Magnox

Integrated Decommissioning and Waste Management Strategy

2022

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1. Introduction

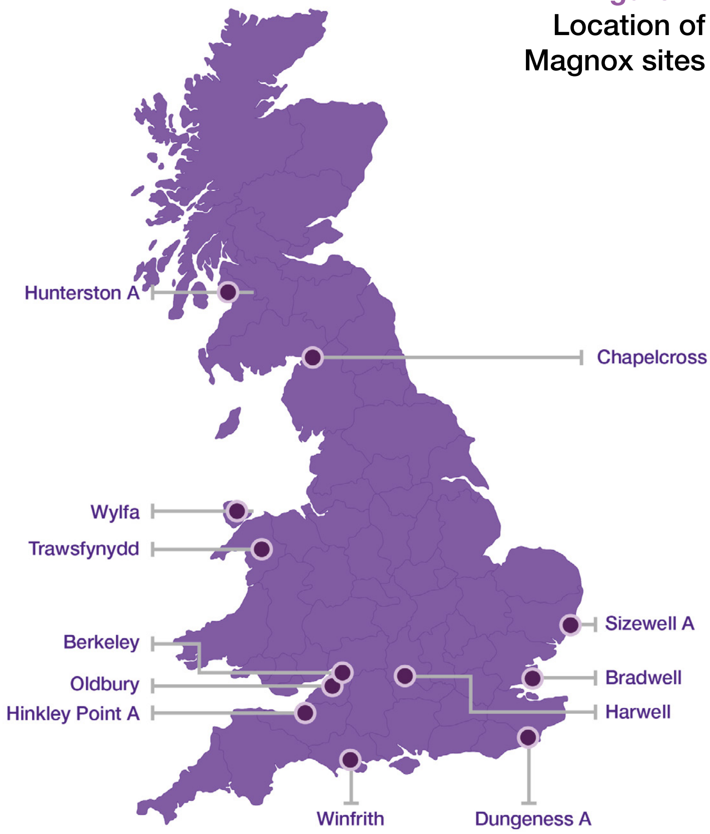
1.1 Background

Magnox Ltd ('Magnox') is the site licence company (SLC) responsible for the safe and secure clean-up and decommissioning of 12 civil nuclear sites owned by the Nuclear Decommissioning Authority (NDA). The NDA is the strategic authority, established under the Energy Act 2004, responsible for the safe and secure clean-up of civil nuclear facilities, and delivers its strategy through SLCs such as Magnox.

The 12 Magnox sites are varied, comprising two sites used for atomic energy research and the first fleet of graphite reactors (ten sites) used to generate electricity in the UK between the 1950s and 2010s. All sites have now ceased research operations / electricity generation and are in the decommissioning phase of their lifecycle.

Over the remaining lifecycle for each site a large quantity of waste will need managing. Some of this waste exists, having arisen during the site's research operations / electricity generation, and some will arise from decommissioning, for example from the demolition of redundant buildings.

Figure 1: Location of Magnox sites



This document details how Magnox manages its waste in an integrated and sustainable way. It sets out the approaches that have been put in place to ensure best use of existing and planned waste management capabilities.

1.2 Context for IWS review

Since the last integrated decommissioning and waste management strategy (IWS) review of 2019 Magnox has become a direct subsidiary of the NDA and a major strategy change has been agreed that will lead to the decommissioning of each Magnox site as part of a 'rolling programme' (see Section 1.4).

The Magnox portfolio is also expanding. In June 2021, the UK government directed the NDA to take on the future ownership of the seven EDF Energy advanced gas-cooled reactor (AGR) sites for decommissioning. This work will be undertaken by Magnox and the decision is a testament to the skills, knowledge and experience held in Magnox and the NDA. In addition, in September 2021 it was announced that Dounreay Site Restoration Ltd ('Dounreay') will join with Magnox to simplify the organisational structure beneath the NDA and increase the opportunity for collaboration and sharing of skills and knowledge.

In the wider NDA group, Low Level Waste Repository Ltd (LLWR) and Dounreay have also joined Sellafield Ltd and Magnox as NDA subsidiaries. Beneath the NDA, a Nuclear Waste Services (NWS) division has been formed through the merger of Radioactive Waste Management Ltd (RWM) and LLWR, and a Nuclear Transport Solutions (NTS) division has been formed through the merger of Direct Rail Services (DRS) and International Nuclear Services (INS). Collectively, and along with other subsidiaries of the NDA, there has been increasing movement towards a 'One NDA' working model. The Integrated Waste Management Programme (IWMP) represents one significant part of this integration, seeking to maximise benefits from the pooling of problems and resources.

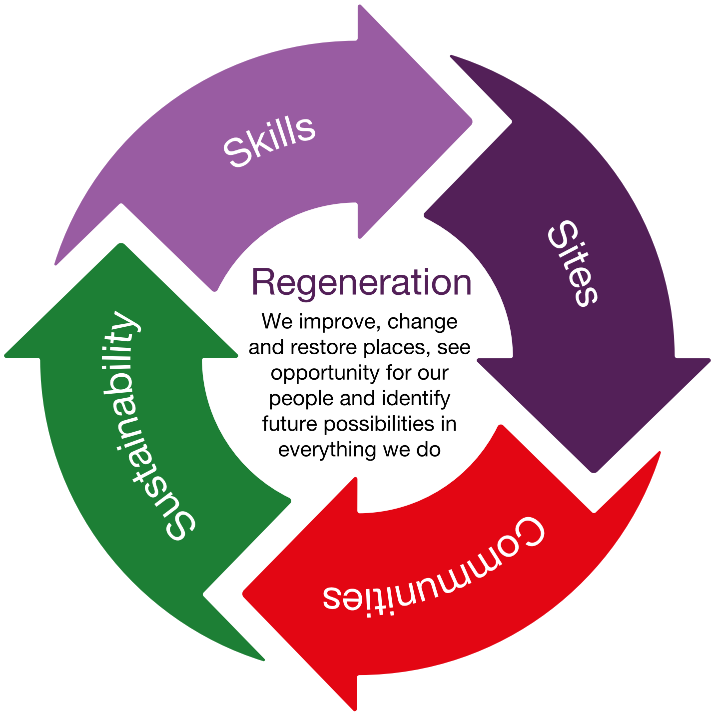
More broadly, this IWS review has taken place in the context of the COVID-19 pandemic, the UK's exit from the European Union, and a climate crisis. Magnox is seeking to lead the way in its response to these challenges in line with its vision, as set out below.

1.3 The vision

Magnox has moved from a "closure business" to an enduring business, taking on new and important missions, and a new company vision has been set in this context.

This is one of regeneration, the fundamental tenets of which are set out in Figure 2:

Figure 2: The Magnox Vision - Regeneration



Regenerating skills

- Investing in nuclear and specialist skill for the future.
- Planning and transforming our workforce for new missions.
- Appealing to new generations of talent.

Regenerating sites

- Recognising our power generation site history with pride.
- Restoring sites back to safe use.
- Transforming sites to a new future of power generation.

Regenerating communities

- Continuing our relationship with local communities to help them thrive.
- Providing new employment opportunities for generations to come.
- A strong socio-economic impact

Sustainable regeneration

- Net zero commitment.
- Commitments to the environment, safety, community prosperity, and equality and diversity.
- Readiness for future opportunities

1.4 The mission

The Magnox mission is set within the context of its vision, where regeneration of a site is focused through delivery of strategic objectives. Magnox's primary mission, also known as "Mission One", is to deliver each of its current 12 sites to their *end state*. In the context of regeneration, an end state signifies the completion of decommissioning and site restoration activities and the beginning of a new chapter in the site's use. The next use may be different at each site, and could see small modular reactors, new housing or commercial premises being installed, or the land given to public access, amongst other possibilities.

This mission is to be progressed over several decades during which time decommissioning and waste management objectives (see Section 3.1) will be systematically achieved.

These objectives were to be delivered according to an historic strategy of deferred reactor dismantling, in which each reactor would have been dismantled 85 years after it shut down and all sites would be maintained in a quiescent state until this work took place. However, increased costs and lifecycle risks on some sites have resulted in an agreement with the NDA to adopt site-specific decommissioning strategies, to accommodate each site's unique characteristics. This change will result in a rolling programme of decommissioning, beginning with the dismantling of reactors at Trawsfynydd.

As noted earlier, Magnox is also to take on a new mission to decommission the AGR sites and will also come together with Dounreay in a single organisation. Other missions may also be taken on in the future, for example other nuclear liabilities could be transferred from private ownership to the NDA and Magnox appointed to manage them. Collectively, these are referred to in Magnox as 'Future Missions'.

> **Explainer: End States**
>
> An end state is the condition to which a site, or part of it, needs to be restored to make it suitable for the next planned use.

1.5 Document purpose

This document presents the Magnox IWS and sets out to answer the following questions:

- Where are we today?
- Where do we want to get to and when?
- What actions are needed to get there?

By answering these questions, this document intends to clearly articulate what the established strategy is and how future strategies will be developed and optimised, with the delivery of this work focused through an IWS Action Plan.

This document builds on previous issues, the last of which was issued in 2019 [1]. It is produced in accordance with NDA specification [2] and has been updated to support delivery of site-specific decommissioning strategies along with reflecting wider changes to national policy and strategy.

1.6 Document scope

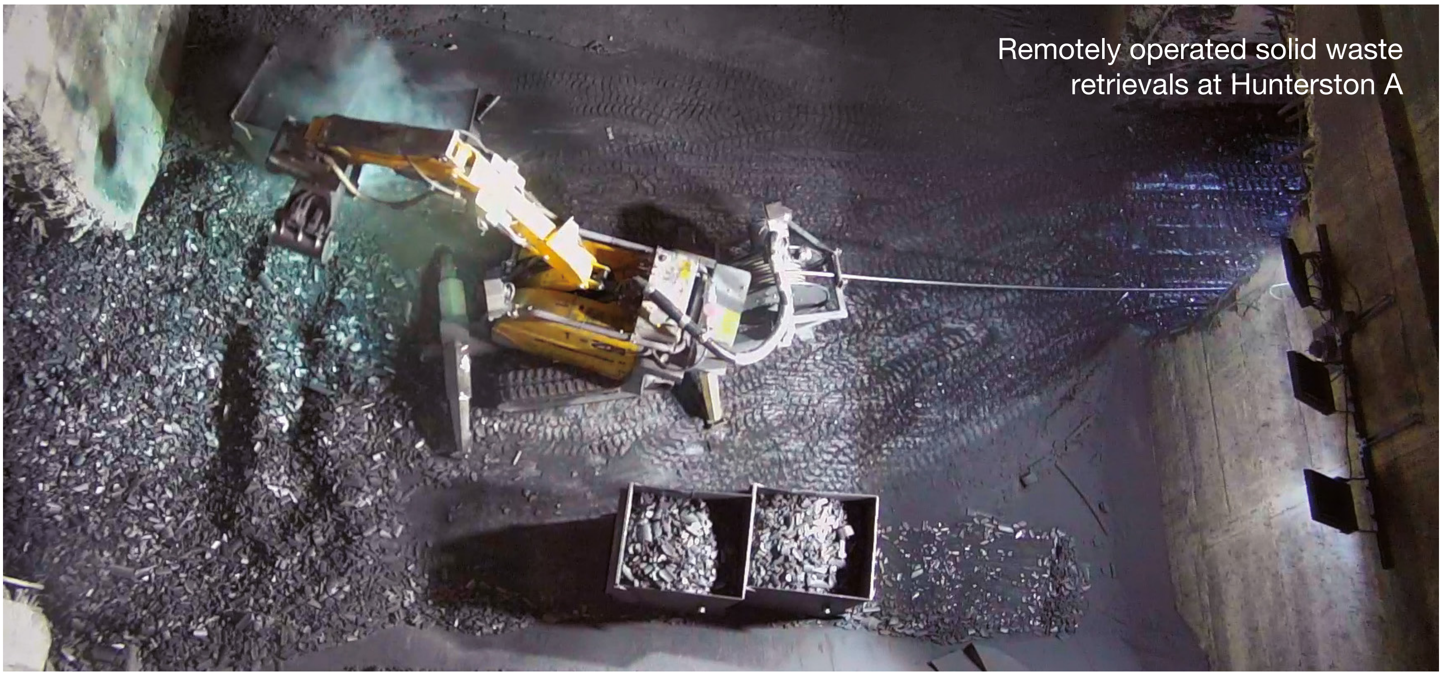
This document covers the post-defueling phases of each site's decommissioning lifecycle. It applies to all of the Magnox nuclear licensed sites (and their associated landholdings) and all their *wastes* (including discharges). This includes wastes that currently exist, including those generated from historic site operations, as well as materials/assets that have the potential to become waste in future, for example: nuclear materials, redundant assets, and contaminated land. This document includes consideration of wastes arising from future missions though does not present a strategy for managing these wastes at this stage.

Explainer: **Wastes**

Article 3(1) of the Waste Framework Directive defines waste as "any substance or object which the holder discards or intends or is required to discard". The Waste Framework Directive excludes radioactive waste, however, which the UK regulators describe as "material that is either radioactive itself or is contaminated by radioactivity, for which no further use is envisaged".

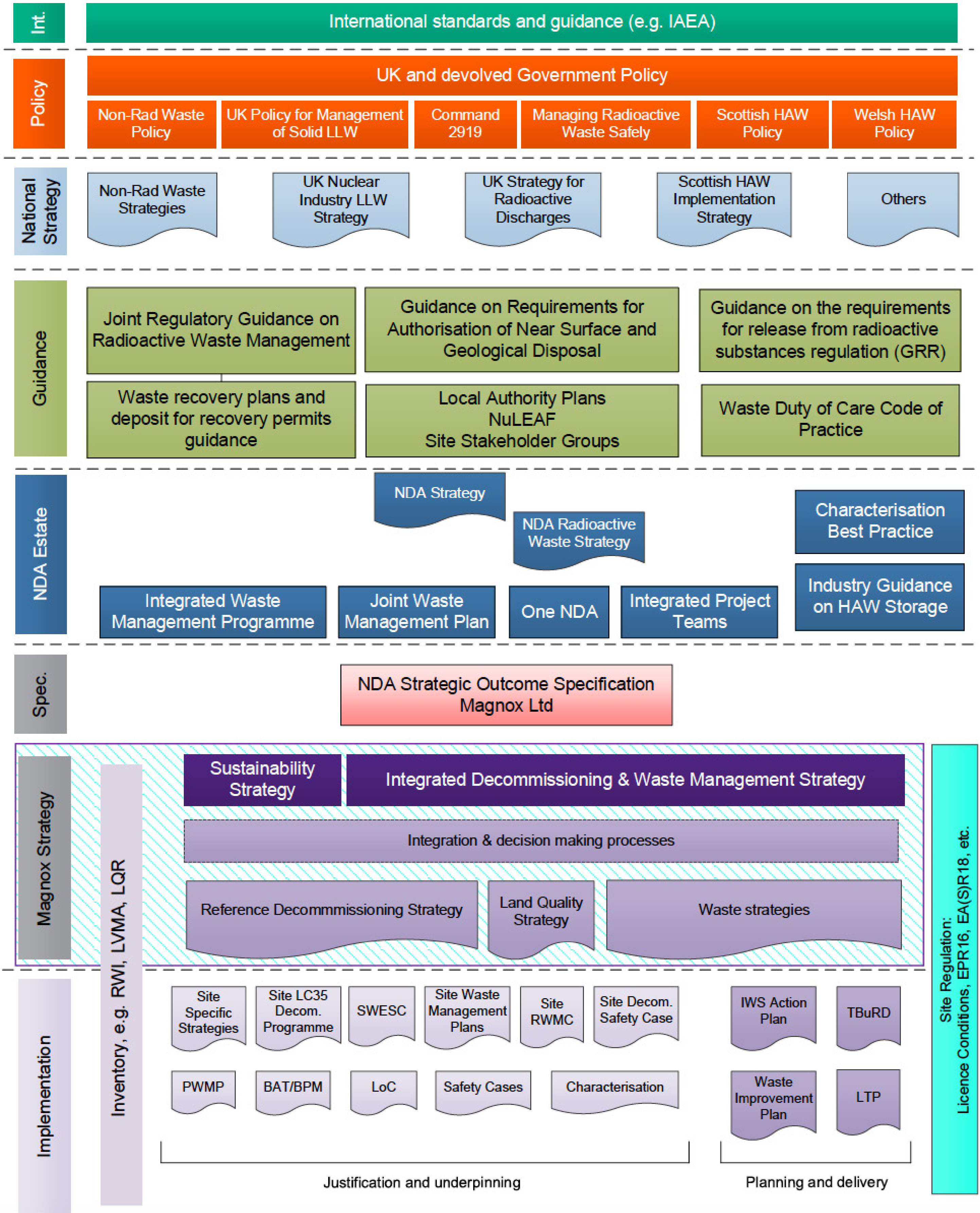
Figure 3 shows the context for this document, beneath international standards and guidance, the devolved government policies in the UK, and within a framework of national strategy, regulatory guidance, and industry initiatives. It forms part of a management system through which established aspects of the strategy are set out and is principally supported by each site's Radioactive Waste Management Case (RWMC) which provides, or signposts to, the justification and underpinning for each site's radioactive waste management strategy.

