in our annual '*Liquid and Gaseous Effluent Discharge Summary*' report [57]. Each year, we report on minor arisings from the Drigg Grouting Facility (DGF) 'suspect active' sump. The aqueous wastes are sampled and analysed prior to discharge to the MHT via the leachate management system (GD4).

Other ad hoc waste management operations can lead to minor arisings of liquid waste. Some examples from recent years are as follows.

- In 2023, approximately 1 m^3 of water was removed from 17 partially grouted ISO containers containing LLWs. The liquid was discharged to the leachate management system after sampling and analysis had shown that the activity concentration fell within the normal range of leachate.
- In 2023, approximately 2.8 m^3 of water was removed from 16 trench cap probe holes to allow decommissioning of the probes. The liquid was visually checked for suspended solids but was not radiologically analysed before being re-released into the leachate management system.
- In 2021 and 2022, large volumes of low activity minor arisings from the commissioning of the Vault 9 leak detection layer were disposed of in the leachate system. Disposal in the leachate system was considered to be BAT as the concentrations of radiological and non-radiological contaminant species were expected to be significantly less than those found in leachate. Analysis of these minor arisings was therefore not required at source.
- In 2022, approximately 2 m^3 of settled borehole drilling waters were disposed of as minor arisings. The drilling waters were stored in two IBCs and allowed to settle for three months prior to discharge to the leachate system via a sock filter to mitigate the risk of discharge of entrained solids. Samples were analysed for their radiological content prior to discharge.
- In 2020, and the in the years prior when PCM decommissioning programme constituted a regular minor arising that was routinely sampled and analysed prior to discharge to the leachate management system.

We will continue to generate varying amounts of minor arisings during the repository's operational period, but they are expected to remain low. Minor arisings are considered on a case-by-case basis to ensure that the BAT disposal solution is identified with consideration of an appropriate degree of sample interrogation. If compliant with the Permit, minor arisings are usually disposed of to the leachate management system for discharge to the sea via the MHT.

7.1.4 Surface Water

Vault run-off, or vault leachate, is permitted for discharge to sea via the Marine Pipeline, as discussed in Subsection 7.1.1.

The run-off from the interim trench cap is collected in the trench cap perimeter drains and routed to the Drigg Stream. The entire trench cap perimeter drainage system was upgraded in 2010 and is designed with capacity for run-off from a 1-in-75-year rainfall event. Run-off from the trench cap does not interact with the waste and is managed in such in a way that reduces its likelihood of migrating into the vaults as leachate or into the groundwater flows in the region of the disposal facilities. The run-off, therefore, remains as uncontaminated surface water that does not require consent for discharge.

Our '*Monitoring*' report [9] describes the water quality and flow measurements that are made on surface water drainage from the trench cap, both streams that flow through the site, and two land drains that enter the Drigg Stream. Several water quality samples are also collected from drainage channels, seepages, surface water bodies and the River Irt. The objective of these measurements is to identify any site-derived contamination of river or surface waters.

Recently, slightly elevated tritium activity has been detected in the Drigg Stream surface water, at the Lonesome Pine Weir and OF1 Weir, during periods of low rainfall. The base of Trench 1 is at ground level to the south and Trench 1 was formed in what was originally an old railway cutting. As a result, leachate may be migrating via old railway drains or from groundwater to surface water. The sources of activity are currently being investigated. The activity levels reported are not replicated in the surface water samples collected at the GD0011 Weir, prior to the exit point of the Drigg Stream from the LLWR site.

The historical presence of elevated tritium activity in the railway drain and subsequently in the East-West Stream indicated the presence of a pathway from the trenches to the railway drain. The presence of tritium in this location prompted the construction of the bentonite cut-off wall along the northern and eastern flanks of the trench disposal area (Trenches 1 to 6 in 1988 and extended along Trench 7 in 1995). Current and historical monitoring data from the railway drain, since 1995, has shown that levels have significantly reduced in recent over time, indicating that the pathway no longer allows the migration of contaminants.

Drigg Stream is known to contain sediments with an above background level of radioactivity as a result of the authorised discharge of leachate directly to the stream prior to the construction of the MHT in 1991. Cessation of leachate discharges to the Drigg Stream has significantly reduced the presence of radionuclide contamination in surface water, but there is residual radioactivity bound to sediments in the stream bed. This results in small, declining concentrations of radioactivity in the stream water as radionuclides slowly desorb.

The impact of leachate discharges to the Drigg Stream in storm event and the impact of historic discharges to Drigg Stream are assessed as part of our '*Environmental Safety*

During the Period of Authorisation' [13] and '*Assessment of Impacts on Non-human Biota*' [16] reports.

Rainwater that falls on the area of site occupied by the magazines, which were used to store plutonium contaminated materials, is diverted to the MHT via the engineered drainage system and is permitted for discharge to the sea. Other areas of the site are subject to land contamination from historic activities, as detailed in Section 6. This land contamination is currently left in situ as we develop our plans for its management. Meanwhile, there is a risk that this contamination could be mobilised and transported in surface water.

However, our environmental monitoring programme shows that concentrations of relevant radiological and non-radiological species do not occur in surface waters on or close to the site in concentrations that exceed the relevant water quality standards [13, 15]. Although the presentation in references [13] and [15] is focussed on the repository, our monitoring programme covers locations up-gradient and down-gradient of the repository. The monitoring data also provide information on the migration of contaminants irrespective of their source. The data therefore provide evidence that contamination left in situ has little effect on surface water at the site.

7.1.5 Groundwater

Releases to groundwater may occur via direct releases from permitted disposals. There are no managed releases to groundwater. The disposal facilities at the LLWR are designed to limit the transfer of radiological and non-radiological contaminants to the groundwater system [5, 10]. The engineered concrete vaults are highly effective at preventing contamination from entering the groundwater system as they divert all leachate to the leachate management system with almost no opportunity for it to interact with the geosphere.

We have observed that tritium and C-14 have migrated from the trenches into groundwater flowing beneath the site towards the coast, indicating the presence of viable pathways from the trench disposal area − see our '*Monitoring*' report for further details [9]. Although localised activity concentrations of tritium and C-14 in groundwater exceed the relevant LLWR Assessment Standards, the exceedances are low, the groundwater is unlikely to be exploited in the near term, and the activity concentrations are expected to soon decrease with installation of the first strip of the final cap and replacement of the interim membrane over the southern part of the trenches. We maintain a programme of monitoring to detect any changes in the activity concentrations or migration patterns of these radionuclides.

Our environmental monitoring programme includes sampling and analysis of groundwater, at a range of depths, across the site and in its immediate environment. Except in the few instances mentioned above, we do not detect contaminants in groundwater in concentrations that exceed relevant water quality standards, suggesting that the site's impact on groundwater is minimal. This evidence also applies to the areas of historic land contamination, discussed in Section 6, for which we do not observe mobilisation and transport of the contaminants from the areas of land contamination into the groundwater system, suggesting that leaving the contamination in situ for the time being is not having an adverse impact on people or the environment. This evidence is presented in our *'Hydrogeological Risk Assessment'* report [15].

7.2 Optimisation of the Management of Liquid Discharges

Features of the repository are optimised to prevent and control liquid discharges such that their environmental impact is minimised [5, 10]. For example, we:

- reduce the quantity of leachate by physically limiting the contact between wastes and infiltrating water;
- improve the quality of leachate by creating a near-field chemical environment that is conducive to contaminant retention, implementing WAC that prohibit the disposal of e.g. free liquids, and removing solids from leachate by allowing settlement to occur;
- collect and divert leachate through engineered channels for discharge to sea, thus limiting its potential to interact with the terrestrial environment.

Consideration was given to alternative leachate management practices, such as recycling of leachate (e.g. in grout and concrete formulations), and possible treatment or decay storage options. The reasons why these options are not favoured are presented in the *'Optimisation and Site Development Plan*' [10].

Liquid discharges, whether controlled or uncontrolled, are a key consideration achieving two of our key strategic environmental safety objectives: to contain the source and to manage residual releases. Minimisation of the release of contaminated liquids to the environment is therefore an important consideration in a range of optimisation areas. It is particularly important to the design and timing of repository closure engineering solutions, the primary function of which is to limit the water ingress into the repository, with a view to reducing the volume of contaminated water being released.

Potential discharges from the wider site are also considered through our environmental monitoring and site characterisation programmes. Our Land Quality Register is an important source of information of potential sources of liquid discharges. As the site is optimised according to the framework set out in our '*Optimisation and Site Development Plan*' [10], we will ensure that the BAT solution to management of wastes on the site is adopted. This optimisation will take account of the environmental impact associated with liquid discharge of radiological and non-radiological contaminants originating from sources outside of the designated disposal facility on the LLWR site.

The following are examples of optimised waste management of liquid discharges arising on the LLWR site, including the response to the finding that the interim trench cap is not performing as intended and the contents of a legacy wash-down tank.

Example: interim trench cap replacement to reduce water ingress

An analysis of water balance data for the trench cap suggested that a significant proportion of Hydrologically Effective Rainfall (HER) was infiltrating into the trenches through the interim cap. Calculated average cap efficiency for the period from 1995 to 2009 was 58% and between 2010 and 2015 it was 65%. This prompted a review of the options for hydrological management options of the trenches, culminating in our 2019 BAT outcomes [62], in which we commit to capping the area of the trenches adjacent to Vault 8 as soon as is practicable and replacing the remainder of the existing trench cap.

