Nuclear Decommissioning Authority

# An Overview of NDA Higher Activity Waste

**November 2015**

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## Contents

# 1.0 Introduction

Radioactive wastes are produced as a by-product from many important industrial, medical, research and defence activities. In the UK, radioactive wastes are classified according to the type and quantity of radioactivity they contain and how much heat that this radioactivity produces. Higher Activity Waste (HAW) includes High Level Waste, Intermediate Level Waste and a relatively small volume of Low Level Waste that is unsuitable for disposal at existing facilities. As a pioneer of nuclear technology, the UK has accumulated a legacy of HAW at nuclear sites. More HAW will be generated by continuing nuclear operations and from the decommissioning and clean-up of facilities at the end of their lifetime.

For HAW, the long-term management policy of the UK government is to package and hold wastes in secure interim storage facilities until they can be transferred to a geological disposal facility (GDF). The Scottish government's policy is the long-term management of HAW in near surface facilities. Radioactive Waste Management Limited (RWM), a wholly owned subsidiary of the NDA, is responsible for implementing the UK government's policy on geological disposal of HAW.

In the time before disposal routes are available for HAW, NDA's strategy is to treat and package the waste and place it into safe and secure interim storage facilities. Depending on the timing of waste arisings, interim storage requirements may extend over several decades.

The purpose of this report is to provide an overview of current HAW production and management processes across the NDA estate. It presents summary information on the volumes and forms of HAW in stock and projected to arise in future from NDA estate activities.

The report also includes a summary of total radioactive waste volumes across the UK (from all radioactive waste producers) and an overview of the government and devolved administrations' long-term radioactive waste management policies.

Information on the volumes and forms of HAW given in this report is taken from the 2013 UK Radioactive Waste Inventory (RWI), the latest national record of radioactive wastes in the UK. The UK RWI is periodically published by the UK government (Department of Energy and Climate Change) and NDA, and comprises information on the quantities and properties of the different types and forms of radioactive waste that are produced at sites in the UK.

This report is an updated version of a report issued in February 2012, which was based on information from the 2010 UK RWI (*An Overview of NDA Higher Activity Waste, NDA/ST/STY(11)0058*).

Further information on NDA's strategy for HAW management and the 2013 UK RWI can be found on its website at http://www.nda.gov.uk.

# 2.0 Radioactive Waste in the UK

***A summary of key points:***

- *The 2013 UK RWI reports radioactive waste stocks and future arisings totalling 4,720,000 $m^3$ (in terms of final packaged volume).*
- *About 90% of the volume of radioactive waste is LAW (consists of LLW and VLLW).*
- *About 10% of the volume of radioactive waste is HAW (consists of HLW, ILW and a small part of LLW).*
- *HAW total lifetime packaged volume is 463,000 $m^3$.*
- *By country the proportions of HAW are England (85%), Scotland (9%) and Wales (6%).*

## 2.1 Categories of Radioactive Waste

In the UK radioactive wastes are classified in terms of the nature and quantity of radioactivity they contain and the heat they produce.

**High Level Waste (HLW)** - waste in which the temperature may rise significantly as a result of its radioactivity, so this factor has to be taken into account in the design of storage or disposal facilities.

**Intermediate Level Waste (ILW)** - waste exceeding the upper boundaries for LLW that do not generate sufficient heat for this to be taken into account in the design of storage or disposal facilities.

**Low Level Waste (LLW)** - waste having a radioactive content not exceeding 4 Gigabecquerels per tonne of alpha activity, or 12 Gigabecquerels per tonne of beta/gamma activity.

**Very Low Level Waste (VLLW)** - a sub-category of LLW, it comprises waste that can be safely disposed of with municipal, commercial or industrial waste, or can be disposed of to specified landfill sites subject to limits on radioactivity content.

Radioactive wastes can also be categorised as:

**Higher Activity Waste (HAW)** - comprises HLW, ILW and a small fraction of LLW (<13,500 $m^3$ packaged volume) with a concentration of specific radionuclides that prohibits its disposal at existing and planned future disposal facilities for LLW.

**Lower Activity Waste (LAW)** - comprises LLW and VLLW.

A small proportion of LLW near the ILW threshold would be classed as HAW where the remainder would be suitable for disposal at existing LLW facilities.

Some radioactive materials that are not currently classified as waste would need to be managed as wastes if it was decided at some future time they had no further use. These materials include spent nuclear fuel, uranium and plutonium

## 2.2 The Lifecycle of Radioactive Waste

HAW can exist in four main states representing different stages in the waste management lifecycle from production through to disposal:


**Unconditioned** - waste that has been freshly generated or is a legacy of past operations that requires further processing and has not been conditioned.

**Conditioned** - waste that has been processed to give a solid and stable wasteform, for example by encapsulation in a suitable medium such as cement.

**Packaged** - waste that has been loaded into a container suitable for long-term storage or final disposal.

**Disposed** - waste that has been emplaced in a suitable facility without intent to retrieve it.

Typically, wastes are loaded into a container suitable for long-term storage or disposal as part of the conditioning process, and can therefore be regarded as packaged. However some wastes may require overpacking in an outer container before their disposal. Where risk reduction is a priority, the retrieved wastes may be interim stored in suitable containers in an unconditioned state and conditioned before they are dispatched for disposal.

Also, a new management approach for HAW makes use of thick-walled containers to provide shielded interim storage for wastes without encapsulation. It is expected that these packages will be suitable for final disposal, although in some circumstances, an additional encapsulation step may be required.

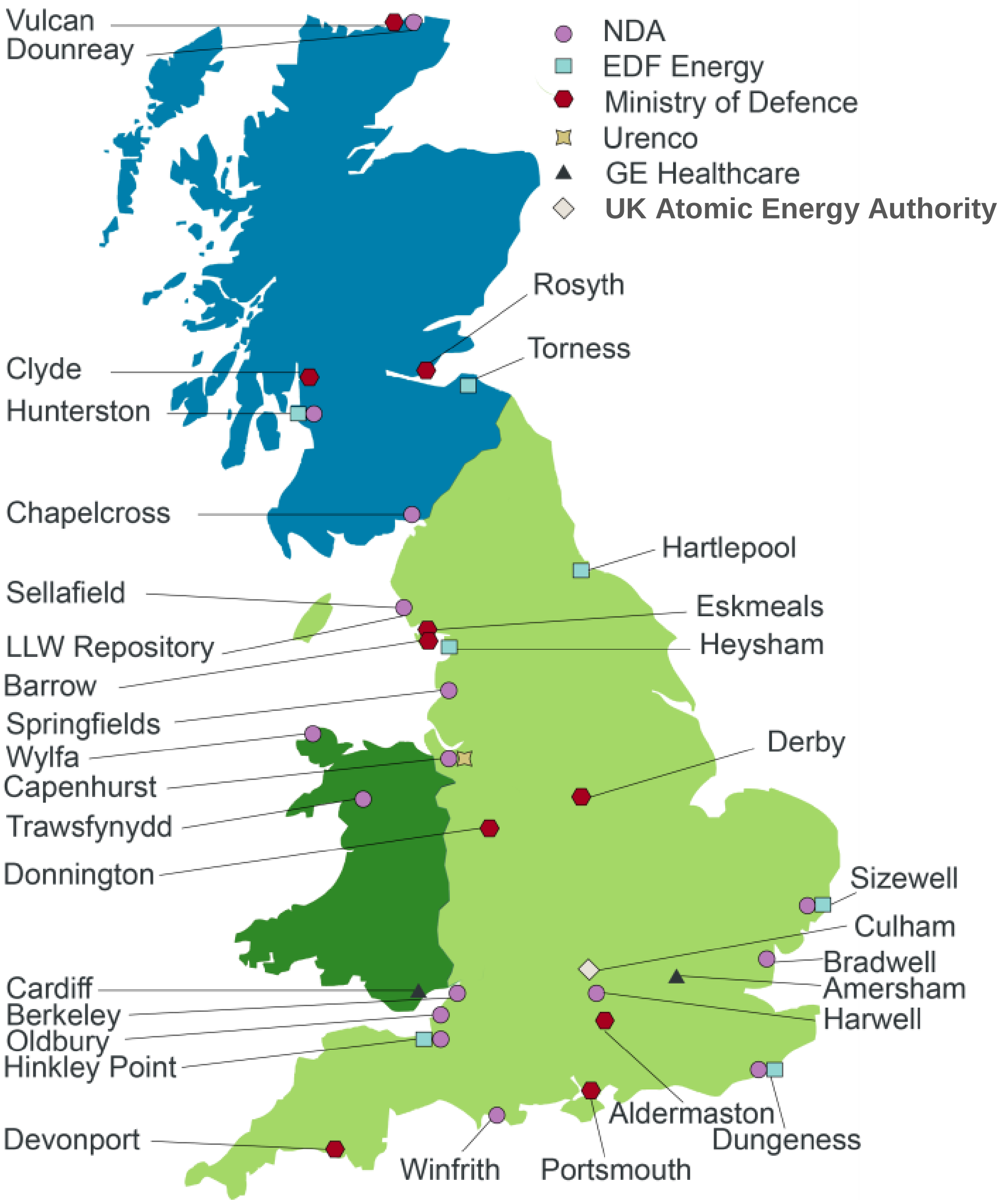
Throughout this report, the volumes of HAW stored at 1st April 2013 include unconditioned and conditioned wastes. Projected future arisings volumes comprise unconditioned wastes, except for a relatively small number of particular wastes that are being conditioned as they arise. Lifetime packaged volumes of HAW are the total of current stored wastes and estimated future arisings once they have been packaged.

## 2.3 Organisations that Produce Radioactive Waste in the UK

The map below shows the sites of the largest waste producers: these are located in England, Scotland and Wales (there are no major HAW generating sites in Northern Ireland).

In addition there are many 'small users' of radioactive materials throughout the UK such as hospitals and industrial, educational and research establishments producing small quantities of radioactive wastes; their sites are not shown. In this report these small users are collectively referred to as 'Minor producers'.

**Major producers of radioactive waste in the UK**




The NDA is responsible, on behalf of the government and taxpayers, for overseeing the clean-up and decommissioning of 17 of the UK's civil nuclear sites spread across the UK, which date back as far as the 1940s.

## 2.4 Volumes of Radioactive Waste in the UK

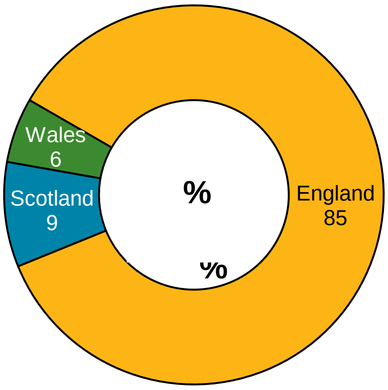
On 1st April 2013, the total volume of UK radioactive waste on all sites was about 165,000 $m^3$. This volume includes waste that is unconditioned as well as waste that has already been conditioned. The volume of future waste was forecast to be 4,330,000 $m^3$. The volume of waste changes as it is treated, conditioned and packaged, and once all wastes are packaged the total volume is estimated to be 4,720,000 $m^3$. Over 60% of this is VLLW and a further 30% is LLW. ILW represents about 10% of total packaged volume, and the proportion of HLW is very small at only 0.03%.

| Waste producer | Volume ($m^3$) (1) | HLW | ILW (2) | LLW | VLLW | Total |
|---|---|---|---|---|---|---|
| **NDA** | Waste at 1.4.2013 | 1,770 | 87,700 | 61,200 | 1,140 | 152,000 |
| | Future arisings | -695 (3) | 159,000 | 1,120,000 | 2,830,000 | 4,100,000 |
| | Total packaged | 1,410 | 403,000 | 1,290,000 | 2,830,000 | 4,520,000 |
| **EDF Energy** | Waste at 1.4.2013 | 0 | 3,320 | 785 | 0 | 4,110 |
| | Future arisings | 0 | 25,200 | 128,000 | 0 | 153,000 |
| | Total packaged | 0 | 46,900 | 84,400 | 0 | 131,000 |
| **GE Healthcare** | Waste at 1.4.2013 | 0 | 344 | 88.4 | 0 | 433 |
| | Future arisings | 0 | 70 | 4,080 | 0 | 4,150 |
| | Total packaged | 0 | 249 | 2,400 | 0 | 2,650 |
| **Ministry of Defence** | Waste at 1.4.2013 | 0 | 4,090 | 2,780 | 27 | 6,890 |
| | Future arisings | 0 | 5,360 | 24,600 | 8,500 | 38,500 |
| | Total packaged | 0 | 6,570 | 15,500 | 8,530 | 30,600 |
| **United Kingdom Atomic Energy Authority** | Waste at 1.4.2013 | 0 | 61.5 | 220 | 1.0 | 283 |
| | Future arisings | 0 | 184 | 5,780 | 60 | 6,020 |
| | Total packaged | 0 | 825 | 7,160 | 61 | 8,040 |
| **Urenco** | Waste at 1.4.2013 | 0 | 0.7 | 1,020 | 0 | 1,020 |
| | Future arisings | 0 | 1.8 | 13,400 | 0 | 13,400 |
| | Total packaged | 0 | 3.0 | 12,700 | 0 | 12,700 |
| **Minor producers (4)** | Waste at 1.4.2013 | 0 | 2.1 | 648 | 0 | 650 |
| | Future arisings | 0 | 4.5 | 8,840 | 0 | 8,850 |
| | Total packaged | 0 | 19.1 | 12,800 | 0 | 12,900 |
| **Total** | **Waste at 1.4.2013** | **1,770** | **95,600** | **66,700** | **1,170** | **165,000** |
| | **Future arisings** | **-695 (3)** | **190,000** | **1,300,000** | **2,840,000** | **4,330,000** |
| | **Total packaged** | **1,410** | **458,000** | **1,420,000** | **2,840,000** | **4,720,000** |

(1) All numbers are reported with up to three significant figures.
(2) Includes 9,230 $m^3$ packaged volume for which the current management strategy is decontamination to LAW and disposal at the LLWR.
(3) The number represents the change in volume once all HLW has been conditioned.
(4) Minor producers comprise hospitals and industrial, educational and research establishments.

The total lifetime packaged volume of UK HAW is currently estimated to be 463,000 $m^3$, of which 404,000 $m^3$ (about 87%) was associated with NDA sites. Nearly all LLW that falls into the HAW designation is core graphite from the decommissioning of NDA's Magnox reactors and the advanced gas-cooled reactors (AGR) operated by EDF Energy. ILW will result from activities at most major waste producer sites in the UK, but volumes vary considerably. All HLW will come from reprocessing nuclear fuel at NDA's Sellafield site.

The waste volumes given in the table on page 7 are those declared in the 2013 UK RWI. They are the current best estimates of what will be produced. However future arisings may change if assumptions as to the nature and scale of operations are revised. Also total packaged volumes may change because packaging schemes for certain wastes are yet to be fully developed.




The chart on the right shows the percentage contributions to the total packaged volume of UK HAW from sites in England, Scotland and Wales. The corresponding total packaged volumes are 396,000 $m^3$ (England), 41,400 $m^3$ (Scotland) and 25,700 $m^3$ (Wales).

## 2.5 Government Policy on HAW Management

Government radioactive waste management policy supported by a regulatory framework ensures that the wastes are safely and appropriately managed in ways that pose no unacceptable risks to people and the environment.

The long-term management policy of the UK government and that of the Northern Ireland executive is geological disposal, preceded by safe and secure interim storage and supported by ongoing research. The recently published White Paper 'Implementing Geological Disposal'[1] sets out the framework for achieving this.

The Welsh government has also decided to adopt a policy for geological disposal for the long term management of HAW and continues to support the policy of voluntary engagement[2].

The Scottish government policy is for the long-term management of HAW in near-surface facilities rather than geological disposal. These facilities should be located as near to the site, where the waste is produced, as possible. A detailed statement of policy was published in January 2011[3]. The Scottish government is currently developing a strategy for implementing its policy[4].

The UK government policy for the long-term management of HAW through geological disposal includes some radioactive materials that are not currently classified as waste, but would need to be managed as wastes if it was decided at some future time they had no further use. These materials include spent nuclear fuel, uranium and plutonium. The Scottish government policy for HAW does not cover radioactive materials that are not currently classified as radioactive waste.

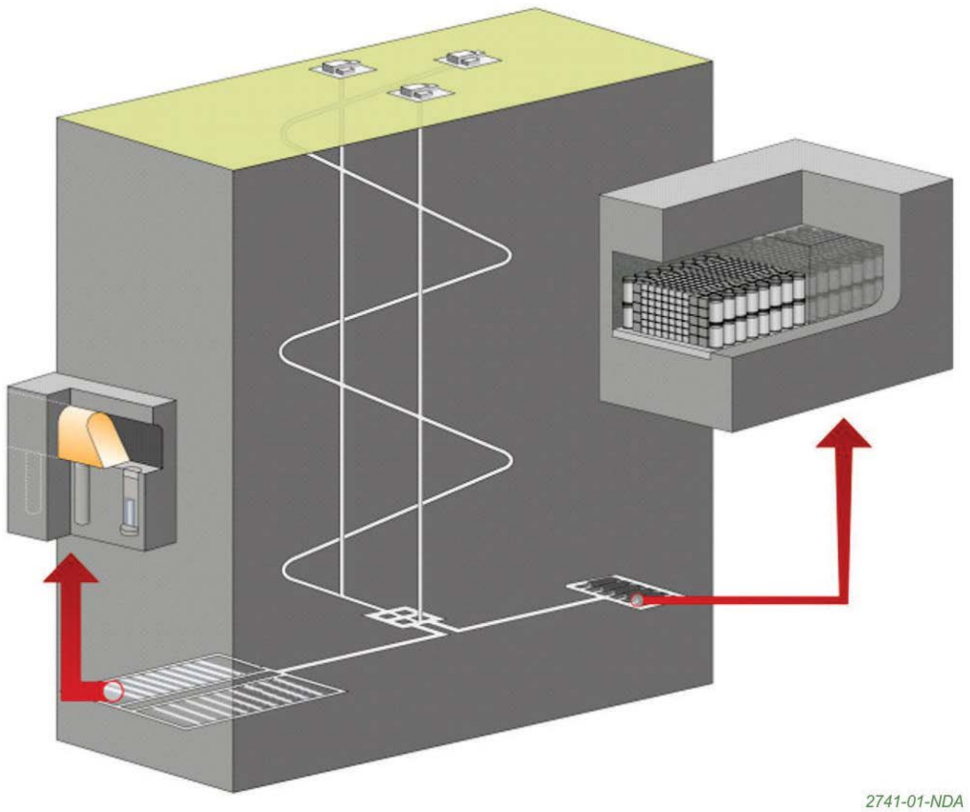
[1] Department of Energy & Climate Change. Implementing Geological Disposal. A Framework for the long-term management of higher activity radioactive waste. July 2014.
[2] Welsh Government (2015), Welsh Government Policy on the Management and Disposal of Higher Activity Radioactive Waste.
[3] The Scottish Government. Scotland's Higher Activity Radioactive Waste Policy 2011. January 2011.
[4] The Scottish Government, Consultation on an Implementation Strategy for Scotland's Policy on Higher Activity Radioactive Waste, May 2015.

Geological disposal involves isolating the wastes deep inside suitable rock to ensure that no harmful quantities of radioactivity ever reach the surface. To achieve this, the waste will be emplaced in a highly-engineered containment facility – a geological disposal facility (GDF). Packaged HAW would be emplaced in underground vaults and disposal tunnels. Radioactive Waste Management (RWM), a wholly-owned subsidiary of the NDA, is responsible for delivering a GDF[5].

A GDF will be designed using natural geology and engineering (waste package and the underground engineered vaults and tunnels) so that the waste is contained inside these multiple barriers to provide protection over hundreds of thousands of years. It is not a case of simply depositing waste underground. The multiple barriers that provide safety for geological waste disposal are a combination of:

- the form of the radioactive waste itself, for example high level waste that arises initially as a liquid is converted into a durable, stable solid glass form before storage and disposal
- the packaging of the waste
- engineered barriers (buffer) that protect the waste packages and limit the movement of radionuclides if they are released from the waste packages
- engineered features of the facility that the waste packages are placed in
- stable geological setting (rock) in which the facility is sited

The detailed layout and design of a GDF will depend on the waste inventory and the specific geological characteristics of the site. The diagram below illustrates one possible design for a GDF and shows the separation of high heat (HLW and spent fuel) and low heat generating wastes within the facility.




*Possible design for a geological disposal facility*

[5] Details of RWM's work can be found at [www.nda.gov.uk/rwm](http://www.nda.gov.uk/rwm).

# 3.0 NDA Higher Activity Waste

***A summary of key points:***

- *The total lifetime packaged volume of NDA HAW is 404,000 $m^3$ (~87% of all UK HAW).*
- *About 75% of all NDA HAW is from the Sellafield site and about 20% from the Magnox sites.*
- *HAW is produced in various radiological, chemical and physical forms that can be described using a set of waste groups.*

## 3.1 NDA Sites and Waste Volumes

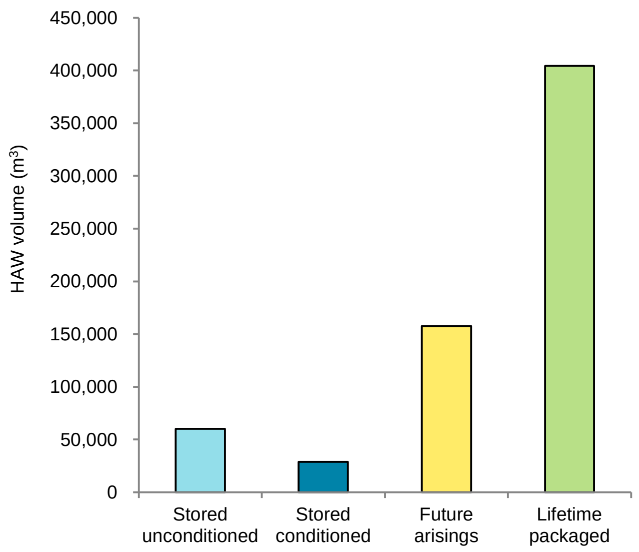
NDA oversees the continuing operations, decommissioning and clean-up across its estate. It has established Site Licence Companies (SLCs) to carry out the day-to-day operations at its sites.

The table below gives the volumes of HLW, ILW and LLW making up HAW at 1st April 2013, for projected future arisings and total packaged (i.e. all wastes once they have been packaged for disposal to a GDF or for management in line with Scottish government policy).

| SLC | Site | Volume ($m^3$) (1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HLW | | | ILW | | | | LLW | |
| | | Stock at 1.4.2013 | Future arising | Total packaged | Stock at 1.4.2013 | Future arising | Total packaged (disposal as HAW) | Total packaged (disposal as LAW) | Future arising | Total packaged |
| Sellafield Ltd | Sellafield | 1,770 | -695 (2) | 1,410 | 69,600 | 107,000 | 300,000 | 5,610 (3) | 6.3 | 12.3 |
| Magnox Ltd | Berkeley | 0 | 0 | 0 | 1,610 | 3,680 | 8,400 | 33.5 | 33 | 40.8 |
| | Bradwell | 0 | 0 | 0 | 767 | 3,740 | 5,580 | 37.1 | 215 | 266 |
| | Chapelcross | 0 | 0 | 0 | 116 | 4,560 | 6,110 | 152 | 6 | 7.4 |
| | Dungeness A | 0 | 0 | 0 | 222 | 4,060 | 5,480 | 445 | 0 | 0 |
| | Hinkley Pt A | 0 | 0 | 0 | 1,250 | 4,100 | 6,330 | 21.5 | 47 | 58.1 |
| | Hunterston A | 0 | 0 | 0 | 2,660 | 3,750 | 9,640 | 0 | 6.7 | 8.3 |
| | Oldbury | 0 | 0 | 0 | 588 | 3,980 | 5,950 | 20.2 | 1,890 | 2,340 |
| | Sizewell A | 0 | 0 | 0 | 692 | 4,060 | 5,560 | 142 | 0 | 0 |
| | Trawsfynydd | 0 | 0 | 0 | 2,010 | 4,670 | 13,100 | 19.5 | 48 | 59.3 |
| | Wylfa | 0 | 0 | 0 | 823 | 6,450 | 9,080 | 71.5 | 2,740 | 3,380 |
| | Harwell | 0 | 0 | 0 | 2,300 | 486 | 6,600 | 0 | 0 | 0 |
| | Winfrith | 0 | 0 | 0 | 5.5 | 65 | 1,440 | 0 | 0 | 0 |
| DSRL | Dounreay | 0 | 0 | 0 | 4,600 | 2,530 | 12,900 | 0 | 0 | 0 |
| LLWR Ltd | LLWR | 0 | 0 | 0 | 33.9 | 491 | 275 | 0 | 0 | 0 |
| **Total** | | **1,770** | **-695** | **1,410** | **87,300** | **153,000** | **397,000** | **6,550** | **4,990** | **6,170** |

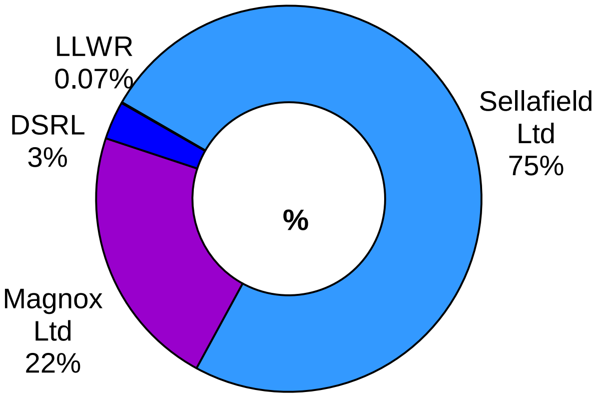
(1) All numbers are reported with up to three significant figures. There is no LLW in stores at 1.4.2013.
(2) The number represents the change in volume once all HLW has been conditioned.
(3) Assumes that Magnox pond furniture currently classified as ILW is recategorised as LLW upon retrieval.