This document presents a consistent strategic approach so far as is practicable given the different policies of each devolved administration of the UK government. However, these policies require different approaches in some areas, notably for higher activity waste (HAW) management (the relevant policies and strategies for which are shown in Figure 3).



Remotely operated solid waste retrievals at Hunterston A

Figure 3: IWS document context



This document is submitted by Magnox to the NDA as a statement of company strategy. Implementation of the company strategy on a site is subject to regulatory permissioning; it is dependent on completion of all necessary underpinning and the granting of appropriate authorisations, licences, permits or approvals.

2. Communication and consultation

Established strategies, which are set out in this document, have been developed with the involvement of the NDA, regulators, and other stakeholders such as local planning authorities, site stakeholder groups, Nuclear Legacy Advisory Forum (Nuleaf) and other local interest groups. Progress against delivery of decommissioning and waste management strategies is communicated to stakeholders on a regular basis as are any potential changes to the strategies and implementation plans.

Significant changes to Magnox strategy are taken to the NDA Senior Strategy Committee for endorsement in accordance with their published guidance on strategy management [3].The recent strategy change from deferred reactor dismantling to a rolling programme of decommissioning, with Trawsfynydd as the lead site, has, along with other aspects of Magnox strategy, been subject to public consultation as part of NDA's business strategy update and is now included in the published strategy [4].

Stakeholder engagement has commenced regarding the development of site-specific strategies in support of the rolling programme of decommissioning.

Magnox is also actively participating in the IWMP and other One NDA initiatives, to improve the industry's overall effectiveness and to support delivery of national targets including those set out by the UK's climate commitments and Nuclear Sector Deal [5].

Magnox CEO Gwen Parry Jones presenting at the STEM Gogledd Launch event

3. Objectives and aims

3.1 Objectives

The primary strategic objectives of Magnox are to:

- treat and/or store (as appropriate) and dispose[1] of all waste generated from site operations and decommissioning activities; and to
- decommission, demolish or reuse all buildings, and enable all landholdings to be de-designated or reused.

For each site these objectives are expressed in greater detail as 'outcomes' and agreed with the NDA in a strategic outcome specification [6]. Each outcome will be achieved for each site according to its site-specific strategy (see Section 4.2).

3.2 Aims

In relation to the IWS the aims of Magnox are to:

Drive the optimisation of decommissioning and waste management strategies

This means:

- applying robust decision-making processes and common principles including the waste hierarchy;
- promoting good practice including the timely characterisation and segregation of waste;
- implementing risk-informed approaches to decommissioning and waste management, based on assessment of lifecycle hazards and benefits;
- making best use of existing and planned UK/global infrastructure or developing and implementing new infrastructure where beneficial to do so;
- identifying and coordinating any research and development needed to ensure that a sustainable, robust infrastructure is available to support delivery; and
- improving strategic flexibility to respond to changing factors, such as funding or plant degradation, as well as to enable future opportunities to be pursued and threats to be mitigated.

Facilitate the timely delivery of strategic objectives supporting the regeneration of our sites, skills, and communities

This means:

- integrating common approaches into standard practice;
- implementing strategies compliantly and efficiently, seeking to cause zero harm;
- ensuring that scope is understood such that work can be correctly prioritised and supported by a fit-for-purpose and sustainable organisational capacity and supply chain;
- improving how strategy implementation, and value, is measured; and
- managing knowledge, capturing learning and feeding this into strategy development and delivery to ensure continuous improvement;

Promote a 'One NDA' practice and culture

This means:

- instilling a culture of inclusivity based on a common mission;
- using effective communications methods to ensure a common understanding of waste management and to share good practice and learning; and
- embedding a culture of waste-informed decommissioning into working practice.

Grow Magnox as a global leader in sustainable decommissioning and waste management

This means:

- successfully delivering "mission one" and earning further missions;
- being an attractive company to work for, with modern values and career pathways;
- actively improving the effectiveness of decommissioning and waste management as an industry, seeking a 20% productivity gain by working smarter and more efficiently;
- taking full responsibility for the intergenerational consequences of our actions, going 'beyond compliance' to create value and resilience for future generations; and
- delivering on our net zero commitment.

[1] Dispose of all waste remaining following application of the waste hierarchy (see Section 6).

4. Decommissioning strategy

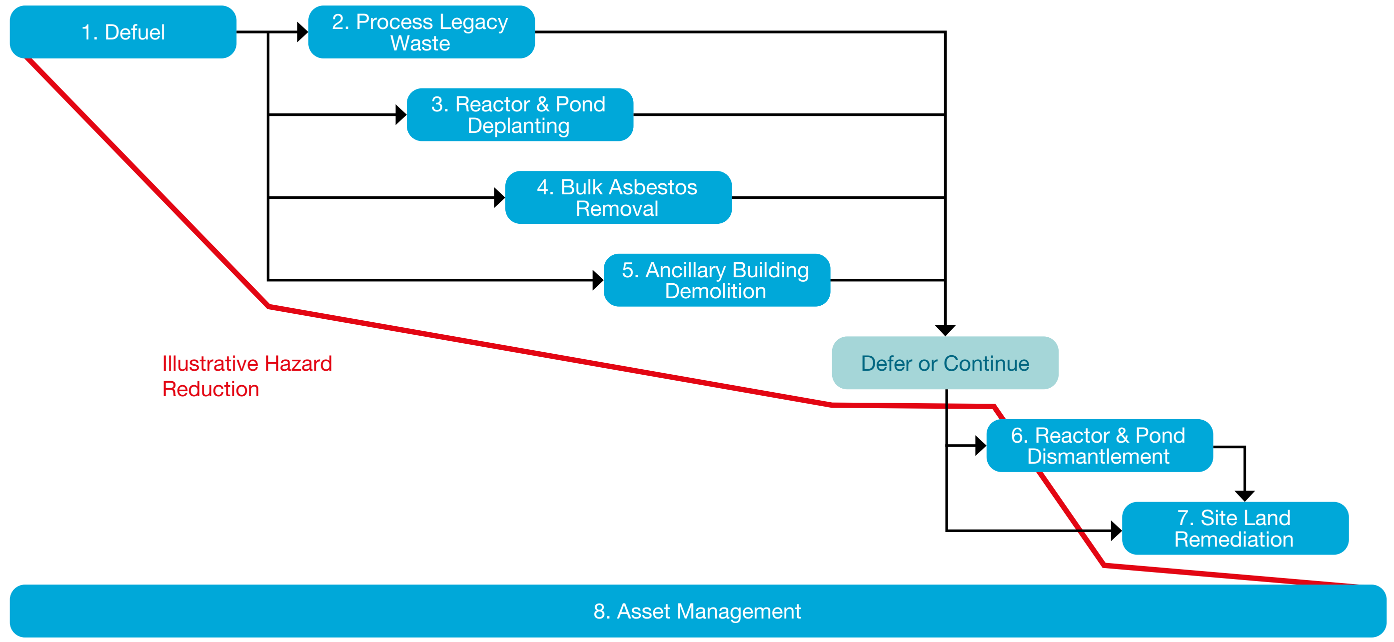
4.1 Hazard reduction

Magnox's primary mission ("mission one") is to deliver each of its current 12 sites to their end state, enabling their next use. This is done by systematically achieving decommissioning and waste management objectives at each site, in a way that progressively reduces hazards. This approach is illustrated in Figure 4 which shows a generalised sequence of the main activities required to deliver a Magnox reactor site to its end state, and how this progressively reduces hazard to people and the environment.

On a reactor site, defueling is the first priority and results in 99% of the radiological inventory being removed from site. The next priorities are to process the legacy waste (that was created during power generation, and is stored in vaults, tanks, etc. on site), commence pond decommissioning (draining the water, decontaminating and de-planting active equipment) and remove bulk asbestos. The decision of when to demolish many of the ancillary buildings is a balance between ongoing asset management, deterioration, and available funding. Final activities are to dismantle the reactors and remediate the land, with any residual hazard permitted to remain under regulatory permissioning.

Throughout this process the remaining assets at site must be safely managed. To do this it is fundamentally important to understand their condition and how this is likely to evolve over time, to determine asset management requirements and inform each site's strategy.

Figure 4: Simplified reactor site decommissioning sequence



4.2 A Rolling programme of decommissioning

Work will be progressed at each Magnox site according to its site-specific strategy and overall sequence of decommissioning across the estate.

A significant programme of work is underway to develop these strategies (see Section 6.3.1) and underpin changes to each site's lifetime plan.

Whilst maintaining the highest standards of safety, environmental, security and regulatory compliance, the pace of decommissioning is ultimately dictated by the following key factors that could result in changes to site prioritisation:

- Annual funding, which will act to enable or limit the amount of decommissioning that can be delivered across all sites.
- Emergent asset degradation and management considerations, which may serve to reduce the amount of resource that can be applied to decommissioning projects.
- Revised end state assumptions, which may serve to act as an accelerator for decommissioning at particular sites to free land for the next planned use.
- Developments in the UK radioactive waste management supply chain, e.g. metal recycling capability.

For some sites, the strategy is to defer reactor decommissioning and maintain the site in a state of quiescence[2].

Hazards will be removed to ensure risks remain As Low As Reasonably Practicable (ALARP) at all times, including during any period of quiescence, and, where appropriate, the process of radioactive decay is taken advantage of to reduce levels of radioactivity and hence risk to people and the environment.

Across the Magnox estate the site-specific strategies will provide a 'rolling' programme of decommissioning, where the first site is progressed as a lead and learn site, followed by a combination of selected sites progressing directly to the FSC phase, with the remainder of sites having quiescent periods. Compared with the previous decommissioning strategy this reduces the total time spent in quiescence and results in site remediation being brought forward significantly at many sites.

Dismantling redundant plant at Hinkley Point A

[2] Quiescent periods are similar to previous 'care and maintenance' phases and mean there is no decommissioning activity on site and the only permanent physical presence is security.

Explainer: **Why choose Trawsfynydd as the lead site for the rolling programme?**

Construction of the site commenced in 1959 with electricity generating plant from reactors synchronising to the national grid by 1965. The reactors were permanently shut down in 1993, followed by prompt defueling. Trawsfynydd was selected as the lead site for several reasons including:

- It is located in an area that can benefit significantly from the investment associated with reactor dismantling with a high proportion of the local workforce employed at Trawsfynydd and the site being identified as a key component of the Snowdonia Enterprise Zone.
- It is one of the earliest sites to be taken offline, was of a relatively low power output and operated for a relatively short period compared to other Magnox reactors and is therefore predicted to have one of the lowest radiological inventories in the Magnox fleet.
- The reactor buildings at Trawsfynydd have experienced a high-level of asset degradation that means that considerable investment would be necessary at the site to enable a long-term deferral strategy.
- The delivery of the majority of the high-hazard reduction work has been completed at Trawsfynydd – bulk asbestos materials have been removed and the bulk operational HAW programme is well advanced, this would enable the highly-skilled workforce to be redeployed to the early phases of the reactor dismantling programme.

The aim of the decommissioning work conducted to date has been to reduce the hazards on the site to a level such that the site could be placed into a quiescent state. The remaining decommissioning activities continue to progress such as de-planting of the Active Effluent Treatment Plant (AETP) of seven large stainless-steel tanks, eight pumping units, electrical cabling and over 500m of associated pipework. Recently highly-skilled Magnox operatives successfully trialled the use of plasma cutting techniques to size-reduce and remove two of the stainless steel tanks with the progression from using reciprocating saws and circular saws resulting in a significant reduction in hand-to-arm vibration issues and consumable costs.

Figure 5: **Trawsfynydd reactor buildings overlooking the lake**

Figure 6: **Operatives size reducing a tank from the AETP**

4.3 Decommissioning phases

The rolling programme of decommissioning means that phases of work are less distinct than before for some sites, however they can broadly be considered as the following.

4.3.1 Preparations for quiescence / final site clearance

During this phase the following work is performed:

- Fuel is removed from site and the fuel storage ponds are drained.
- Reactor buildings are put into 'safestore' configuration else prepared for dismantling.
- Redundant buildings and facilities are made safe else demolished.
- Interim storage facilities (ISFs) are constructed, as required.
- Land quality is managed.
- Voids are backfilled or else left for management during the subsequent phase.
- Waste is managed (see Section 6).

Note: this does not apply at Winfrith, as reactor dismantling and site clearance will take place in the current decommissioning phase. See Section 4.3.3.

4.3.2 Quiescence

During this phase the following work is performed to keep risks ALARP:

- Reactor safestores and other facilities are inspected and maintained.
- HAW packages are inspected and monitored.
- For English and Welsh sites, HAW packages are despatched to the geological disposal facility (GDF), if it becomes available during this phase, and ISFs are demolished. For Scottish sites, HAW packages continue to be stored in the ISF.
- Land quality is maintained and monitored. Contaminated land is managed in-situ in a manner that avoids the need for intervention during the quiescence.

Explainer: **Where a site is to enter quiescence the typical prerequisites for doing so include:**

- **Reactor buildings**: cladding restored or replaced; buildings deplanted according to risk, boilers/heat exchangers left in-situ.
- **Redundant contaminated facilities**: ponds and vaults left in-situ and made safe including height-reduction and over-cladding, where appropriate.
- **Other redundant facilities**: demolished to slab level; voids infilled as suitable material becomes available, where appropriate.
- **Water pipes, drains, ducts, culverts, and tunnels**: all above ground components removed, inner containment of the active drains removed and outer containment backfilled with grout, all other below ground components left in-situ.
- **Land**: radioactively contaminated land remediated, as required; non-radioactively contaminated land remediated as required to meet regulations.
- **HAW storage**: ISFs constructed where HAW packages cannot be consolidated for storage in another facility.

An example of where this generalised approach did not suit a particular site is Berkeley, where the boilers were situated separately to the reactor buildings and hence were removable without disrupting the reactor building structure.

4.3.3 Final site clearance

During this phase the following work is performed to deliver each site to its end state:

- Reactor buildings are dismantled.
- All other facilities are demolished.
- Remaining wastes are processed and despatched. For English and Welsh sites, HAW is packaged and disposed of if the GDF is available, else stored until it is. For Scottish sites, HAW is packaged and managed according to Scotland's HAW Policy which could involve up to 300 years of on-site storage (during this time new ISFs will be constructed as required).
- Land is remediated as required for delivering the site to its end state and enabling the *site reference state* to be met.

Given the long timescales on which they are to be achieved, end states are given flexible definitions until the final stages of site restoration. These will be reviewed, in consultation with stakeholders, as decommissioning progresses.

Depending on the decommissioning timescales, assumptions are made on the optimal end state for the site and its components (e.g. land zones or major structures), and these end state assumptions are used to guide decommissioning in the meantime. Current working assumptions to achieve site end states and site reference states are that:

- All buildings will be demolished to ground level for the site end state.
- Some subsurface structures will remain for the site end state.
- Nuclear site licences and environmental permits surrendered once the site reference state is reached.

A programme of work is in progress to review the end state assumptions for each site, following the issuing of guidance from the environment agencies on the requirements for releasing sites from radioactive substances regulation (the 'GRR') [8] (see Section 6.3.2).

Explainer: **Site reference state**

The 'site reference state' describes the condition of a nuclear site when it is fully compliant with the requirements for release of the site from Radioactive Substances Regulations (RSR).
This condition may be achieved once work involving radioactive substances has been completed, or after a subsequent period of control for the purpose of radiological protection.

Demolition of administration facilities at Sizewell

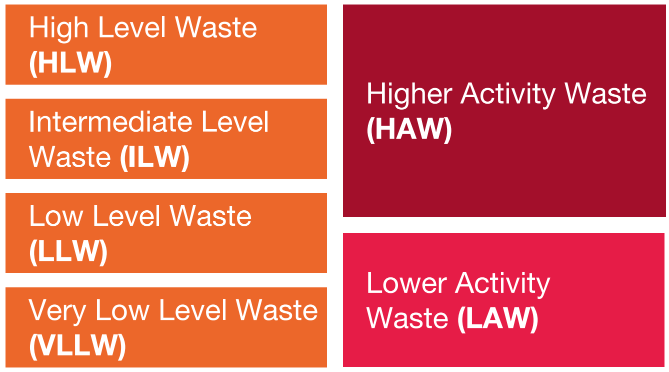
5. Data gathering

5.1 Waste categories

The wastes categories covered by this strategy are described below:

- **Radioactive Waste** – Any material that is either radioactive itself or is contaminated by radioactivity, and for which no further use is envisaged. This includes a wide variety of items, ranging from wastes that can be decontaminated and recycled to items that need remote handling and heavy shielding to be managed safely. These items are considered within this document under the categories of Higher Activity Waste (HAW) and Lower Activity Waste (LAW). As Magnox has no High Level Waste (HLW), HAW accounts for all Intermediate Level Waste (ILW) and any Low Level Waste (LLW) that is unsuitable for management under the UK Strategy for Management of Solid LLW from the Nuclear Industry [9]. Examples of radioactive wastes include: metals, pond skips and miscellaneous contaminated items (MCI); oils, solvents and combustibles; sand and gravel; desiccant; concrete, rubble and soil; liquors, sludges; ion exchange materials; asbestos; caesium removal unit filters and cartridges; fuel element debris (FED); miscellaneous activated components (MAC); and graphite.
- **Controlled Waste** – Any waste not within scope of Radioactive Substances Regulation (RSR). The controlled wastes considered within this document are under the categories: hazardous (referred to as 'special waste' in Scotland); and non-hazardous (which includes inert waste, eg concrete and rubble). Examples of controlled wastes include concrete, rubble and soil; metals; sewage; hazardous wastes such as asbestos, mercury and oils; and miscellaneous inert or non-hazardous wastes. Certain wastes may also be hazardous by virtue of contamination, for example asbestos contaminated materials.
- **Discharges** – Aqueous and gaseous wastes may be discharged (disposed) via outlets such as ventilation stacks or pipelines at each site, where permitted / authorised under the relevant environmental regime. Such wastes arise from normal modes of operation at each site with more significant quantities generated from decommissioning and waste management activities. Discharges arise from a variety of sources and activities, including: radioactive aqueous effluent from sources such as fuel storage pond water or active drains; non-radioactive aqueous effluent from sources such as sewage or surface water drains; radioactive gaseous discharges from sources such as the reactor buildings, ISFs or waste processing facilities; non-radioactive gaseous discharges from sources such as plant exhaust systems.