Example: disposal of the contents of the B723 tank

Building B723 was originally used as a skip-wash facility for tipper trucks that transported LLW from the Sellafield site to LLWR during the early 1980s until the early 1990s. All above ground fittings were removed after tipper operations ceased in the 1990s but the B723 tank remains underground. A BAT assessment was undertaken to identify an appropriate disposal route for the approximately 3000 litres of liquid in the tank.

Sampling and analysis for radiological and non-radiological properties of the tank contents were undertaken. Results from the sampling and analysis campaign demonstrated that there was very little radioactivity present in the liquid but there was chemical contamination of the liquid (visible oil). Although from a radiological perspective, the permitted discharge route via the MHT would have been preferrable, the presence of oil prevents the discharge of the liquid to sea.

A BAT assessment was undertaken and the waste hierarchy was applied as part of the assessment of waste route options. Viable options for the liquid were incineration of the whole volume of liquid, treatment with microbes followed by discharge to sea, and treatment using oil absorbent pads followed by discharge to sea.

Incineration was not selected due to packaging requirements for transport, the cost and the carbon use by incineration and transport. Treatment using bioremediation techniques followed by discharge was ruled out due to concerns over the efficacy of the treatment under the conditions present, the time potentially needed and the additional visual inspections required to determine efficacy. Treatment using oil absorbent pads followed by discharge was selected as, although small amounts of secondary waste were generated that require Low Activity LLW or VLLW disposal, confidence in the effectiveness and timescales were highest for this option. Therefore, the B723 tank contents were treated using oil absorbent pads to remove the small layer of oil on the surface of the water. Further tests were carried out before the tank contents were discharged in accordance with the Permit.

7.3 Expected Future Liquid Discharges

Liquid discharges are expected to decrease as we progress with capping. Addition of the first strip of the final cap over Vault 8, a portion of Vault 9, and the adjacent section of the trenches will reduce the volume of leachate discharged via the MHT by reducing the volume of water that enters the disposal area.

We are also currently undertaking construction work to replace the interim membrane over the rest of the trenches. 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. This will further reduce water ingress into the trench waste mass, therefore, reducing the volume of leachate discharged via the MHT and the extent of uncontrolled discharge from the trenches to the underlying groundwater system.

There may be a short-term increase in the volume of leachate and associated releases as a result of the increased loading, consolidation of waste and displacement of leachate caused by the construction work to replace the interim trench cap. We also expect to observe a similar effect when vault wastes (and waste in the adjacent area of the trenches) are intentionally surcharged to express available voidage prior to installation of the first strip of the final cap.

The environmental monitoring programme will need to adapt to accommodate these site developments in the coming years. The programme will need to:

- Monitor the impact of construction works. For example, additional surface water monitoring points have been established to monitor surface water run-off from the final capping works and the haul road running through the site.
- Adapt to new infrastructure. For example, replacement of the interim membrane will cause substantial changes to monitoring infrastructure on the trench cap, including the extension of existing probe holes and the installation of sacrificial loggers
- Be equipped to monitor the performance of the new infrastructure. For example, the monitoring programme will be expected to provide additional data to substantiate our assumptions regarding the effectiveness of the final cap and new interim trench cap on reducing water ingress and subsequent discharge.

In the longer term, we will continue to collect, monitor and discharge leachate via the MHT for the rest of the active management phase of the site. Pumping will be terminated during or at the end of the management control period, and monitoring continued to the end of control to confirm performance is as expected. Monitoring data will play an important role in providing the assurances that the final cap is performing as intended and it is safe to transition to the passively managed leachate system. Plans for decommissioning the actively managed leachate system and transitioning to the passively managed system are outlined in our '*Engineering Design*' report [5]. As discussed in Subsection 4.5, the infrastructure associated with the active leachate management system will be managed as decommissioning waste under the remit of the WMP.

Other liquid discharges, such as sewage effluent and minor arisings, will cease as the site becomes non-operational. The site will eventually reach a point where the only liquid discharges will be associated with small volumes of passive discharges to groundwater from the designated disposal facility or from any wastes disposed of in situ. Discharges of this nature would be documented in the SWESC that would support a Permit surrender application, to show that the discharges do not pose a significant risk to people or the environment.

8 Gaseous Discharges

8.1 Sources of Gaseous Discharges

Our gaseous discharges include:

- landfill gases from our designated disposal facility, a portion of which may be radioactive;
- radon from our designated disposal facility;
- discharges from the DGF and B746 via HEPA filtered stacks;
- dust and other airborne particles generated in the vaults, and from on-site construction activities, ground disturbances, vehicular movement, transport of materials etc.

We are permitted to dispose of gaseous waste generated from the B746 (PCM Drum Processing Building) and DGF active discharge stacks. We assess the impact of such discharges as part of the assessment reported in our '*Environmental Safety During the Period of Authorisation*' report [13]. The report describes the monitoring data that we use to underpin the assessment. These data are routinely collected as part of our environmental monitoring programme, which is described in full in our '*Monitoring*' report [9].

8.1.1 Discharges from the Designated Disposal Facility

Our permitted disposals release gases into the atmosphere. The impact of such releases is a key consideration within the ESC that affects, for example, our capacity for certain radionuclides, the engineering design of the facility, and our WAC. Our ESC is implemented in a such a way that the impact of gaseous releases from the designated disposal facility are maintained within acceptable limits for the duration of the repository lifecycle.

Our '*Near Field*' report [6] describes the processes that generate gases within the disposal facility. Gases generated in the disposal area are principally landfill gases, methane and carbon dioxide, and hydrogen, which are generally formed as degradation products of components of the waste inventory. A small proportion of the gases may themselves be radioactive as they contain of C-14 or tritium. The bulk gas flows may also create a vector for advective transport of other radioactive gases, such as radon or thoron, generated by radioactive decay in situ. Potential non-radioactive gases of importance also include mercury, arsenic, hydrogen sulphide and volatile organic compounds.

We monitor the rate and composition of gases generated from disposal facility, as described in our '*Monitoring*' report [9]. We use the data from the monitoring programme as input to our assessment of environmental safety during the Period of Authorisation [13]. The assessment shows that the radiological impacts are within safe limits.

Trace components of landfill gas are periodically analysed. In the most recent analysis [63], toxic trace gases were detected in the trench wastes, with significant concentrations recorded at some locations, however, the flow rates of landfill gases emanating from the trenches are so low that the calculated 'process contributions to air' were classified as insignificant emissions for all substances [63].[8]

8.1.2 Permitted Discharges

There are currently two operational active ventilation systems on the LLWR site. One is associated with the grouting facility and the other with a waste store. Prior to discharge, all gaseous discharges pass through a double HEPA filtration system. The total activity in the gaseous discharges from the discharge stacks at the LLWR are very low, as shown in Figure 8.1.

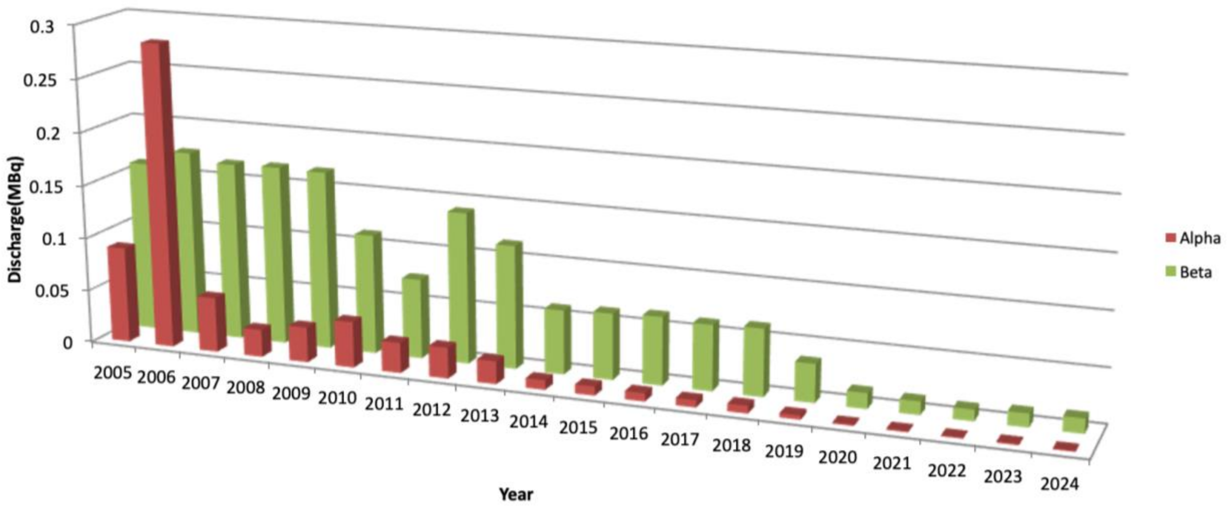


Figure 8.1: LLWR aerial discharges

Gaseous effluent discharges of total alpha and total beta reduced significantly following the removal of the PCM from the magazines in 2006. The total activity of discharges declined again in 2019 alongside successful decommissioning of the magazines and the associated retrievals infrastructure, which operated a further four discharge stacks.