For completeness, also included in the table is total packaged ILW (see ninth column) for which the current strategy is treatment, *e.g.* decontamination, to LAW and disposal at the Low Level Waste Repository (LLWR). All volumes in the table are those declared in the 2013 UK RWI by SLCs.




At 1st April 2013 the total volume of HAW stored at NDA sites was 89,100 $m^3$ (made up of 60,200 $m^3$ in the unconditioned state and 28,900 $m^3$ in the conditioned state). An additional 158,000 $m^3$ was forecast in future arisings. Once all HAW is conditioned and packaged the total volume is estimated to be 404,000 $m^3$, comprising about 209,000 waste packages. This lifetime packaged volume indicates how much HAW will need to be transported off-site and disposed. (Note: these quantities exclude ILW expected to be packaged for disposed as LAW as shown in the table on page 10).

Sellafield Ltd is the custodian of the majority of HAW across the NDA Estate - it is forecast to produce about 75% of the lifetime packaged volume from its Sellafield site. Much of the remaining forecast HAW (about 22%) is produced by Magnox Ltd at its ten nuclear reactor sites and two research sites.



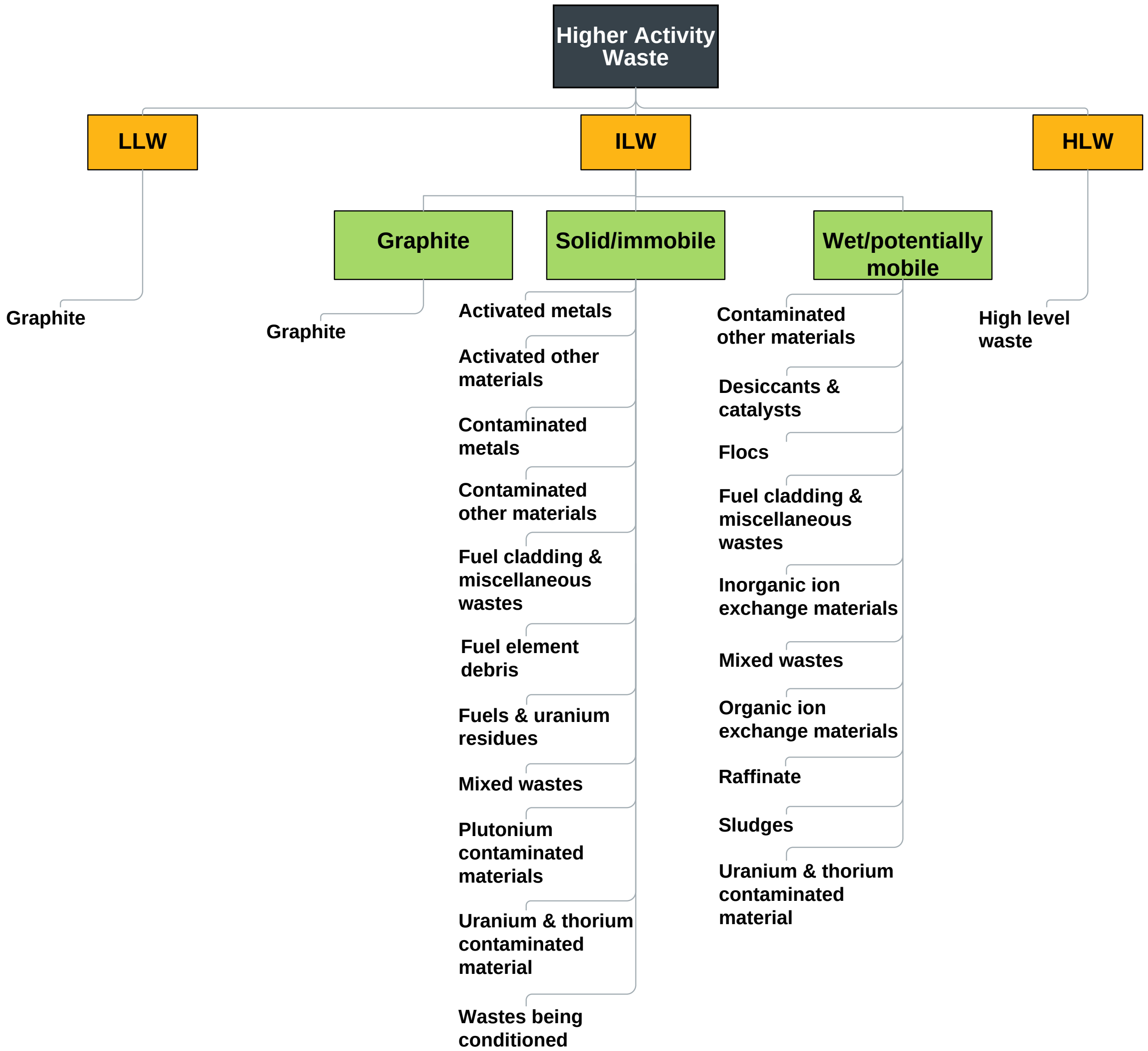

## 3.2 Waste Production and Properties

At NDA sites HAW comes from past and continuing operations and from subsequent decommissioning of facilities. The different activities at the sites mean that the radiological, chemical and physical forms of HAW are highly varied. Waste can range from large solid items that are relatively inert to mobile sludges and liquids.

These different forms of HAW may need separate management arrangements that include conditioning and packaging solutions appropriate for their properties. Therefore to facilitate the explanation of how the wastes are to be processed and stored, the HAW produced by each SLC has been split into a number of different groups informed by the proposed waste groupings in Appendix 3 of NDA's credible options strategy paper for HAW[6].

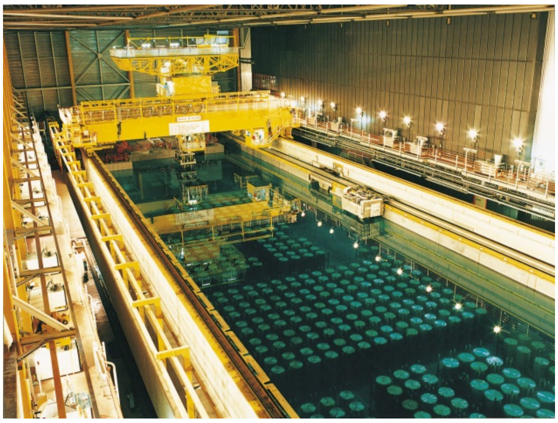
The diagram below is an updated version of that given in the credible options strategy paper for HAW following consideration of current SLC waste management arrangements. It includes the same topic strands (orange and green boxes), but for each strand the revised waste groups. ILW that is already being conditioned for long-term management is included as a separate group to distinguish it from wastes yet to be processed. The waste groups shown remain subject to change.

[6] NDA, Higher Activity Waste Credible Options (Gate A), SMS/TS-D1-HAW/001A, February 2011.


Higher Activity Waste
LLW
ILW
HLW
Graphite
Graphite
Solid/immobile
Wet/potentially mobile
Graphite
Activated metals
Activated other materials
Contaminated metals
Contaminated other materials
Fuel cladding & miscellaneous wastes
Fuel element debris
Fuels & uranium residues
Mixed wastes
Plutonium contaminated materials
Uranium & thorium contaminated material
Wastes being conditioned
Contaminated other materials
Desiccants & catalysts
Flocs
Fuel cladding & miscellaneous wastes
Inorganic ion exchange materials
Mixed wastes
Organic ion exchange materials
Raffinate
Sludges
Uranium & thorium contaminated material
High level waste

The following text gives an overview of how HAW is produced at each SLC and tabulates the different waste groups. Section 6.1 gives further information on the nature of each waste group.

## Sellafield Ltd



*Thorp reprocessing plant*

Sellafield Ltd operates one large site in Cumbria, comprising two separate licensed sites (Sellafield and Windscale).

The Magnox reactors at Sellafield (Calder Hall) are shut down. Some HAW remains on site from station operation. Further HAW will be produced during the final dismantling and site clearance phase of decommissioning.

Sellafield is a large nuclear chemical facility supporting the UK's civil nuclear programme.

At Sellafield, HAW is produced from spent nuclear fuel reprocessing operations. This includes HLW generated during the chemical separation of uranium and plutonium from spent fuel (a proportion of HLW associated with the reprocessing of overseas spent fuel is returned to the country of origin). The decommissioning of site facilities at Sellafield also produces HAW.

Some HAW from historic reprocessing operations at Sellafield remains in ageing ponds and silos. These higher hazard legacy wastes are a focus for risk reduction.

The diverse nature of activities across the Sellafield site gives rise to a wide variety of HAW.

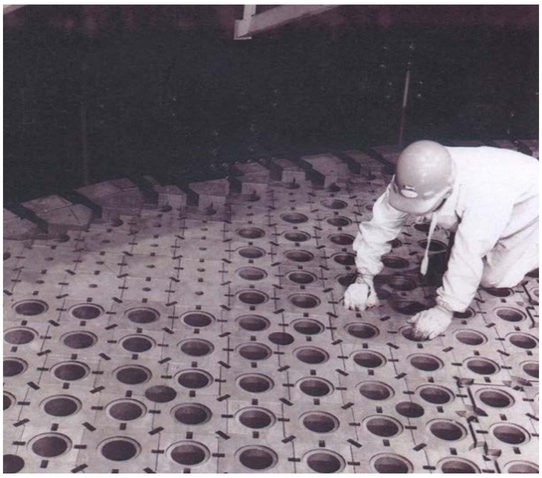
Windscale was established with the initial purpose of plutonium production for the UK weapons programme and development of fuel reprocessing technology. Subsequently the site housed the Windscale Advanced Gas-cooled Reactor (WAGR) prototype reactor. All facilities have been shut down. HAW comes from past operations and from current and future facilities decommissioning.

## Magnox Ltd (Magnox sites)

Magnox Ltd manages ten Magnox reactor sites. One reactor at Wylfa is still generating electricity, but will shut down in December 2015. All other reactors are shut down. These are either being defuelled or have already been defuelled, and are being prepared for a period of care and maintenance that involves removing most plants and structures on the site other than the reactor building.

Care and maintenance is a period of deferment currently planned to be about 50-70 years that will be followed by final dismantling and site clearance, and the disposal of all remaining wastes.

HAW comes from the operation and subsequent decommissioning of the reactor plant and buildings. This includes some LLW (graphite) from final dismantling.



*Reactor core graphite*

## Magnox Ltd (Harwell and Winfrith)

Magnox Ltd's sites at Harwell and Winfrith have been centres for nuclear energy and reactor R&D. All reactors and research facilities have been shut down.

At Harwell, HAW has been produced from experimental and materials testing reactors (including GLEEP, BEPO, DIDO and PLUTO), and other site facilities including radiochemical and engineering laboratories. HAW has also been received from external waste producers (e.g. from other nuclear licensed sites, and from the medical, teaching and industrial applications sectors). Further HAW comes from decommissioning activities.

At Winfrith, HAW has been produced from experimental and prototype reactors along with supporting nuclear fuel facilities. Further HAW comes from decommissioning activities.

*Inside the Dragon reactor at Winfrith*

## Dounreay Site Restoration Ltd

*Demolition of old facilities adjacent to the DFR*

Dounreay Site Restoration Limited's (DSRL) Dounreay site was the UK's centre for fast reactor research and development (R&D).

The site's three reactors - the Prototype Fast Reactor (PFR), the Dounreay Fast Reactor (DFR) and the Dounreay Materials Testing Reactor (DMTR) - and supporting fuel production and processing facilities are no longer operating and are being decommissioned.

HAW comes from historic operations and from current and future decommissioning activities.

## LLWR Ltd

*LLW containers in engineered vaults at the repository*

LLWR is an operational repository in the UK for LLW. In the past, the site was used to store plutonium contaminated materials (PCM), but most of this material has now been transferred to Sellafield. HAW comes from the decommissioning of the storage facilities.

The table below summarises the waste groups at the SLC's sites. The waste group 'Mixed wastes' typically includes miscellaneous activated and contaminated materials.

| Waste groups | Sellafield (1) | Magnox stations | Dounreay | Harwell | Winfrith | LLWR |
|---|---|---|---|---|---|---|
| Activated metals | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Activated other materials | | | ✓ | ✓ | | |
| Contaminated metals | ✓ | ✓ | ✓ | ✓ | | |
| Contaminated other materials | ✓ | ✓ | ✓ | ✓ | | |
| Desiccants & catalysts | | ✓ | | | | |
| Flocs | ✓ | | ✓ | | | |
| Fuel cladding & miscellaneous wastes | ✓ | | ✓ | | | |
| Fuel element debris | | ✓ | | | | |
| Fuels & uranium residues | ✓ | ✓ | ✓ | ✓ | | |
| Graphite (ILW) | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Graphite (LLW) | ✓ | ✓ | | | | |
| High level waste | ✓ | | | | | |
| Inorganic ion exchange materials | ✓ | ✓ | ✓ | | | |
| Mixed wastes | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Organic ion exchange materials | | ✓ | | | | |
| Plutonium contaminated materials | ✓ | | ✓ | ✓ | | ✓ |
| Raffinate (ILW) | | | ✓ | | | |
| Sludges | ✓ | ✓ | | | | |
| Uranium & thorium contaminated material | | | ✓ | | | |
| Wastes being conditioned | ✓ | ✓ | | ✓ | | |

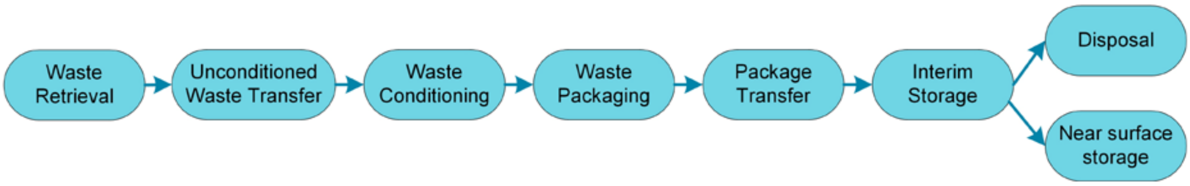
(1) Includes the Calder Hall Magnox station.

# 4.0 NDA Higher Activity Waste Management

***A summary of key points:***

- *The UK has a legacy of unconditioned HAW, with a significant fraction of this waste stored in ageing facilities that do not meet modern standards.*
- *The effective application of the waste hierarchy supports our general approach to HAW management.*
- *Our SLCs will continue to package HAW into a form that is suitable for storage and disposal.*
- *The current generic approach for waste treatment is to immobilise the waste and store it within purpose built facilities.*
- *At facilities where our immediate priority is near term risk reduction, we are prepared to retrieve wastes and provide containerisation knowing that further waste treatment steps will be necessary prior to disposal.*
- *New storage facilities are being built across the estate to store HAW until the disposal routes become available.*
- *The NDA estate used a range of container types (shielded and unshielded) for the long-term management of HAW.*
- *RWM's disposability assessment process supports HAW conditioning and packaging compatible with long-term management.*

Currently the majority of HAW is either being stored in an unconditioned state or is a forecast future arising principally from nuclear plant decommissioning. Over the next several decades, NDA sites will continue to progress waste retrieval, containerisation, conditioning and packaging programmes for historical wastes and for future operational and decommissioning waste arisings, so that ultimately all wastes will be held in modern interim storage facilities and ready for disposal or final conditioning. At 1st April 2013, approximately 38,400m$^3$ of HAW (packaged volume) was in interim storage, comprising about 59,800 individual waste packages, and representing about 9.5% of all HAW forecast at NDA sites.




In summary, NDA's general approach to HAW management includes:

- Prioritising the retrieval, transfer, conditioning and passive storage of legacy wastes;
- For some wastes, it may be necessary to adopt a multi-stage process to achieve a final disposable product;
- Minimising the storage of HAW in unconditioned form;
- Minimising the volume of ILW produced from decommissioning;
- Packaging HAW into a form that is suitable for long-term storage and disposal; and
- Ensuring safe and secure interim storage pending availability of a GDF.

Key aspects of the approach to HAW management are described below. In Section 5, more information is provided by using routing diagrams to illustrate the strategy for managing the different waste groups at NDA sites, and the current and planned packaging plants and interim storage facilities for HAW.

## 4.1 The Waste Hierarchy

A central theme of UK radioactive waste management strategy is the waste hierarchy (see right), which sets out five steps for dealing with waste, ranked according to environmental impact. There is a preference for managing wastes at higher levels of the hierarchy, with prevention of waste where practicable, minimisation where creation is unavoidable, re-use and recycling where there are opportunities to do so, and ultimately disposal for wastes that are not amenable for managing at these higher levels.

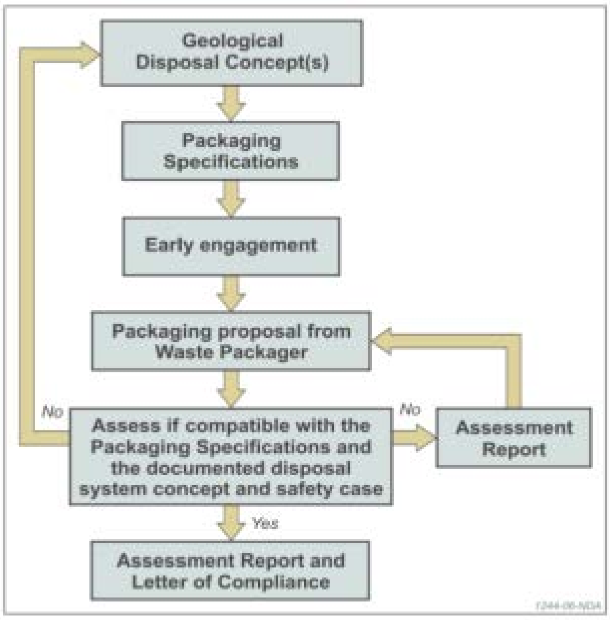

For HAW, there are no direct re-use or recycling opportunities. However treatment of some waste can be undertaken to reduce packaged volume for interim storage and disposal. This includes decontamination, decay storage or waste sorting/segregation (with additional characterisation) leading to recategorisation as LAW, and treatment (e.g. compaction, dissolution) for volume reduction.

## 4.2 Disposability Assessment Process

As plans in the UK for the geological disposal of HAW are at an early stage, the information necessary to develop waste acceptance criteria for a GDF is not available. However, in order that wastes can be converted to passively safe and disposable forms as soon as reasonably practicable, RWM has developed generic packaging specifications. These provide site operators and regulators with a clear definition of the properties and performance requirements for waste packages that are compatible with the anticipated systems and safety cases for transport to and disposal in a GDF.

RWM has established the Disposability Assessment Process as a means of supporting the UK nuclear industry in the conditioning and packaging of HAW for disposal, compatible with plans for the implementation of a GDF. The process has been developed in co-operation with site operators and industry regulators, and in a manner that aligns with regulatory expectations for the long-term management of HAW.

The principal aim of the Disposability Assessment Process is to minimise the risk that the conditioning and packaging of radioactive wastes results in packages incompatible with geological disposal, as far as this is possible in advance of the availability of Waste Acceptance Criteria for a geological disposal facility.  As such, it is an enabler for early hazard reduction on UK nuclear sites.




*The disposability assessment process*

A Letter of Compliance (LoC) can be issued as endorsement, if the Disposability Assessment Process does not identify any significant issues or uncertainties with a proposed packaging approach.

The process is available to all nuclear licensed site operators in the UK. Although the process is primarily aimed at the production of waste packages that are compatible with generic plans for deep geological disposal, the Scottish Environmental Protection Agency (SEPA) and the Office for Nuclear Regulation (ONR) have provided advice to the Scottish government that packages produced to these standards are also suitable for long-term storage while not unduly foreclosing alternative management options that might emerge in the future.

## 4.3 Packaging of Radioactive Waste

Waste packaging is the responsibility of the waste producers. However, as part of the process to ensure that packages comply with the requirements of a geological disposal system, RWM has developed a suite of standard containers for conditioned ILW and LLW. Also, there are a limited number of other containers, designed by waste producers, used for ILW.

There are three types of ILW package:

- For some ILW of lower activity, sufficient radiation shielding can be provided by concrete boxes or concrete-lined steel boxes. These are known as *'shielded'* waste packages. They can be handled using normal industrial warehousing methods (*'contact-handled'*) and can be transported as low specific activity material (as an IP-2 package) without the need for overpacking.
- Higher activity ILW requires greater radiation shielding and containment. It is packaged in thin-walled steel drums and boxes. These are known as *'unshielded'* packages. They require remote-handling facilities and a Type B shielded transport container.
- Thick-walled waste containers can be used to provide both radiation shielding and physical containment, and to create robust shielded waste packages. Such packages are capable of being stored, transported and disposed without the need for remote handling techniques or overpacking.

The HLW vitrified product storage canisters will require additional packaging in robust containers before they are suitable for disposal. RWM is developing a concept design for the HLW disposal container.

| **Current waste container types** |
|---|
| **High Level Waste (HLW):** |
| HLW storage canister (will require overpacking) |
| **Intermediate Level Waste (ILW)** |
| ***Unshielded packages (UILW)*** |
| 500 litre drum* |
| 500 litre drum (with pre-cast annulus)* |
| 500 litre drum (with basket for waste)* |
| 3 $m^3$ box (round corners or square corners) |
| 3 $m^3$ drum |
| MBGWS box |
| Sellafield 3$m^3$ box (single skinned) |
| Sellafield enhanced 3$m^3$ box (double skinned) |
| ***Shielded packages (SILW)*** |
| 2 m box (with concrete shielding) |
| 4 m box (with concrete shielding) |
| 6 $m^3$ box (with standard or high density concrete) |
| 500 litre concrete drum |
| 1$m^3$ concrete drum |
| ***Thick walled containers*** |
| 3$m^3$ robust shielded box (DCIC Type VI) |
| 500 litre robust shielded drum (DCIC Type II) |
| **Low Level Waste (LLW)** |
| 4 m LLW box (with no shielding) |
| 2 m LLW box (with no shielding) |

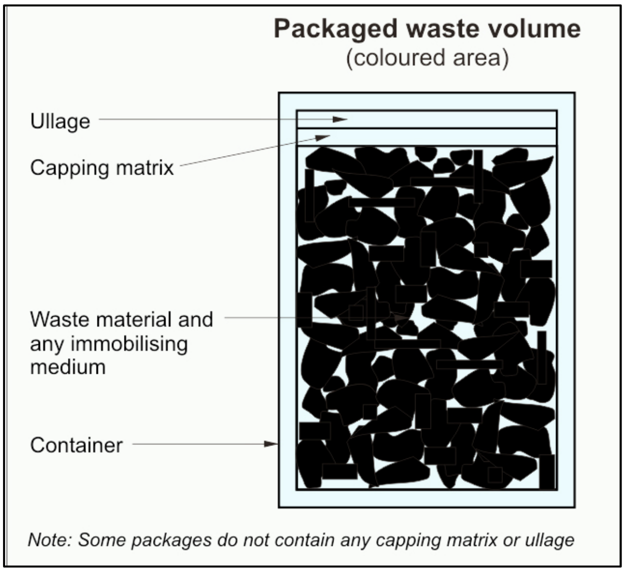
*500 litre drum packages will be transported and disposed using four-drum disposal stillages.