Figure 7: Radioactive waste categories



These wastes exist in the form of legacy wastes and as wastes that will arise from the decommissioning of existing or new facilities, plant and equipment, if/when they become redundant. Wastes may also arise from site restoration work. Additionally, some secondary wastes will arise from the processing of wastes.

5.2 Waste inventory management

Magnox maintains a radioactive waste inventory (RWI) to account for solid[3] radioactive wastes which provides a key input to strategy development and project delivery planning. It also inputs to a national dataset compiled every three years (and which is publicly accessible [10]). The RWI forms the basis of information presented in this section for solid radioactive wastes, except where explicitly stated otherwise.

Historically there has been no requirement to forecast the amount of controlled waste that will arise from decommissioning until the planning phase of a specific project. This is an area of current focus, and a bulk demolition inventory is being developed to better understand the volume and nature of controlled wastes that will arise from facility decommissioning. The aspiration is for this database to include volumes and further information such as material type (by European Waste Code), known contaminants and hazards as well as confidence in information quality. Future updates of this IWS should be able to formally present and analyse information from this inventory.

This IWS presents information from a draft version of the bulk demolition inventory in Section 5.3.4 for illustrative purposes.

The nature and scale of discharges are closely linked to the schedule of decommissioning and waste management activities as well as the technologies and methods used to conduct such work. Consequently, it is not possible to generate reliable longer-term forecasts. Discharge estimates are made for permit applications and variations associated with near-term activities, for example a new discharge outlet associated with a waste conditioning plant. Discharges are minimised in accordance with regulatory requirements and best practice (see Section 6.2.3) and records are kept of discharges that have been made to demonstrate compliance with any limits specified in the site's permit.

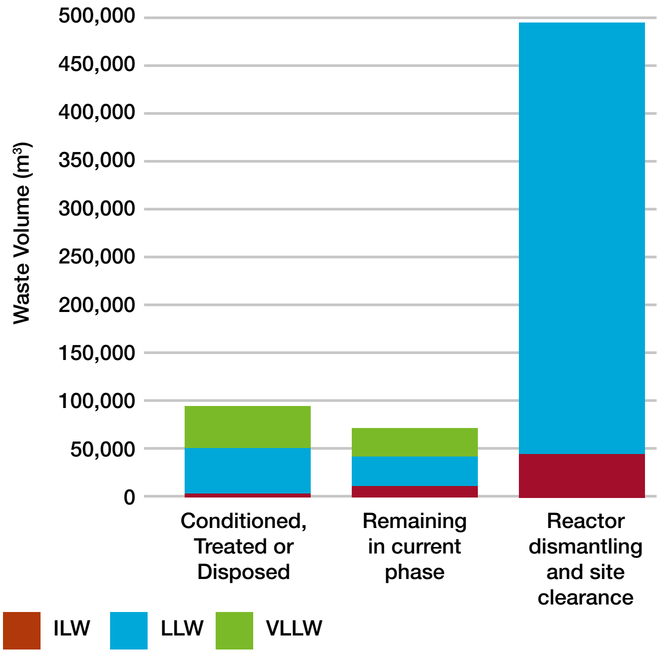
5.3 Waste arising during each decommissioning phase

Figure 8 shows the total amount of radioactive waste that is forecast to arise in the current decommissioning phase and the final site clearance phase[4]. This information is taken from the RWI. However, as this does not currently reflect the rolling programme of decommissioning, the waste groupings presented in this section for the stated phases are based on those currently grouped in the RWI under analogous phases, e.g. 'care and maintenance preparations' and 'final site clearance'.

The volume of radioactive waste 'dealt with' to date is also shown for context, illustrating that most of the LLW to manage in the current decommissioning phase has been conditioned, treated, or disposed of. The ILW is difficult to distinguish on the graph as it is volumetrically small compared to LLW, however it accounts for the vast majority of radiological hazard remaining on site and the supporting data show that approximately a third of all ILW to manage in the current decommissioning phase has been conditioned, treated, or disposed of.

Figure 8 shows that the volume of waste to deal with in the final site clearance phase is much greater than that in the current phase. Most is shown to be LLW though it is expected that a large proportion of this is incorrectly categorised at present and will be VLLW. There is shown to be four times the amount of ILW to manage in the final site clearance phase than the current phase. However, these volumes may be under-estimated as the rolling programme of decommissioning will see most sites enter the final site clearance phase decades before envisaged in the current RWI, meaning less radioactive decay will have been experienced and hence there will be a greater total radiological inventory to manage[5].

Figure 8: Total forecast of radioactive arisings by phase



[3] i.e. not aqueous or gaseous wastes.

[4] For illustrative purposes, wastes arising during quiescent phases are accounted for within the reactor decommissioning and site clearance phase, however these are very small in volume and not distinguishable in these graphs.

[5] Extensive characterisation work is required to plan for conducting this work, however, and a better picture of waste volumes and categorisations will emerge as the rolling programme of decommissioning is developed.

5.3.1 Wastes to manage in the current decommissioning phase

During this phase:

- Nuclear materials and legacy radioactive waste are retrieved from existing storage facilities for management. LAW is processed and, unless reused on-site, despatched for off-site management. HAW in general is packaged, transported (if necessary) and placed into interim storage.
- Controlled waste, generated during demolition of buildings and facilities, is reused, recycled, or disposed of, as appropriate.
- Liquid and gaseous discharges, for example those arising as ponds are drained and waste is processed, are managed under regulatory permit.

Wastes being managed in the current decommissioning phase include 'legacy' radioactive wastes, which arose during each site's research operations / electricity generation phase, as well as those arising from decommissioning which generate large volumes of VLLW and controlled waste, for example from the demolition of turbine halls [11]. At Winfrith and Harwell (BEP0), there will also be waste arising from reactor dismantling and site restoration work as this is taking place in the current decommissioning phase.

Figure 9 illustrates the diversity of ILW being managed, in contrast with Figure 11, though most of the waste can be grouped as FED (predominantly magnox alloy fuel element cladding), ion exchange material, MCI, and sand, gravel and sludge. Accordingly, it illustrates the challenge to maximise commonality of strategies for their management, though Section 6.2 sets out how this challenge is being met.

Figure 10 shows that most LLW, by volume, is contaminated soil or MCI, and these are worthy subjects of focus for reuse or recycling options, particularly on-site options for contaminated soil. There are, however, wastes such as radioactively contaminated asbestos which present challenges as 'problematic wastes', and a relatively small volume of LLW will require managing as HAW.

Figure 9: Breakdown of ILW to manage in the current decommissioning phase

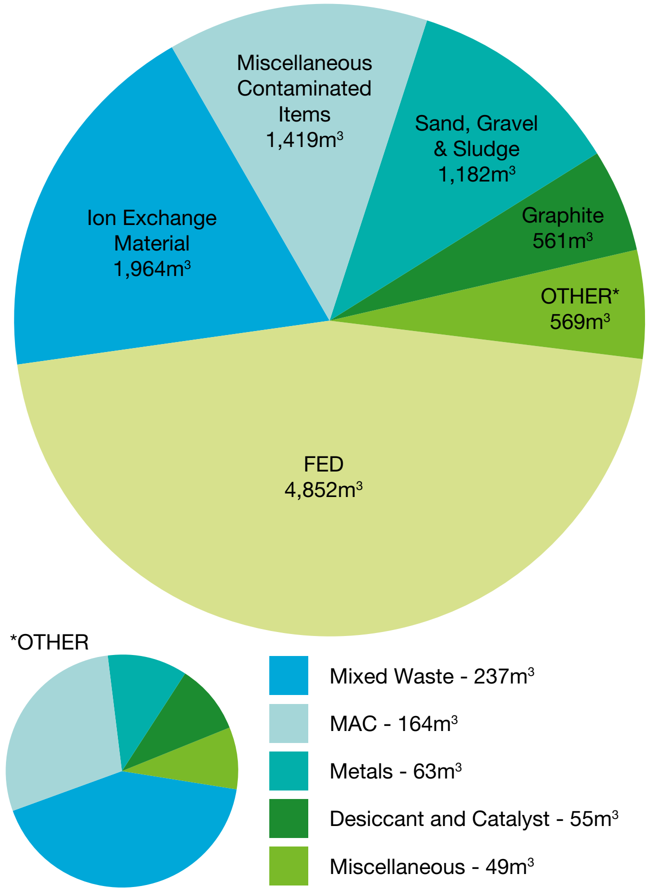
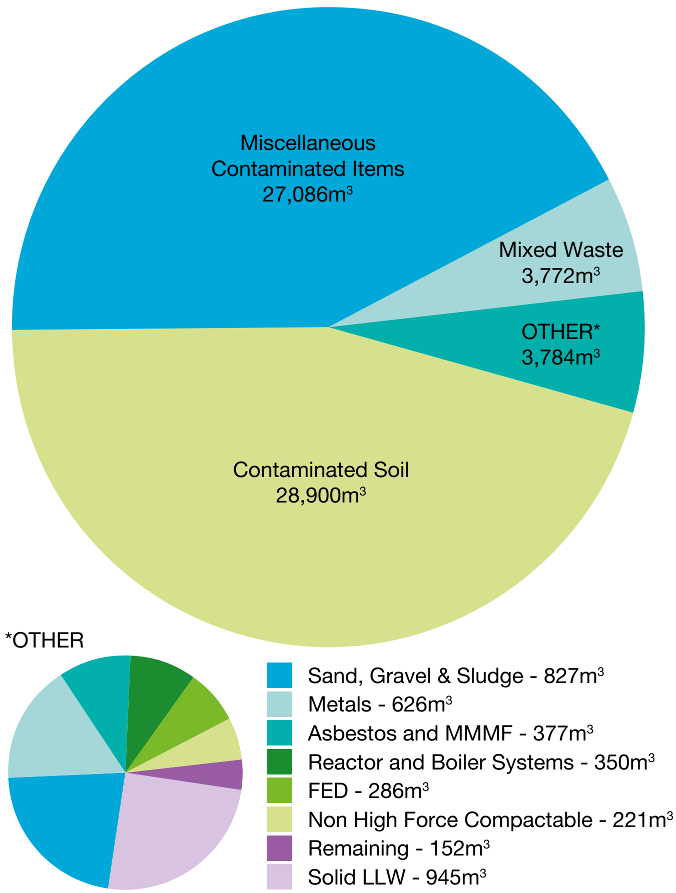


Figure 10: Breakdown of LLW to manage in the current decommissioning phase



5.3.2 Waste to manage in the quiescent phase

In addition to the volumes of waste shown above and below, small volumes of waste will arise during each site's quiescence, where it applies. During this phase:

- Small volumes of radioactive waste generated from routine inspection and monitoring activities are processed and despatched for off-site management.
- Small volumes of controlled waste, generated from maintenance of remaining facilities and the demolition of ISFs, are reused, recycled, or disposed of, as appropriate.
- Liquid effluent discharges will be minimal and gaseous discharges, for example those from the reactor safestore and ISF, will continue at very low levels and be monitored and managed under regulatory permit.

5.3.3 Wastes to manage in the final site clearance phase

During this phase:

- Radioactive waste is retrieved as the reactors are dismantled. Waste from the demolition of any remaining facilities, and excavation of radioactively contaminated ground, is also managed.
- Controlled waste, generated during demolition of the remaining buildings and facilities is reused, recycled, or disposed of, as appropriate.
- Liquid and gaseous discharges, arising as the reactors and facilities are dismantled and waste is processed, are monitored, and managed under regulatory permit.

During the final site clearance phase, large amounts of waste will arise as redundant facilities are dismantled and demolished[6]. The most significant facilities yet to dismantle / demolish are the reactor buildings.

Of the radioactive waste that will arise from reactor dismantling, the ILW will mainly be core graphite and activated steels (as Figure 11 shows), as well as a small amount of concrete rubble from the inner part of the biological shield and the LLW will mainly be concrete rubble (as Figure 12 shows), a small proportion of steels and potentially a small volume of the graphite located at the extremity of the cores at some sites. Significant volumes of controlled waste will also arise from these activities, estimates of which are being incorporated into the bulk demolition waste inventory.

Figure 11: Breakdown of ILW to manage in the final site clearance phase

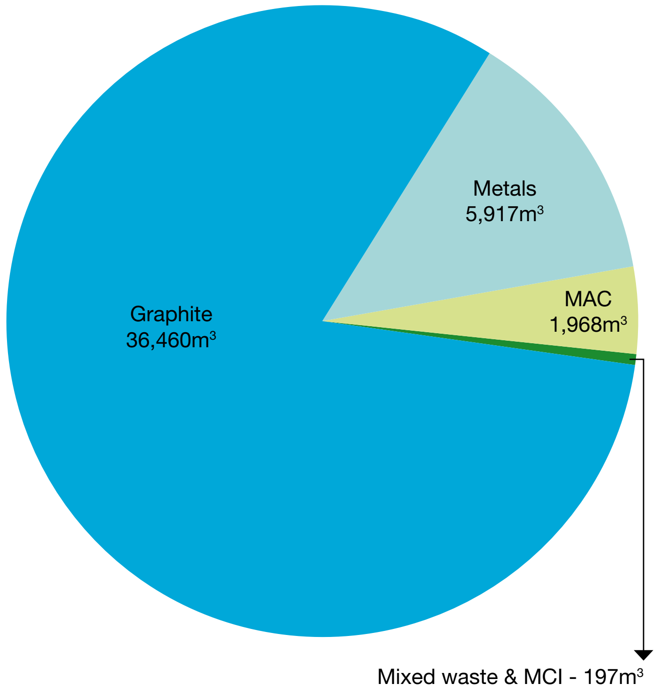
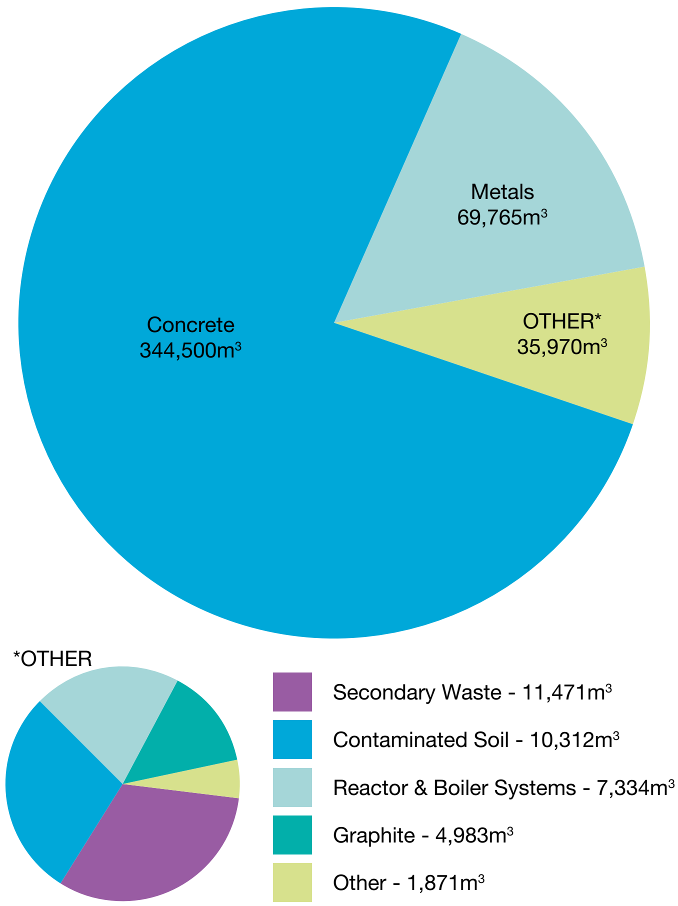


Figure 12: Breakdown of LLW to manage in the final site clearance phase



[6] Note: Winfrith's reactor dismantling and site clearance wastes are omitted from this section as they arise during the current decommissioning phase (see Section 5.3.1).