Stack discharges are continuously monitored with sample filter cards, which are bulked for radiological analysis on a quarterly basis. The results are reported annually in our '*Liquid and Gaseous Effluent Discharge Summary*' report. Total alpha and total beta discharges in 2024 remained low at 0.92 and 13.54 kBq, respectively [57]. Each year, we assess the risk associated with such discharges using a methodology derived from reference [59]. This provides confidence that the environmental impact associated with the gaseous discharges from our active stacks, combined with the dose associated with our liquid discharges, is very low [57].

[8] The process contribution to air (PC_{air}) is the estimated concentration of the emitted substance after dispersion into the receiving environmental media in units of µg m^{-3}. The methodology is described in reference [63].

8.1.3 Other Aerial Releases

Dust may be generated by waste handling, vehicular movement, earthworks, and the disturbance of soils or waste material. Windy conditions can increase dust dispersion, particularly during dry spells.

Arisings of dust from the site may be contaminated by radiological and non-radiological species, which may lead to health impacts for site staff and the population in the site's surrounding environment.

Contamination control measures and the containerised and grouted waste form mean that we expect releases of any dispersible dust in the disposal vaults will be low.

Dust monitoring was carried out during Vault 9 construction and would be carried out during future vault construction activities. We are also carrying out dust monitoring for the capping works. The dust monitors provide an alarm function should any unplanned releases of dust occur.

Air sampling is a statutory requirement and is undertaken at the site perimeter. In 2024/25, as in previous years, no measurements exceeded environmental sampling reporting levels. It is likely that authorised discharges from Sellafield and fall-out and natural sources are significant contributors to the concentrations that we measure.

As part of our '*Environmental Safety During the Period of Authorisation*' assessment [13], we undertake a retrospective dose assessment that calculates the dose that would be incurred by a hypothetical adult with continuous occupancy inhaling dust at the concentration measured by our high-volume air sampler. The high-volume air sampler is not radionuclide-specific and it is likely that authorised discharges from Sellafield, fall out and natural sources are significant contributors to the measured concentrations [13]. The annual doses calculated from 2016/17 to 2024/25 range between 0.5 to 0.1 µSv and have not exceeded 0.1 µSv since 2019/20.

The monitoring results and retrospective assessments place an upper bound on any current impacts from dust or airborne particulates.

Authorisation is not required for any gaseous releases from disposed wastes.

Building monitoring in the southern area of the site is also completed as a precaution against the potential migration of landfill gas from the former Cumbria County Council landfill site that borders the site.

8.2 Optimisation of the Management of Gaseous Discharges

The processes that lead to the generation of gases are difficult to control directly, although where possible this has been done [10]. For example, the LLWR waste grouting facility has been designed to minimise airborne releases.

No options have been identified that could feasibly replace the current fugitive and vented discharge of bulk gases and radon to atmosphere.

Optimisation of the repository to take account of gas release is discussed in our *'Optimisation and Site Development Plan'* report [10].

We consider that current practice (discharge to atmosphere following HEPA filtration) represents BAT for aerial discharges from our active stacks. The ventilation and monitoring systems are already in place and operating, with very low levels of discharge (consistently less than 1 kBq alpha and beta per month) and sample cards from the filters continue to be bulked and analysed on a quarterly basis to confirm that there have been no sudden changes in performance.

The main identified alternative to current practice would be to provide additional abatement through further HEPA filtration (for particulate release) or activated carbon filtration (for radionuclides released in gaseous form). Although this is likely to further reduce emissions to atmosphere, it could prove difficult to update and alter existing plant without incurring considerable installation costs. Additional secondary wastes (in the form of spent HEPA filters) would be generated, and there is likely to be a higher energy use in order to maintain ventilation flows through the additional filter sets. Since the impact of current discharges is already very low, we do not consider the benefit that would be achieved to be proportional to the cost and secondary environmental impact that would arise.

On that basis, the current approach to mitigating aerial discharges from our active stacks at the DGF and B746 represents an optimised set of control measures.

The grouted and containerised nature of the vault wastes ensures releases are minimal. Similarly releases from the trench wastes are minimal, not least as they are covered by the interim cap and associated overburden.

The monitoring results and retrospective assessments provide confidence that if dust or airborne particulates have been released from the LLWR, doses received would be very low. We will continue to monitor air concentrations and would take action if we believed that releases from the LLWR site were causing more significant doses.

Dust during construction activities is therefore not considered any further here and no other controls other than good practice are required. Conventional approaches to construction management will in any case be deployed to ensure releases are minimised, such as dust suppression using misted water [64].

As discussed in Section 6, asbestos and other non-radiological and radiological contaminants are present in the near-surface soils across the site due to its historical use. We have documented our understanding of this contamination in our Land Quality Register and will continue to update it. We will refer to our Land Quality Register when making decisions on site development that may affect regions of contaminated land; for example, we control excavations on site to minimise the potential mobilisation of asbestos fibres and other particulates.

Our Land Quality Register is an important source of information for our WMP on potential aerial releases from the wider site. As the site is optimised according to the framework set out in our '*Optimisation and Site Development Plan*' [10], we will ensure that the BAT solution to management of wastes on the site is adopted. This optimisation will take account of the environmental impact associated with aerial releases of radiological and non-radiological contaminants originating from sources outside of the designated disposal facility on the LLWR site.

8.3 Expected Future Gaseous Discharges

The overall volume of gaseous discharges from the designated disposal area will increase as further waste is emplaced. We will progressively add the final cap to the facility [5]. Both the interim and final caps also incorporate measures that permit gas to be collected and released in a controlled way. The strip cap seals for Vault 8 and Vault 9 (including any leading-edge extension into Vault 10) will also include vents, as vents will not be included in the final cap itself for those strips of the cap. These features provide the ability to control points of release and, to some extent, the rate of release. Features such as the trench probes also enable gas to be monitored.

The cap is designed to ensure that bulk gases generated within the waste body can be safely dissipated, without risk to the integrity or stability of the overlying layers, and in particular the low-permeability composite. The substantial nature of the final cap will also provide an important benefit by arresting the migration of radon gas and thus permitting a significant period during which it will decay before being released. Details of the final cap are outlined in our *'Optimisation and Site Development Plan'* [10] and '*Engineering Design*' reports [5].

The gas pathway is assessed as part of our '*Environmental Safety During the Period of Authorisation*' report [13], '*Assessment of Impacts on Non-human Biota*' [16] and '*Assessment of Long-term Radiological Impacts*' reports [14]. Our '*Implementation*' report [17] discusses our radiological and non-radiological capacities and other WAC that we enforce to ensure that the environmental impact of the gas pathway is within acceptable limits.

Dust may be released during construction of the cap, but such releases will not carry a radiological signature. For example, for the surcharge and profile fill placement process, the layers of material placed on top of the wastes before the full height of material is achieved and container deformations and waste movements occur will ensure a sufficient barrier is in place to ensure radiological releases via dust are negligible. Conventional approaches to construction management will in any case be deployed to ensure releases are minimised, such as dust suppression using misted water [64].

Future site development will be carried out in consultation with our Land Quality Register and contaminated land will be managed in accordance with our WMP. Both will ensure that future excavation, clearance, construction, remediation etc. that are carried out as we progress towards our final and interim end states, are done so in a way that is optimised to ensure that environmental impacts, including aerial discharges, are as low as reasonably achievable.

9 Management of Non-radioactive Decommissioning Waste

In addition to radioactive waste arisings on the LLWR site, non-radioactive decommissioning waste will be generated, for example, through the demolition of buildings and infrastructure. This non-radioactive waste is referred to in the GRR as 'Directive waste'[9], however we now use the term 'controlled waste'.

We control waste management using robust procedures to ensure full compliance with all relevant regulations [65]. The application of the waste hierarchy is a key principle, with a strong emphasis on avoidance followed by minimisation. In line with the NDA Group’s long-term objective, we are committed to achieving zero waste to landfill by 2035.

Beyond our own operations, we actively support the wider NDA Group in enhancing controlled waste management practices. To drive progress, we lead several group-wide initiatives aimed at improving waste management practices. These improvements will be fed into future iterations of this WMP.

9.1 Processes for Controlled Waste Management

We have a management procedure that governs how both hazardous and non-hazardous controlled waste that is stored on the LLWR site, prior to legally compliant disposal, re-use or recycling [65, 66, 67].

A key aspect of this procedure is the requirement to develop Project Waste Management Plans (PWMPs). PWMPs are an integral part of the work planning process and are completed at an early stage to identify any waste that will be generated after the waste hierarchy has been applied and to determine the compliant route for disposal [67]. The development of PWMPs require input from several stakeholders and approval from the Environmental Management team.

We actively monitor and report on all aspects of waste management, with performance targets focused on increasing recycling and reuse. This information is submitted to the NDA as part of our environmental reporting process. In addition, we work toward annual environmental objectives set by the NDA, which often include initiatives to enhance controlled waste management.