*HLW storage canister (cutaway)*

*Ductile Cast Iron Container (DCIC)*

*ILW 500 litre drum and stillage containing four 500 litre drums*

A range of techniques may be used to minimise the volume of waste for packaging and disposal. For solid wastes this is usually achieved by compaction or mechanical size reduction, although chemical techniques may also be used. Volume reduction of liquid wastes can be achieved by evaporation or dewatering. In most cases, the wastes are then mixed with encapsulating materials such as cement to give a solid and immobile wasteform and also to make them more suitable for disposal. The overall change in volume from waste conditioning is the net result of any volume reduction treatment and encapsulation.




Throughout this report we refer to 'packaged volume'. This is the displacement volume of the waste package, and comprises the waste material, any immobilising or encapsulating material, any capping grout, ullage and the container (see diagram on the left).

Packaged volume represents a 'final' waste volume for either eventual disposal or long-term storage, except where requirements of the disposal system (e.g. in the case of HLW storage canisters) or long-term storage system would not be met and waste containers would be overpacked.

There are a number of HAW packaging plants in the UK, with others being planned (see Section 5).

The images below show packaging plants at Dounreay in Caithness and Sellafield in Cumbria.

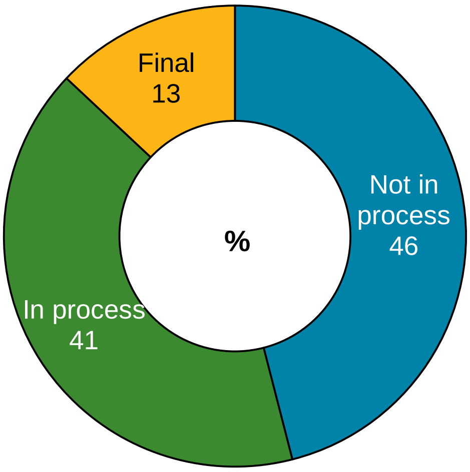

*Dounreay Cementation Plant (DCP)*

*Encapsulation line at Sellafield Waste Packaging and Encapsulation Plant (WPEP)*

## 4.4 Summary of Progress in Packaging HAW

RWM publishes an annual report of its interactions with site operators concerning the packaging of HAW. The latest report[7] can be found on NDA's website.

The figure on the right illustrates the progress being made with the packaging of ILW. It shows the proportion of the waste that is in the disposability assessment process and that which has completed the process and therefore has a final LoC. At present about 13% of all forecast ILW (in terms of conditioned volume) has completed this process - made up of 8% of waste that has been packaged and 5% that is awaiting packaging. A further 41% of ILW is currently within the process.




For HLW about 84% of all forecast waste (by conditioned volume) has been packaged in storage canisters, and a further 9% is currently within the LoC process.

## 4.5 Storage of Radioactive Waste

HAW packages will continue to be stored in secure buildings and monitored until a suitable long-term disposal route becomes available. Unshielded waste packages will be stored in shielded buildings to protect people and the environment from radiation. Where radiation shielding is provided primarily by the waste container, unshielded or lightly shielded stores can be constructed.

Currently HAW is being stored in both unconditioned and conditioned states. The proportion of conditioned waste in storage will increase as existing waste conditioning programmes continue and new conditioning plants are built and operated. In some circumstances, waste retrieved from legacy facilities will be interim stored and final conditioning will be required prior to disposal.

*Vitrified HLW store at Sellafield*

HLW is produced as a liquid that is stored in stainless steel tanks. These tanks are cooled because HLW gives off a significant amount of heat.

The liquid wastes are dried and the residues heated in a furnace with crushed glass to give a molten product. This process is called vitrification and is undertaken at the Sellafield site in Cumbria. The molten product is poured into stainless steel canisters and lids are welded on. Each canister holds approximately 150 litres of conditioned waste. The canisters are held in a dedicated engineered store (see left).

[7] NDA RWMD interactions with waste packagers on plans for packaging radioactive wastes April 2013 - March 2014, NDA Report no. NDA/RWM/119, July 2014.

There have been a number of storage solutions for the different forms of ILW. Historically a variety of vaults, tanks, ponds, silos and other storage facilities have been used. Modern ILW processing facilities now convert the wastes into solid and stable forms for storage[8]. Thus, certain materials and small items of equipment can be supercompacted, while other solid wastes are cut up to reduce their size. ILW that has higher water content may need to be dried.

ILW is packaged to ensure that it can be safely stored, and subsequently transported and disposed. The current generic approach for ILW, packaging consists of immobilisation in cement-based materials within 500 litre stainless steel drums of $3m^3$ stainless steel boxes. Large items can be packaged in higher capacity steel and concrete boxes or ductile cast iron containers.

The current status of ILW storage covers the following situations:

- Untreated, i.e. unconditioned waste, in historical storage facilities (see below right);
- Historically treated waste in storage that needs further treatment before long-term storage/disposal;
- Interim storage of waste already conditioned for disposal (see below left);
- The continued storage of waste in modern engineered stores that will require further conditioning before disposal; and
- Waste *in situ* such as in reactor cores waiting decommissioning.

Nearly all the LLW component of HAW exists as *in situ* reactor core graphite.

*Modern packaged ILW interim store*

*Legacy storage facility (the waste will be retrieved, treated and packaged*

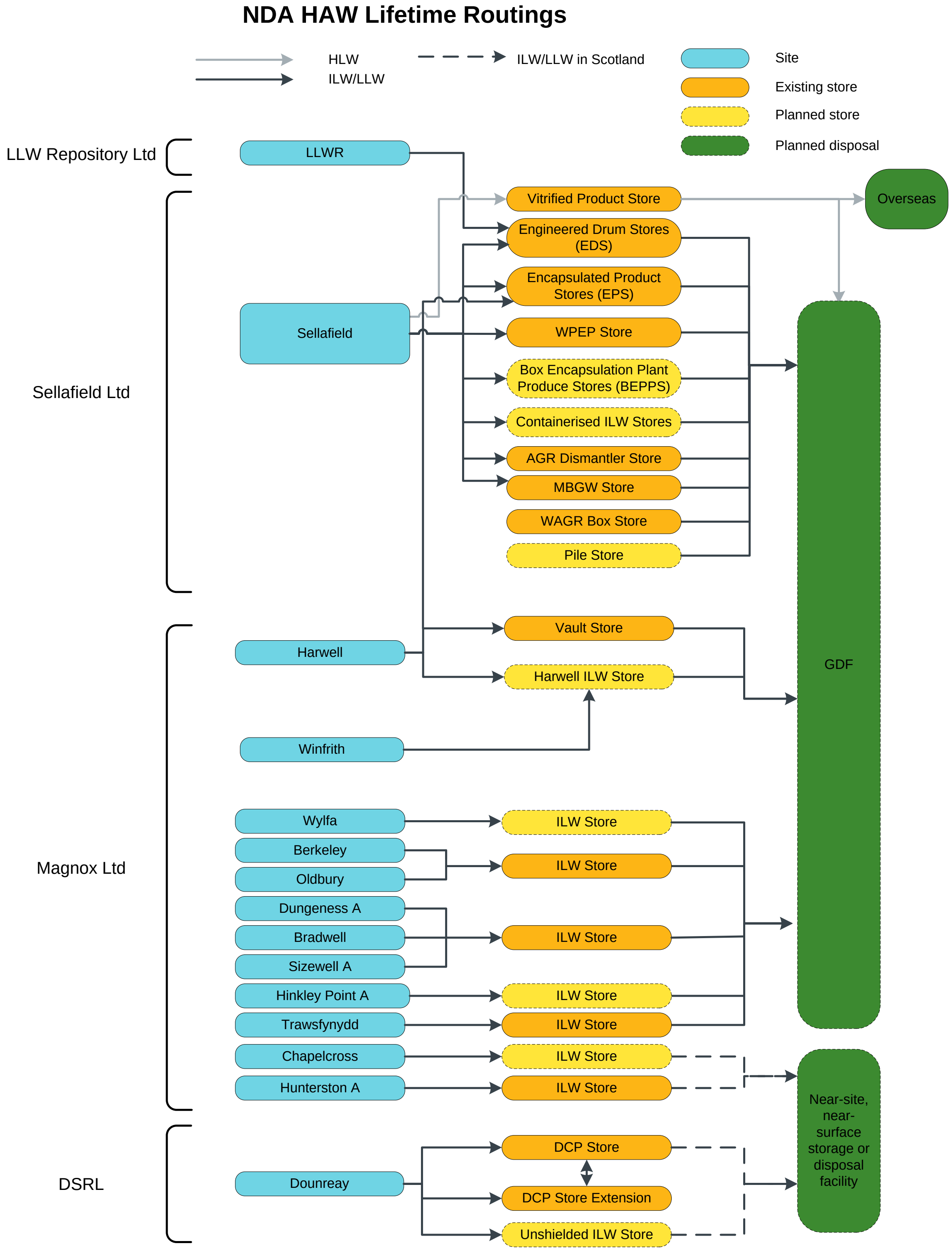
[8] For specific higher hazard legacy wastes, e.g. those in Sellafield legacy ponds & silos, where a timely single step approach to retrieval and waste conditioning may prove to be very difficult, a progressive hazard reduction approach of waste retrieval and containerisation that meets modern standards could be employed, with final conditioning and packaging being deferred until a later date.

# 5.0 NDA Higher Activity Waste Routing Diagrams

The routing diagrams provide an overview of HAW management at NDA sites, reflecting current operations and plans. Changes may occur should HAW policies or management strategies be revised.

## 5.1 High-level routing diagram

The diagram illustrates the HAW routes at NDA sites to existing and planned key interim stores before eventual disposal to a GDF or, for Scottish waste, to a near-site near-surface facility.



Further information about the key interim HAW stores is given in the table below. Existing stores are shown in black typeface, planned stores in grey typeface. Some existing stores may be extended in the future.

| Site | Interim store | Description |
|---|---|---|
| Sellafield | Vitrified Product Store (VPS) | Canisters of vitrified HLW stored in a series of channels and cooled by natural air convection. |
| | Encapsulated Product Stores (EPS) | Encapsulated 500-litre ILW drums from the Magnox Encapsulation Plant (MEP) and the Waste Encapsulation Plant (WEP) – also drums of AGR dismantler waste, WPEP product and Windscale Piles decommissioning waste.<br>Three stores are operating. |
| | Engineered Drum Stores (EDS) | Conditioned waste including 500-litre drums of ILW PCM wastes (including those transferred from the LLWR). |
| | WPEP Store | Conditioned ILW flocs in 500-litre drums from WPEP. |
| | Box Encapsulation Plant Product Stores (BEPPS) | Encapsulated ILW in Sellafield 3m³ boxes and Sellafield enhanced 3 m³ boxes from the Box Encapsulation Plant (BEP) and other packaging plants. |
| | Containerised ILW Stores | Encapsulated decommissioning ILW in Sellafield 3 m³ boxes.<br>These are 'Class 2' stores, which are of a simpler engineered design. |
| | AGR Dismantler Store | AGR spent fuel assembly graphite and stainless steel components in 500-litre drums. |
| | Miscellaneous Beta/Gamma Waste Store (MBGWS) | Miscellaneous ILW beta/gamma contaminated wastes in MBGWS boxes. |
| | WAGR Box Store | Conditioned ILW in WAGR boxes. |
| Magnox Ltd sites | ILW Stores | Shielded ILW stores at Hunterston A and Trawsfynydd for various unshielded packaged wastes in drums and boxes. Lightly shielded ILW stores at Berkeley and Bradwell for self-shielded ductile cast iron containers (DCICs).<br>Storage requirements for other sites continue to be reviewed by Magnox Ltd including waste consolidation. |
| Dounreay | DCP Stores | Cement encapsulated raffinate in 500-litre drums. |
| | DCP Store Extension | An extension to the DCP store with additional drum capacity for encapsulated raffinate. |
| | Unshielded ILW Store | Grouted wastes in 6 $m^3$ boxes, and shielded and unshielded waste drums. |
| Harwell | Vault Store | Packaged wastes in 500-litre drums plus a small number of 3 $m^3$ boxes. |
| | ILW Store | Conditioned decommissioning waste in 6 $m^3$ boxes. |
| Winfrith | Waste in 6 $m^3$ boxes transferred to Harwell ILW store. | |
| LLWR | PCM transferred to Sellafield Engineered Drum Stores (EDS). | |

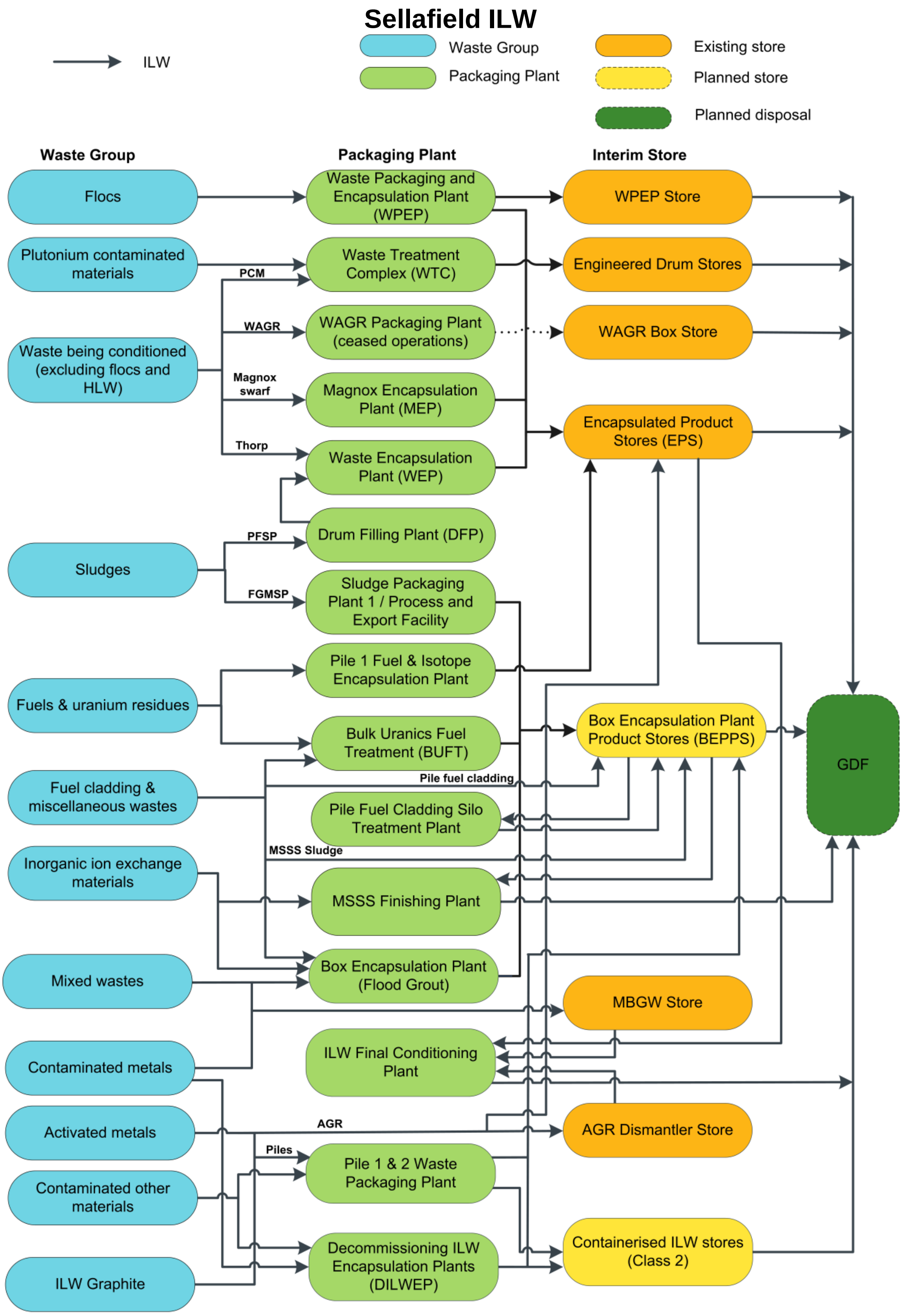
## 5.2 Detailed site routing diagrams

The site diagrams on the following pages illustrate the waste route(s) for each waste group (see Section 6.1 for more information on the sources and nature of the wastes). Existing and planned packaging plants and interim stores are shown. There is a single diagram covering all Magnox Ltd reactor sites as the waste groups are common.

As a risk mitigation measure, some wastes retrieved from legacy facilities will first be containerised in an unconditioned state and routed for short-term storage, before being transferred to a packaging plant.

# An Overview of NDA Higher Activity Waste

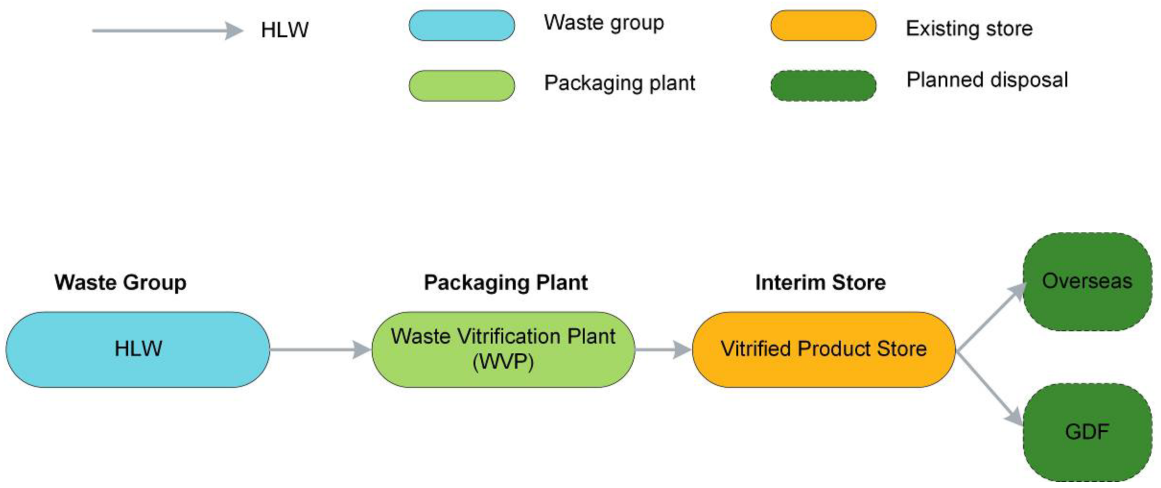
## November 2015



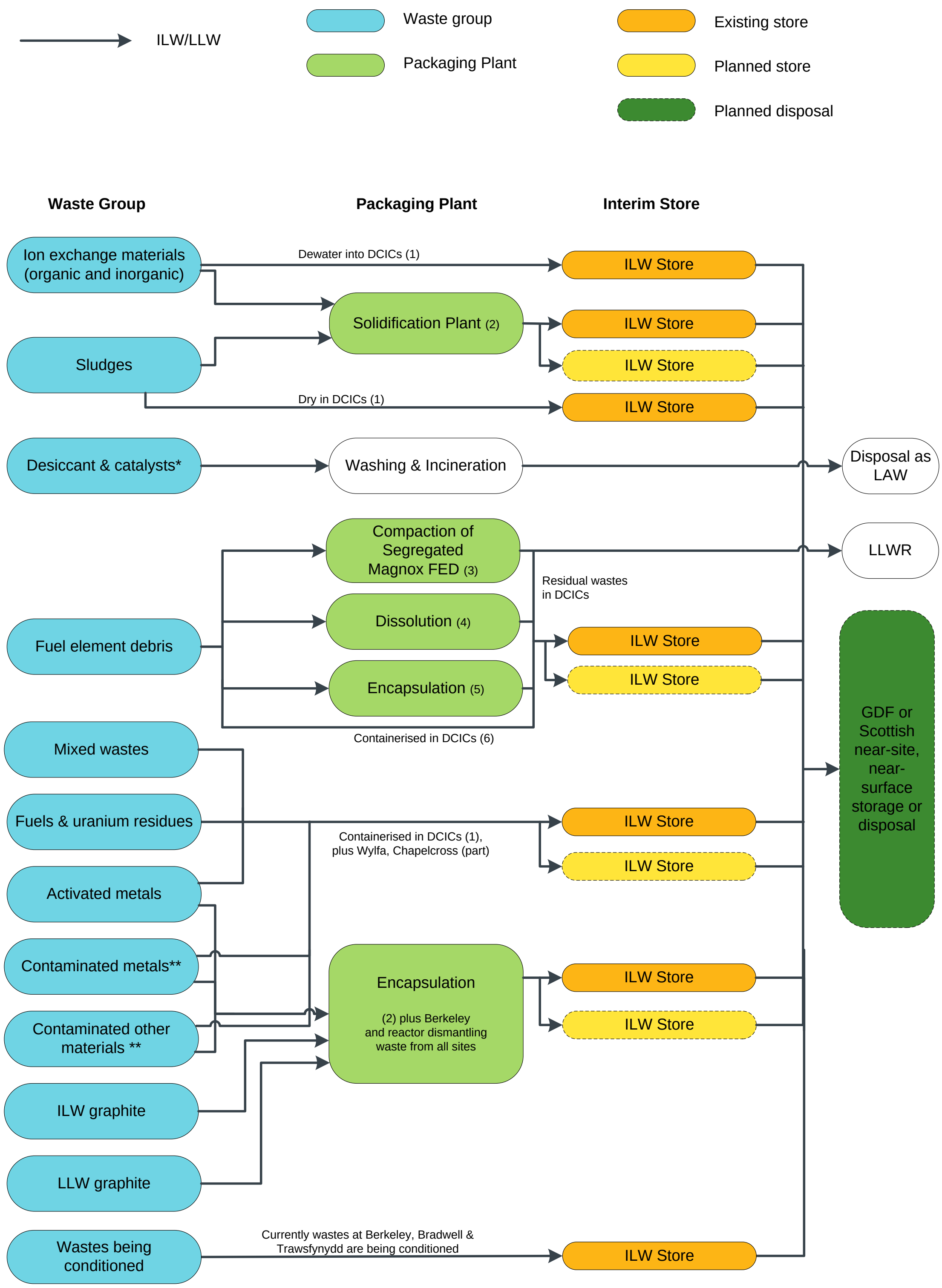

Some wastes will be containerised and final conditioning deferred.

Calder Hall ILW/LLW is not separately identified. It is likely that the small volume of existing waste will be routed to the MBGW store and that future decommissioning waste will be aligned with the processing of Sellafield site waste.