Contaminated land[7] is managed in-situ until final site restoration activities take place unless this would lead to unacceptable risks such as those which could affect regulatory compliance. A central inventory of contaminated land is not held (and contaminated land does not become designated as waste unless it is excavated) though future management needs are being developed as part of each site's end state assumptions review. These reviews may conclude that it is appropriate for some radioactively contaminated land and/or structures to remain as part of a site's end state (see Section 6.3.2).

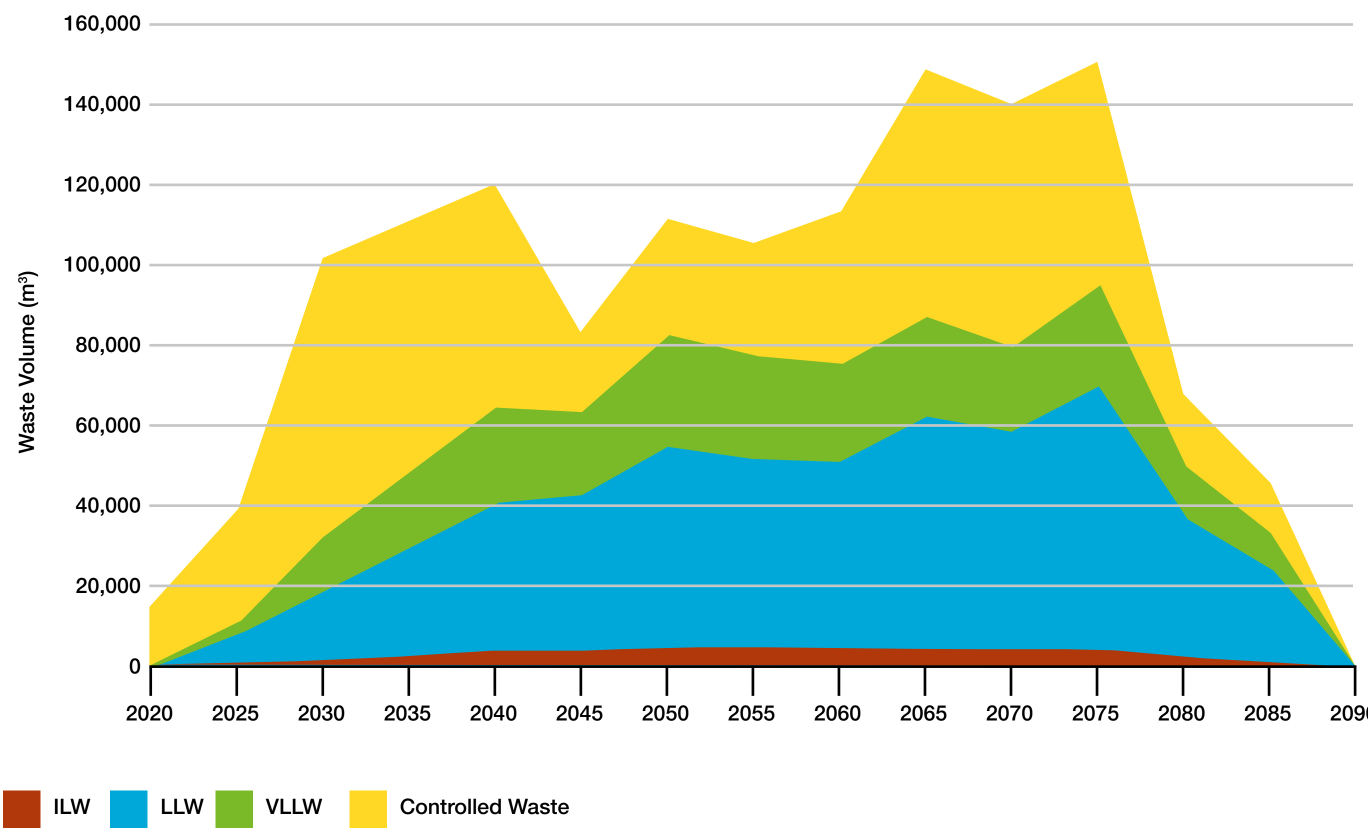
To support this work it is necessary to develop an inventory of radioactive components at the site, primarily focussing on above and below-ground concrete structures. Lifecyle void and materials assessments are also being developed to quantify the volume of cementitious / masonry waste that may arise from decommissioning and the volume of voids that may need filling, with the aspiration to maximise reuse of waste on-site for site restoration.

5.3.4 Illustrative waste arising profile

As noted earlier, the RWI does not yet align with site-specific strategies (see Section 4.2) as further work is needed to underpin these changes. An indicative waste arisings profile has been prepared for this IWS, below, which is based on RWI data but has been supplemented with information from the draft bulk demolition inventory and aligned to potential site schedules.

This illustrates the scope of work Magnox is to undertake over the coming decades, in a marked change to the previous strategy of deferred reactor decommissioning in which each reactor would have been dismantled 85 years after it shut down and all sites would be maintained in a quiescent state for decades.

Figure 13: Illustration of when waste might arise from the rolling programme of decommissioning



[7] Including that which is radioactively contaminated as well as that which is contaminated by non-radioactive contaminants.

Figure 13 shows the arising profile 'ramping up' from 2025 onwards, owing to the waste arising from final site clearance at Trawsfynydd, the lead site in the rolling programme. Following Trawsfynydd the other sites are worked on in a manner which roughly aims to 'smooth' waste generation, though there are peaks and troughs shown as different sites are started and finished, as well as waste inventories varying between sites, for example greater volumes of waste are expected to arise from sites such as Oldbury, Bradwell and Harwell.

Figure 15 and Figure 16 show waste arising profiles for AGR and Dounreay wastes. Caution is needed when comparing these profiles against the illustrative profile for Magnox sites as, although there is more waste to manage from the Magnox sites in totality, supplementary data and assumptions have been used to build the illustrative profile.

5.4 Waste arising from future missions

Figure 14 shows a comparison of total waste volumes between 12 Magnox sites, 7 AGR sites and Dounreay. Note: these volumes are shown for the entire lifecycle.

Figure 14: Comparison of lifecycle volumes between Magnox sites, AGR sites, and Dounreay

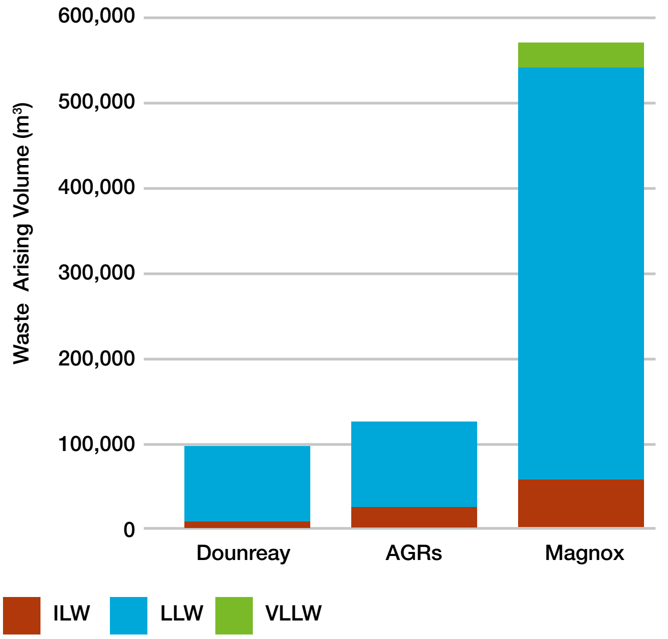


Figure 14 shows that the total volume of radioactive waste to manage at Dounreay appears similar to that from seven AGR sites, and how these compare to the much larger volume across 12 Magnox sites. This illustrates somewhat the challenge posed by the UK's older facilities, and how the AGR design has generated far less waste than its Magnox predecessors. It also illustrates how VLLW is under-reported in the RWI.

5.4.1 Advanced gas-cooled reactors (AGRs)

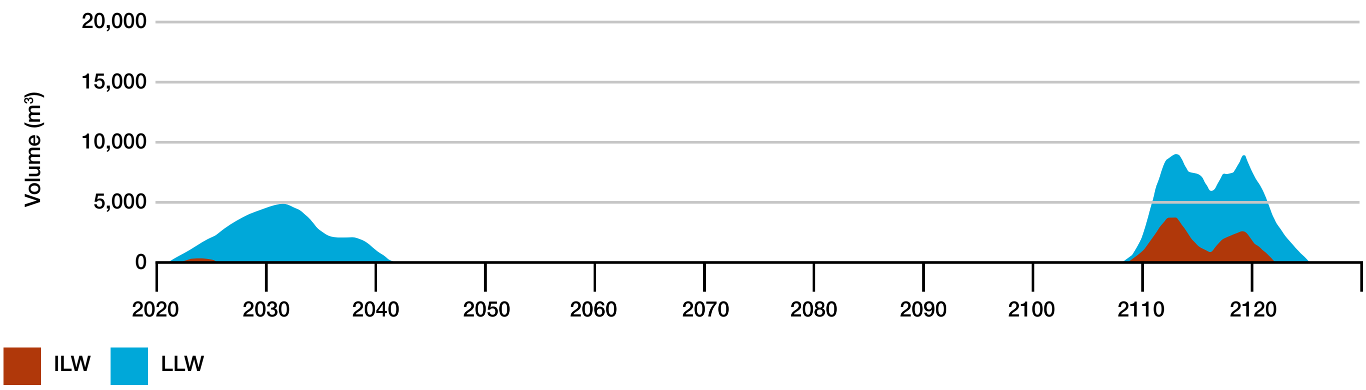
In June 2021 it was announced that ownership of the UK's fleet of AGR sites will be transferred to the NDA, following each site's defueling, and Magnox will decommission these sites on behalf of the NDA. This IWS has not considered in detail the waste management needs of AGRs, however the present understanding of the total AGR waste inventory is illustrated in Figure 15 compared to the Magnox inventory for the whole lifecycle.

The AGR waste types compare well with those at Magnox power station sites and include MCI, MAC, sludges, ion exchange materials, desiccant, metals, graphite, and concrete. The AGR and Magnox RWIs are organised differently making direct comparison difficult, however the nature of the waste appears similar. A much greater volume of waste is associated with the Magnox sites; this difference is at least partly explained by the different number of sites and the differing designs and operation (and purpose, in the case of Harwell and Winfrith) though data certainty will also need to be considered as plans for AGR decommissioning are developed.

Hunterston A (background) and B (foreground)

Figure 15 shows when these wastes are expected to arise, illustrating that the AGRs are currently on a deferred reactor dismantling strategy:

Figure 15: Arising profile for AGR wastes



5.4.2 Dounreay

In September 2021 it was announced that Dounreay is to join with Magnox, which brings greater opportunity for collaboration and sharing of skills and knowledge. Dounreay has an established IWS [12] and has been progressing decommissioning and waste management at the site for several years.

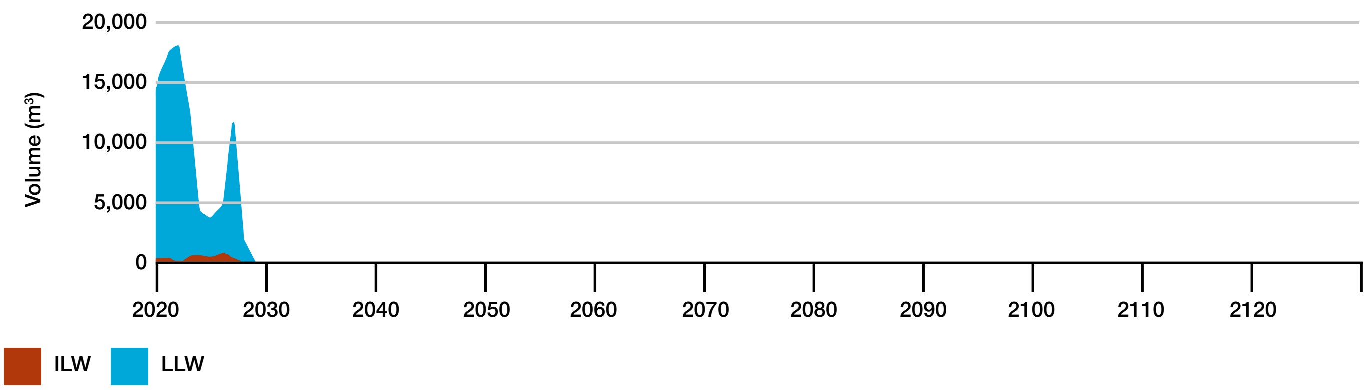
The Dounreay site is complex in its nature with a large volume of waste to manage; the RWI shows a total volume of waste similar to that shown for all AGR sites combined. Dounreay is unique as it has its own LLW disposal facility adjacent to the site.

The waste types compare with those found at Magnox's former research sites (Harwell and Winfrith) and include activated metals, graphite, sludges, wastes contaminated with uranium and plutonium, as well as bulk decommissioning / demolition wastes.

The Dounreay inventory is approximately twice that of Harwell and Winfrith combined by volume. Dounreay has a significant radiological inventory, with a large portion of waste not suited to near-surface disposal.

Figure 16 shows when these wastes are expected to arise. The strategy for Dounreay is to deliver the site to an 'interim' end state in the relative near-term:

Figure 16: Arising profile for Dounreay wastes

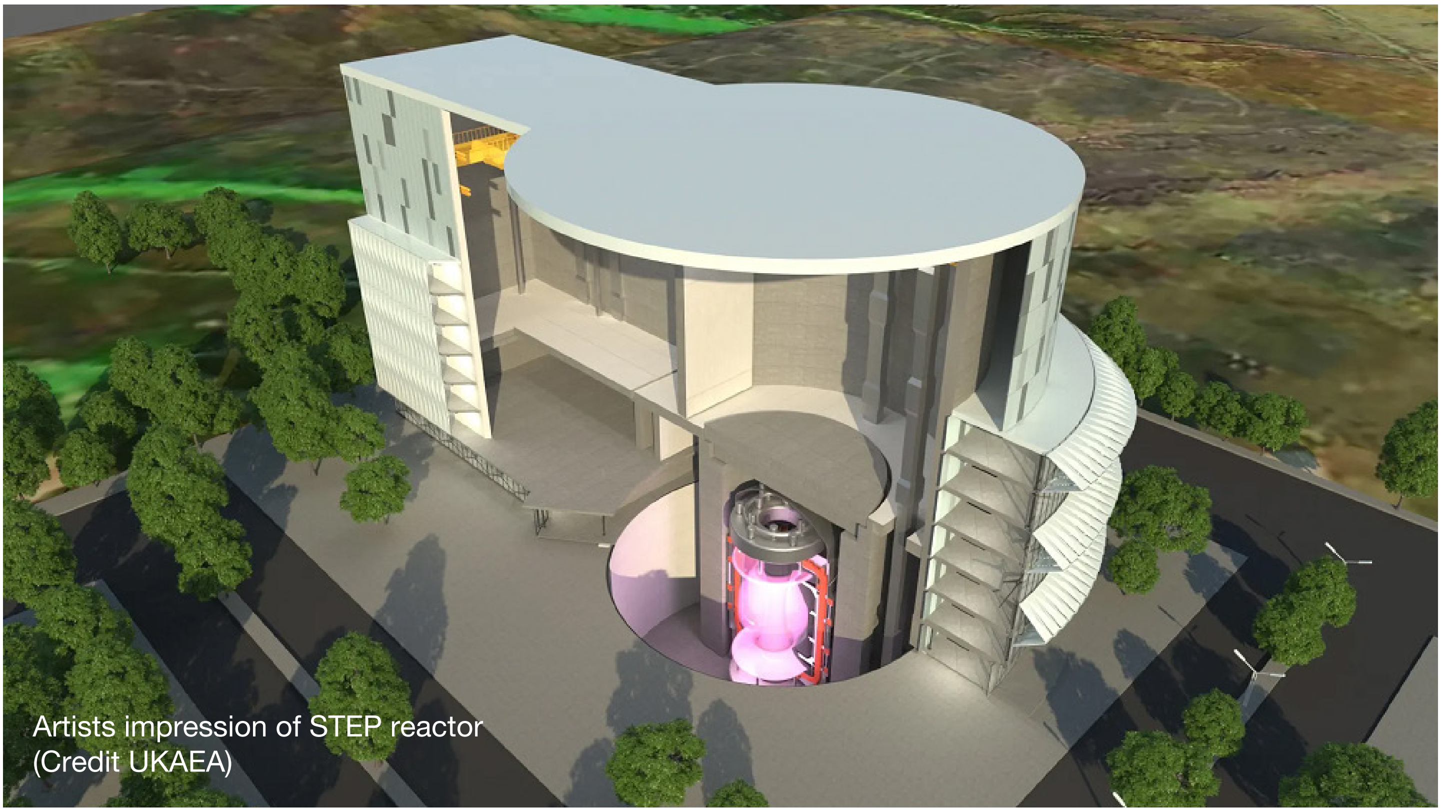


5.4.3 Other future missions

It is possible that Magnox is appointed to manage other liabilities transferred to the NDA, which will be reflected in future updates to this IWS[8]. The following future missions are currently under investigation:

- Responsibility for additional UK civil nuclear sites
- International engagement opportunities
- Magnox people and sites for development e.g. STEP fusion reactor
- UK Ministry of Defence liabilities

Dounreay aerial image taken 2013



Artists impression of STEP reactor (Credit UKAEA)

[8] Note: The NDA is currently reviewing the value of the IWS in its current format and expects to, in future, require SLCs to produce an Integrated Waste Implementation Plan (the specification for which is being developed).