9.2 Applying the Waste Hierarchy

We continually seek opportunities to minimise waste requiring disposal. In line with this ambition, we have identified the potential to reuse construction-generated waste as infill

[9] Directive waste: Any substance or object which the holder discards or intends or is required to discard, subject to the exclusions and definitions laid down in Article 2 of Directive 2008/98/EC [73].

material for our repository closure operations. These operations require several hundred thousand cubic metres of infill material, and multiple options are being explored to source this from on-site generation, existing stockpiles, and additional opportunities across the NDA Group. To enable these initiatives, we are in the process of applying for a deposit-for-recovery permit. Volumes and characteristics of the waste used under the deposit-for-recovery permit will be added to the next iteration of this WMP.

9.3 Opportunities and Further Integration

9.3.1 Controlled Waste Work Package

The controlled waste work package supports us and the wider NDA Group in developing and implementing opportunities to enhance controlled waste management. It promotes collaboration and the sharing of best practices, for example through regular waste practitioner forums. Recognising that knowledge of controlled waste across the estate is more limited than of radioactive waste, a key initiative within this work package is the development of the Controlled Waste Inventory (CWI). This aims to create a comprehensive dataset reporting controlled waste across the NDA estate for strategic planning. The CWI is scheduled for implementation by 2030 and is designed to support the circular reuse of controlled materials, aligning with principles similar to those underpinning the UKRWI.

Developing the information to support the CWI will help inform future iterations of this WMP, so that we can add estimates of future controlled waste arisings.

9.3.2 National Strategic Waste BAT Studies

We maintain a suite of national strategic BAT studies to support the nuclear industry in managing radioactive waste. These studies, developed over 15 years ago, are widely used across the sector. They are currently under review as part of an ongoing project to identify opportunities for improvement. While BAT does not currently apply to controlled waste management, it has been recognised that including controlled waste within these studies could help waste producers improve practices and foster greater collaboration across the NDA Group. This work is ongoing, and feedback from industry has been positive and broadly supportive of this approach. Further work is required to better understand how this could be implemented but if taken forward could provide waste producers with a better understanding and tools for controlled waste management.

10 Forward Plan

The LLWR is currently an operational site with a dedicated disposal facility, with many more decades of waste disposal operations planned. Given the stage of the site's lifecycle and the remaining planned operating period, there are further assessments and decisions that will need to be made in relation to 'site wastes' and areas of contamination. However, our processes for optimisation are established and we will undertake the assessments and decision-making process at the appropriate time. The WMP is embedded within the site's ESC. Maintaining the WMP and reducing uncertainties over time will ensure the site will be brought to a condition that meets regulatory requirements for release from radioactive substances regulation. This section sets out our forward plan to achieve this including listing forward work programme actions.

10.1 Maintenance of the WMP

As described in our '*Management and Dialogue*' report, the ESC is maintained as a 'live' safety case. This means that it is not treated as a static submission produced solely to demonstrate regulatory compliance at a single point in time, but as an active site management tool that is applied, reviewed and updated throughout the life of the facility.

Maintenance of the ESC as a live safety case is achieved through formal governance and review processes. New information arising from environmental monitoring, operational experience, design development, assessment work or regulatory feedback is systematically evaluated to determine whether it has implications for the safety arguments, assumptions or conclusions of the ESC. Where relevant, such information is incorporated into the ESC in a controlled and auditable manner through established change control, periodic review and document management processes.

This approach ensures that the ESC continues to reflect current site conditions, understanding and regulatory expectations, and that it remains fit for purpose as a basis for both regulatory engagement and the safe management of the LLWR over time.

Similarly, we will maintain the WMP as a live product. We will achieve this by relying on the ongoing maintenance of the important underlying evidence bases that support the WMP. These are the:

- eMWaste tracking system for inventory management [4];
- generated waste inventory management arrangements [27];
- site and land usage management system and the associated GIS [29];
- Buildings Register [35];
- Land Quality Register [34].

They are maintained on an ongoing basis, according to our management arrangements [2]. Any relevant change that would have a bearing on the ESC will be assessed using our 'Assessment of New Information' process [22].

We will maintain this WMP report in line with the ESC Major Review cycle. We anticipate for this to align with the GRR requirement of comprehensively updating the WMP no less frequently than every 10 years. Doing so will mean that any decisions to dispose of waste in situ or to leave contamination in place will be made in the context of up-to-date understanding of the site and its evolution, of climate projections and the current regulatory context.

10.2 Reporting Tools and Change Management

Key reporting tools that will allow us to communicate our ongoing understanding of data relevant to the WMP include:

- each ESC Annual Review submitted to the Environment Agency, which will include site-derived waste records going forward;
- each annual JWMP and its supporting Waste Forecast Form;
- updates to the WMP with each Major Review of the ESC;
- ongoing dialogue with regulators and wider stakeholders.

Once any decision is made to propose on-site disposal of site-derived wastes (e.g. disposal 'in situ' or 'for a purpose'), we will apply to for a Permit variation. That application would be supported by a comprehensive and up-to-date WMP and SWESC.

10.3 Collaboration and Learning from Experience

We participate in a range of collaborative groups within industry. The Nuclear Industry Group on Land Quality (NIGLQ) has been a valuable source of information on other operators' experience in producing WMPs. We will continue to attend and contribute to this forum. Peer review of our WMP was obtained by collaboration with Nuclear Restoration Services (NRS). We have also talked directly with Sellafield in preparing our WMP and SWESC.

One notable difference in our WMP compared with a site that is closer to its end state is that we have not prepared a dedicated WMP spreadsheet with quantitative estimates of all waste arisings. We have reported quantitative estimates with waste codes where we have them (e.g. Subsection 5.6), but in other areas we do not yet have full characterisation information available as infrastructure is still in use and will be for many decades to come (e.g. the Marine Pipeline). In addition, another significant difference is that for LLWR, the vast majority of the site-wide inventory is held within the dedicated disposal facility, which has its own inventory tracking system (eMWaste). The site and land usage management system and the associated GIS, and the Building Register are established systems controlled by our existing arrangements. Therefore, the most effective approach at this stage in the lifecycle of LLWR has been to signpost to these embedded systems, and to summarise a snapshot from these in this WMP report. In the future, when we are approaching our end state and have a better-defined site-wide inventory, we may adopt the approach of developing a WMP spreadsheet.

10.4 Uncertainties and Forward Plan

The key aim of the WMP forward plan is to reduce uncertainties over time and ensure we are gathering the required information to support and evidence decision-making.

Since the publication of the GRR, and the requirement to develop and maintain a WMP was added to our Permit, we have embedded the requirements in our management arrangements for example by updating the procedure that governs the development and application of our ESC [68]. There are, however, further improvements that would ensure we are gathering the required information to support future decisions and reduce uncertainties. These are given in Table 10.1.

Table 10.1: WMP uncertainties and Forward Plan

Uncertainty Area	Description	Forward Plan
Site contamination	Site characterisation is ongoing and therefore the full extent of site contamination is not currently known. However, findings of our quantitative risk assessment identify that risks from land contamination at the LLWR are low given the current land use and management procedures that are applied [13, 7, 49].	Site characterisation is ongoing, driven by the Site Development Plan [10]. We hold detailed records and will continue to build our understanding of the extent of site contamination over time [34]. Ongoing environmental monitoring ensures we continue to assess risks and can take action if required [9].
Waste arisings from remediation	Potential waste arisings from remediation are uncertain. Any remediation activities that may generate radioactive waste should be recorded in the WMP. Radioactive and non-radioactive properties of the waste will be assessed and recorded.	As characterisation is undertaken, the Land Quality Register will be updated [34]. Waste arisings are considered in the BAT process and will be recorded and managed in accordance with our procedures [69].
Decommissioning waste arisings	Future arisings of radioactive and non-radioactive decommissioning waste are uncertain.	Further populate the Buildings Register [35] with information to derive estimates of volumes and types of future decommissioning waste e.g. from engineering

Uncertainty Area	Description	Forward Plan
		drawings of buildings and infrastructure. Gathering this additional information will help reduce this uncertainty over time. Future iterations of the WMP will include these estimates.
Unrecorded below-ground structures	Unrecorded below-ground structures that may be radioactive waste are may be discovered during site characterisation activities. They will be recorded and included in the WMP.	Recording of potential radioactive waste below-ground (e.g. legacy pipes) has been formalised in our procedures to avoid inadvertent unauthorised disposal of radioactive waste [34]. Future iterations of the WMP will include up-to-date information from the Land Quality Register, including of below-ground structures.
Site evolution and climate	Future climate and its impact on the LLWR site is uncertain. We address climate uncertainty in the ESC by using a range of climate projections [8].	To ensure future decisions are taken with the most up-to-date understanding of climate projections, each major review of the ESC will review and update where necessary, our understanding of climate and its impact on site evolution [8].
Site End State	The detailed, final configuration of the Site End State is not currently known.	The Site End State will be reviewed with each major update of the ESC. This will take into account our updated understanding of the site and information from ongoing stakeholder engagement [10, 2].