## Sellafield HLW



## Magnox Ltd (Magnox Sites)

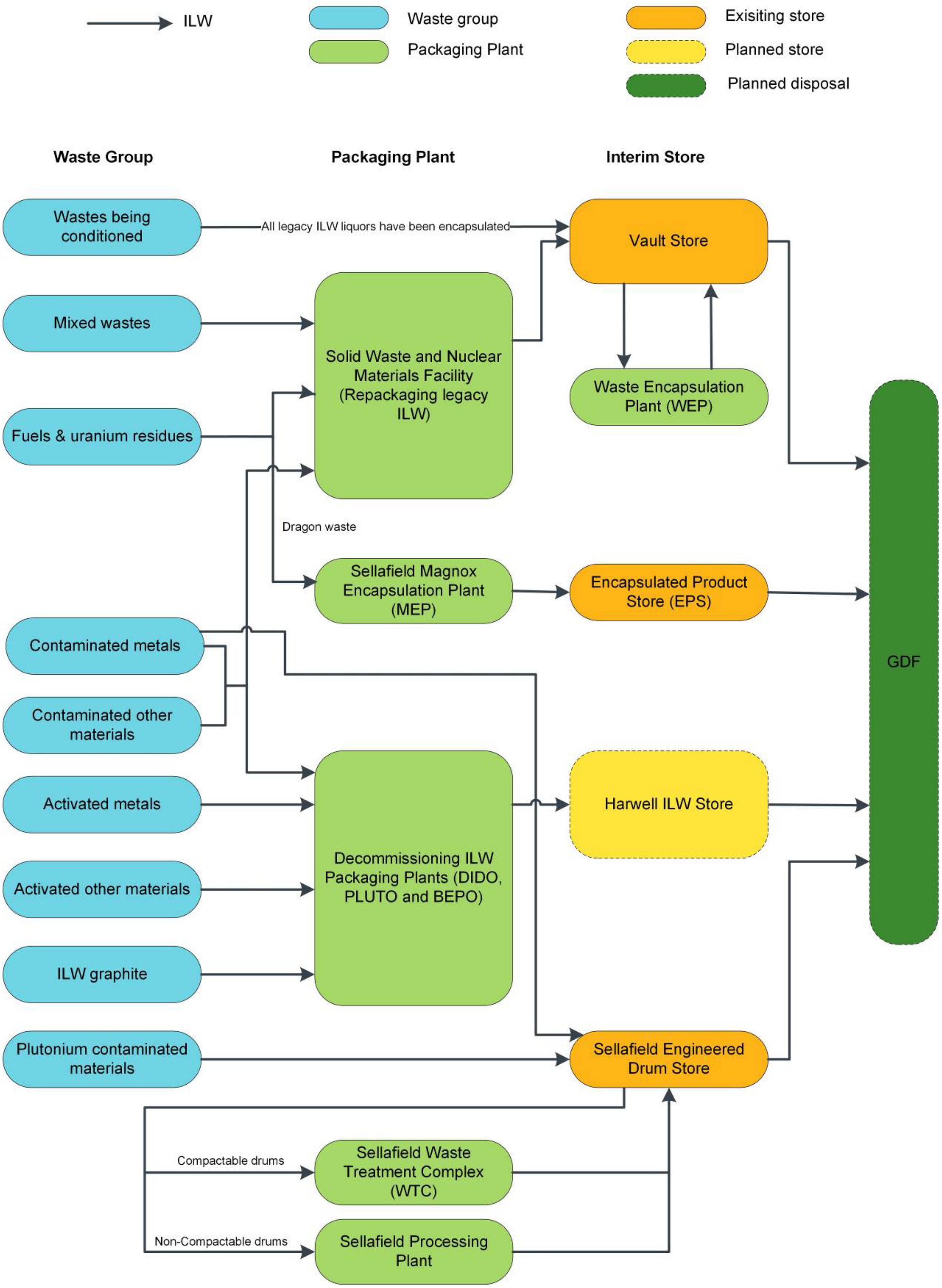



* Subsequent to the publication of the 2013 UK RWI, the waste management strategy for desiccant and catalysts has been revised. These wastes (56.6m$^3$ packaged volume) will now be disposed of as LAW.
** Where practicable, contaminated waste is decontaminated and managed as a lower category.

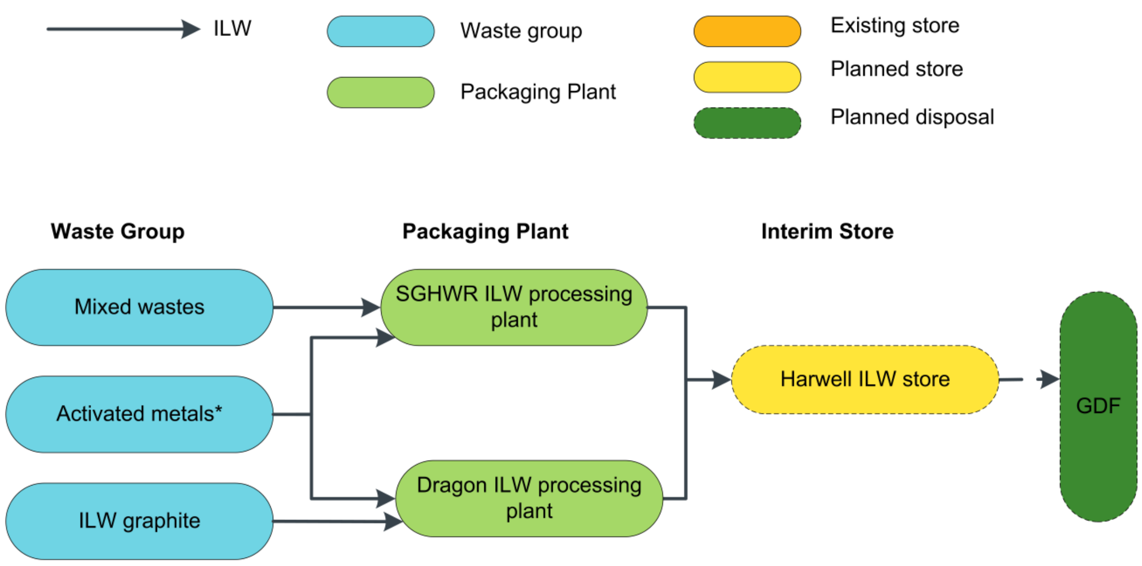
Wastes at Chapelcross and Hunterston A are subject to the Scottish Government policy of near-site, near-surface storage or disposal of packaged HAW. Chapelcross will be adopting staged packaging for highly tritiated wastes.

(1) Berkeley, Bradwell, Oldbury, Sizewell A, Dungeness A
(2) Trawsfynydd, Hunterston, Hinkley Point A, Chapelcross (part)
(3) Oldbury, Sizewell A
(4) Bradwell, Dungeness A
(5) Trawsfynydd, Hunterston A, Berkeley (part), Hinkley Point A
(6) Berkeley (part)

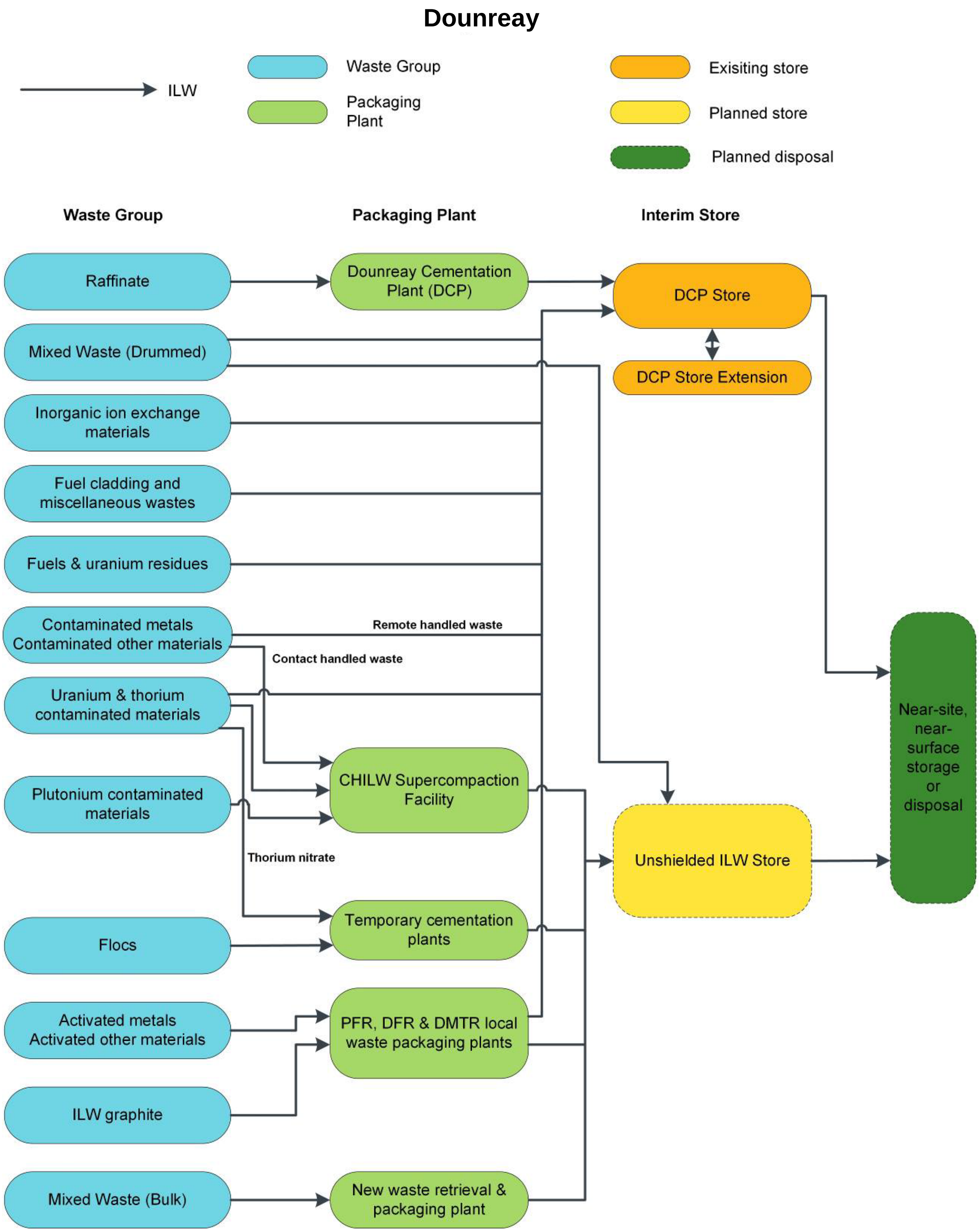
### Magnox Ltd (Harwell Site)



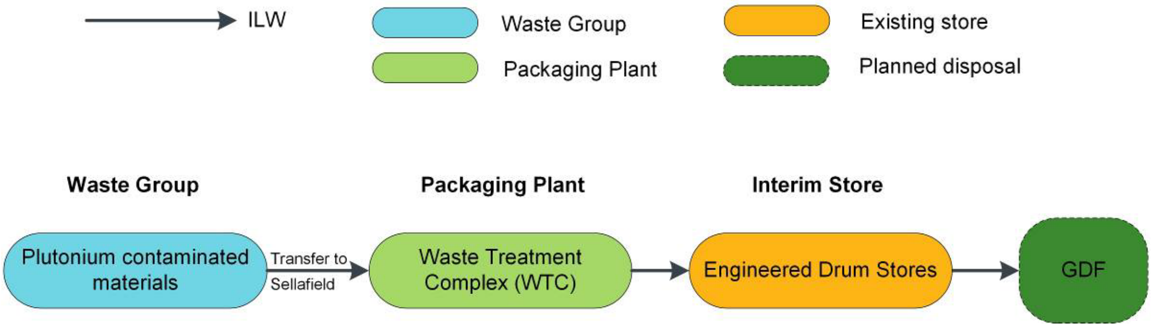
### Magnox Ltd (Winfrith Site)




* Sources will be exported to Harwell


Dounreay
ILW
Waste Group
Packaging Plant
Exisiting store
Planned store
Planned disposal
Waste Group
Packaging Plant
Interim Store
Raffinate
Dounreay Cementation Plant (DCP)
DCP Store
Mixed Waste (Drummed)
DCP Store Extension
Inorganic ion exchange materials
Fuel cladding and miscellaneous wastes
Fuels & uranium residues
Contaminated metals Contaminated other materials
Remote handled waste
Contact handled waste
Uranium & thorium contaminated materials
CHILW Supercompaction Facility
Plutonium contaminated materials
Thorium nitrate
Unshielded ILW Store
Near-site, near-surface storage or disposal
Temporary cementation plants
Flocs
Activated metals Activated other materials
PFR, DFR & DMTR local waste packaging plants
ILW graphite
Mixed Waste (Bulk)
New waste retrieval & packaging plant

**LLWR**


ILW
Waste Group
Packaging Plant
Existing store
Planned disposal
Waste Group
Packaging Plant
Interim Store
Plutonium contaminated materials
Transfer to Sellafield
Waste Treatment Complex (WTC)
Engineered Drum Stores
GDF

# 6.0 NDA Sites Higher Activity Waste Properties and Quantities

## 6.1 HAW Properties (Waste Groups)

The following tables provide information on the sources and characteristics of the waste groups introduced in Section 3.2.

### Sellafield Ltd (Sellafield site)

| | |
|---|---|
| **Activated metals** | Stainless steel debris from the dismantling of AGR fuel assemblies.<br>Items from the Calder Hall reactor structure generated during final dismantling.<br>Metal core structural support components and equipment from Piles decommissioning. |
| **Contaminated metals**<br>**Contaminated other materials** | Mainly wastes from decommissioning reprocessing plants, active handling facilities, AGR examination caves, tanks, silos, ponds, waste stores etc.<br>Also included are some contaminated operational wastes (filters, Magnox fuel magazines) and secondary waste from packaging plants. |
| **Flocs** | Ferric hydroxide and aluminium-ferric hydroxide flocs from the treatment of reprocessing plant effluents in EARP to recover plutonium and other transuranic elements. This includes legacy waste accumulated before EARP operation. (*Note: flocs are being conditioned in WPEP but are not included in the conditioned waste group because of how volumes are reported in the 2013 UK RWI*, *i.e. a separate unconditioned 'parent' stream with negative future arisings indicating the reduction in volume with conditioning*). |
| **Fuel cladding & miscellaneous wastes** | Legacy wastes stored in the Magnox swarf storage silos (MSSS) and the Pile Fuel Cladding Silo (PFCS). MSSS contains Magnox swarf from decanning irradiated fuel and magnesium hydroxide sludge from corrosion of the swarf in the wet conditions of the silos. PFCS contains aluminium and magnesium fuel cladding from early reprocessing programmes. MSSS and PFCS also contain miscellaneous beta/gamma wastes including those from other sites. |
| **Fuels & uranium residues** | Legacy wastes comprising Magnox fuel end crops, various irradiated and unirradiated uranium metal and oxide fuel samples, and depleted uranium. |
| **Graphite – ILW & LLW** | Activated graphite debris arising from the dismantling of AGR fuel assemblies before they are reprocessed.<br>Activated graphite cores from the Calder Hall and Piles reactors generated during final dismantling. |
| **HLW** | Nitric acid solutions stored in tanks that contain the waste fission products from reprocessing spent Magnox and oxide nuclear fuels. It also includes the vitrified waste product from conditioning the liquid wastes in WVP, and redundant high level contaminated plant items from WVP. |
| **Inorganic ion exchange materials** | Principally aluminosilicate materials, with some silicotitanate material, used for removing soluble radioactivity from irradiated fuel storage pond water. |
| **Mixed wastes** | Miscellaneous activated and contaminated materials, principally miscellaneous beta/gamma wastes from general Sellafield site operations. Wastes include redundant equipment from spent fuel handling operations including PIE, storage pond furniture, HEPA filters etc. and wastes from other sites transferred to Sellafield for storage. |
| **Plutonium contaminated materials** | A wide range of items including filters, small plant items, redundant glove boxes and soft wastes produced during the operation, maintenance, refurbishment and decommissioning of plutonium process facilities associated with final stages of spent fuel reprocessing. It includes wastes transferred from legacy stores at the LLWR. |
| **Sludges** | Most sludge is legacy waste from the corrosion of irradiated Magnox fuel cladding during pond storage and from effluent streams associated with fuel handling. There are smaller quantities of sludge from irradiated oxide fuel storage ponds. |
| **Wastes being conditioned*** | There are a number of wastes from current reprocessing operations being conditioned, including Magnox fuel cladding, PCM, and oxide fuel cladding and other waste streams from the Thorp reprocessing plant.<br>Graphite fuel sleeves removed from irradiated WAGR fuel assemblies and wastes from WAGR decommissioning have been conditioned. |

* Excludes HLW, which although it is being conditioned is reported separately for transparency.

## Magnox Ltd (Magnox sites)

| | |
|---|---|
| **Activated metals** | Miscellaneous activated components (MAC), comprising redundant or unserviceable items from the reactor generated during normal operation and including control rods and chains and flux measuring instrument heads. Items are normally accumulated within purpose built vaults and storage tubes in the reactor biological shields. The waste also includes metal items from final dismantling of the reactor structure. |
| **Contaminated metals** | Miscellaneous contaminated items (MCI) of equipment generated during normal plant operation and maintenance, principally from the fuel cooling ponds and fuel route. The wastes include spent filters. Unconditioned wastes are stored in either vaults or in cooling ponds. |
| **Contaminated other materials** | Gravel from the base of fuel element debris storage vaults; filter sand and small quantities of contaminated concrete. |
| **Desiccants & catalysts** | Exhausted materials from the reactor gas drier system. Desiccants are a molecular sieve (sodium aluminium silicate) used to remove moisture from the $CO_2$ coolant. Catalysts are platinum on an alumina substrate used to recombine degraded $CO_2$. |
| **Fuels & uranium residues** | Small quantity of corroded uranium debris at Wylfa. |
| **Fuel element debris** | Irradiated fuel element fins, lugs or splitter blades removed from irradiated fuel elements before fuel shipment to Sellafield. The waste is stored in vaults and comprises mostly Magnox metal and swarf (some of which has degraded or corroded to dust or sludge). Also present are very small quantities of highly radioactive Nimonic springs. At Berkeley and Hunterston the waste also includes graphite sleeves or struts and associated zirconium and steel fuel element components. |
| **Graphite - ILW**<br>**Graphite - LLW** | Core graphite from final dismantling of Magnox reactors. |
| **Inorganic ion exchange materials**<br>**Organic ion exchange materials** | Ion exchange materials are used for the removal of soluble radionuclides (e.g. caesium) from irradiated fuel cooling pond water. Spent materials are generally stored in tanks. |
| **Mixed wastes** | Miscellaneous waste and a small quantity of concrete and paint fines. |
| **Sludges** | Wastes from the routine filtration of liquid effluents and irradiated fuel cooling pond water, and from clean-up operations. |
| **Wastes being conditioned** | Comprises a number of waste streams at Trawsfynydd (including FED, MAC, sludge and ion exchange materials) encapsulated in cement or polymer, ion exchange materials and MCI at Bradwell conditioned in DCICs. At Berkeley, sludges and FED are being conditioned in DCICs. |

## Magnox Ltd (Harwell site)

| | |
|---|---|
| **Activated metals**<br>**Activated other materials** | Miscellaneous core hardware from decommissioning research and prototype reactors. |
| **Contaminated metals**<br>**Contaminated other materials** | Mainly CHILW, from the decommissioning of facilities - radiochemical laboratory, solid waste complex and active handling facility. |
| **Fuels & uranium residues** | Legacy wastes including lightly irradiated GLEEP fuel, and irradiated fuels from the Dragon and Zenith reactors that have been transferred from Winfrith. |
| **Graphite - ILW** | Core graphite from decommissioning research reactors BEPO, DIDO and PLUTO. |
| **Mixed wastes** | Miscellaneous activated and contaminated materials comprising some of the legacy drums from the abandoned 1982 sea disposal campaign, and legacy operational solid RHILW from research reactors and active cells (used for a variety of tasks including fuel examination and source production). |
| **Plutonium contaminated materials** | Comprises legacy PCM transferred from Winfrith and legacy CHILW from historic operations in gloveboxes and other alpha handling facilities. |
| **Wastes being conditioned** | Legacy ILW liquors and sludges (all wastes have been conditioned). |

## Magnox Ltd (Winfrith site)

| | |
|---|---|
| **Activated metals** | Redundant metallic components from SGHWR, miscellaneous sources and core hardware from decommissioning research and prototype reactors. |
| **Graphite - ILW** | Core graphite from decommissioning the Dragon reactor. |
| **Mixed wastes** | Miscellaneous activated and contaminated materials comprising some of the legacy drums from the abandoned 1982 sea dump campaign. |

## Dounreay Site Restoration Ltd (Dounreay site)

| | |
|---|---|
| **Activated metals**<br>**Activated other materials** | Solid wastes from decommissioning the DFR, PFR and DMTR, including DFR breeder fuel cladding and PFR mixer breeder sections. |
| **Contaminated metals**<br>**Contaminated other materials** | Comprises legacy RHILW and CHILW from historic reprocessing support activities, analytical and waste facilities and development work, and decommissioning wastes from site reprocessing plants, laboratories, waste stores and other facilities. |
| **Flocs** | Ammonium diuranate (ADU) floc is a legacy waste from operations in the flocculation plant of the ILW liquor storage facility. The floc was formed by a chemical precipitation process to remove the majority of uranium and plutonium radioactivity from liquors. |
| **Fuel cladding & miscellaneous wastes** | DFR breeder fuel cladding metals. |
| **Fuels & uranium residues** | Legacy wastes comprising irradiated thorium fuel pin pieces and the irradiated fuel component of PFR mixer breeder sub-assembly sections. |
| **Graphite - ILW** | Waste graphite from decommissioning DFR and DMTR. There is also THTR fuel sphere graphite from historical reprocessing work. |
| **Inorganic ion exchange materials** | Ion exchange columns are used for the clean-up of legacy liquid wastes from reactor coolant and fuel cooling ponds mainly from DFR and PFR operations. |
| **Mixed wastes** | Bulk waste: legacy miscellaneous activated and contaminated RHILW including waste from historic disposal facilities that will be retrieved. Wastes were produced during reprocessing and PIE examination of irradiated fuels from DFR, PFR and DMTR. Those wastes low in alpha radioactivity were originally consigned to historic disposal facilities.<br>Drummed waste: from 1980 when PFR fuel reprocessing started, higher activity alpha/beta/gamma activity wastes were stored in 200 litre drums. Sludge was disposed of to the Dounreay shaft and silo. |
| **Plutonium contaminated materials** | Contaminated waste from fuel reprocessing support operations and decommissioning of plutonium handling facilities. |
| **Raffinate (ILW)** | Legacy liquid wastes from historic operations stored in steel tanks in the ILW liquor storage facility. There are three streams:<br>* MTR raffinate from reprocessing irradiated MTR fuel is an aluminium nitrate solution containing fission products and some actinides. (*Note: this includes MTR raffinate that has already been conditioned in the DCP. It has not been identified in a separate conditioned waste group because of how volumes are reported in the 2013 UK RWI, i.e. a separate unconditioned 'parent' stream with negative future arisings indicating the reduction in volume with conditioning*). All MTR Raffinate is now conditioned<br>* PFR raffinate from reprocessing irradiated PFR fuel is a nitric acid solution containing fission products and traces of uranium and plutonium.<br>* DFR raffinate from reprocessing irradiated DFR fuel is a ferric/aluminium nitrate solution containing fission products and actinides. |
| **Thorium & uranium contaminated materials** | Comprises a number of streams:<br>* Legacy contact handled uranium contaminated waste from fume cupboard and glovebox operations including ex-fuel type materials.<br>* Legacy thorium nitrate liquors from uranium recovery from THTR fuel spheres.<br>* Legacy radium and thorium contaminated LSA scale from oil tubular descaling operations<br>* Waste from decommissioning the uranium recovery plant. |

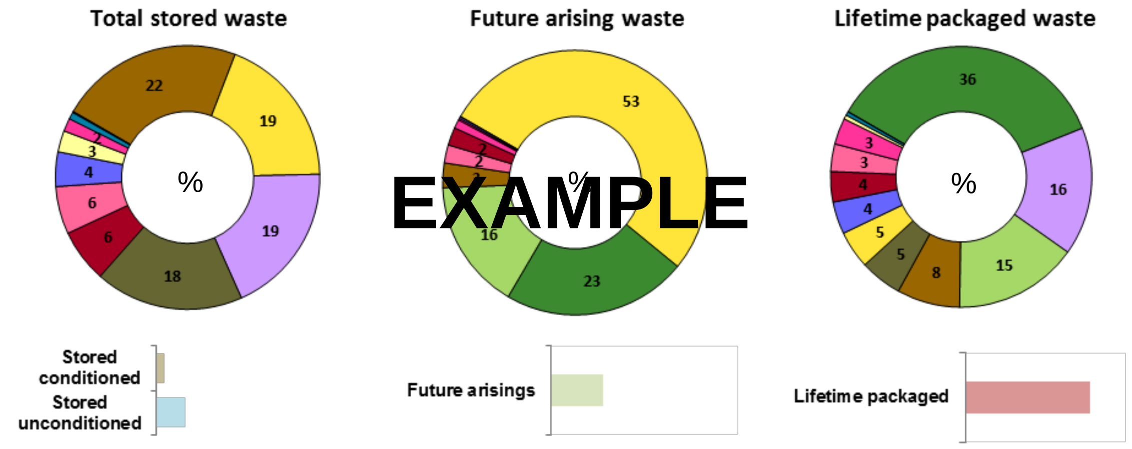
### LLWR Ltd (LLWR site)

| | |
|---|---|
| **Plutonium contaminated materials** | Legacy material stored at the site originating from operations at Sellafield and other nuclear sites including Aldermaston and Harwell. The waste comprises solid materials such as gloves, filters, paper and small plant items. Also there are solid wastes from decommissioning the PCM infrastructure. |

## 6.2 HAW Quantities

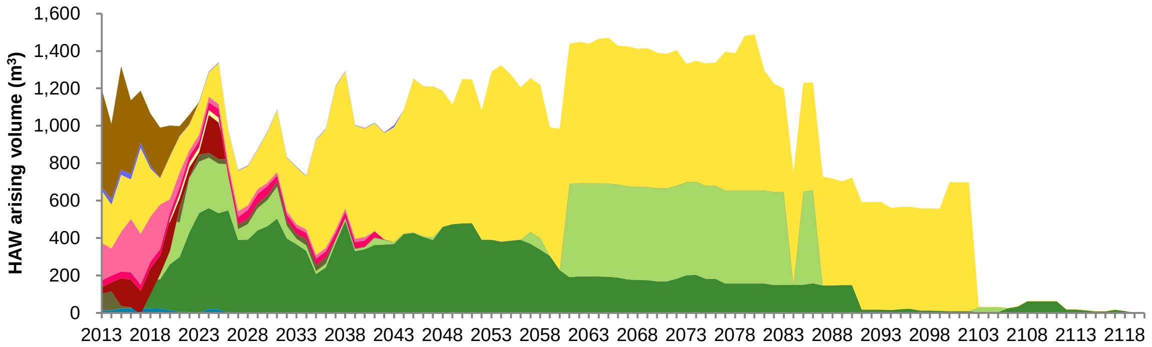
On the following pages a standard template is used to present information on the quantities of HAW for each SLC and each site. The standard template is explained overleaf.