6. Waste management strategies

The key components of the IWS can be summarised as follows:

- The strategy for managing all types of waste is based on common principles and approaches. Where possible these apply across waste categories such that waste management practice can be integrated throughout the Company.
- The strategy for managing all waste is to apply the waste hierarchy, firstly by preventing unnecessary waste from being created. For waste that exists or will necessarily be created, the strategy is to optimise its management with preference of approach given to higher tiers of the waste hierarchy (see Figure 17), with least preference given to off-site disposal options. For radioactive wastes this means applying Best Available Techniques (BAT) / Best Practicable Means (BPM) and ALARP.
- The requirement for new infrastructure is minimised by making best use of existing or planned facilities, such as interim storage facilities or treatment[9] facilities. New waste management options, techniques, and enablers are pursued where they are likely to further optimise any aspect of waste management. Where relevant, such improvements are sought as part of NDA group collaborations, for example the IWMP, so that the greatest benefit can be gained for the UK taxpayer.

A summary of strategic positions is given in Section 6.1. The sections that follow after describe strategies for managing wastes in the current decommissioning phase (Section 6.2) and in the reactor dismantling and site clearance phase (Section 6.3). A separate ‘critical evaluation’ has been performed to review these strategies, which is discussed in Section 7.

Waste containers inside the Bradwell Interim Storage Facility

6.1 Summary of strategic positions

Magnox applies a common process [13] to appropriately manage any given waste in support of each decommissioning lifecycle phase, based on the following steps:

1. Characterise the waste.
2. Determine strategy for the waste.
3. Operate existing (or design new) equipment to manage the waste.
4. Retrieve, process, treat (if appropriate), package, transport, store and monitor the waste, as appropriate.
5. Discharge / dispose of the waste.

Strategic positions for each of these process steps are stated below.

6.1.1 Characterise the waste

Characterisation forms the basis of robust waste management plans and allows effective implementation of the waste hierarchy. Reliable information facilitates the optimisation of decommissioning and waste management strategies.

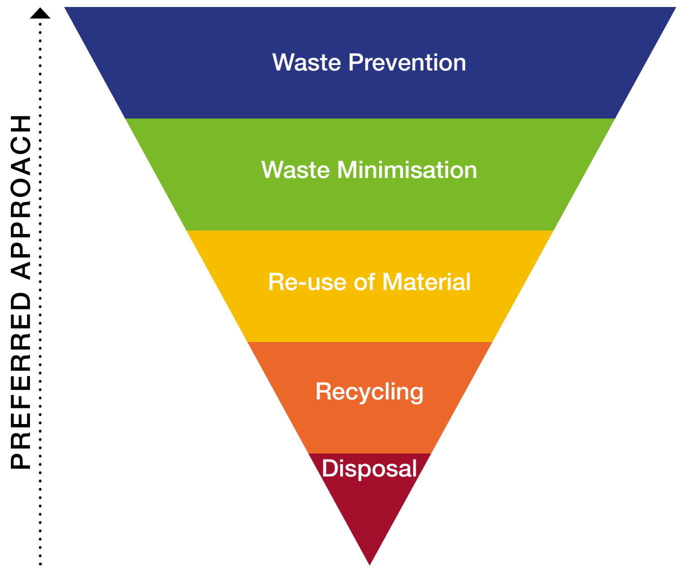
Characterisation is performed to a common standard [14] to ensure consistency across the company, including the management of fingerprints[10]. Radioactive waste characterisation information is held within a single repository, the radioactive waste inventory (RWI), which is used to feed into the UK RWI as an international reporting requirement. It is essential that data used to compile the RWI are credible, collected in a consistent and efficient manner and are presented appropriately to meet stakeholder needs and requirements. The integrity of this database is managed to a common standard [15], its contents are change controlled and subject to continuous improvement.

Controlled wastes are characterised in a timely manner to inform project waste management plans (PWMPs). An improved understanding of future arisings will inform future needs for on-site infrastructure and supply chain capabilities.

6.1.2 Determine strategy for the waste

Waste management options are assessed using robust decision-making processes and underpinned to an appropriate degree depending on the hazard and complexity of the waste. The waste hierarchy is used as a framework for decision making.

Figure 17: Simplified illustration of the waste hierarchy



Opportunities to apply the higher tiers of the waste hierarchy can be limited at each site as most waste already exists, though generation of further waste can be prevented or minimised.

It is generally beneficial to manage waste within the lowest radioactive category possible (and most preferably out of scope of RSR) as lower categories of waste can usually be treated or disposed of promptly and cost-effectively.

When determining the strategy for a radioactive waste, in compliance with BAT (in England and Wales) or BPM (in Scotland) requirements, opportunities to use techniques such as decay storage, decontamination or treatment, to facilitate management as a lower category, are assessed.

Magnox integrates waste management practice between categories through a risk-informed approach, based on the hazard and complexity of the waste, which seeks to enable wider application of the waste hierarchy and make best use of waste management infrastructure.

[9] Treatment is used for a variety of reasons, including material recovery (recycling) and volume reduction.

[10] Fingerprints, also known as a scaling factors, are a list of reportable radionuclides that, based upon a carefully managed review of a given material or waste, provide an approximate estimate of the relative amount of radioactivity of each radionuclide commonly expressed as a percentage of the total activity.

For wastes that are not appropriate for management via the common approaches applied to other wastes, alternative treatment and/or disposal solutions are sought. To maximise what commonality there may be between such 'problematic' wastes, where possible solutions are sought as part of an integrated project team with other NDA companies.

Assurance and review form an important part of continuous improvement. Implementation monitoring is achieved with the use of metrics for key strategies such as consolidated interim storage.

Reviews are conducted periodically to reflect on successes and failures, the findings of which inform future strategies and development needs.

The establishment of the *IWMP* provides new opportunities to optimise waste management strategies and Magnox is supporting this initiative as outlined below.

Explainer: **IWMP**

The Integrated Waste Management Programme (IWMP) vision is "to deliver safe sustainable, timely and cost-effective management of all radioactive waste in the UK, enabling waste producers to optimise waste management from generation to disposal."

The IWMP intends to integrate waste management activities across the NDA group from waste generation to disposal:

- Ensuring waste is managed in a more integrated, cross-group way
- Removing barriers and engender value-based decision making
- Delivering a change in capability and culture across the NDA group

Approximately 34 projects/initiatives are currently being developed under 5 themes:

- Rapid, safe and cost-effective waste management
- People capability for the future
- Provide infrastructure
- Culture of integrated waste management
- Sustainability, environment and supply chain activities

Magnox is leading on the following projects:

- Consistent processes for routing and consigning waste
- Virtual mobile waste teams (including 'centres of excellence')
- Rolling programme of reactor decommissioning (NDA group)
- Waste culture - career pathways
- Graphite management

Magnox is supporting all other projects including the following:

- Enterprise model
- Characterisation
- Near surface disposal
- Thermal treatment
- Sustainability
- Waste culture roadmap for change
- Waste container catalogue

6.1.3 Design and build new equipment

The ability to optimise decommissioning and waste management strategies depends on having the availability of an appropriate range of treatment, storage and disposal capabilities.

For plant and equipment installed on Magnox sites to manage wastes, design, installation and commissioning is controlled using a common design and safety justification process [16]. This process is aligned to a waste authority review process [17] which ensures that sufficient knowledge is held about a given waste to underpin the next stage of a project to manage it.

Common designs and processes are applied where possible to enable learning to be transferred between sites and projects. Plant and equipment are shared between sites, where feasible, either by transferring the plant/equipment or by transferring the waste. Opportunities to share such assets more widely are being reviewed, for example whether interim storage facilities can be shared between Magnox and AGR ('A' and 'B') sites.

6.1.4 Retrieve, process, treat, package, transport, store and monitor the waste

Note that these steps are not always all applied or applied in sequence and some iteration may be necessary. Within this section the term "appropriate" is used to encompass many considerations including the demonstration of BAT/BPM and ALARP.

Retrieve

The imperative is to retrieve legacy wastes from ageing storage locations on site to reduce overall hazard. For some wastes this imperative means that it is appropriate to apply a multi-stage process, for example to separate the retrieval and management of bulk waste from residual waste.

Wastes are segregated at source, as appropriate, by waste category, physical and chemical properties to enable effective waste management. Legacy radioactive wastes have not always been segregated at source and in many cases there are mixed waste streams to manage. Sorting and segregation is applied as appropriate during retrieval to facilitate a specific waste management strategy.

Process

Processing is applied to render the waste in a form suitable for its subsequent management. In-situ decontamination is applied where appropriate and a combination of sorting and size reduction may be applied to effectively minimise the amount of waste requiring management in higher categories.

HAW that requires interim storage is conditioned (passivated) by means of encapsulation or vacuum drying, depending on the properties of the waste and HAW container. Typically, conditioning is performed in-container.

Treat

The majority of waste treatment occurs off-site at third-party facilities, for example metal recycling provided within NWS's waste management services [18]. However, where appropriate, on-site facilities are established, such as those that were used at Dungeness A and Bradwell for the dissolution of magnox fuel element debris.

Magnox works with NWS, other SLCs, and key suppliers to develop waste routes and contracts that offer value in the treatment of LLW, and maintains a 5-year joint waste management plan, in conjunction with NWS, to demonstrate how the National LLW Programme is improving implementation of UK solid LLW strategy.

Harwell site team celebrating 50,000 bags of soil dug and assessed from the former liquid effluent treatment plant

Magnox is supporting the NDA in developing strategic opportunities for alternative treatment technologies which could lead to cost savings, risk reduction, waste product quality improvements, and volume reduction. In particular, a thermal treatment programme, led by Sellafield Ltd, could offer benefits for the treatment of problematic waste, and the use of naturally occurring radioactive material (NORM) waste management routes are being explored.

Package

Wastes are packaged into containers which are designed for specific purposes, for example to transport radioactive material and/or comply with the waste acceptance criteria (WAC) of a treatment facility. Where HAW is to be packaged for disposal a key aspect involves selecting the most appropriate container and conditioning method.

In all instances a standard set of containers is used so far as practicable and, as a principle, Magnox seeks to minimise the variety of containers used. Magnox is supporting an IWMP work stream, led by NWS, on the standardisation of packaging choices which will be of particular importance for wastes that will arise during reactor decommissioning.

Transport

Effective delivery of this strategy relies heavily on the ability to transport radioactive wastes between sites and to facilities such as the LLW Repository.

Magnox applies common arrangements [19] to govern such transports and seeks to maximise the use of existing assets rather than develop new ones.

Authorised roles are held at each site to ensure the safety and compliance of consignments of dangerous goods, including radioactive waste, to and from Magnox sites. Continuous improvement is also gained from the sharing of learning among this community of practitioners, together with shared learning from industry forums such as the Radioactive Materials Transport User Committee (RAMTUC).

Where it is beneficial to develop new (or modify existing) transport packages Magnox has the specialist capability to licence and approve such assets together with access to specialist skills and peer review functions via access to NTS as part of the NDA Group. Magnox actively participates within the NDA Transport & Logistics Working Group which seeks to ensure a unified approach is taken for package licencing strategy and programme priority, and that transport solutions are optimised.

Magnox also engages with NTS on behalf of NDA through the Integrated Transport Programme to explore opportunities for package management, design authority support, and sustainable transport.

Store and monitor

Delivery of this strategy requires that packaged HAW is safely and securely stored until disposal routes become available ('interim storage'). In England and Wales, HAW is stored until the GDF becomes available. In Scotland, HAW is stored for up to 300 years while final management solutions are developed. Where appropriate, HAW is consolidated for storage to minimise the need for new infrastructure (and the need to subsequently decommission such infrastructure and manage the associated waste), and to reduce the management burden during storage.

During interim storage, a programme of inspection and monitoring is used, based on a common approach [20], to ensure that waste package integrity is maintained until a disposal route becomes available. This includes remote inspections on the stored waste packages as well as the inspection and testing of package surrogates such as corrosion coupons and dummy packages.

In combination, and along with monitoring the storage facility itself, this provides evidence to assess how the storage system is performing, and to predict how it will perform in the future.

Magnox participates in the Store Operators Forum and observes industry guidance for good practice for HAW storage

It may also be appropriate to 'decay store' a waste for a period of time, after which, by virtue of radioactive decay, other management options are enabled. The decision to decay store a waste is based on identifying significant lifecycle benefits, and on the presumption that if a management route for the waste is available now at a reasonable cost it will be used, and supported by a robust safety case and business case. Decay storage options are reviewed for all radioactive wastes as part of the company options assessment process [21].

Storage may be best achieved in-situ, for example reactor 'safestores' provide safe and secure storage for redundant plant and equipment that will become waste in the final site clearance phase. At some sites, legacy waste is also stored within reactor voids as part of a deferred retrieval strategy which benefits from radioactive decay.

Chapelcross team with the first package to go into the Interim Store Facility

6.1.5 Discharge / dispose of waste

Radioactive waste is discharged or disposed of in accordance with each site's environmental permit under the relevant regime.

For discharges, Magnox engages with the NDA and regulators to develop improvements for more sustainable management. A recent example is the Harwell off-site discharge pipeline, where a new treatment route to decontaminate 1800t of cast iron pipe has been established using facilities at a site used to handle NORM from the oil and gas industry. The effluent arising from this process will be reused to stabilise NORM waste rather than discharged to the environment.

For LLW, the feasibility of disposal is established against the WAC of existing facilities sourced via the NWS waste services framework, diverting waste from the LLW Repository where possible. For suitably low activity wastes, on-site disposition options are assessed, to support the decommissioning and remediation of each site, following the GRR (see Section 6.3.2).

For HAW, Magnox follows the NWS disposability assessment process within the context of the relevant government policy and is supporting the NDA in evaluating Near-Surface Disposal (NSD) options (see Section 6.2.1.1).

For controlled wastes, off-site disposals are made following standard procedures [22] in compliance with the relevant legislation. The amount of controlled waste disposed of off-site is reduced in accordance with the waste hierarchy, which includes evaluation of on-site re-use and disposal options, e.g. where waste could usefully backfill voids or provide landscaping.

6.2 Strategies for managing wastes in the current decommissioning phase

This section sets out strategies for managing wastes arising from activities preparing each site for its quiescence (or reactor dismantling where there is no quiescence). This section also includes reactor dismantling and site clearance wastes at Winfrith.

Wastes to be managed in the current decommissioning phase are, for the most part, covered by existing strategies and are limited by currently available technologies / third-party capabilities. These strategies are summarised within the following categories: radioactive wastes, controlled wastes, and discharges.

6.2.1 Radioactive wastes

The management routes for such wastes can be summarised as:

- Reuse,
- Treatment, for example to recover material (recycle) or reduce volume,
- Permitted burial of VLLW and low activity LLW,
- Disposal to the LLW Repository,
- Disposal as HAW (interim storage required pending availability of a disposal facility, which will either be a NSD facility or a geological disposal facility (GDF)).

Secondary wastes that arise from the processing of radioactive wastes are also accounted for within this section. Options for managing radioactive wastes are assessed using the company options assessment process [21] to ensure that strategies are optimised with respect to RSR, permit requirements and minimise radiation exposure to both workers and the public. The management strategy for a specific waste is described in full within the relevant site's *RWMC*.

Explainer: **RWMC**

Magnox maintains a Radioactive Waste Management Case (RWMC) for each site in accordance with corporate arrangements [23]. Its purpose is to provide a transparent demonstration of adequate management for radioactive wastes, by identifying:

- The management strategy, and its justification, for each waste, and how these strategies are integrated at the site and any interfacing sites / parties.
- How the key elements of long-term safety and environmental performance will be delivered.

It supports the IWS by providing, or signposting to, the justification and underpinning for each site's radioactive waste management strategy. This is included in detail for HAW and at a high-level for LLW and discharges.

Where management strategies have not been identified for certain radioactive wastes, or remain subject to uncertainties, the RWMC records these gaps and any plans to address them; for example, to perform characterisation.

6.2.1.1 Higher activity waste

HAW is managed to a common standard [24], a key objective of which, in line with joint regulatory guidance [25], industry practice and NDA radioactive waste strategy [26], involves recovering HAW from various ageing storage facilities and packaging for future disposal[11], seeking endorsement of packaging proposals from NWS in the form of LoCs. HAW may also, where BAT/BPM and ALARP, be decay stored for future management by treatment and/or as a lower category of waste.

In England and Wales, government policy is for HAW to be disposed of in a GDF [27]. In Scotland, government policy is that the management of HAW should be in near-surface facilities which are located as near as possible to the site where the waste is produced [28]. The NDA recently issued a strategy position paper on NSD [29] to consider the benefit of implementing NSD in England and Wales as well as earlier implementation in Scotland. Magnox is supporting the NDA with this work. Aside from the small-scale storage facility required at Wylfa, all planned interim storage facilities for legacy HAW have now been constructed and transfers of packaged waste are in progress between Dungeness A and Bradwell, Oldbury and Berkeley, and Harwell and Sellafield. An additional storage facility will be required for storing HAW arising from reactor dismantling at Trawsfynydd though further storage facilities at other sites are not currently envisaged (see Section 6.3.1).