10.5 Gap Analysis and Forward Work Programme

We have undertaken a gap analysis by comparing our WMP with the objectives that it sets out to achieve (Subsection 1.1). The gap analysis is presented in Table 10.2. The analysis is structured so that the components of existing and potential future site wastes, discussed in previous sections of this report, are each considered in terms of the work that has been done to characterise the wastes ('Characterisation') and the work that has been done to determine the optimal management route for those wastes ('Assessment and management').

Table 10.2: WMP gap analysis

Component		Characterisation	Assessment and management	Gap analysis
Solid	Disposal facility inventory	Characterised in the '*Disposal Facility Inventory*' report [4].	As per wider ESC.	No gaps identified.
	Solid waste arisings on site	The inventory of waste generated on the LLWR site is managed according to the 'Generated Waste Inventory Management' procedure [27]. Near-term forecasts of operational and decommissioning wastes are presented in the JWMP (see subsections 2.3 and 5.2).	Our 'Radioactive Waste Management' process [26] outlines the process for managing potential and actual radioactive waste arisings, to ensure acceptance to a permitted waste route through application of the waste hierarchy and BAT. Solid waste arisings include, for example, soil from remediation activities and demolition arisings from decommissioning of buildings. Solid waste arisings are therefore affected by the decisions that we take regarding the optimal management of in-situ structures and land contamination and the timing of such.	Our management arrangements for solid waste arisings on the site are robust to these plans that will evolve as we progress towards our end state, therefore no gaps have been identified. Although no gaps have been identified, we commit to widening the scope of the ESC Annual Review reporting to include solid waste arisings from the site. This is intended to identify any emerging trends, highlight any new information relevant to the WMP, and trigger assessment through the ESC change control processes where necessary.
	In-situ structures	We maintain a Building Register of all LLWR facilities [35]. Some are	The projects we undertake to decommission infrastructure are	There are gaps in our knowledge as some buildings and

		redundant and some are operational. Our current end state assumptions involve removal of surface buildings (although some infrastructure, e.g. roads, may be left in situ if demonstrably safe). The dedicated disposal facility will be left in situ. We may leave some below-ground infrastructure in situ if it is demonstrably safe. Any application to do so would be supported by proportionate supporting justification including characterisation and case-by-case options assessment. At present, some of our in-situ structures are well characterised but others are not. Further characterisation is needed to understand to extent of wastes that would be generated and to support decision-making in the optimisation process. There are some in-situ structures that are related to the site's	guided by the Site Development Plan. Where the Site Development Plan identifies an upcoming need, e.g. clearance of an area, then targeted characterisation is carried out to support optimised decision-making regarding management of any wastes generated. This is carried out in compliance with our 'Generated Waste Inventory Management' procedure and 'Radioactive Waste Management' process, which ensure application of the waste hierarchy and BAT. An assessment of the environmental impact may also be required to support the proposed management option should it be deemed proportionate to do so. We present two examples of instances where we have determined the BAT option for management of demolition rubble from decommissioning of in-situ infrastructure to be disposal in Vault 8 (see Subsection 5.5). The contribution of such waste to the	infrastructure are not well characterised. It is therefore not possible to know at this stage the extent of all waste that will be generated or determine what the most appropriate management route will be. Our monitoring programme shows that the contamination associated with our in-situ structures is not currently having an adverse impact on people or the environment. We would respond appropriately should this position change. We have identified a new action to progressively enhance the Building Register to support better estimates of decommissioning waste arisings and forecast waste streams in future iterations of the WMP. This information will supplement the targeted characterisation that we carry out, in compliance with our existing processes and procedures for

		previous operation as a ROF. This infrastructure is redundant and there are often land quality issues related to its past use. In the context of the WMP, this infrastructure, often comprising building slabs, is managed as contaminated land.	disposal facility inventory has been included in the Reference Inventory for the disposal facility [4]. We are committed to these disposal options, subject to suitable assessment of the final, detailed arrangements, including final characterisation information. Progressive decommissioning of redundant infrastructure will be carried out during our operational period before completion of repository closure engineering, although there may be cause to accelerate the process in areas of the site that are affected by plans for possible early release from regulation. An optimised Site Development Plan forms part of our SWESC. The Site Development Plan will continue to guide the necessary activities to decommission or otherwise manage in-situ structures such that we achieve our end state along appropriate timescales.	managing solid waste arisings on site.

	Contaminated land	Our '*Hydrogeology*' report [7] describes the potential sources of land contamination on the site and our investigations to characterise it. We have recently produced a Land Quality Register that sits within our management system and is our principal method of recording our latest understanding of contaminated land. The current version documents a total of 32 'areas of concern'. The areas of concern chart the source, type, location and extent of contamination across the site based on our conceptual understanding of the site's historical use and existing site characterisation information. The areas of concern inform monitoring requirements and guide future site investigations. They are also the primary source of information for the risk assessments that we periodically undertake.	Past remediation of contaminated land at LLWR has focused on targeted actions in areas where contamination posed a potential risk to human health or the environment, as identified through site investigations and risk assessments. Our '*Hydrogeology*' [7] report provides specific examples of remediation we have carried out. Plans for further remediation are guided by the requirements of site development. The Land Quality Register will be an important decision-making tool in the options assessment process as we work towards our interim and final end state, guided by the optimised Site Development Plan. We have a procedure to manage use and development of land [29]. The Site Development and Coordination Committee (SDCC) reviews, evaluates and approves all space management and	We have undertaken a significant amount of work in recent years to better understand the contaminated land on the site, which has allowed us to produce the Land Quality Register. Although we have a reasonably good understanding of the extent of the land contamination and legacy in-situ structures across the site, we have not yet undertaken the full process of optimisation that is required to determine the preferred management option needed to bring the site to a condition that is suitable for its next use. This represents a gap in our current WMP that will be progressively addressed in future iterations. The site-wide optimisation of the BAT solution for management of the contaminated land may require further targeted characterisation, plans for which will be considered on a case-by-case basis and be

		Hazard maps are also used to record locations of specific hazards (e.g. radiological contamination, asbestos, unexploded ordnance), and are updated regularly based on investigation findings. There is a possibility that as yet undiscovered land contamination or in-situ structures will be found as the site is developed.	planning matters to ensure all future development is coordinated, that impacts are considered, and that any development is aligned with the ESC. In our WMP, we have classified the areas of concern as: • potential future waste arisings; or • in-situ contamination. These classifications are linked to the legal difference between waste and contamination (see Subsection 6.2). The classifications provide a coarse view on the likely management requirements of or waste arisings from the land contamination or in-situ structures associated with each area of concern. In all cases, further optimisation is required to arrive at the definitive preferred option. Only once we have arrived at a definitive preferred option will we apply to the Environment Agency for the	proportionate to the hazard that is presented. As discussed in Subsection 6.3.1, the contaminated land is not currently having an adverse impact on people or the environment, as demonstrated by our environmental monitoring programme, and we have controls and procedures in place to further ensure safety by, e.g., controlling access to affected areas.

			relevant permissions with the necessary supporting justification.	
Liquid	Sewage	Through our programme of monitoring and regular inspection, we ensure that our sewage plants are operating as intended and that the discharge is of appropriate quality. The results of this programme are presented annually in the '*Liquid and Gaseous Effluent Discharge Summary*' report [57]. The series of reports also document the remedial and mitigative actions that we have taken when performance of the sewage treatment plants has been observed to be below the expected standard.	The LLWR is permitted to discharge treated sewage from two sewage treatment plants (STP1 and STP2). Discharges from two further sewage treatment plants (STP3 and STP4) are released into the site surface water drainage system, and ultimately the Drigg Stream, and are less than 5 m^3 per day. Due to the low daily discharge volumes, the plants comply with the General Binding Rules and do not require a permit. The sewage treatment plants are logged in the Building Register. They will be decommissioned before the end of operations on site. The non-radioactive decommissioning waste that they give rise to will be managed according to our procedures non-radiological waste (see Section 9).	We will continue to monitor and report on the quality of the sewage treatment plants in our annual '*Liquid and Gaseous Effluent Discharge Summary*' reports. We will respond appropriately to any unexpected changes in performance. Sewage management arrangements are considered to be robust and no gaps have been identified.

	Minor arisings	We report on our minor arisings in our annual '*Liquid and Gaseous Effluent Discharge Summary*' report [57]. Each year, we report on minor arisings from the Drigg Grouting Facility 'suspect active' sump. Other ad hoc waste management operations can lead to minor arisings of liquid waste. Targeted characterisation is carried out to support decision-making on the optimal waste management route. These are reported annually in the effluent discharge summary report and examples are given in Subsection 7.1.3.	Our consent to discharge (NPSWQD002191) permits discharge of minor arisings, which are defined as groundwaters from borehole sampling operations and environmental monitoring operations and waters from waste storage and recovery operations. Minor arisings are considered on a case-by-case basis to ensure that the BAT disposal solution is identified with consideration of an appropriate degree of sample interrogation. If compliant with the Permit, minor arisings are usually disposed of to the leachate management system for discharge to the sea via the MHT.	We will continue to generate varying amounts of minor arisings throughout the PoA, but they are expected to remain low. We are permitted to discharge minor arisings and our management arrangements for ensuring that this is carried out in an optimised manner are robust. No gaps have been identified.