## Example template and explanation

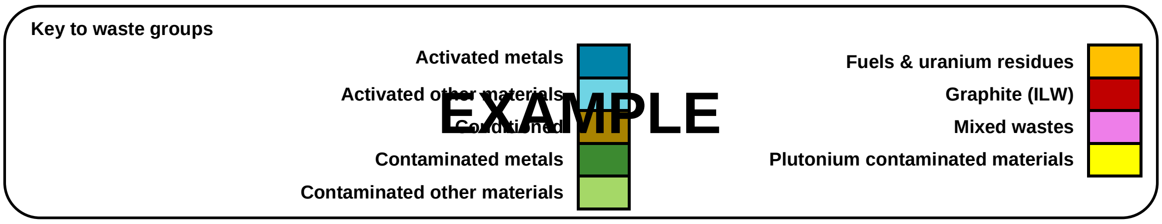



The three doughnut charts above show the make-up of HAW volumes for: wastes stored at 1st April 2013 (in unconditioned and conditioned forms); projected future waste arisings (in the unconditioned form except for any component that is currently being conditioned and will continue to be conditioned in the future); the lifetime total once all HAW has been packaged. The horizontal bars below the donuts give the corresponding HAW volumes (note: all quantities exclude ILW expected to be packaged for disposal as LAW as shown in the table on page 10).

The line chart below shows the volume arising profile of the various waste groups from 2013.

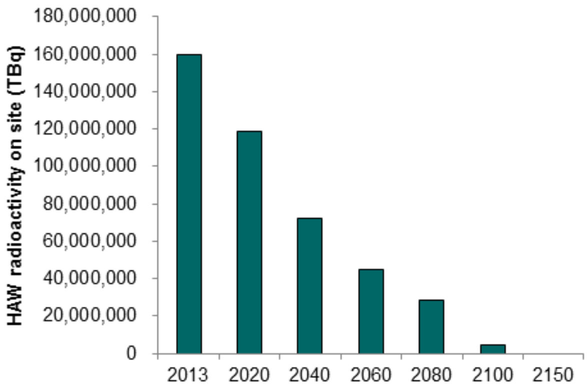



The key below shows the waste groups and the colours used in the doughnut and arising profile line charts.

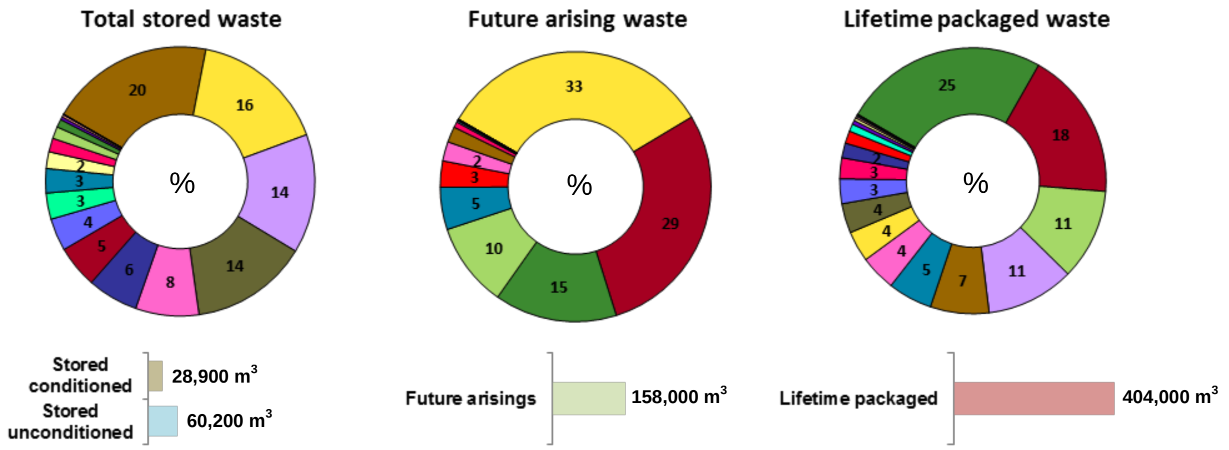



The bar chart on the right gives the calculated radioactivity of HAW remaining in site stores at 2013, 2020, 2040, 2060, 2080, 2100 and 2150. HAW that has been dispatched to the GDF is excluded. The radioactivities are snapshots in time reflecting radioactive decay and projected dispatch to the GDF. For Scottish sites, HAW is assumed to remain on the site of arising (this may change as Scottish government strategy for HAW is developed).

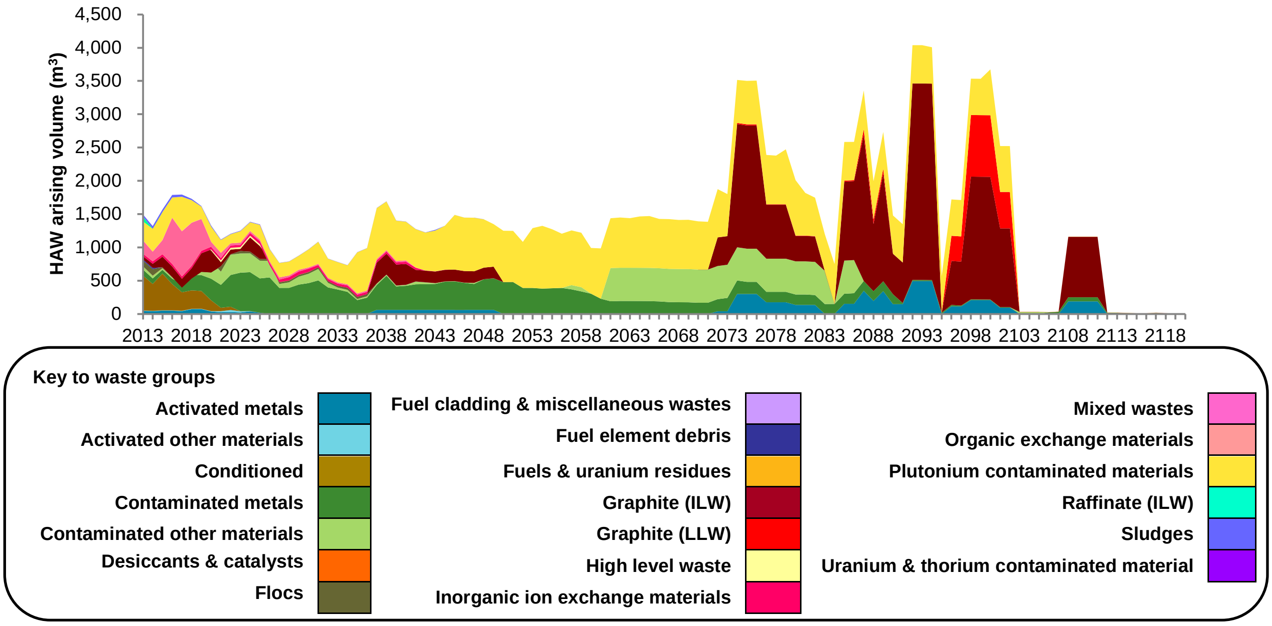
**The data shown on the charts is from the 2013 UK RWI, and will be subject to change.**



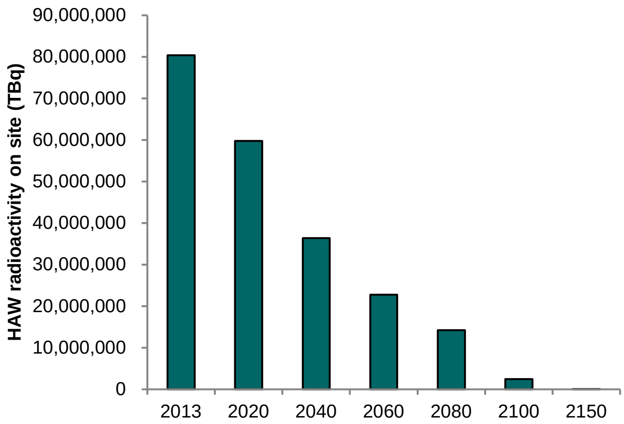
## NDA



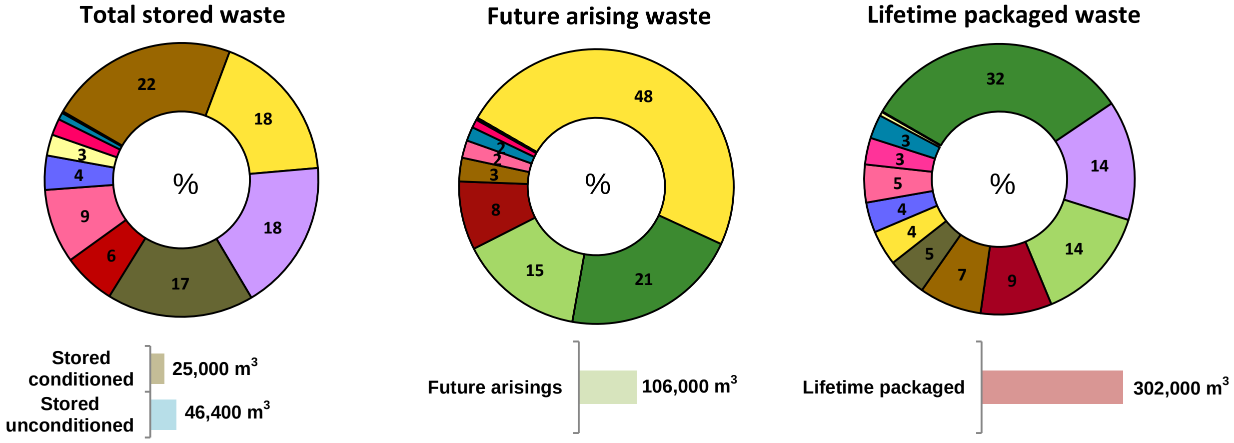

There are currently 89,100 $m^3$ of HAW stored on NDA sites. The major components are conditioned waste, PCM, fuel cladding & miscellaneous wastes, and flocs. An additional 158,000 $m^3$ of future arisings are forecast with final waste in 2118. Most of this is PCM from Sellafield and graphite from the decommissioning of Magnox reactors. HAW from the sites will occupy 404,000 $m^3$ when it has all been packaged.



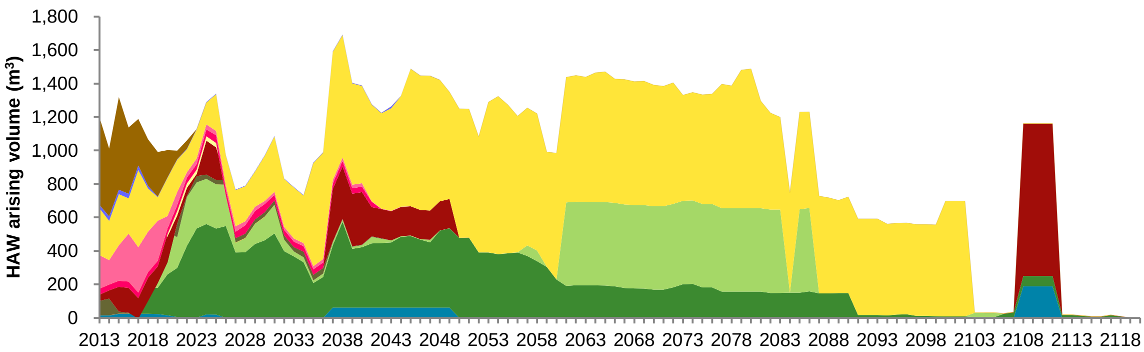

The radioactivity of the stored HAW is currently about 80,400,000 TBq, with 97% from the HLW. Radioactivity on sites decreases over time as activity decays and as waste is removed from sites. By 2150 the radioactivity on sites has decreased to 21,500 TBq comprising waste only at the Scottish sites.

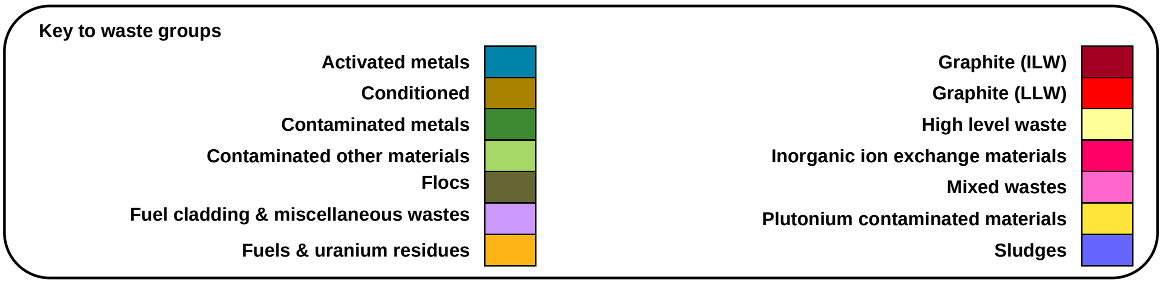


## Sellafield Ltd



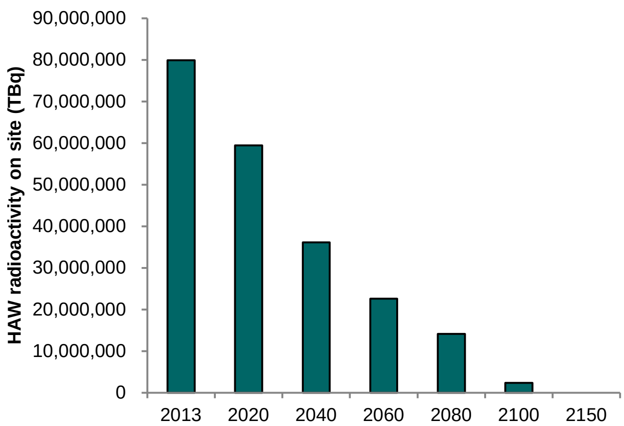

There are currently 71,400 $m^3$ of HAW stored at the Sellafield site. The major components are conditioned waste, PCM, fuel cladding & miscellaneous wastes, and flocs. An additional 106,000 $m^3$ of future arisings is forecast. Most of this is PCM, contaminated metals and other materials with final waste in 2118. HAW will occupy 302,000 $m^3$ when it has all been packaged



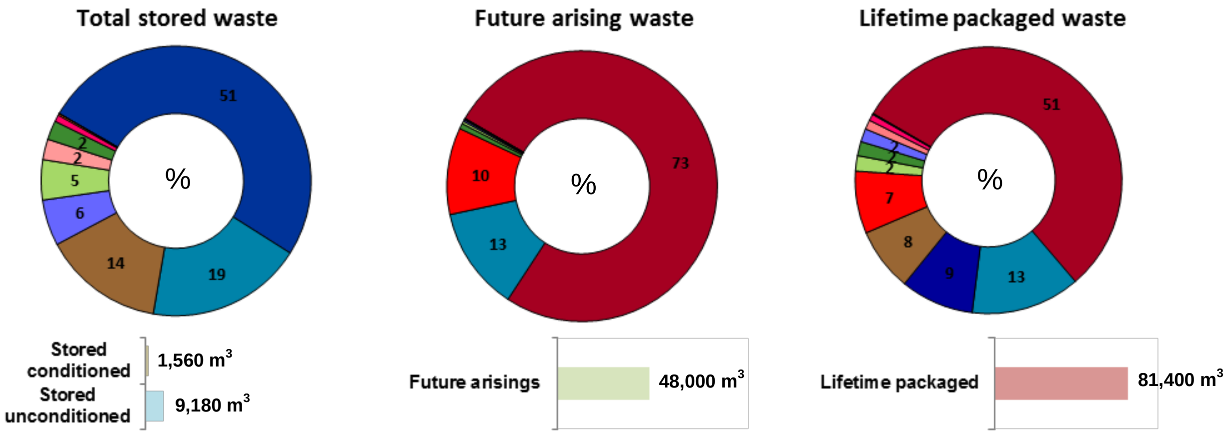




The radioactivity of the stored HAW is currently about 79,900,000 TBq, with 97% from the HLW and 3% from the ILW. Radioactivity on site decreases over time as activity decays and as waste leaves the site.

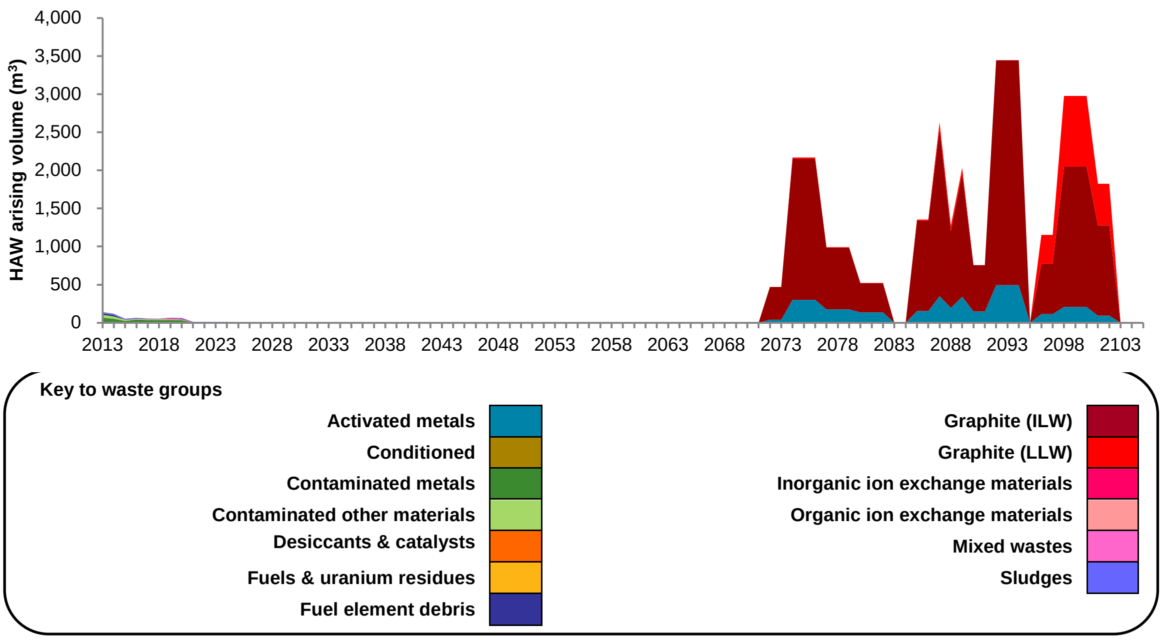
It is assumed that HLW is dispatched from the site in the period 2089-2104. ILW is dispatched from 2040, and most has left the site by 2100. The activity remaining at 2100 is 2,400,000 TBq. All waste has left the site by 2150.



## Magnox Ltd (Magnox sites)

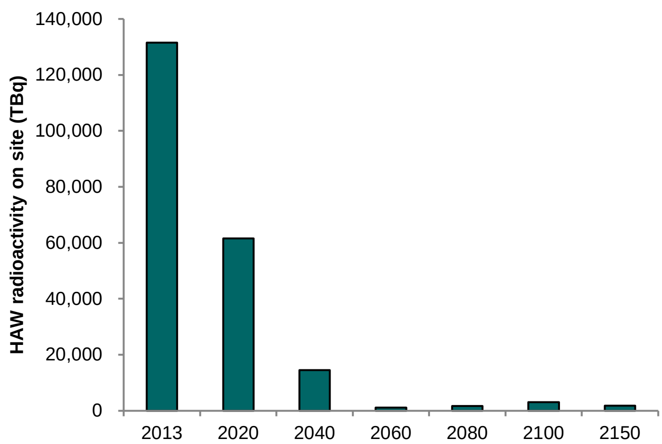



There are currently 10,700 m$^3$ of HAW stored on Magnox Ltd sites. The major components are fuel element debris, activated metals and conditioned waste. An additional 48,000 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2072-2102. HAW will occupy 81,400 m$^3$ when it has all been packaged.

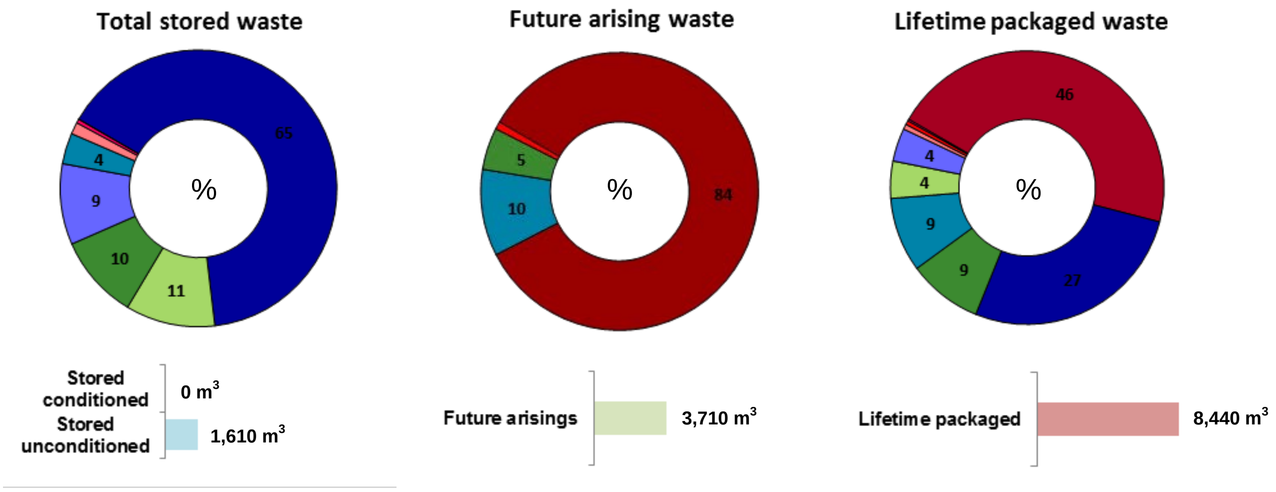



The radioactivity of the stored HAW is currently about 132,000 TBq; with about 70% from short-lived radionuclides in activated metals at Wylfa (the site has the last remaining operating Magnox reactor). Radioactivity on site decreases over time as activity decays and as waste is removed from site.