The amount of waste requiring management as HAW is, where practicable, reduced by effective characterisation and segregation, or by applying techniques such as decontamination or dissolution. Conditioning methods such as vacuum drying can also be used to minimise waste volumes, and standard HAW containers and packaging approaches are applied.

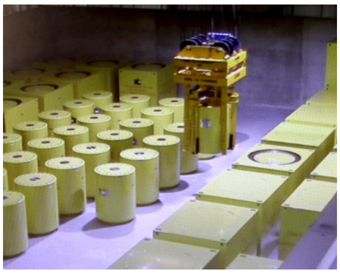


Figure 18: DCICs in a storage facility

Figure 19: Concrete boxes in a storage facility

Explainer: **HAW containers**

Current HAW management strategy is based on selecting the best container for a given waste and/or scenario. There are mainly three options: thin-walled stainless steel containers, robust Ductile Cast Iron Containers (DCICs) and 6m3 reinforced Concrete Boxes.

Stainless steel containers are industry standard containers and relatively low cost, with HAW conditioned by encapsulation, and the assumption for many years was that HAW at Magnox would be packaged in these containers. DCICs were introduced to Magnox after identifying the following advantages: simpler stores with simpler conditioning plants (encapsulation not required), they were self-shielded, packages capable for transport and made for ease of handling. However, they are the most expensive container. $6m^3$ reinforced Concrete Boxes were introduced most recently; they are cheaper than DCICs but also self-shielding containers, which allow simpler stores to be used; HAW is conditioned by encapsulation.

The different containers available have given flexibility to how different wastes are managed, enabling the selection of an optimised container, tailored to the properties of the waste and the circumstances at different sites (such as the total volume of HAW present). However, the time, effort and cost in introducing and permissioning new containers is not insignificant and experience has shown this may have eroded some of the financial benefits initially identified. NWS assess packaging proposals for any HAW destined for the Geological Disposal Facility through the disposability assessment process. After a thorough assessment of Magnox's proposals, two recent achievements were the endorsements by NWS of the Concrete Box and the Type VI DCIC through the issuance of final stage Letter of Compliances for specific Berkeley site waste streams, providing assurance that Magnox are producing HAW packages using these containers that are suitable for disposal in the GDF.

[11] In Scotland, HAW packages are made suitable for long-term storage (up to 300 years), allowing time for final management options to be developed in accordance with Scotland's HAW Policy. The LoC process is followed, and packages are conditioned in anticipation of geological disposal as these "are also suitable for the long-term management in near-surface facilities as required by the government policy in Scotland" [25].

The management strategies for all legacy HAW are summarised overleaf. In addition or clarification:

- Opportunities to optimise management of ‘borderline’ wet wastes (at the ILW/LLW boundary) are being pursued at Dungeness A.
- ILW desiccant is disposed of via a wash-and-incinerate method. The by-products from this process are managed as VLLW / discharges.
- Where passive safety is assured, MAC is left for storage in reactor voids during a site’s quiescent phase.
- Staged packaging of highly tritiated wastes (Chapelcross only) is used to reduce discharges, gain benefit from radioactive decay and improve confidence in disposability.
- Several strategies are under review. Of note:
    - » the strategy for managing FED from Oldbury and Sizewell is being reviewed as the extant strategy to recategorise eligible FED as LLW for disposal at the LLW Repository (an approach successfully applied to a large volume of FED from Bradwell) may not be possible due to sorting and segregation challenges amongst other factors,
    - » a multi-site strategy review is in progress for pond skips, and
    - » the use of TRU-Shields, as interim storage containers at Hinkley Point A, is under review.

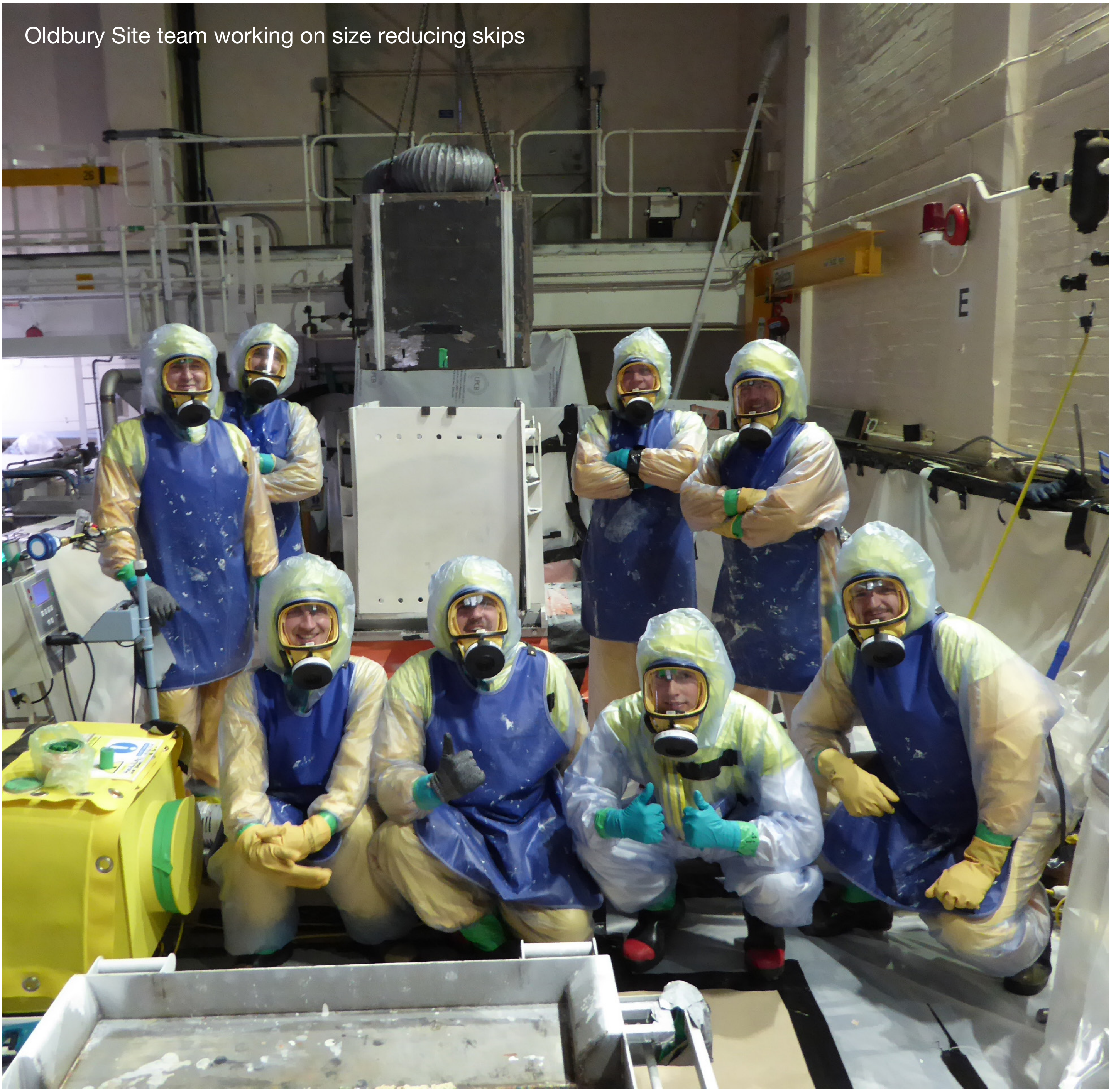
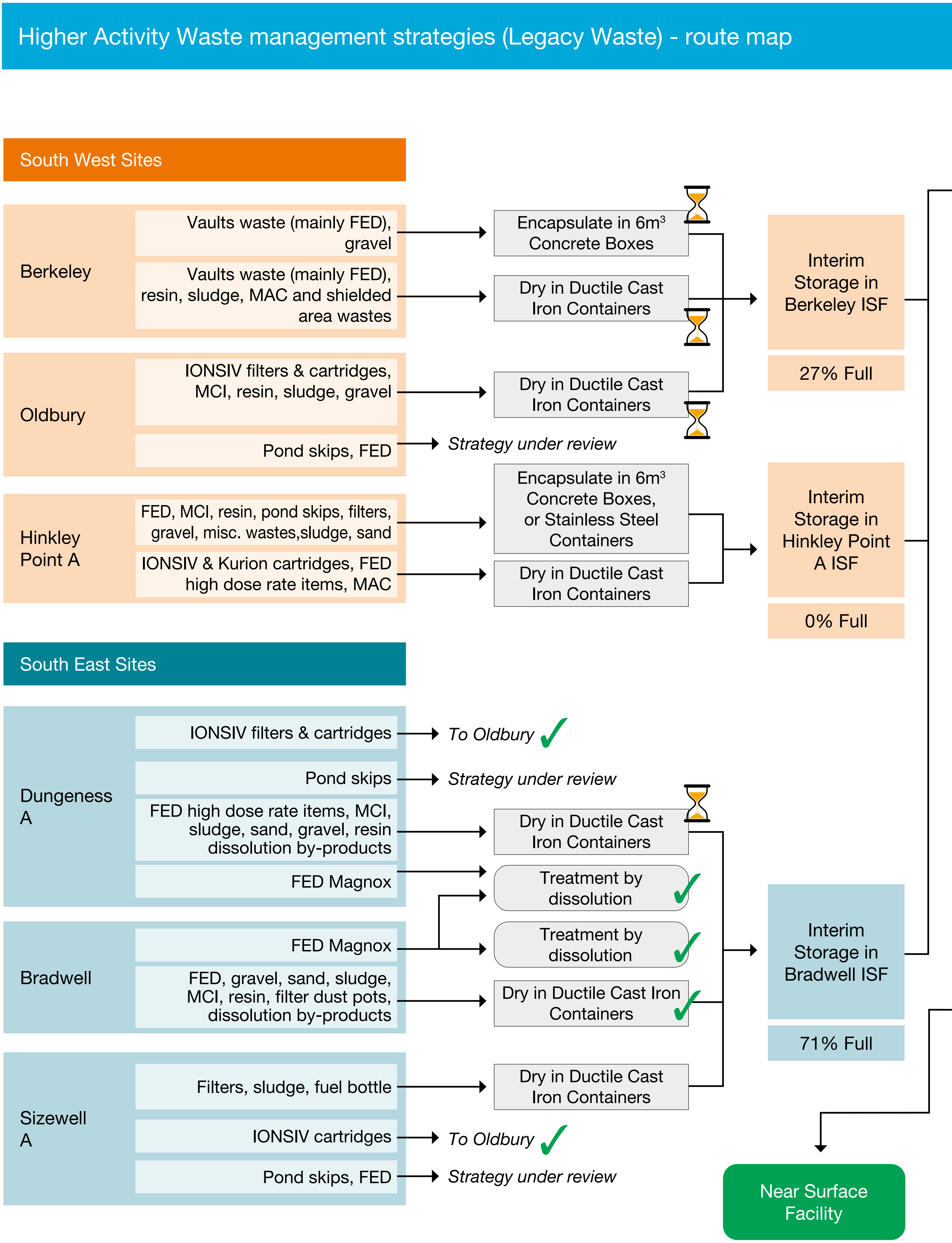
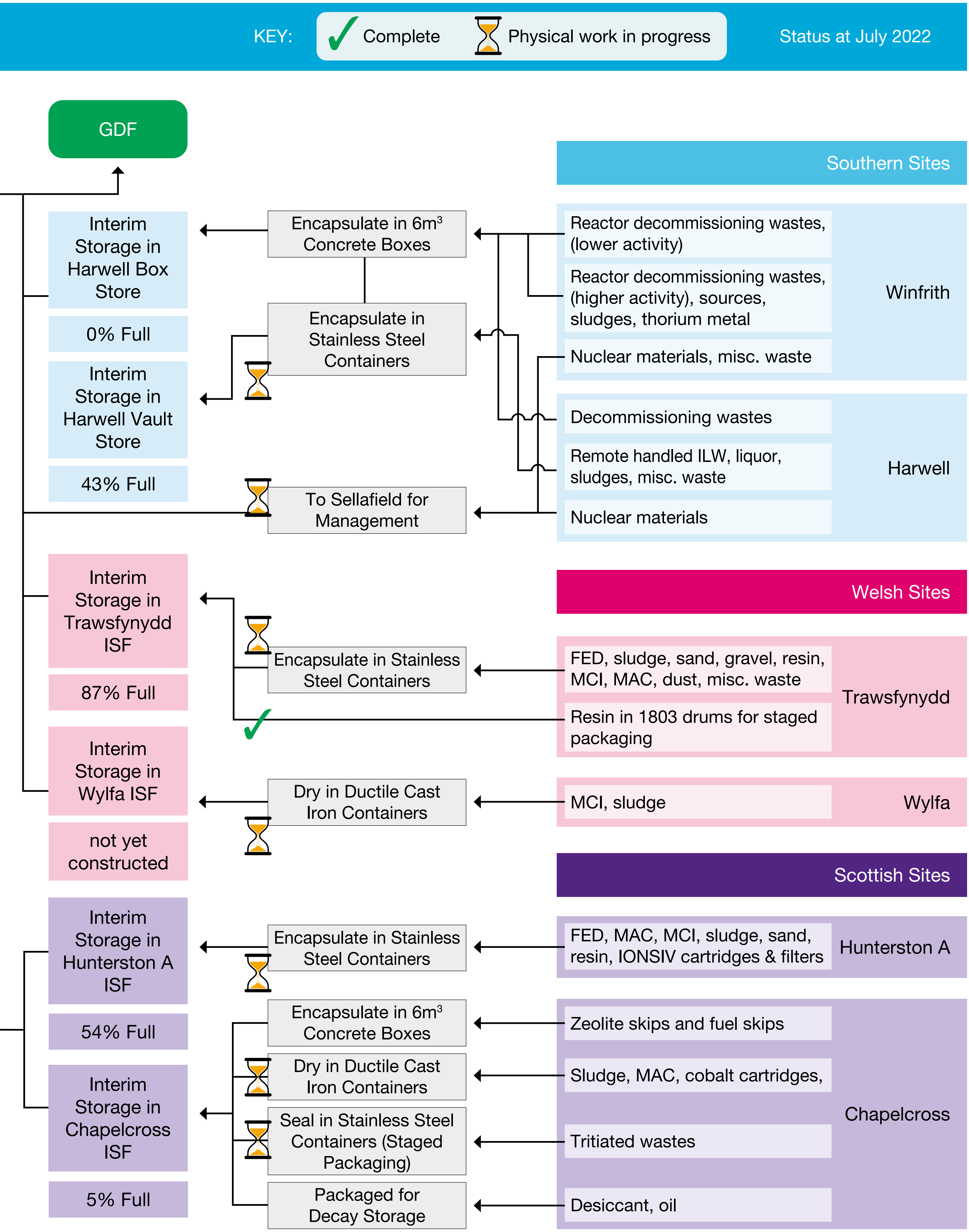