	Surface water	The impact of the dedicated disposal facility on surface water and groundwater is addressed in the wider ESC. Our '*Monitoring*' report [9] describes our environmental monitoring programme, including the regime of groundwater and surface water sampling and analysis.	The monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards. The evidence for this is presented in our: • '*Hydrogeological Risk Assessment*' report [15], which presents monitoring data in support of the argument that the LLWR is not having an adverse impact either on groundwater or on surface water; • '*Environmental Safety During the Period of Authorisation*' report [13], which presents monitoring data relevant to discharges to air, surface water and groundwater, and radiation dose measurements at the site boundary in support of	Our site monitoring shows that the dedicated disposal facility and the wider site are not having an adverse impact on people or the environment. The hazard associated with the wider site wastes and land contamination is very low and is likely will decrease in the future as we progressively enact our plans for remediation. The monitoring programme is designed to be responsive, allowing it to adapt to new information and promptly characterise any developing trends. This information will allow us to take appropriate actions to mitigate any risks to the environment should they arise. Our arrangements for protecting groundwater and surface water are robust and no gaps have been identified.
	Groundwater			

			its assessment of the site's environmental impact. These reports are principally concerned with the risk associated with the designated disposal facility and our permitted discharges. However, the analyses presented are in many cases applicable to the potential impacts of the wider site wastes and land contamination. This extensive dataset would allow us to identify any significant levels of contamination migrating from the wider site wastes or contaminated land into the groundwater or surface water systems should they arise.	
Gas	Releases from permitted disposals	Our '*Near Field*' report [6] describes the processes that release gases from our permitted disposals. Our '*Monitoring*' report [9] describes our characterisation of those gases.	The gas pathway is assessed as part of our '*Environmental Safety During the Period of Authorisation*' report [13], '*Assessment of Impacts on Non-human Biota*' [16] and '*Assessment of Long-term Radiological Impacts*' [14] reports.	Addressed as part of the wider ESC. No gaps identified.

	Permitted discharges	There are currently two operational active ventilation systems on the LLWR site. One is associated with the grouting facility and the other with a waste store. Prior to discharge, all gaseous discharges pass through a double HEPA filtration system. Stack discharges are continuously monitored with sample filter cards, which are bulked for radiological analysis on a quarterly basis. The results are reported annually in our '*Liquid and Gaseous Effluent Discharge Summary*' report [57]. The total activity in the gaseous discharges from the discharge stacks at the LLWR are very low.	Each year, we assess the risk associated with such discharges using a methodology derived from reference [59]. This provides confidence that the environmental impact associated with the gaseous discharges from our active stacks, combined with the dose associated with our liquid discharges, is very low.	We consider that current practice (discharge to atmosphere following HEPA filtration) represents BAT for aerial discharges from our active stacks. The ventilation and monitoring systems are already in place and operating, with very low levels of discharge (consistently less than 1 kBq alpha and beta per month) and sample cards from the filters continue to be bulked and analysed on a quarterly basis to confirm that there have been no sudden changes in performance. Our arrangements are shown to be optimised and the impacts are minimal. No gaps have been identified.
	Other aerial releases	Arisings of dust from the site may be contaminated by radiological and non-radiological species. Air sampling is a statutory requirement and is undertaken at the site perimeter. In 2024/25, as in	Contamination control measures and the containerised grouted wasteform mean that contamination levels of any dispersible dust in the disposal vaults will be low.	Impacts from other aerial releases are minimal and we take precautions to minimise our releases. Our air sampling at the site perimeter provides ongoing assurance that impacts are low

		previous years, no measurements exceeded environmental sampling reporting levels. It is likely that authorised discharges from Sellafield and fall-out and natural sources are significant contributors to the concentrations that we measure. Dust monitoring is carried out when undertaking significant construction activities.	As part of our '*Environmental Safety During the Period of Authorisation*' assessment [13], we undertake a retrospective dose assessment. Calculated doses are low and the site-derived contribution to the dose is even lower. In compliance with our 'Construction Environmental Management Plan' [64], dust suppression systems are used when carrying out significant construction activities.	and would allow us to respond appropriately to any emerging trends that challenge that position. No gaps have been identified.

Actions arise from considerations of the uncertainties (Table 10.1) and gap analysis (Table 10.2). These are grouped below into three categories:

- Ongoing work (things we are already doing and will continue to do). These are already embedded in our management arrangements.
- New actions (things we will do in the near term). These will be added to our Issues Register to ensure they are recorded and tracked. Processes will be updated where necessary.
- Long-term actions (things we will do at specific points in the longer term, with the timing determined by the Site Development Plan).

Ongoing work

We will progressively improve the characterisation of the site over the course of its lifetime with monitoring and site characterisation activities in support of our WMP. Further characterisation will be driven by the Site Development Plan. There are uncertainties inherent in the Site Development Plan that are outside of our control, for example, the rate that industry produces waste requiring LLW disposal and wider policy changes. Therefore, the timings of characterisation in certain areas, or when decisions will be made, cannot be determined at this point. However, we will continue to make decisions through our site and land usage management procedure, with oversight from the Site Development and Coordination Committee. This ensures a clear decision-making process is in place with links between site development planning and the ESC. Decisions are supported by our established procedures that ensure that we are working in an optimised manner, in compliance with our Permit.

New actions

We will progressively enhance the Building Register to support robust estimates of decommissioning waste arisings and forecast waste streams. This will include (as available and proportionate to the lifecycle stage) improved information on building area, construction form and principal materials, embedded services and below-ground elements, known or suspected hazardous materials (e.g. asbestos) and any known radiological history or proximity to areas of concern. These data will be used to develop indicative waste volumes and types for forward planning and to inform subsequent characterisation and BAT option assessments as each asset approaches redundancy. As projects move from planning to execution, the Building Register will be supplemented by the site’s established arrangements for waste characterisation and inventory management, including the generated waste inventory records and the requirement for Project Waste Management Plans, ensuring traceability from asset information through to the selected waste route.

We will also widen the scope of the ESC Annual Review reporting to capture a clear, year-on-year record of site-derived wastes. This will include a summary of the quantities and types of site-derived wastes generated and their permitted management routes (including any use of treatment or diversion routes), alongside any material changes to the underlying inventories, registers or monitoring evidence that support the WMP. By bringing these data into the established ESC annual reporting and governance cycle, we will provide a transparent mechanism to identify emerging trends, highlight any new information relevant to the WMP, and trigger assessment through the ESC change-control processes where necessary, helping to ensure the WMP remains a live product aligned with the wider ESC evidence base.

Long-term actions

Where any in-situ disposal or ‘disposal for a purpose’ is proposed, or we wish to apply for partial surrender of our Permit, the following actions will be undertaken in line with our established ESC governance and optimisation processes:

1) Characterisation and documentation. Adequate, proportionate characterisation of the relevant area, structures and/or materials will be undertaken, including radiological and non-radiological components, supported where necessary by targeted surveys, sampling and analysis. The resulting evidence will be documented and reflected within the appropriate maintained records that underpin the WMP (e.g. inventories, registers and supporting reports).
2) Options assessment, BAT and engagement. We will undertake an options assessment, applying the waste hierarchy and the principles of BAT, balancing all relevant factors. As required by the GRR and our governance arrangements, we will undertake appropriate stakeholder engagement to support the preferred option.
3) ESC assessments, guidance levels and permitting. Specific assessment calculations and supporting safety case evidence will be developed for any such proposals, to demonstrate environmental safety and to show that the relevant guidance levels can be fulfilled. Where required, any material change will be progressed through ESC change control, and we will engage with the Environment Agency and prepare the necessary regulatory submissions (e.g. a Permit variation for an on-site disposal activity or a surrender/partial surrender application), with full traceability to the underpinning evidence and decisions.

These longer-term actions cannot be time-bound at this stage because the timing and sequencing of site development and lifecycle decisions are influenced by a range of factors, including external drivers. As described in this WMP, we will manage progress through our established management arrangements that keep the ESC and WMP live, including ongoing site characterisation and environmental monitoring, maintenance of the underlying evidence base (e.g. inventories, the Building Register, the Land Quality Register and GIS/site development records), and formal governance and change control (including assessment of new information and coordination of site development proposals). We will continue to operate in compliance with our Permit and will progress the site towards the Site Reference State and, ultimately, a condition suitable for release from regulation.

11 Summary

Purpose and scope

This is the first iteration of the WMP for the LLWR, forming part of the 2026 ESC. It describes how we, NWS, will deliver optimised waste management throughout the site's lifecycle, to achieve eventual release from regulation once the site's mission is complete.

The WMP aims to take an integrated approach, addressing both radioactive and non-radioactive waste and contamination. Optimisation is the key driver, with decisions guided by the waste hierarchy and BAT.

The WMP covers the management of solid, liquid, and gaseous radioactive wastes, as well as land contamination. It includes recent and forecasted waste arisings, routes for treatment and disposal, and the processes for characterising, tracking, and optimising waste management decisions. Non-radioactive decommissioning waste arisings are also discussed.

Regulatory drivers

The WMP has been developed to meet Requirement R2 of the GRR, which requires development and maintenance of a waste management plan that identifies all current and prospective disposals of radioactive waste and demonstrates optimised waste management.