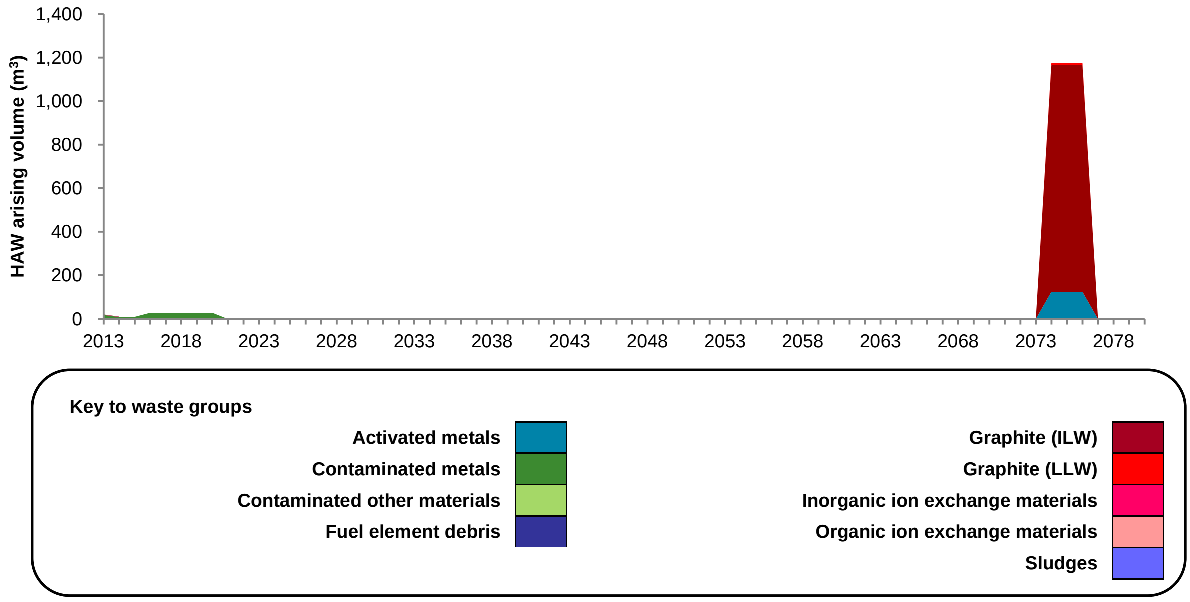
All waste has been removed from sites in England and Wales by 2150, and only waste at sites in Scotland remains with a total activity of 1,840 TBq at 2150.



## Berkeley (Magnox Ltd)

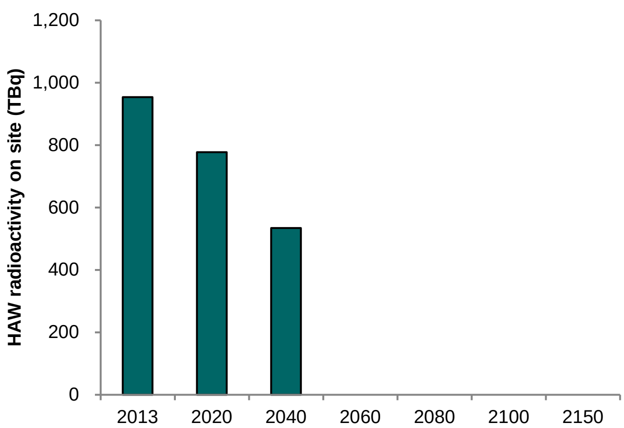



There are currently 1,610 m$^3$ of HAW stored on site. The major components are fuel element debris, contaminated other materials and metals. An additional 3,710 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2074-2076. HAW will occupy 8,440 m$^3$ when it has all been packaged.

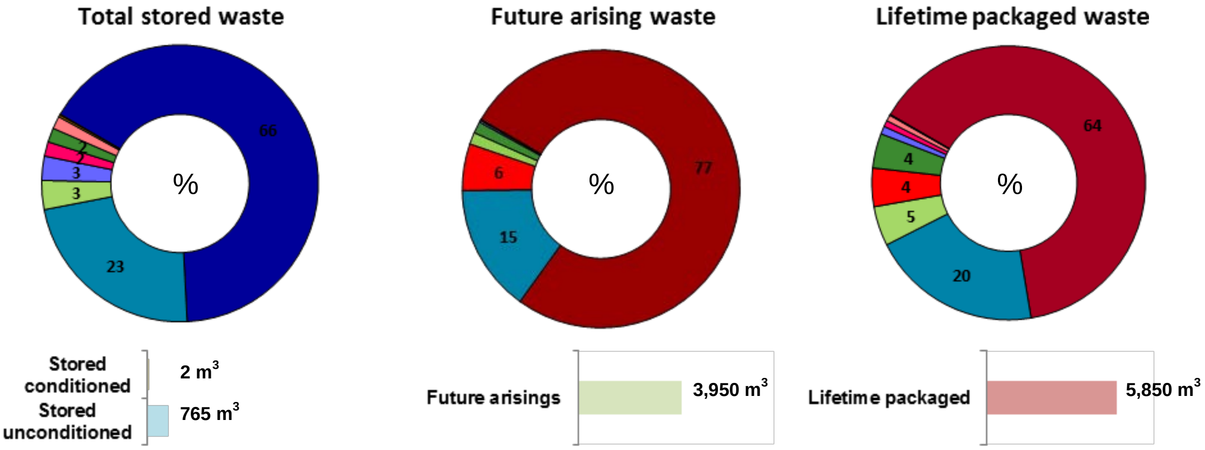



The radioactivity of the stored HAW is currently about 954 TBq. Radioactivity on the site decreases over time as activity decays and as waste is dispatched from the site.

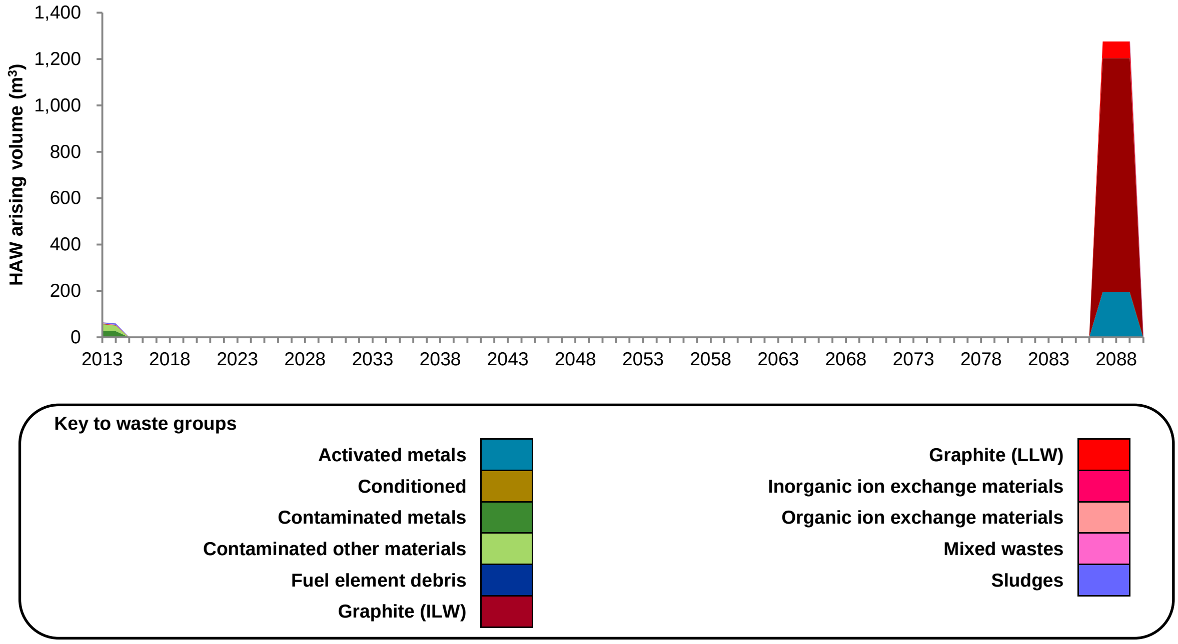
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060, and that all HAW has left the site by 2080.



## Bradwell (Magnox Ltd)

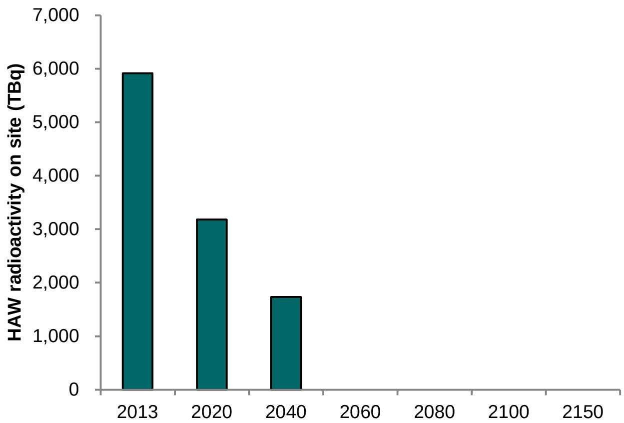



There are currently 767 $m^3$ of HAW stored on site. The major components are fuel element debris and activated metals. An additional 3,950 $m^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2087-2089. HAW will occupy 5,850 $m^3$ when it has all been packaged.

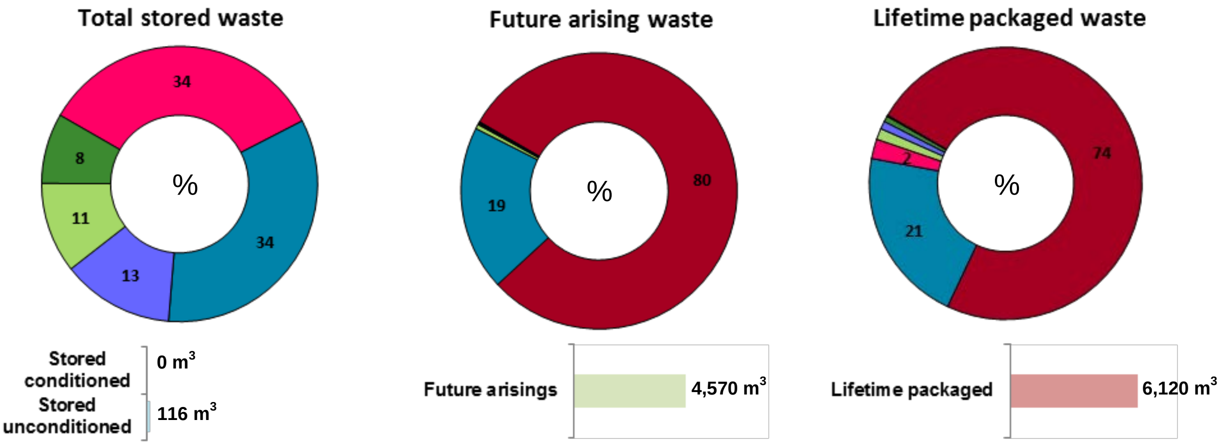



The radioactivity of the stored HAW is currently about 5,910 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

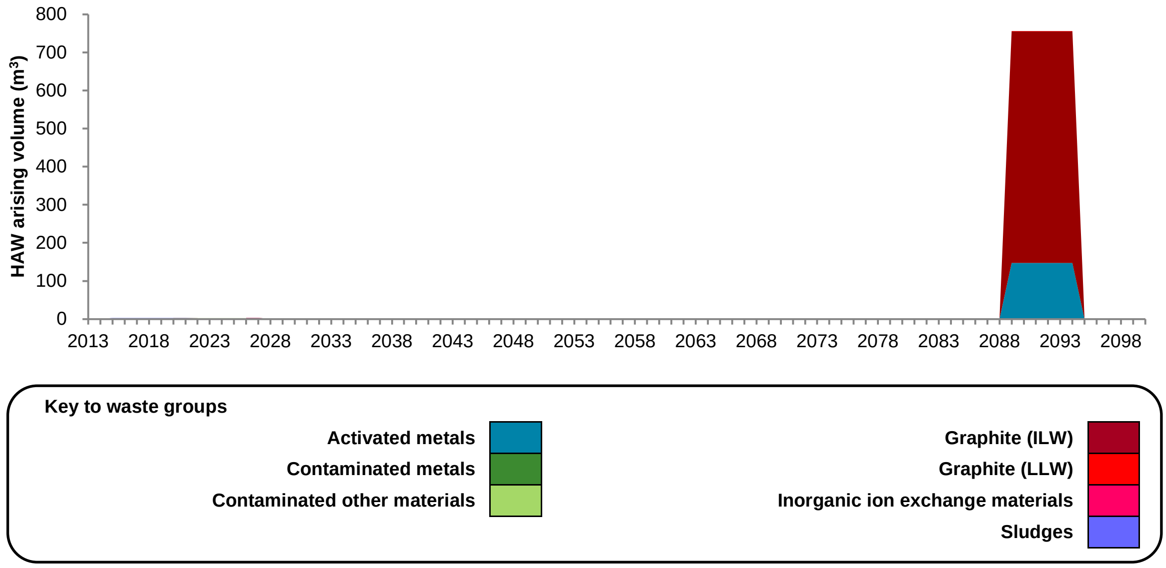
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060, and that all HAW has left the site by 2100.



## Chapelcross (Magnox Ltd)

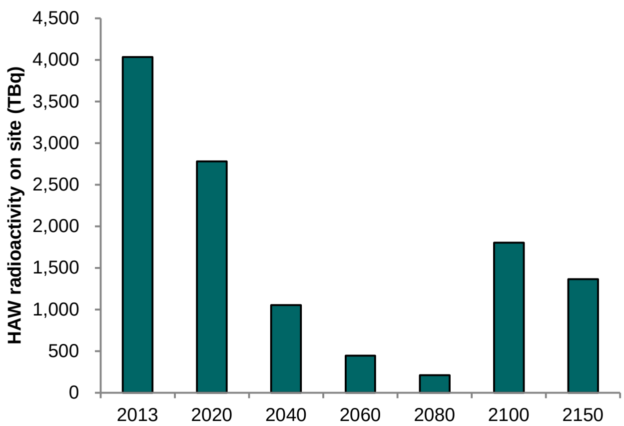



There are currently 116 $m^3$ of HAW stored on site. The major components are inorganic ion exchange materials and activated metals. An additional 4,570 $m^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2089-2094. HAW will occupy 6,120 $m^3$ when it has all been packaged.

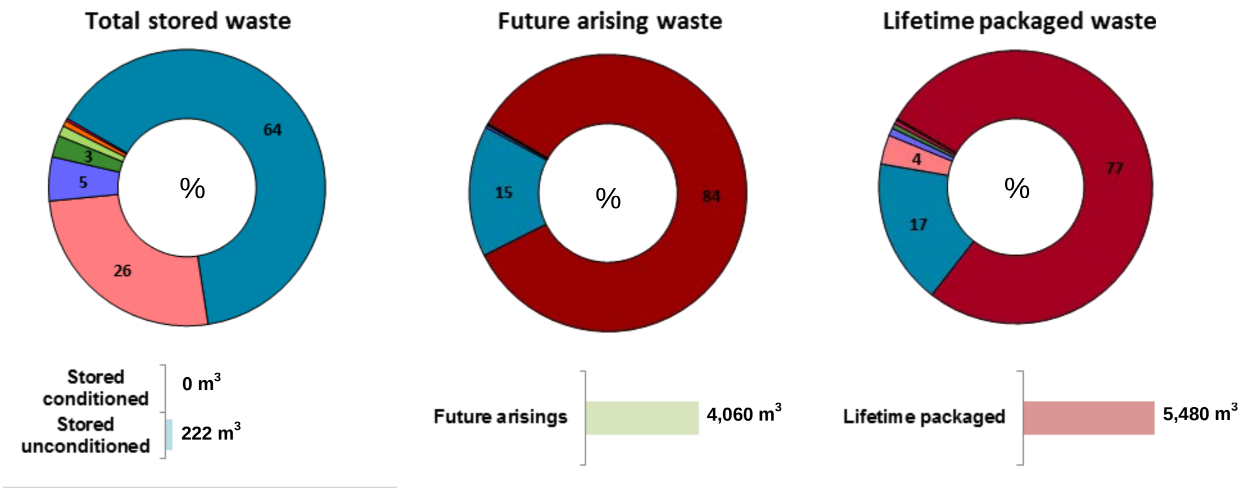



The radioactivity of the stored HAW is currently about 4,030 TBq. Radioactivity on site decreases over time as activity decays. At 2100 there is an increase in activity on site from final dismantling of the reactor structure.

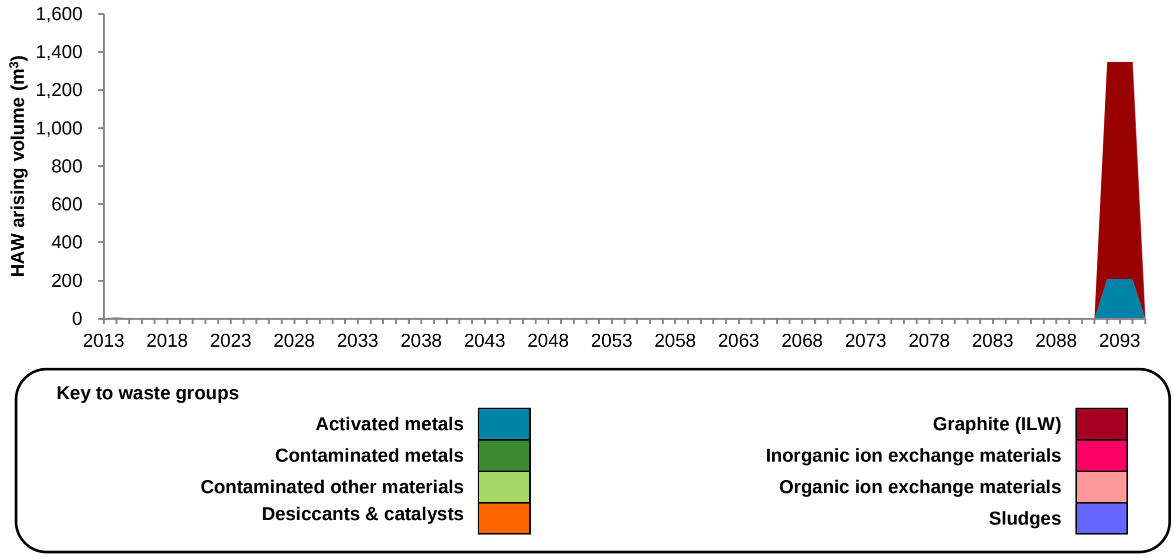
It is assumed that all HAW remains on site to be managed under Scotland's higher activity radioactive waste policy.



## Dungeness A (Magnox Ltd)

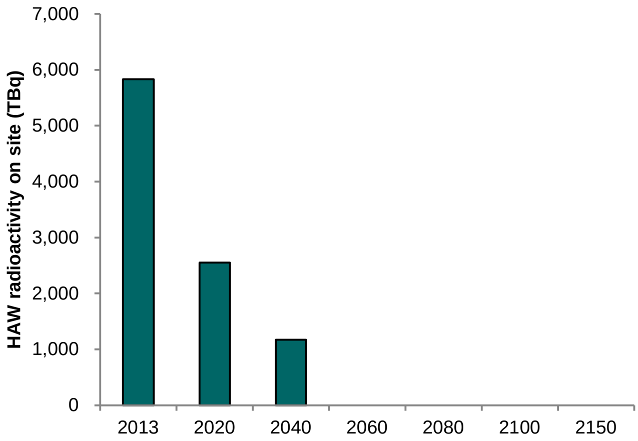



There are currently 222 m$^3$ of HAW stored on site. The major components are activated metals and organic ion exchange materials. An additional 4,060 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2092-2094. HAW will occupy 5,480 m$^3$ when it has all been packaged.

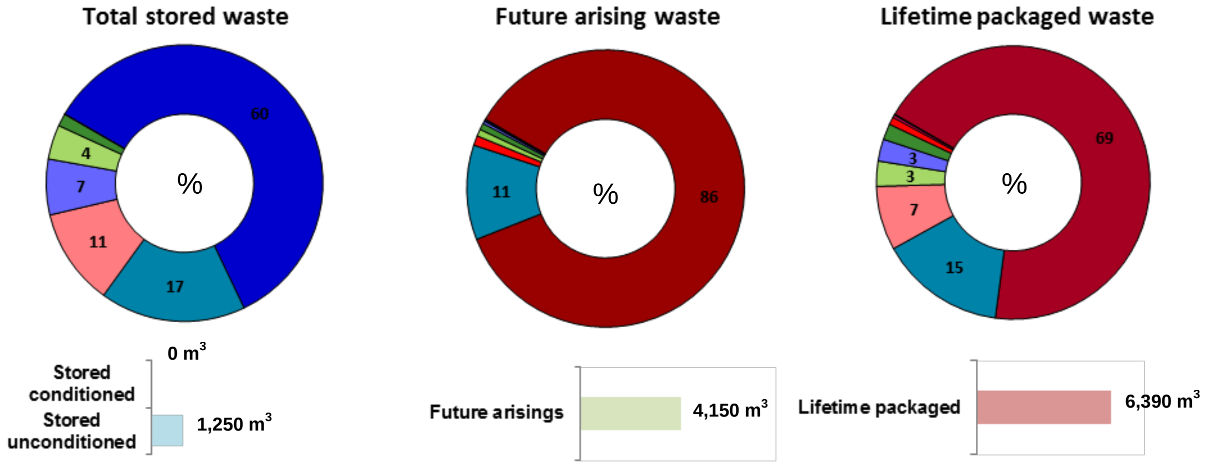



The radioactivity of the stored HAW is currently about 5,840 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

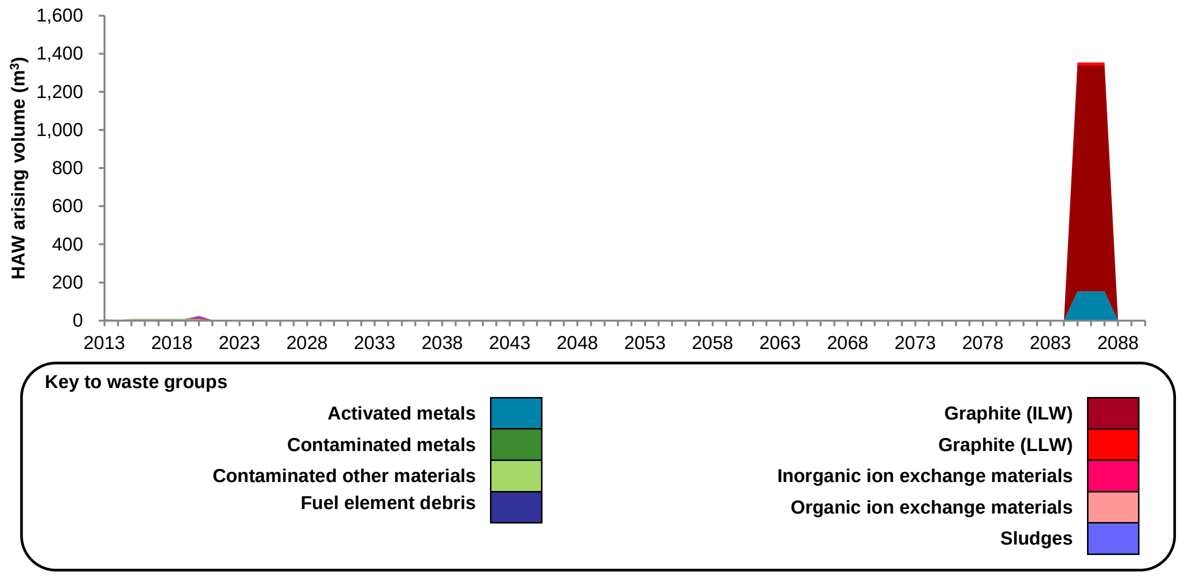
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060, and that all HAW has left the site by 2100.



## Hinkley Point A (Magnox Ltd)

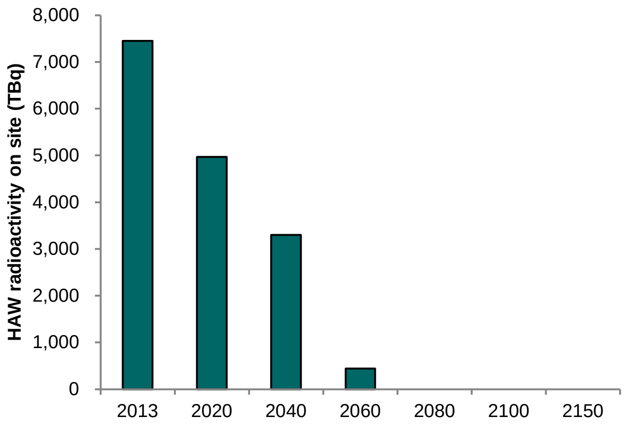



There are currently 1,250m$^3$ of HAW stored on site. The major components are fuel element debris, activated metals and organic ion exchange materials. An additional 4,150m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2085-2087. HAW will occupy 6,390m$^3$ when it has all been packaged.