Oldbury Site team working on size reducing skips

Figure 20: Legacy HAW route map



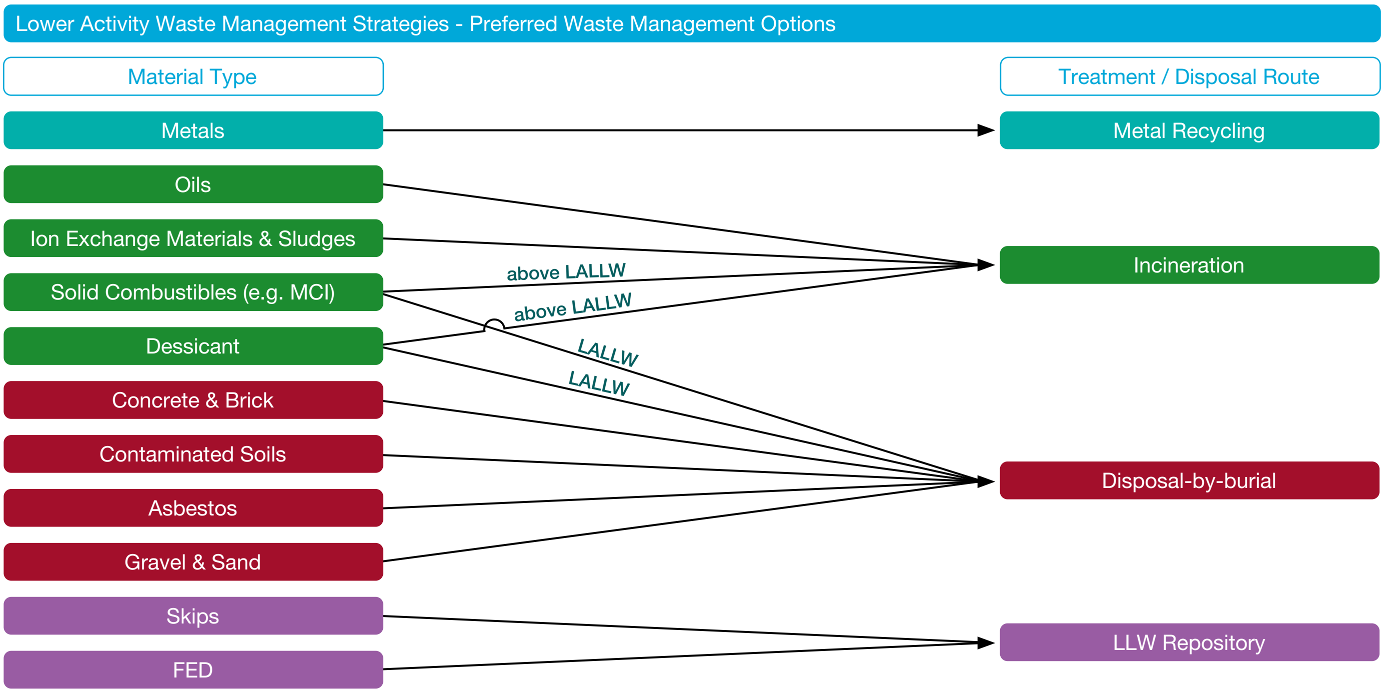

KEY:
Complete
Physical work in progress
Status at July 2022
GDF
Southern Sites
Interim Storage in Harwell Box Store
0% Full
Interim Storage in Harwell Vault Store
43% Full
Encapsulate in 6m³ Concrete Boxes
Encapsulate in Stainless Steel Containers
To Sellafield for Management
Reactor decommissioning wastes, (lower activity)
Reactor decommissioning wastes, (higher activity), sources, sludges, thorium metal
Nuclear materials, misc. waste
Winfrith
Decommissioning wastes
Remote handled ILW, liquor, sludges, misc. waste
Nuclear materials
Harwell
Welsh Sites
Interim Storage in Trawsfynydd ISF
87% Full
Encapsulate in Stainless Steel Containers
FED, sludge, sand, gravel, resin, MCI, MAC, dust, misc. waste
Resin in 1803 drums for staged packaging
Trawsfynydd
Interim Storage in Wylfa ISF
not yet constructed
Dry in Ductile Cast Iron Containers
MCI, sludge
Wylfa
Scottish Sites
Interim Storage in Hunterston A ISF
54% Full
Encapsulate in Stainless Steel Containers
FED, MAC, MCI, sludge, sand, resin, IONSIV cartridges & filters
Hunterston A
Interim Storage in Chapelcross ISF
5% Full
Encapsulate in 6m³ Concrete Boxes
Dry in Ductile Cast Iron Containers
Seal in Stainless Steel Containers (Staged Packaging)
Packaged for Decay Storage
Zeolite skips and fuel skips
Sludge, MAC, cobalt cartridges,
Tritiated wastes
Desiccant, oil
Chapelcross

6.2.1.2 Lower activity waste

Magnox applies a common approach for the management of LAW [30]. A key objective is to divert waste away from the LLW Repository, in accordance with the UK strategy [9]. Preferred options for the management of LLW (including VLLW and borderline LLW / ILW) have been identified [31] which build on national strategy and best practice. These are illustrated below for the most common waste types. Note these preferred options apply to most cases though there may be instances where it is appropriate to apply an alternative solution,

NWS facilitates a range of waste treatment services to maximise diversion from disposal at the LLW Repository, to preserve disposal capacity. Where practicable VLLW and LLW is treated to reduce the volume of waste requiring disposal. VLLW and LLW have a range of treatment options including metal decontamination and incineration. Optimisation techniques such as high force compaction are also applied.

Figure 21: Preferred options for managing LAW



Case Study: Opening a new waste treatment route for contaminated metal

For large arisings of lower activity waste metals, Magnox undertakes case specific assessments to determine what the BAT/BPM option is for the waste arisings, with a preference for recycling of metal. This was the case for the boilers at Berkeley site (15 in total, each weighing approximately 300 tonnes), which were sent for metal melting overseas in 2012/2013. Fast forward to present day and Magnox has developed a solution for the recycling of the off-site discharge pipeline (ODP) at Harwell. The ODP was the main discharge line which ran from the liquid effluent treatment plant to the River Thames at Sutton Courtenay. It comprised 9 km of pipe with approximately 1,650 sections which are 5.5 metres in length, 45 centimetres in diameter and weigh approximately 1.2 tonnes each.

Following several decontamination trials over the past couple of years, the Harwell legacy waste team has consigned its first shipment of ODP for treatment off site, the ODP sections will be decontaminated using ultra-high pressure water jetting. Establishing the route has opened up the opportunity for future metal arisings for both Magnox and the wider nuclear industry.

It is expected the project will take approximately 16 months to complete opening up a new, cost-effective route for the decontamination of large metal arisings, enabling the reuse of the large quantity of metal and demonstrating effective use of the waste hierarchy.

6.2.1.3 Borderline waste

Many opportunities to optimise the waste lifecycle occur where wastes are close to the boundary between categories. Through effective characterisation and targeted treatment, it is possible to take a risk-informed approach to maximise the amount of waste that can be managed in a lower category.

Magnox has applied this approach to maximise the use of the LLW Repository for FED from Bradwell. Further opportunities are being pursued for Dungeness A, using techniques to combine and condition borderline wet wastes to maximise the volume that can be disposed of at the LLW Repository, and minimising the volume requiring management as HAW.

These approaches build on the success of diverting waste away from the LLW Repository and apply a more risk-based approach to waste management; enabling more proportionate disposability requirements to be applied, with simpler, fit-for-purpose solutions.

6.2.2 Controlled waste

Controlled waste exists at each site in the form of redundant plant and facilities, arising from the decommissioning and demolition of these site components.

The UK has a well-established, comprehensive and prescriptive regulatory regime for the management of controlled waste. Waste management strategies have been developed at national, regional and local levels by the UK government, devolved administrations and local and regional authorities. Magnox has collated the established practices and principles that underpin these strategies and implements them across its sites.

Wastes are segregated as far as is reasonably practicable to enable appropriate management. Magnox applies a common approach to the management of all controlled waste [22]; the key objectives are to reduce waste generation and optimise management practice. The management routes for controlled waste can be summarised as:

- Reuse, either on-site or off-site,
- Recycling where appropriate,
- Incineration where the waste acceptance criteria can be met,
- Disposal to an appropriate licenced facility.

Appropriate routes are currently available and will be required throughout the lifecycle of the site. Magnox currently diverts a large amount of waste from landfill disposal by applying the waste hierarchy. Magnox consistently diverts over 80% of its controlled waste from landfill, the vast majority being recycled.

Magnox processes controlled wastes via these management routes in accordance with waste hierarchy principles, where:

- The amount of generated controlled waste is reduced through good practice, facilitated by shared learning between sites through practitioner groups.
- Preference is given to reuse and recycling over incineration and disposal options.
- Wastes are segregated as close to the point of generation as possible.
- The requirement for new plant (which will become waste in the future) is minimised by consolidating facilities, e.g. for HAW processing and storage, where possible.
- Inert wastes are reused, where possible, for backfilling voidage or for landscaping to avoid or reduce the need to import material for site restoration. Magnox is also supporting the NDA in its evaluation of wider options including the use of reclaimed material for construction of new facilities.

6.2.3 Discharges

Gaseous and aqueous wastes are generated during decommissioning and on-site waste management activities and must be managed alongside other radioactive and non-radioactive wastes.

It is a requirement of each site's permit to apply BAT/BPM to minimise radioactive discharges and any resulting environmental impacts. Assessments of radioactive discharges are performed to common arrangements [32] [33]. The principal isotopes of interest are usually caesium-137 and tritium for radioactive aqueous discharges, and tritium and carbon-14 for gaseous discharges. Non-radioactive discharges are also controlled by limits as applicable under the relevant regulation. Discharges are reduced in line with the OSPAR Convention (for the Protection of the Marine Environment of the North-East Atlantic) and the UK Strategy for Radioactive Discharges [34] which was reviewed in 2018 [35].

Magnox strategy is to apply the following general principles:

- Radioactivity will not be introduced into the environment unnecessarily.
- The waste hierarchy and BAT/BPM are applied to minimise the activity of aqueous and gaseous radioactive waste disposed of by discharge to the environment.
- The approach of ‘concentrate and contain’ is preferred over ‘dilute and disperse’ in cases where there would be a definite benefit in reducing environmental pollution.
- The ‘precautionary principle’ is applied in situations where there is evidence of potential harm in the absence of complete scientific proof.
- The ‘polluter pays’ principle applies, where those responsible for producing the waste bear the costs of prevention, control and reduction measures.
- Recognition of the requirement for flexibility to ensure that hazard and risk reduction activities are not compromised.

Prior to the implementation of a project, consideration is given to the techniques available to minimise any discharges and associated environmental impacts. Appropriate techniques include:

- Active effluent and pond water treatment plants for aqueous discharges abatement.
- Within these plants, caesium removal units (beds of ion exchange resin) are used, where required, to reduce the amount of caesium and other radionuclides in aqueous discharges. Filters are also used for particulate control.
- Mechanisms to remove particulate, such as sediment traps or settling tanks, from aqueous discharges.
- Sewage treatment plants and surface water drains including oil traps.
- High efficiency particulate air (HEPA) filtration for gaseous discharges abatement.

As decommissioning and waste management work progresses and sites move between different stages of their lifecycle, the nature and quantity of discharges changes and appropriate changes to the treatment processes and discharge routes will need to be made.

6.3 Strategies for managing wastes in the final site clearance phase

This section sets out strategies for managing wastes in the final site clearance phase (other than for Winfrith, which is included within Section 6.2). Wastes to be managed in this phase are those for which there are less well-defined strategies and greater freedom to underpin new approaches; time exists to establish new technologies / capabilities. These strategies are summarised within the following categories: decommissioning, site restoration and discharges.

6.3.1 Wastes arising from decommissioning activities

The ‘reference decommissioning strategy’ [7] provides a single point of reference for decommissioning strategies, signposting to the associated underpinning for each aspect of site strategy. Along with the site RWMCs this document provides a key input to the IWS. The reference decommissioning strategy is updated as and when significant changes to the strategy are approved.

A large volume of waste will arise during decommissioning activities, most significantly during decommissioning of each Magnox reactor and associated facilities. Decommissioning and waste management strategies for this work are largely derived from plans developed in the 1990s and require complete review as part of developing plans for a Rolling Programme of Decommissioning (RPD); initially focused on Trawsfynydd though with a view to the entire programme as set out by the suite of site-specific strategies in development.

The assumptions for RPD are based on the historic plans and represent a starting point from which strategies can be developed.

These assumptions are based on the use of existing or planned waste routes and technologies, and a range of enabling waste management steps have been identified that are compatible with and would support use of these routes. These starting assumptions are, however, known to be sub-optimal in many respects.

A wider variety of routes is likely to be needed, to enable the most appropriate route to be selected for specific waste types, considering the physical, chemical, and radiological characteristics of the waste. Credible options are being defined for each waste type, e.g. graphite, contaminated metals, concrete, etc., and it could be demonstrated that there is benefit in establishing new treatment routes for certain waste types. As part of the IWMP there is a greater scale of opportunity to investigate establishing new routes and enablers such as containers, storage, and transport solutions.

These credible options will be developed following the process outlined in Reference [36], with a series of topic-specific papers being developed for endorsement at the Magnox-NDA Senior Strategy Committee. Certain aspects will be developed within the IWMP. A range of other work is also in progress to support strategy development, such as characterisation and inventory improvements.

Size reduction using laser cutting at Winfrith

6.3.2 Wastes arising from site restoration activities

Site restoration strategy aims to minimise the amount of waste that is generated, in particular that which requires off-site disposal, and to minimise the amount of material that is imported to a site for infilling voids or landscaping. This is achieved through in-situ management techniques and on-site reuse opportunities, and guided by site end state assumptions as the acceptability of contaminated land depends on the next planned use for the site. This principle applies to both radioactively contaminated land/structures and those that are not radioactively contaminated, though the regulatory requirements differ.

Each site's end state assumptions are currently being reviewed following *the GRR*.

On-site disposition (OSDn) is likely to form a part of the end state assumptions for some (but not all) sites, as is the case for NDA-endorsed strategies at Winfrith [37], Trawsfynydd [38] and Hunterston A [39]. Different types of OSDn include:

- Radioactive waste disposal in a dedicated disposal facility;
- Radioactive waste disposal for a purpose, such as to infill unwanted sub-surface voids or for landscaping or infrastructure;
- In situ disposition (ISDn); a term used here to cover both the following:
    - » leaving redundant radioactive structures (such as underground tanks, pipes or building foundations) permanently in place; and
    - » leaving existing radioactive in situ contamination of the ground permanently in place.

For site components where all alternatives are available, ISDn is the most preferred form of OSDn, and a dedicated disposal facility is least preferred. This is because ISDn would require the least amount of physical effort to implement and would result in the smallest safety, environmental and cost impacts compared to other potential types of OSDn.

It is now a requirement of the site's environmental permit to maintain a WMP and SWESC, and these are being prepared for each site according to an implementation schedule agreed with the relevant regulator. Along with RWMCs, WMPs will in future be key supporting documents to the IWS.

Explainer: **GRR**

Guidance on Requirements for Release from Radioactive Substances Regulation (The GRR)

In 2018 the Environment Agencies published guidance setting out their expectations about what nuclear site operators need to do when planning and carrying out work to decommission and clean-up their sites. This guidance requires operators to:

- produce a waste management plan (WMP),
- produce a site-wide environmental safety case (SWESC), and to
- make sure the condition of their site meets the Environment Agencies' standards for protection of people and the environment, now and into the future

These requirements apply to both the ways in which radioactive waste is managed and the condition in which sites are left. The aim of which is ultimately to enable the site to be released from radioactive substances regulations.

Case Study: End states strategy and the next planned use - Harwell and Trawsfynydd examples

Each Magnox site has or will have a preferred end state, developed to facilitate the next planned use for the site. At Harwell there is a clear demand for land for non-nuclear industrial / commercial purposes, which is driving the end state for the site. Progress to achieve the site end state continues, the most recent achievement being the demolition of Building B551, a purpose-built analytical chemistry facility. Next the area will be remediated, delicensed, re-fenced and then be available for development as part of the Harwell Science Campus. Another significant project at Harwell is the remediation of the former Liquid Effluent Treatment Plant (LETP) where recently the final bag of waste was dispatched from site. Out-of-scope waste comprised about 72% of waste from the project and, of this, more than 90% has been recycled; for example, concrete is crushed and can be used as aggregate in construction projects. Virtually all of the remaining waste comprises very low level waste that has been disposed of to a suitable permitted facility.

At other sites, not as advanced along the decommissioning timeline as at Harwell, Waste Management Plans (WMPs) are being produced. Recently published UK regulator guidance requires Magnox to develop optimised end state that may conclude there are benefits to the on-site disposal of some low level wastes, such as leaving concrete structures in-situ or using suitable waste as backfill material.

Some of the potential benefits are reduced environmental impact by avoiding the need for off-site transport involving many heavy-goods vehicle movements for off-site controlled burial of low level waste and the avoidance of material imports to fill voids, as well as reduced public and worker doses. At Trawsfynydd the next use for the site does not have the constraints imposed by land demand that exist at Harwell. As a result there are benefits that have been identified for the on-site disposal of some of the structures of the ponds complex, which comprise of different facilities that have most recently been used to store operational wastes. Demolition of the ponds complex is scheduled in the next few years; the preferred strategy includes the in-situ disposal of parts of the below ground concrete structures and disposal of suitable waste materials from demolition of the above ground structures to fill below ground voids arising from the demolition.

Figure 22: Harwell LETP footprint at February 2018

Figure 23: Harwell LETP footprint at March 2021

6.3.3 Discharges

The strategy for managing discharges from decommissioning and site restoration is based on existing practice (see Section 6.2.3) and subject to continuous improvement.

6.4 Strategies for managing wastes arising from future missions

The consequences of AGR decommissioning scope being added to the Magnox portfolio are being assessed from a waste management perspective, and opportunities to share waste processing and/or storage facilities are being considered. To date, the options of storing Hunterston B's HAW packages in Hunterston A's ISF, and Hinkley Point B's HAW packages in Hinkley Point A's ISF, have been evaluated and this approach has been agreed as a strategic planning assumption by Magnox, EDF Energy and the NDA. A programme of work to underpin other key strategic decisions is being progressed.

Strategies for managing wastes arising from other future missions will be developed at a conceptual level as part of the scoping of such missions and developed in detail as and when they are brought into the scope of Magnox.

Case Study: **Sharing of facilities between Hunterston and Hinkley A & B sites**

A synergy to one of the first future missions announced by UK government is the potential for sharing waste processing and storage facilities at adjacent Magnox and EDF Energy AGR sites. Feasibility studies have been completed for both Hunterston A and B and Hinkley Point A and B sites to assess the sharing of the Magnox ISFs for EDF Energy's operational HAW.