Lifecycle and Site End State

The next planned use of site is 'waste management and recreation or nature conservation' and has been agreed with our stakeholders including the local community. The preferred end state for the disposal area involves leaving waste in situ with engineered barriers, with ongoing monitoring to ensure safety and compliance and continued stakeholder engagement.

On the wider site, the preferred end state involves reducing radiological contamination to levels that can be demonstrated as safe by our SWESC. This may include in-situ disposal of contaminated areas where a case-by-case assessment demonstrates it to be optimal. Non-radiological contamination will be remediated to meet the requirements for the designated next use.

For below-ground structures such as discharge pipelines, in-situ disposal is the preferred option if it can be demonstrated to be safe and optimised. This may include filling voids with waste generated from other site remediation works (‘disposal for a purpose’). A Permit variation would be required to authorise any in-situ disposal or disposal for a purpose of radioactive waste. An update to this WMP and a SWESC would accompany any Permit variation for any such proposed disposals.

Solid, liquid and gaseous wastes and discharges

We have identified the solid, liquid and gaseous wastes and discharges that arise from the site and demonstrated that we have arrangements in place to ensure optimised management of these wastes and discharges.

Solid waste arisings are controlled through: application of the waste hierarchy and BAT to select the appropriate route; compliance with our radioactive waste management processes; and robust inventory and records management. We also maintain our JWMP for near-term forecasting of solid waste arisings, which is kept live through annual updates. Wastes are often sentenced through the routes available in our Waste Services Contract.

We have already carried out significant programmes of decommissioning. For example, we have recently completed the decontamination and decommissioning of the remaining legacy magazine structures. We have provided examples of how we have used our well-established framework for optimised decision-making to sentence all wastes generated to the most appropriate management routes (see Subsection 5.5).

Our permitted discharges of liquid and gaseous effluents are managed through our established effluent management arrangements, supported by application of BAT to minimise discharges and their impact.

Liquid effluents (including leachate, sewage effluent and minor arisings) are predominantly routed via the Marine Holding Tanks for controlled discharge through the Marine Pipeline, with routine radiological sampling during each discharge and additional non-radiological monitoring and annual risk assessment reported through our effluent discharge reporting. Permitted stack discharges of gases are subject to double HEPA filtration, which we have demonstrated to be optimised, alongside routine monitoring and risk assessment to provide assurance that the impacts of such discharges are negligible.

Direct release of liquids and gases from permitted disposals in our dedicated disposal facility are a core consideration of the wider ESC. The engineering design of the facility is optimised to minimise the impact of such releases, and the capacities that we set for certain radionuclides and materials ensure that the impacts of the releases are within acceptable limits.

We implement an extensive environmental monitoring programme. The monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards.

Land contamination

We have undertaken a significant amount of work in recent years to better understand the contaminated land on the site, which has allowed us to produce the Land Quality Register.

Although we have a reasonably good understanding of the extent of the land contamination and legacy in-situ structures across the site, we have not yet undertaken the full process of optimisation that is required to determine the preferred management option needed to bring the site to a condition that is suitable for its next use. This represents a gap in our current WMP that will be progressively addressed in future iterations.

The site-wide optimisation of the BAT solution for management of the contaminated land may require further targeted characterisation, plans for which will be considered on a case-by-case basis and be proportionate to the hazard that is presented.

As discussed in Subsection 6.3.1, the contaminated land is not currently having an adverse impact on people or the environment, as demonstrated by our environmental monitoring programme, and we have controls and procedures in place to further ensure safety by, e.g., controlling access to affected areas.

Monitoring and records management

Although there is further site characterisation required as we work towards the Site End State, we are confident that the environmental monitoring programme's coverage of surface waters and groundwaters provides assurance that controlled or uncontrolled discharges from the site, including the wastes outside of the designated disposal facility, are not currently having an adverse impact on surface waters or groundwaters (see Subsection 6.3.1).

Ongoing environmental monitoring and robust records management are maintained to demonstrate compliance with our Permit, support optimisation, and inform future updates to the WMP and ESC.

Forward plan and uncertainties

This is the first WMP for the LLWR site. It shows that our existing management arrangements for all wastes across the site are robust and ensure environmental safety. They also ensure that the principles of Best Available Technique and the waste hierarchy are applied as appropriate.

We have not yet made all the decisions that are needed to finalise our plans an optimised end state. These decisions will affect our WMP as they will affect the quantity and timing of the generation of site wastes in the future. For example, we do not yet know which infrastructure or land contamination we may apply to leave in situ, assuming it is demonstrably safe and consistent with the site's next use to do so. To arrive at these decisions, we must undertake a programme of site-wide optimisation to develop an integrated view on what will happen to the site and the wastes generated. In some cases, this process of optimisation will require further characterisation of potential site wastes to inform decision-making. The characterisation information and resulting decisions will allow us to progressively improve our WMP to make it more complete.

Although there are gaps in our WMP, we do not consider that there is an urgent need to fill them. The reasons for this are as follows.

- We have characterised our site wastes to an extent that we are confident that they can be dealt with using options for waste management that already exist (e.g. disposal in situ or in our designated disposal facility.

- The site has many years of operation remaining before it is required to be in a condition suitable for its next use. Access to the site will be restricted throughout this period.[10]
- Our environmental monitoring programme shows that impacts from the site, from all sources and via all pathways, are below regulatory standards, which shows that leaving the contamination in situ for the time being is not having an adverse impact on people or the environment (see Subsection 6.3.1).
- We are satisfied that the procedures and processes we implement will ensure ongoing environmental safety.

Our timescales for undertaking the necessary programme of site-wide optimisation are linked to our Site Development Plan, which provides a guide as to when those decisions are needed. There is uncertainty in the long-term Site Development Plan because the timing and sequencing of site development and lifecycle decisions are influenced by a range of factors, including external drivers.

We will undertake our programme of site-wide optimisation during the operational period of the site. We will arrive at an optimal end state that is consistent with the preferred next use and develop our view on the preferred waste management options. We will undertake this work at a point that allows us to iterate these plans with the final detailed engineering plans for the completion of closure engineering. We anticipate this being no later than 2100.

Continuous improvement is embedded in our processes, with collaboration, learning from experience, and continued stakeholder engagement as key elements.

We have identified new actions:

- We will progressively enhance the Building Register to support robust estimates of decommissioning waste arisings and forecast waste streams.
- We will widen the scope of the ESC Annual Review to include review of site-derived wastes.

The first will be used to develop indicative waste volumes and types for forward planning and to inform subsequent characterisation and BAT option assessments as each asset approaches redundancy. The second will ensure the WMP remains a live product aligned with the wider ESC evidence base.

We will otherwise continue to work within our established management arrangements, which will ensure ongoing environmental safety and optimised management of the wastes that are generated on site.

[10] An area of the site may be released from regulation before operations are complete. This would only happen if it could be demonstrated that it is safe to do so.

References

[1] Nuclear Waste Services, "The 2026 Environmental Safety Case: Main Report," LLWR/ESC/R(26)10166, May 2026.

[2] Nuclear Waste Services, "The 2026 Environmental Safety Case: Management and Dialogue," LLWR/ESC/R(26)10167, May 2026.

[3] Nuclear Waste Services, "The 2026 Environmental Safety Case: Site History and Description," LLWR/ESC/R(26)10168, May 2026.

[4] Nuclear Waste Services, "The 2026 Environmental Safety Case: Disposal Facility Inventory," LLWR/ESC/R(26)10169, May 2026.

[5] Nuclear Waste Services, "The 2026 Environmental Safety Case: Engineering Design," LLWR/ESC/R(26)10170, May 2026.

[6] Nuclear Waste Services, "The 2026 Environmental Safety Case: Near Field," LLWR/ESC/R(26)10171, May 2026.

[7] Nuclear Waste Services, "The 2026 Environmental Safety Case: Hydrogeology," LLWR/ESC/R(26)10172, May 2026.

[8] Nuclear Waste Services, "The 2026 Environmental Safety Case: Site Evolution," LLWR/ESC/R(26)10173, May 2026.

[9] Nuclear Waste Services, "The 2026 Environmental Safety Case: Monitoring," LLWR/ESC/R(26)10174, May 2026.

[10] Nuclear Waste Services, "The 2026 Environmental Safety Case: Optimisation and Site Development Plan," LLWR/ESC/R(26)10175, May 2026.

[11] Nuclear Waste Services, "The 2026 Environmental Safety Case: Safety Functions," LLWR/ESC/R(26)10177, May 2026.

[12] Nuclear Waste Services, "The 2026 Environmental Safety Case: Engineering Performance Assessment," LLWR/ESC/R(26)10178, May 2026.

[13] Nuclear Waste Services, "The 2026 Environmental Safety Case: Environmental Safety During the Period of Authorisation," LLWR/ESC/R(26)10179, May 2026.

[14] Nuclear Waste Services, “The 2026 Environmental Safety Case: Assessment of Long-term Radiological Impacts,” LLWR/ESC/R(26)10180, May 2026.

[15] Nuclear Waste Services, “The 2026 Environmental Safety Case: Hydrogeological Risk Assessment,” LLWR/ESC/R(26)10181, May 2026.

[16] Nuclear Waste Services, “The 2026 Environmental Safety Case: Assessment of Impacts on Non-human Biota,” LLWR/ESC/R(26)10182, May 2026.