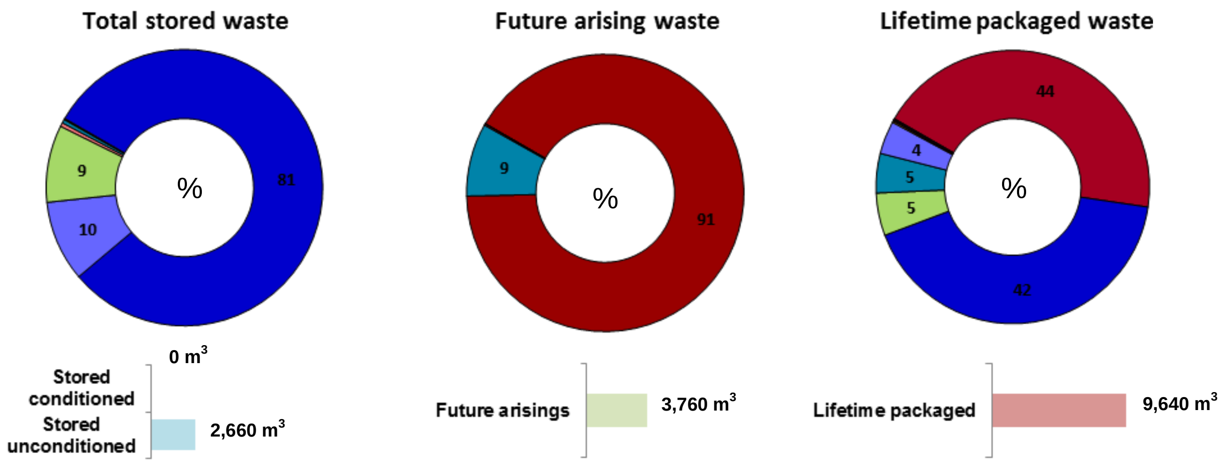



The radioactivity of the stored HAW is currently about 7,450TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

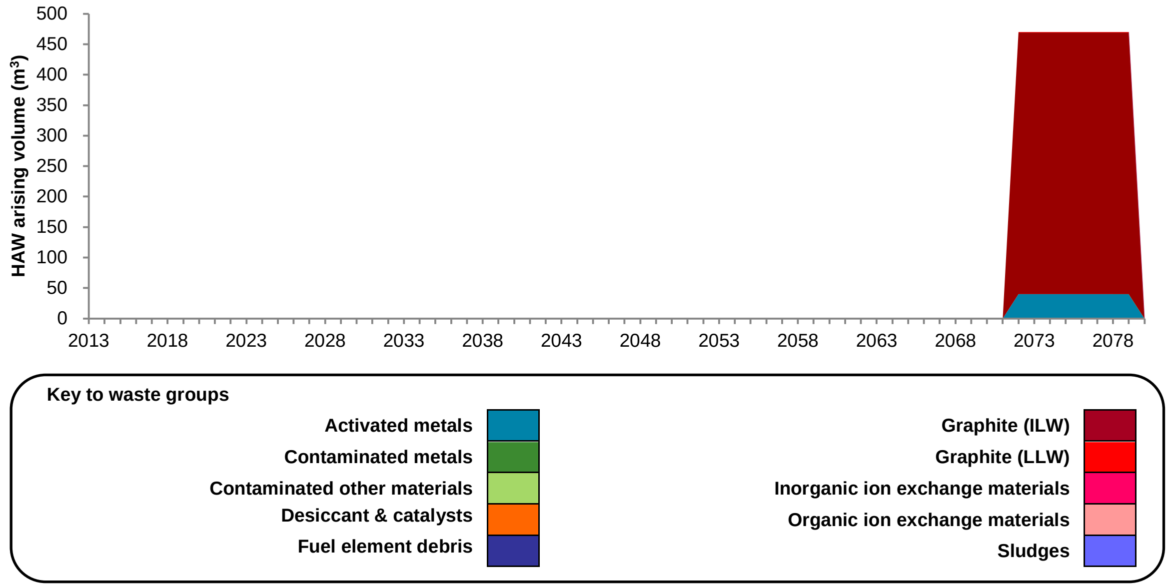
It is assumed that 17% of HAW that has arisen has left the site by 2060, and that all wastes except those from final dismantling and site clearance have left the site by 2080. All waste is assumed to have left the site by 2100.



## Hunterston A (Magnox Ltd)

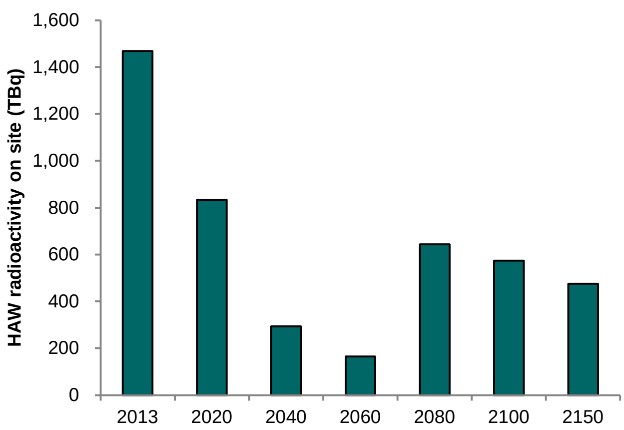



There are currently 2,660 $m^3$ of HAW stored on site. The major components are fuel element debris, sludges and contaminated other materials. An additional 3,760 $m^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2072-2079. HAW will occupy 9,640 $m^3$ when it has all been packaged.

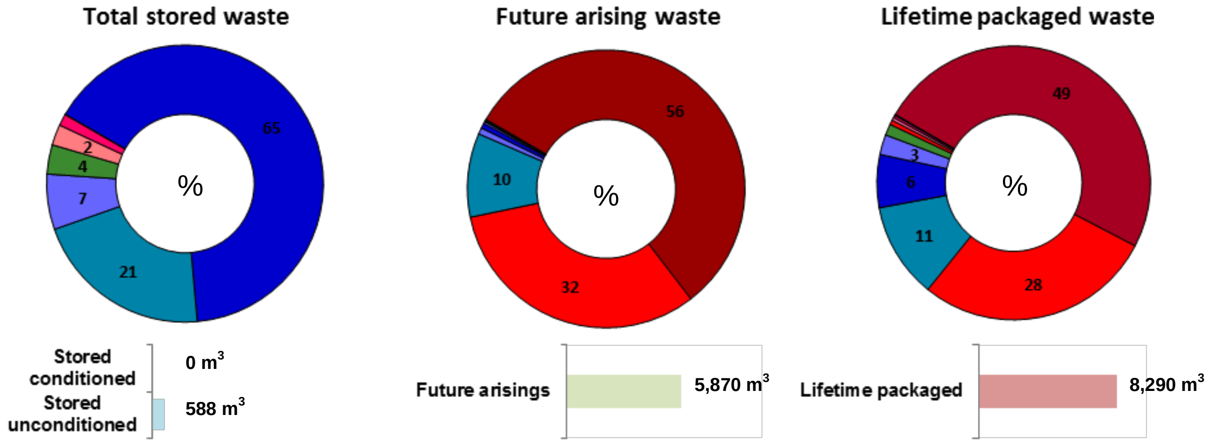



The radioactivity of the stored HAW is currently about 1,470 TBq. Radioactivity on site decreases over time as activity decays. At 2080 there is an increase in activity on site as final dismantling and site clearance wastes arise.

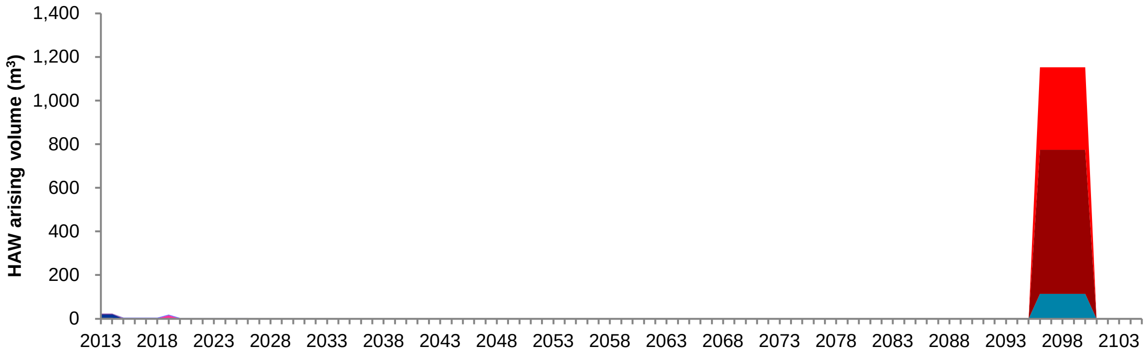
It is assumed that all HAW remains on site to be managed under Scotland's higher activity radioactive waste policy.

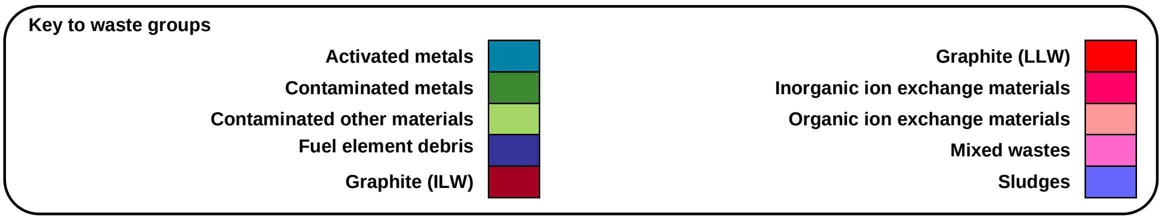


## Oldbury (Magnox Ltd)



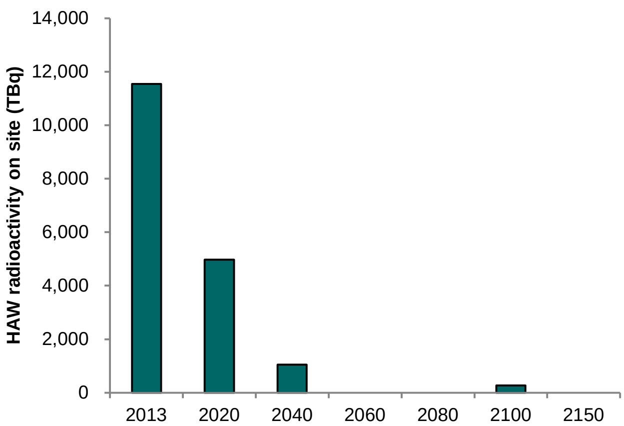

There are currently 588 $m^3$ of HAW stored on site. The major components are fuel element debris, and activated metals. An additional 5,870 $m^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2096-2100. HAW will occupy 8,290 $m^3$ when it has all been packaged.



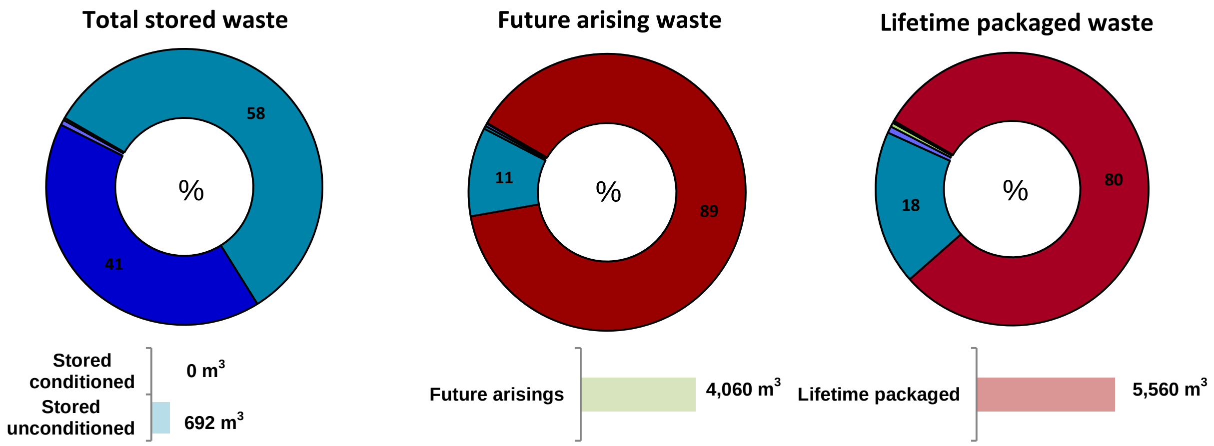




The radioactivity of the stored HAW is currently about 11,500 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

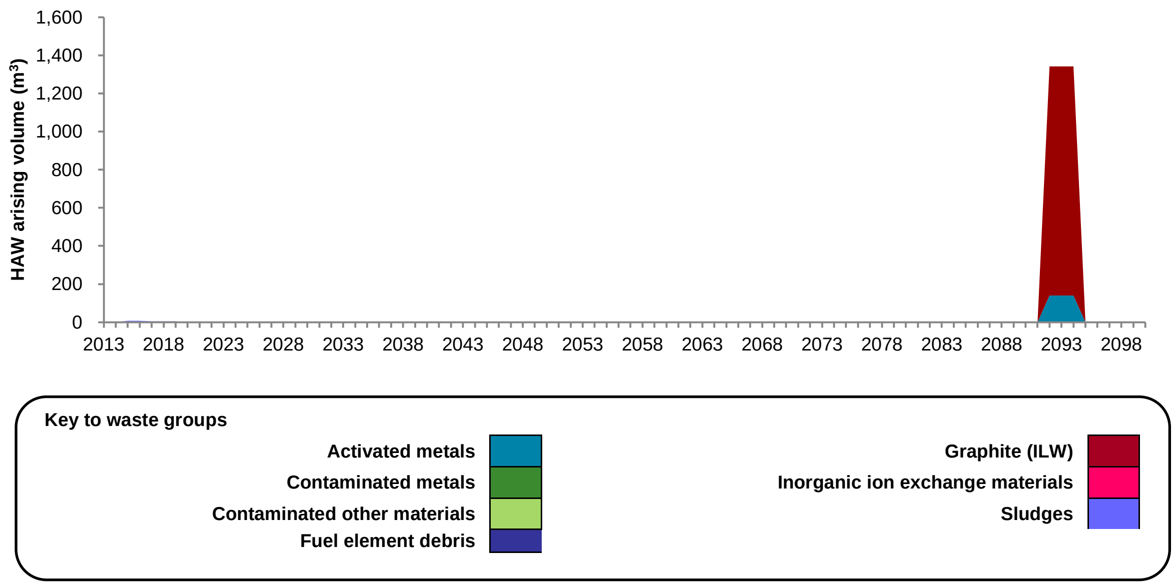
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060. By 2100, 68% of final dismantling and site clearance wastes have left the site, and by 2150 all HAW has left the site.



## Sizewell A (Magnox Ltd)

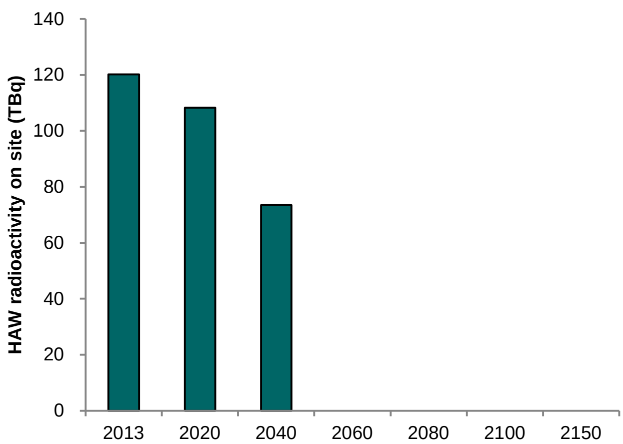



There are currently 692 $m^3$ of HAW stored on site. The major components are activated metals and fuel element debris. An additional 4,060 $m^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2092-2094. HAW will occupy 5,560 $m^3$ when it has all been packaged.

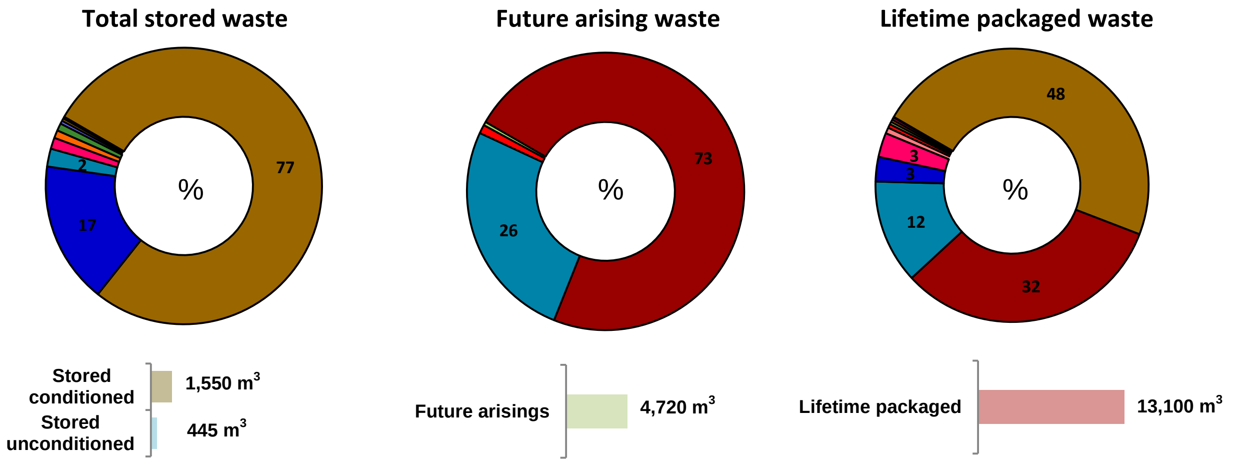



The radioactivity of the stored HAW is currently about 120 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

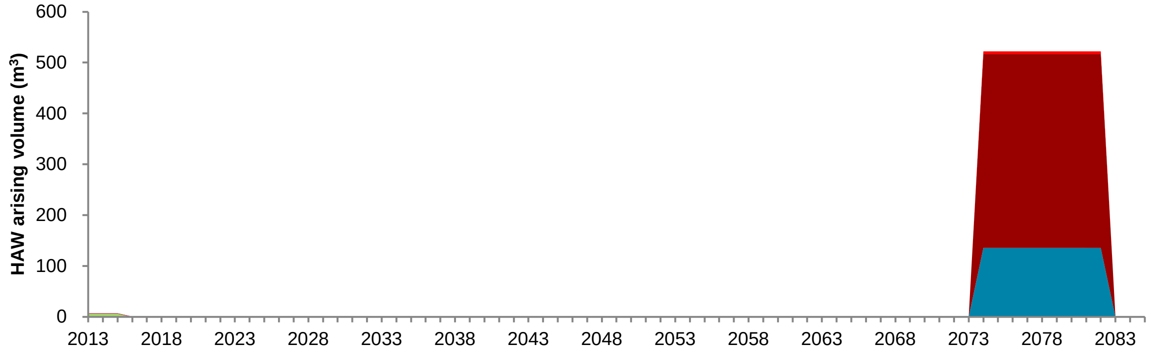
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060, and that all HAW has left the site by 2100.

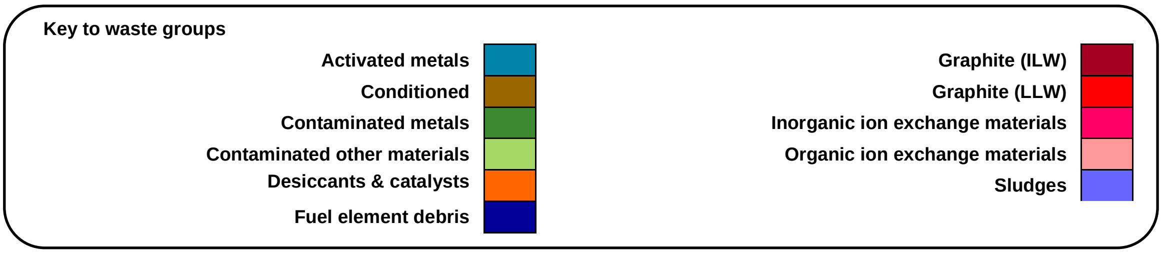


## Trawsfynydd (Magnox Ltd)



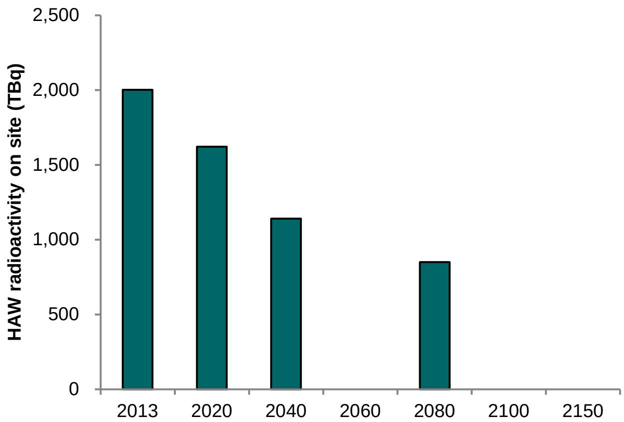

There are currently 2,000 m$^3$ of HAW stored on site. The major components are conditioned waste and fuel element debris. An additional 4,720 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2074-2082. HAW will occupy 13,100 m$^3$ when it has all been packaged.



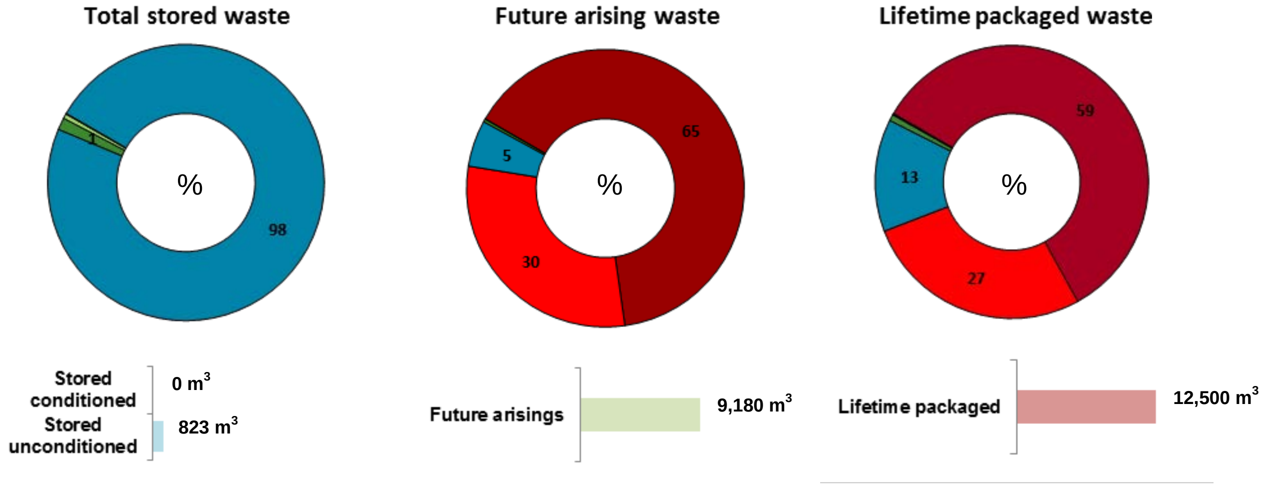




The radioactivity of the stored HAW is currently about 2,000 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

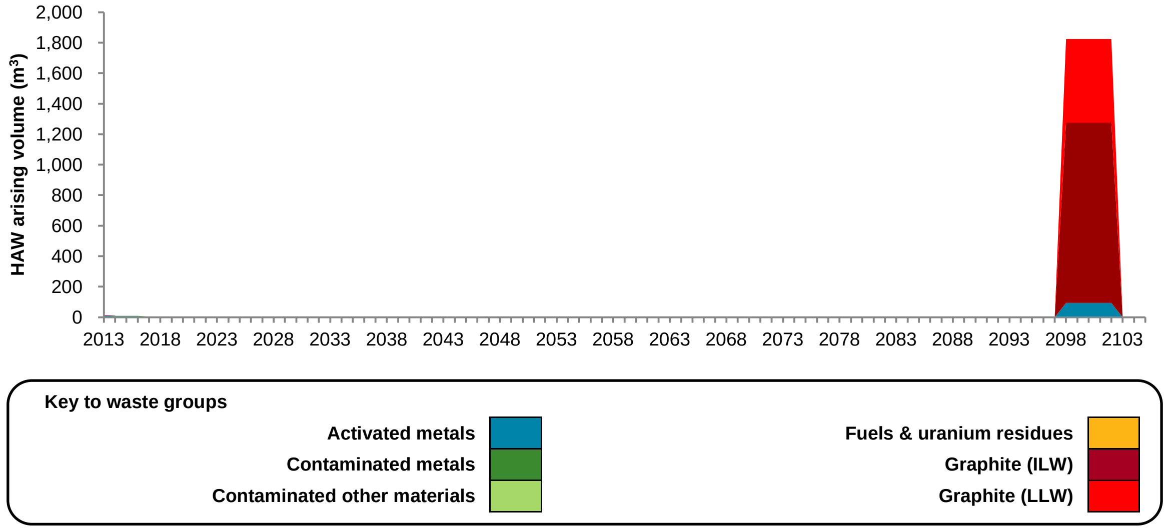
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060, and that all HAW has left the site by 2100.