ISFs at Magnox sites being used to store wastes from other Magnox sites is not new, and inter-site transfer HAW will continue as Magnox fulfils "Mission One". Pursuing a similar strategy for some EDF Energy wastes may offer savings in facility construction and operations costs, as well as environmental and conventional safety benefits and reduced project timescales. These potential savings are to be balanced against the impacts on the Magnox legacy HAW programme. Further future missions and synergies will be considered as opportunities are better understood and in line with the NDA's overall strategy. These will seek to utilise the company's technical expertise and infrastructure, minimise risks, and maximise value for money for the UK taxpayer.

Dungeness A & B. Image captured 2015

7. Strategy implementation

7.1 Key deliverables, decisions and required timescales for delivery

Key deliverables relate to the objectives stated in Section 3.1, which are to be delivered for each site according to its site-specific strategy. As noted within this document, the Magnox lifetime plan and RWI do not yet align with site-specific strategies and much work is needed to develop these strategies and underpin new 'baseline' plans.

The key decisions to be taken in the coming years can be summarised as below.

Table 1: Key strategic decisions to take in the near-term

Topic	Decision	Logic	Timeframe
Rolling programme of decommissioning	What is the optimal decommissioning strategy for each site? What strategies are optimal for the management of reactor decommissioning wastes? What enablers are required in support of these strategies? (initially focused on those arising at Trawsfynydd)	Site-specific strategies to be developed. Waste strategies to be developed according to waste type: graphite, contaminated metals, activated metals, and asbestos contaminated material. Waste strategy enablers to be developed according to topic: containers, storage, and transport.	Decisions made for each site waste type and enabler within the next three years.
Site end states	What is the envisaged end state for each site?	Each site to be reviewed separately: Berkeley, Chapelcross, Dungeness A, Hinkley Point A, Oldbury, Sizewell A, and Wylfa.	Decisions made for each site within the next three years.
Future missions (AGRs)	Should 'A' site storage and/or waste processing facilities be used for 'B' site waste?	Each site to be reviewed separately: Hunterston A/B, Hinkley Point A/B, Dungeness A/B.	Decisions made for each site within the next three years.

Decisions on other future missions will be required as new opportunities are explored.

Magnox

7.2 Risk management in strategy delivery

The strategies described within this document have been subjected to a critical evaluation to review their appropriateness against current and future requirements. As waste management is the core business of Magnox, this review necessarily considered aspects of business strategy and identified findings beyond those directly related to the physical management of waste. Several threats and opportunities were identified, which can summarised within four risk themes:

Table 2: Description of risk themes used for the purposes of this IWS document

Risk Theme	Description
Interim Storage	Threats within this risk theme include that interim storage capacity could be exceeded, as most facilities have now been constructed but not all legacy HAW has been packaged, requiring further facilities to be constructed. Opportunities within this theme include that AGR waste packages are consolidated in fewer storage facilities than currently planned.
Policy and Regulation	Threats within this theme include that policy could change, or that regulatory interpretation of policy could change, resulting in more onerous requirements. Opportunities within this theme include that policy changes improve waste management options such as by facilitating increased use of the LLW Repository, NSD in England and Wales, or proportionate regulation of site de-licensing.
Strategy Development	Threats within this theme include that strategies could be vulnerable due to insufficient waste characterisation or due to improper assumptions / processes having been applied during strategy development. Opportunities within this theme include that decision-making processes could be simplified, or a wider range of waste management routes are established which improves the possibility to optimise strategies.
Strategy Implementation	Threats within this theme include that strategies could fail due to flawed assumptions being unknowingly carried through into implementation, or strategy review triggers not being actively monitored, or things simply turning out to be more complicated than envisaged. Opportunities within this theme include that strategies could be better monitored through improved performance tracking linked to benefits realisation, or cultural changes can improve the standard of waste management practice applied, or learning can be used to improve planning e.g. by having a better understanding of how complicated something is.

7.3 Action planning

The strategies presented in this IWS have been subjected to a critical evaluation that identified a number of observations and recommendations which form the basis of the IWS Action Plan [40]. These were made within the following themes:

- Waste Routes and Plans
  - Characterisation
  - Inventory
  - Infrastructure
  - Reactor Decommissioning
  - Future Missions
  - Site End States
- Waste Strategy Enablers
  - Company Strategy
  - Culture and Communication
  - Organisational Capability
  - Governance
  - Research, Development and Innovation
  - Standardisation and Integration
  - Business Planning and Performance Monitoring

8. Monitoring and evaluation

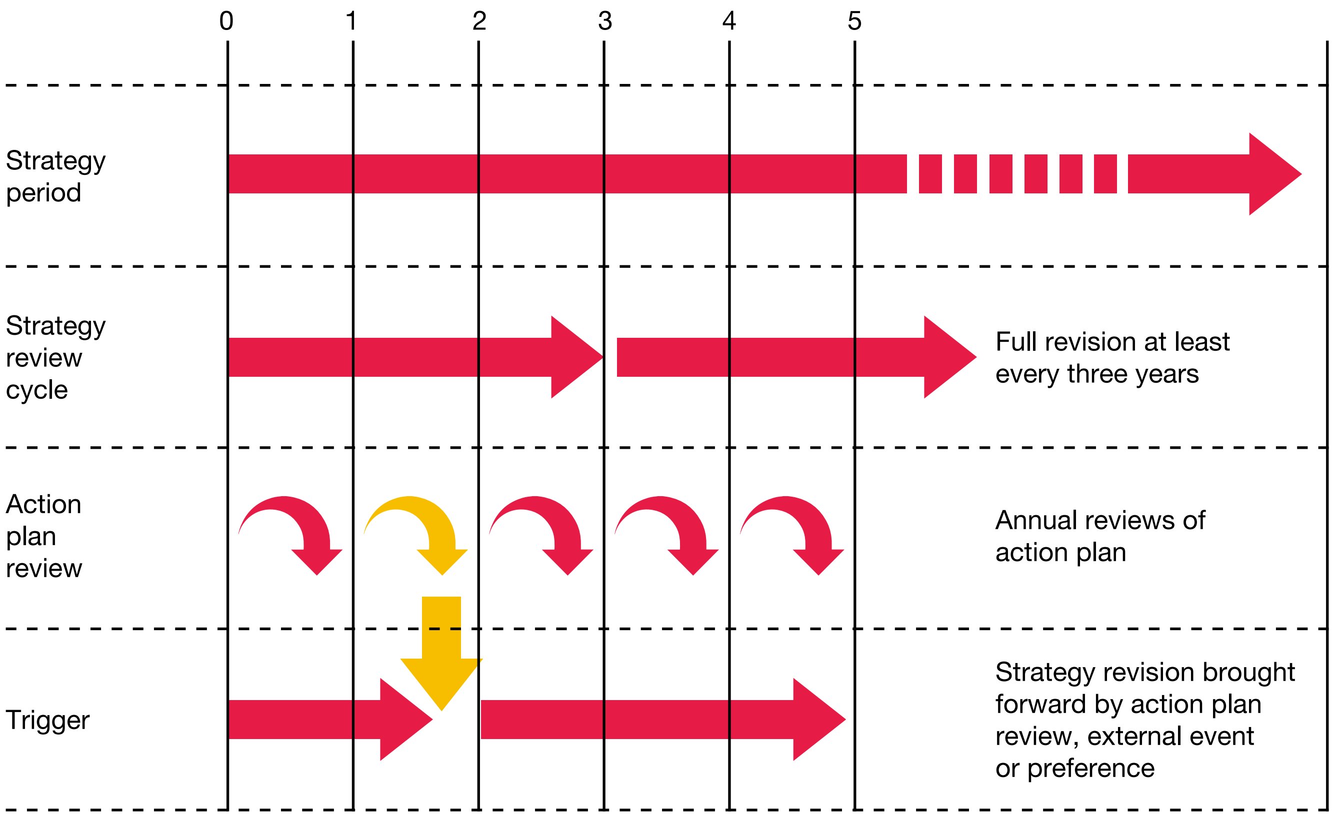
The IWS is ordinarily reviewed every three years and the IWS Action Plan is reviewed annually. More frequent reviews may be prompted by other factors such as significant changes to the company's scope or structure, or external factors such as changes to policy or regulation. This review cycle is illustrated below.

Actions placed by the IWS Action Plan are assigned owners and added to their responsibilities, which will enable the progress of each action to be tracked and recorded. The annual review looks at these actions holistically to determine whether the benefits sought by the IWS Aims are being realised.

The measurement of 'benefits realisation' is also achieved through indicators and metrics which enable the performance of strategies to be tracked. For example, the regional interim storage strategy for HAW is monitored by tracking storage capacity utilisation against estimates of total package numbers, and risks affecting package number uncertainties are actively managed.

Finally, the NDA has introduced the requirement for an Integrated Waste Implementation Plan [41]. Magnox will assess how best to address this requirement in the next strategy review planned for three years' time (2025).

Figure 24: IWS review cycle



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Appendix A: Glossary

TERM	DEFINITION
Advanced Gas-Cooled Reactor (AGR)	The Advanced Gas-cooled Reactor (AGR) are the second generation of British gas-cooled reactors, using graphite as the neutron moderator and carbon dioxide as coolant. There are 14 AGR's in the UK, operated by EDF. Once shut down and defueled, these will transfer to the NDA and be decommissioned by Magnox.
As low as reasonably achievable (ALARA)	Radiological doses or risks from a source of exposure are as low as reasonably achievable when they are consistent with the relevant dose or target standard and have been reduced to a level that represents a balance between radiological and other factors. The level of protection may then be said to be optimised.
As low as reasonably practicable (ALARP)	To satisfy the ALARP principle, measures necessary to reduce risk may be taken until or unless the cost of those measures, whether in money, time or trouble, is disproportionate to the reduction in risk.
Best Available Technique (BAT) / Best Practicable Means (BPM)	In England & Wales, permits require the application of the Best Available Technique (BAT) to various matters including the creation, disposal & discharge of radioactive waste. In Scotland permits require the application of Best Practicable Means (BPM) to the same issues. Wordings differ but the processes are the same for all Magnox sites.
Controlled burial	Refers to the disposal of radioactive waste at a "conventional" landfill (i.e. not the LLW Repository) which is licensed under environmental permitting regulations to accept it.
Discharges	Aqueous and gaseous discharges are regulated under EPR16/EA(S)R18. The principal isotopes of interest are dominated by caesium-137 and tritium for aqueous discharges, and tritium and carbon-14 for gaseous discharges. Non-radioactive discharges are also controlled by limits where applicable under the relevant regulation.
Disposition	On-site disposition (OSDn) covers both on-site disposal (OSD) of radioactive waste and leaving radioactively contaminated ground permanently in-situ. In-situ disposition (ISDn) forms part of OSDn. This involves leaving redundant radioactive structures (such as underground tanks, pipes or building foundations) permanently in place or leaving existing radioactive in-situ contamination of the ground permanently in place.
EA(S)R18	Environmental Authorisations (Scotland) Regulations 2018
End state	The condition to which designated land and its structures and infrastructure need to be restored such that it can be released for its next use.
EPR16	The Environmental Permitting (England and Wales) Regulations 2016
Fuel Element Debris (FED)	Magnox FED was generated from the treatment of spent Magnox reactor fuel prior to transport to Sellafield for reprocessing. FED comprises of the items known as splitter blades and braces (splitters) and lugs that are removed from the outside of fuel elements to assist with packing for transport. The resulting waste is composed predominantly of Magnox metal (a magnesium-based alloy that corrodes relatively easily).
Geological Disposal Facility (GDF)	A Geological Disposal Facility (GDF) will be an engineered facility deep underground to facilitate long term disposal of the UK's higher-activity radioactive waste. A GDF is internationally recognised as the safest long-term solution for this type of waste.
The 'GRR'	Environment agencies' guidance on requirements for release from radioactive substances regulation.
Hazardous waste	Controlled waste that contains any substance specified in The Hazardous Waste (England and Wales) Regulations 2005 and the Special Waste (Scotland) Regulations 2004. These include oils, acids and materials such as asbestos.
Higher activity waste (HAW)	HAW includes ILW and some LLW unsuitable for prompt disposal at the LLW Repository.

Integrated Waste Management Programme (IWMP)	A NDA Group initiative to develop new waste management capabilities and look for opportunities to realise the benefits of cross-group working.
Intermediate level waste (ILW)	Wastes exceeding the upper boundaries for LLW, but which do not require heating to be taken into account in the design of storage or disposal facilities.
Inert waste	Waste subject to the Landfill Directive which does not undergo any significant physical, chemical or biological transformations. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant and pose no danger to surface or groundwater quality. These primarily consist of building rubble and glass.
Interim Storage Facility (ISF)	This facility will be a temporary structure to store ILW until it can be disposed of in the GDF. Not every site will have an ISF, the waste will be consolidated on a regional basis.
Integrated Waste Management Programme (IWMP)	The IWMP intends to integrate waste management activities across the NDA group from waste generation to disposal by ensuring waste is managed in a more integrated, cross-group way.
Integrated Decommissioning and Waste Management Strategy (IWS)	This document details how Magnox manages its waste in an integrated and sustainable way. It sets out the approaches that have been put in place to ensure best use of existing and planned waste management capabilities.
Lower Activity LLW (LALLW)	Refers to waste which would meet controlled burial acceptance criteria, the upper activity limit for such facilities is generally somewhere between the upper limit of VLLW and the upper limit of LLW determined by the facility WAC / permit.
Lower Activity Waste (LAW)	Waste suitable for near-surface disposal in current facilities. Comprises LLW (apart from a small fraction that cannot be disposed of at present) and VLLW.
Low level waste (LLW)	Wastes having a radioactive content not exceeding 4 GBq (gigabecquerels) per tonne of alpha, or 12 GBq per tonne of beta/gamma activity.
Low Level Waste Repository Ltd (LLWR) (now part of NWS)	An NDA subsidiary company that manages the Repository and oversees the National LLW Programme.
Nuclear Decommissioning Authority (NDA)	The Nuclear Decommissioning Authority (NDA) is a non-departmental public body created through the Energy Act 2004. They report to the Department of Energy Security and Net Zero. The NDA funds 4 SLCs directly: Dounreay Site Restoration Limited, Low Level Waste Repository Limited, Magnox Limited and Sellafield Limited. They also have a number of wholly owned subsidiaries working towards achieving the NDA's mission.
Nuclear materials	Materials containing uranium or plutonium which have been produced from fuel cycle operations such as enrichment, fuel fabrication and reprocessing. Where these materials have no future value they may need to be managed as waste.
Non-hazardous waste	Controlled waste which is not covered by the definition of hazardous waste, but which remains biologically, chemically, or physically active if disposed of to landfill. These include metal, timber and other organic wastes. Non-hazardous wastes result both from site occupation, eg office, kitchen, canteen and garden waste and through decommissioning activities, eg metals and treated wood.
Controlled waste	The controlled wastes considered within this document are under the categories: hazardous (referenced to as special waste in Scotland), non-hazardous and inert.

Radioactive waste inventory (RWI)	A 'live' dataset of radioactive wastes that exist now; radioactive wastes that will arise in future; and radioactive materials (radioactive items that are not classed as waste now but may be in future if no further use can be found for them). Every three years this information is contributed to a 'static' UK RWI.
Radioactive waste	Any material that is either radioactive itself or is contaminated by radioactivity, for which no further use is envisaged. This includes a wide variety of material, ranging from wastes that can be decontaminated and recycled to items that need remote handling and heavy shielding to be managed safely. The radioactive wastes considered within this document are under the categories: nuclear materials; Higher Activity Waste (HAW); Low Level Waste (LLW); and Very Low Level Waste (VLLW).
Radioactive Waste Management (RWM) (now part of NWS)	A wholly owned subsidiary of the NDA. RWM (now NWS) is responsible for implementing geological disposal of higher activity radioactive waste in England and Wales.
Radioactive waste management case (RWMC)	Supports the IWS and contains an overview of the site's decommissioning strategy and a summary of the site justification and underpinning for the management of radioactive waste. The scope of the Magnox RWMC is all radioactive waste (solid, liquid and gaseous) through to the end of final site clearance or long-term storage.
Rolling Programme of Decommissioning (RPD)	A combination of continuous and deferred decommissioning that will be applied across all sites on a site-specific basis. This seeks approval to move Magnox away from the current strategy of deferred decommissioning to a rolling programme of decommissioning which accelerates final site clearance.
Site Components	Components of a site used for site restoration planning purposes, e.g. land zones or major structures such as the reactor buildings.
Suitably Qualified Experienced Personnel (SWEP)	Typically, to be regarded as a SQEP, one requires a professional qualification and several years of experience, with recognition that one's skills and understanding can be relied upon to resolve a problem to the required standards.
Very low level waste (VLLW)	Wastes with maximum concentrations of 4MBq (megabecquerels) per tonnes of total activity that can be disposed to specified landfill sites. There is an additional limit for tritium in wastes containing this radionuclide.
Waste	Any substance or object the holder discards, intends to discard or is required to discard.
Waste acceptance criteria (WAC)	Criteria, prescribed by the operator of a facility, to which a waste or waste package must conform in order to gain acceptance into the facility.
Waste Management Plan (WMP)	A documented plan, prepared by the operator of a nuclear site, which provides a comprehensive description of the current intent for dealing with all radioactive substances on or adjacent to the site and demonstrates how waste management has been optimised.

Magnox

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