[17] Nuclear Waste Services, “The 2026 Environmental Safety Case: Implementation,” LLWR/ESC/R(26)10183, May 2026.

[18] Nuclear Waste Services, “The 2026 Environmental Safety Case: Addressing Regulatory Requirements and Feedback,” LLWR/ESC/R(26)10184, May 2026.

[19] UK Government, “The Environmental Permitting (England and Wales) Regulations 2016,” Statutory Instrument 2016 No 1154, London: The Stationery Office, 2016.

[20] Scottish Environment Protection Agency, Environment Agency and Natural Resources Wales, “Management of Radioactive Waste from Decommissioning of Nuclear Sites: Guidance on Requirements for Release from Radioactive Substances Regulation,” Version 1.0, July 2018.

[21] Environment Agency, “The Environmental Permitting (England and Wales) Regulations 2016: Permit with Introductory Note,” Permit Number EPR/YP3293SA, Variation 005, September 2025.

[22] LLW Repository Ltd, “Development and Application of the LLWR’s Environmental Safety Case,” RSP 02.25, Issue 4, March 2020.

[23] LLW Repository Ltd, “Waste Acceptance Criteria – Low Level Waste Disposal,” WSC-WAC-LOW – Version 5.0, July 2016.

[24] LLW Repository Ltd, “Permit Compliance,” RSP 2.01, Issue 18, April 2023.

[25] Nuclear Industry Safety Directors Forum, “Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Wastes: Good Practice Guide (formerly Nuclear Industry Code of Practice - NICoP),” Issue 1, December 2010.

[26] Nuclear Waste Services, “Radioactive Waste Management Process,” RSP 24.03, Issue 4, May 2022.

[27] Nuclear Waste Services, “Generated Waste Inventory Management,” RSP 24.04, Issue 4, November 2023.

[28] Nuclear Waste Services, “Characterisation Guidance,” RSG 24.03_02, Issue 2, April 2021.

[29] Nuclear Waste Services, “Site and Land Usage Management,” RSP 14.20, Issue 5, November 2025.

[30] Nuclear Waste Services, “Site Development and Coordination Committee Terms of Reference (ToR),” RSP 14.20A, Issue 5, December 2025.

[31] Nuclear Waste Services, “The Institutional Control Plan for the LLWR,” LLWR/ESC/R(25)10162 (In Preparation), 2026.

[32] LLW Repository Ltd, “LLWR Site End State. Gate B: Preferred Options and Assumptions,” LLWR/ESC/R(22)10132, January 2022.

[33] Nuclear Waste Services, “Optimisation / Best Available Techniques (BAT) (covering Management of Radioactive Waste using BAT),” RSP 02.01.03, Issue 8, January 2022.

[34] Nuclear Waste Services, “Safe Management of Land Contamination,” RSP 2.08, Issue 12, November 2022.

[35] Nuclear Waste Services, “Management of the LLWR Site Building Register and Compliance with Nuclear Site Licence Condition 16 (Site Plans, Designs and Specifications),” RSP 14.15, Issue 4, March 2022.

[36] R. Cummings, “Register of Significant Uncertainties,” In Preparation, April 2026.

[37] Nuclear Waste Services, “Stage 2 Inventory - Disposed Radionuclides/Activity,” DMF0107 v1, January 2025.

[38] Nuclear Waste Services, “Stage 2 Inventory - Masses of Disposed Materials and Non-radiological Contaminants,” DMF0108 v1, January 2025.

[39] Nuclear Waste Services, “Stage 2 Inventory - Volumes of Disposed Waste,” DMF0109 v1, January 2025.

[40] Nuclear Waste Services, “Stage 2 Inventory - Future Radionuclide/Activity Disposals,” DMF0110 v1, January 2025.

[41] Nuclear Waste Services, “Stage 2 Inventory - Masses of Future Materials and Non-radiological Contaminants,” DMF0111 v1, January 2025.

[42] Nuclear Waste Services, “Stage 2 Inventory - Volumes of Future Waste,” DMF0112 v1, January 2025.

[43] Nuclear Waste Services, “Waste Forecasting Form 2024/25,” RSF 03.02.10_003, April 2025.

[44] M. Looman, “MDA Assessment Report,” P(20)421-MDA Assessment Report-3, November 2022.

[45] LLW Repository Ltd, “Best Available Techniques Assessment for the Management of Demolition Wastes from the PCM Magazines,” LLWR/ESC/R(19)10106, Issue 1, July 2020.

[46] Nuclear Waste Services, “Vault 8 Remaining Disposal Volume: BAT Update,” LLWR/ESC/R(23)10136, March 2023.

[47] P. R. Tulip and D. Jackson, “Disposal of Legacy Drum Store Demolition Waste to Vault 8,” LLWR/ESC/Mem(16)297, September 2017.

[48] Nuclear Waste Services, “Integrated Delivery Strategy for the use of B720 Demolition Rubble as Infill for Vault 8,” 1LLW-1LLW-5091-REP-L-7491, Issue 01, November 2024.

[49] Nuclear Waste Services, “LLWR Site Characterisation Report,” RP-3409334.05-ENV-00042, October 2022.

[50] LLW Repository Ltd, “Site Characterisation Report,” RP/LLWR/PROJ/00192, March 2015.

[51] UK Government, “The Control of Asbestos Regulations 2012,” Statutory Instrument 2012 No 632, London: The Stationery Office, April 2012.

[52] Nuclear Waste Services, “Management and Control of Asbestos,” NWSSOP 47.04, Issue 0, November 2025.

[53] Environment Agency, Scottish Environment Protection Agency, Natural Resources Wales and Office for Nuclear Regulation, “On-site Disposal of Solid Radioactive Waste onNuclear Licensed Sites Joint Regulators’ Statement of Common Understanding,” Version 2, February 2021.

[54] Nuclear Waste Services, “Safe Management of Land Contamination,” NWSSOP 02.06.01, Issue 1, February 2026.

[55] Nuclear Waste Services, “Control of Excavation Activities (Permit to Dig),” NWSSOP 56.05_01, Issue 1, February 2026.

[56] Nuclear Waste Services, “LLWR Site 2024 Retrospective Dose Assessment,” RP-3409334.05-ENV-00278, December 2025.

[57] Nuclear Waste Services, “2024 Liquid and Gaseous Effluent Discharge Summary,” RO-3409334.05-ENV-00259, August 2024.

[58] Environment Agency, “Initial Radiological Assessment Tool 2 – Part 1 User Guide,” Chief Scientist’s Group Report, November 2022.

[59] Environment Agency, “Environmental Management – Guidance: Surface Water Pollution Risk Assessment for your Environmental Permit,” April 2018.

[60] Nuclear Waste Services, “Low Level Waste Repository Environmental Safety Case Annual Review 2022/23,” LLWR/ESC/R(23)10137, June 2023.

[61] Nuclear Waste Services, “Low Level Waste Repository Environmental Safety Case Annual Review 2023/24,” LLWR/ESC/R(24)10150, June 2024.

[62] AECOM, “Aecom, Repository Development Programme - Tranche 1 Design Package 7 - Interim Hydrological Management of the Trenches BAT Outcomes Report,” AEC-RDP-T1.00-RP-052 A 2019, 2019.

[63] Nuclear Waste Services, “Landfill Gas - Trace Components Assessment,” LLWR/MON/Mem(22)010, June 2022.

[64] LLW Repository Ltd, “Construction Environmental Management Plan,” LLWR-RDP-T1 .OO-RDP-116 A, August 2019.

[65] Nuclear Waste Services, “NWS Topic Manual: Environmental Management,” NWSTM 02.00, Issue 3, January 2025.

[66] Nuclear Waste Services, “Disposal of Non-radiological Waste,” NWSSOP 02.03.01, Issue 1, March 2026.

[67] Nuclear Waste Services, “Project Waste Management Plan,” RST 24.03_101, Issue 3, March 2021.

[68] Nuclear Waste Services, "Development and Application of the LLWR's Environmental Safety Case," NWSSOP 40.07.01, Issue 1, March 2026.

[69] LLW Repository Ltd, "Optimisation / Best Available Techniques (BAT) (covering Management of Radioactive Waste using BAT)," RSP 02.01.03, Issue 8, January 2022.

[70] European Union, "Directive 2008/98/EC of the European Parliament and of the Council of 19 Novemebr 2008 on Watse and repealing certain Directives," Official Journal L 312/3, November 2008.

Nuclear Waste Services Limited
Pelham House
Pelham Drive
Calderbridge
Cumbria CA20 1DB
UK

t +44 (0)300 369 0000
w www.nuclearwasteservices.uk

Nuclear Waste Services

Where to find more information

You can find out more about NWS online or by contacting us directly.

About our organisation:
nuclearwasteservices.uk/about-us

You can subscribe for e-mail updates:
public.govdelivery.com/accounts/UKNDA/signup/42429

NWS Helpdesk

0300 369 0000

info@nuclearwasteservices.uk

Freepost NUCLEAR WASTE SERVICES

Follow us:

Nuclear Waste Services

@NuclearWasteServices

@nuclear_waste_services

Nuclear Waste Services