## Wylfa (Magnox Ltd)

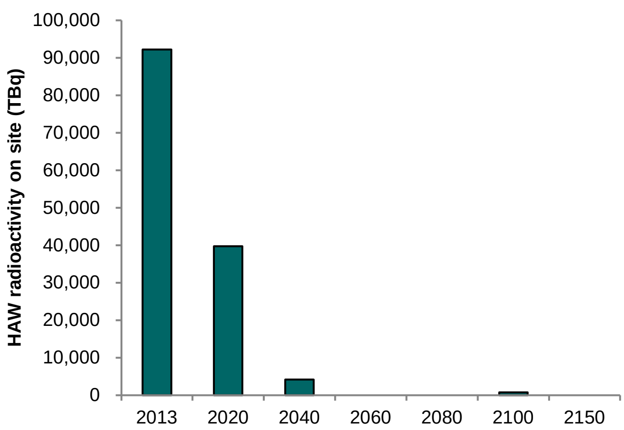



There are currently 823 m$^3$ of HAW stored on site. The major component is activated metal. An additional 9,180 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals from decommissioning over the period 2098-2102. HAW will occupy 12,500 m$^3$ when it has all been packaged.

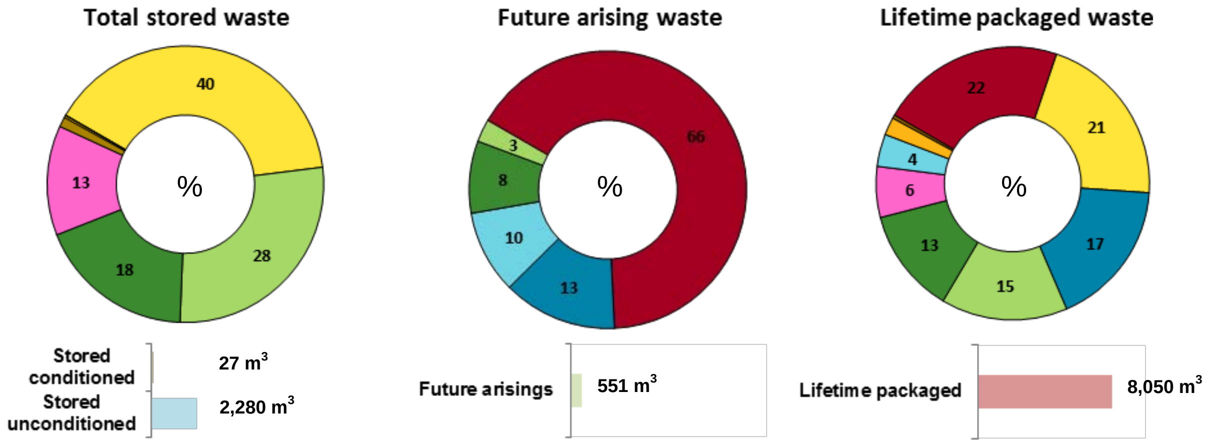



The radioactivity of the stored HAW is currently about 92,200 TBq. Radioactivity on site decreases over time as activity decays and as waste is removed from site.

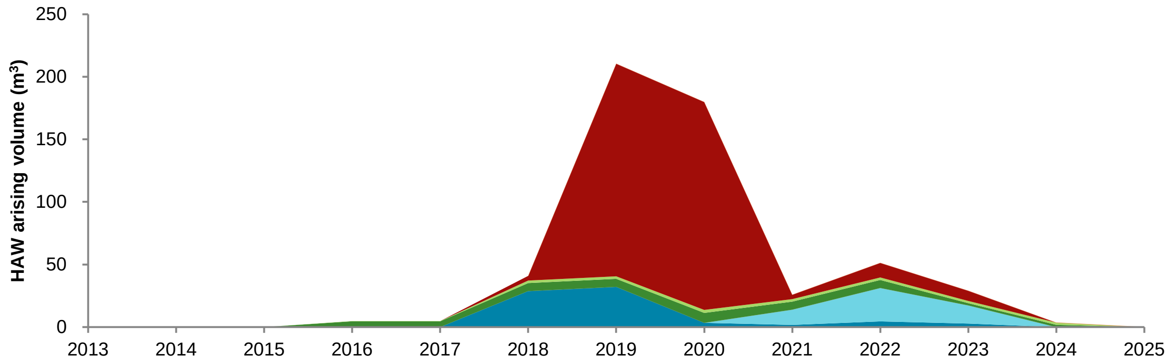
It is assumed that all HAW, other than wastes from final dismantling and site clearance, has left the site by 2060. By 2100 67% of wastes from final dismantling and site clearance have left the site, and by 2150 all HAW has left the site.

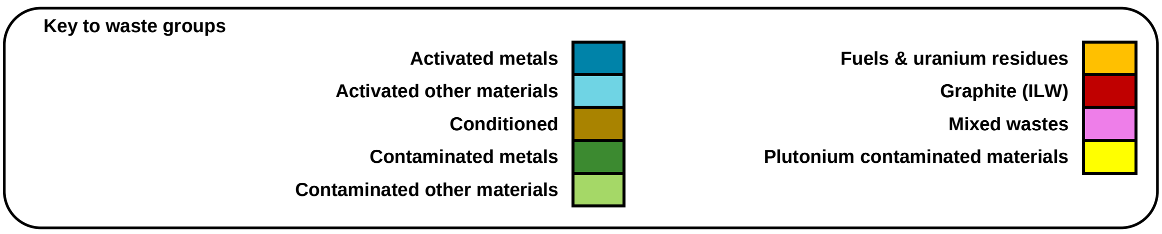


## Magnox Ltd (Harwell & Winfrith)



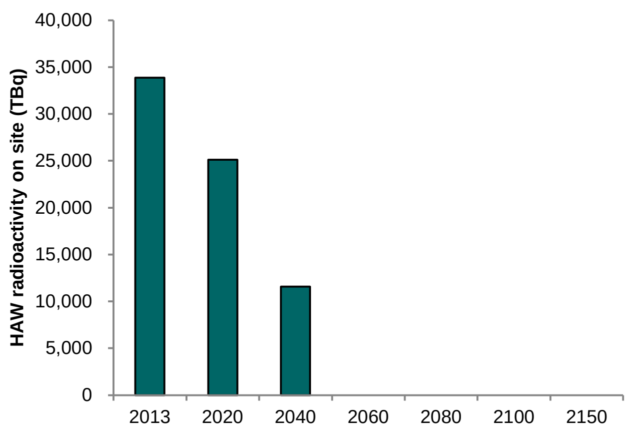

There are currently 2,310 m$^3$ of HAW stored on the sites. The major components are PCM, contaminated other materials and metals. An additional 551 m$^3$ of future arisings is forecast. Most of this is graphite and activated metals and other materials from the decommissioning of reactors over the period 2018-2023. HAW will occupy 8,050 m$^3$ when it has all been packaged.



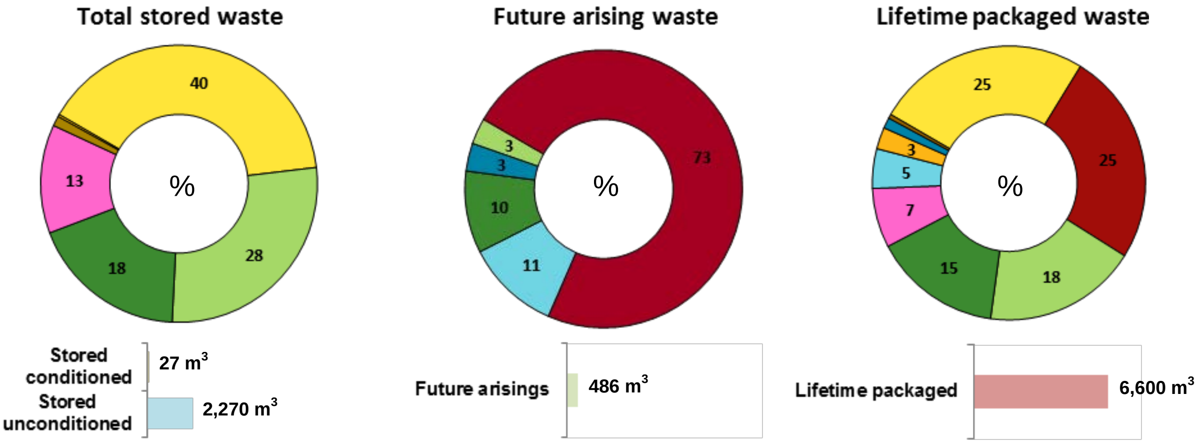




The radioactivity of the stored HAW is currently about 33,900 TBq, of which >99% is at the Harwell site. Radioactivity on the Harwell & Winfrith sites decreases over time as activity decays and as waste is removed from the sites.

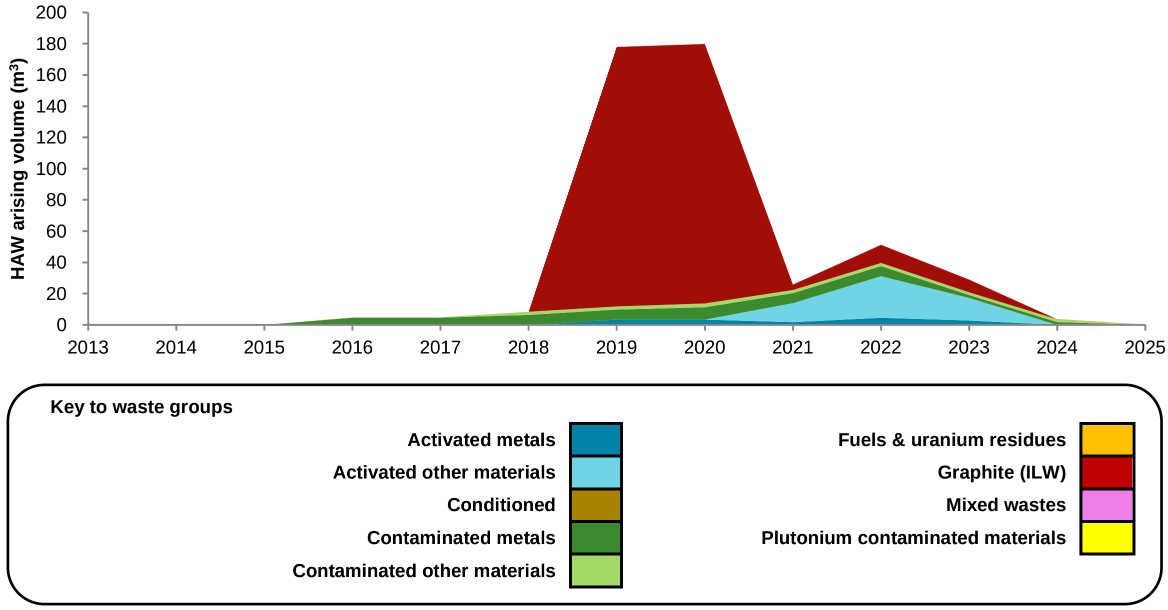
It is assumed that all HAW has left the sites by 2060.



## Harwell (Magnox Ltd)

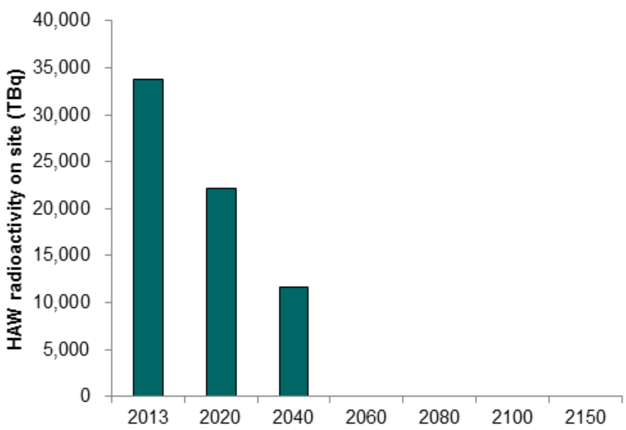



There are currently 2,297 m$^3$ of HAW stored on site. The major components PCM, contaminated other materials and metals. An additional 486 m$^3$ of future arisings is forecast. Most of this is graphite and activated other materials from decommissioning over the period 2019-2023. HAW will occupy 6,600 m$^3$ when it has all been packaged.

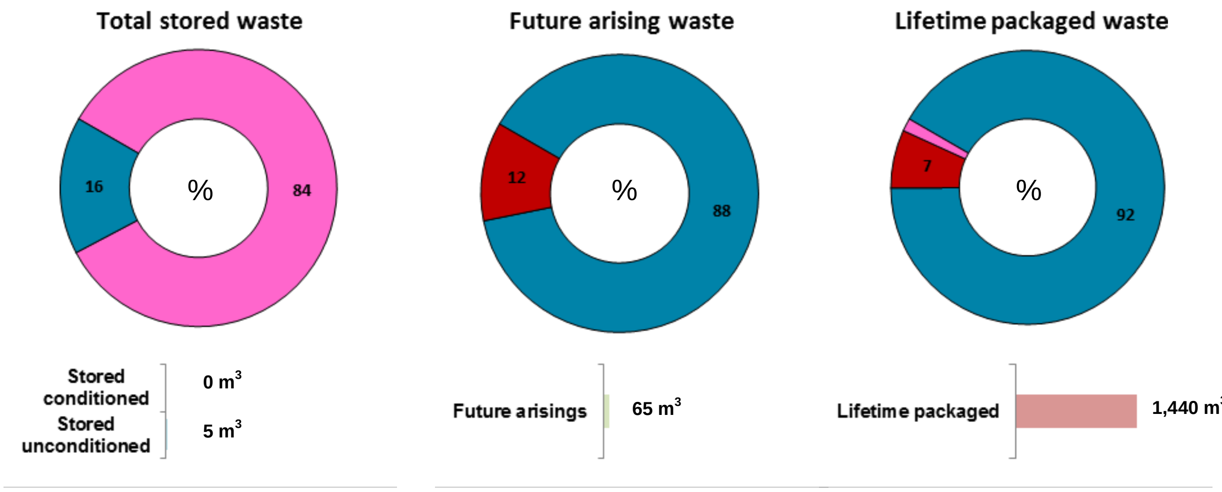



The radioactivity of the stored HAW is currently about 33,700 TBq. Radioactivity on the site increases over time as waste arises from decommissioning and the receipt of packaged waste from Winfrith. The overall radioactivity decreases over the time steps however, as activity decays and as waste is removed from the site.

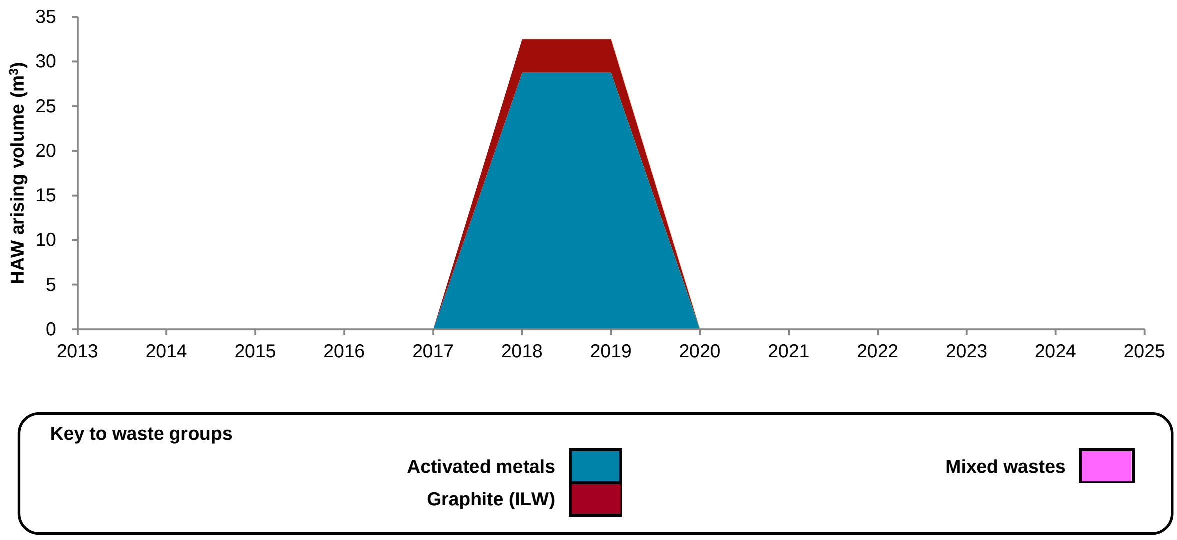
It is assumed that all HAW has left the site by 2060.



### Winfrith (Magnox Ltd)

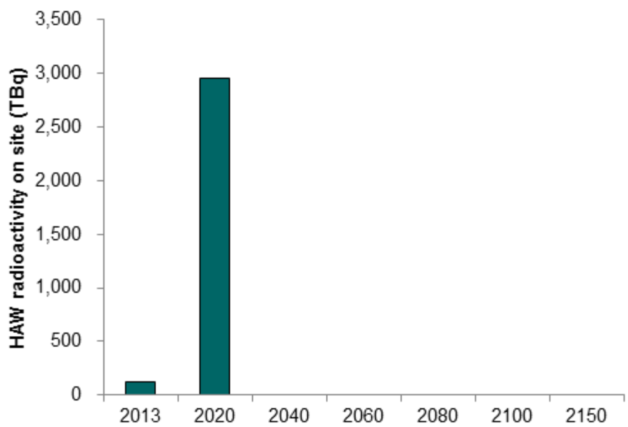



There are currently 5 $m^3$ of HAW stored on site. This comprises mixed wastes and activated metals. An additional 65 $m^3$ of future arisings is forecast. Most of this is activated metals and graphite from decommissioning over the period 2018-2019. HAW will occupy 1,440 $m^3$ when it has all been packaged.




The radioactivity of the stored HAW is currently about 123 TBq. Radioactivity on site increases at 2020 to 2,960 TBq due to wastes from SGHWR and Dragon final stage decommissioning. Radioactivity on the site then decreases over time as activity decays and as waste is removed from the site.

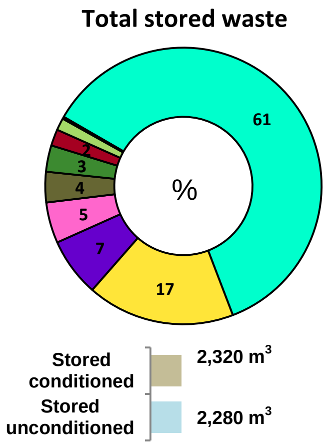
It is assumed that all HAW has left the site by 2021 and is transferred to the Harwell ILW Store.

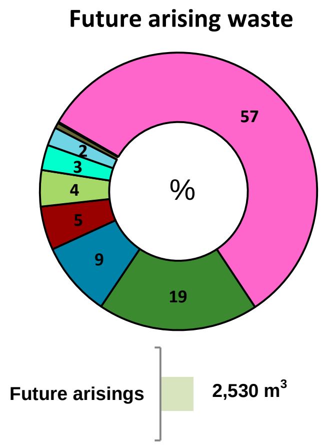


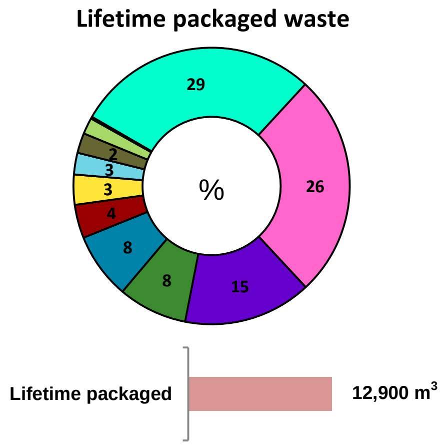
# An Overview of NDA Higher Activity Waste

## November 2015

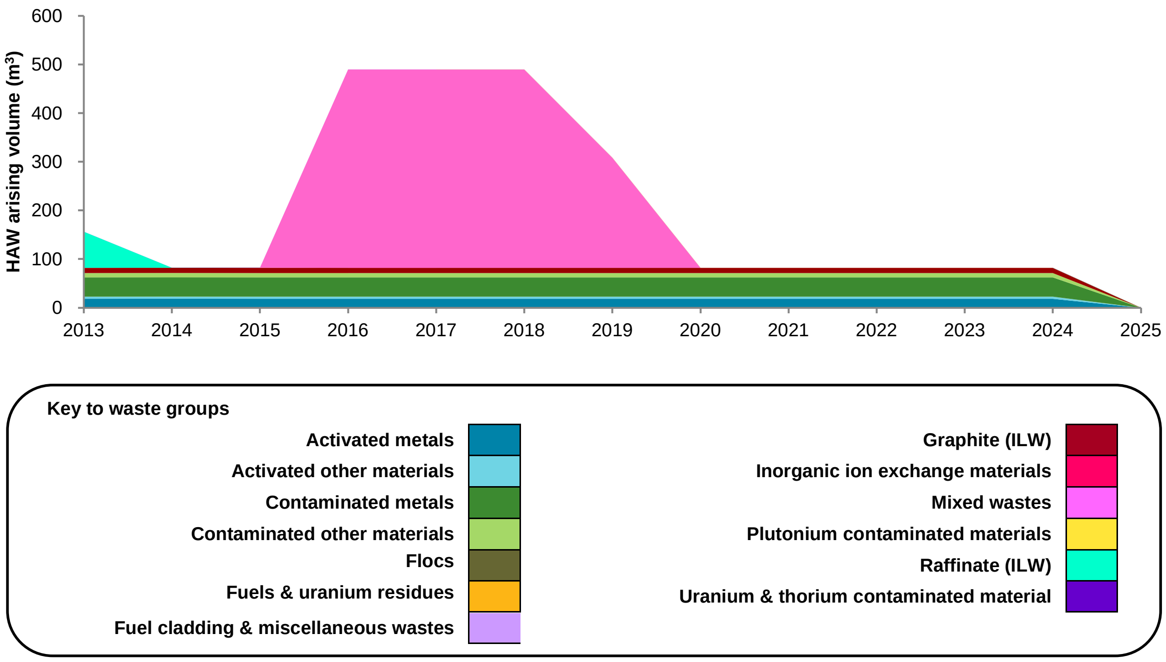
## DSRL (Dounreay)



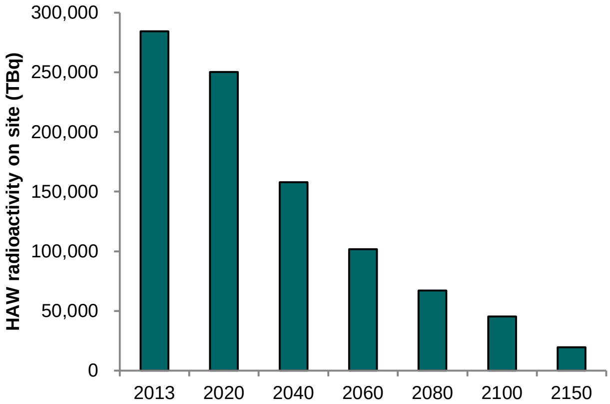




There are currently 4,600 $m^3$ of HAW stored on site. The major components are raffinate, PCM and uranium & thorium contaminated material. An additional 2,530 $m^3$ of future arisings is forecast. Most of this is mixed wastes and contaminated metals. HAW will occupy 12,900 $m^3$ when it has all been packaged.
The pink area (mixed wastes) in the chart below represents existing wastes from the Shaft and Silo (in the 2013 UK RWI these wastes are reported as future arisings corresponding to the schedule for their retrieval).

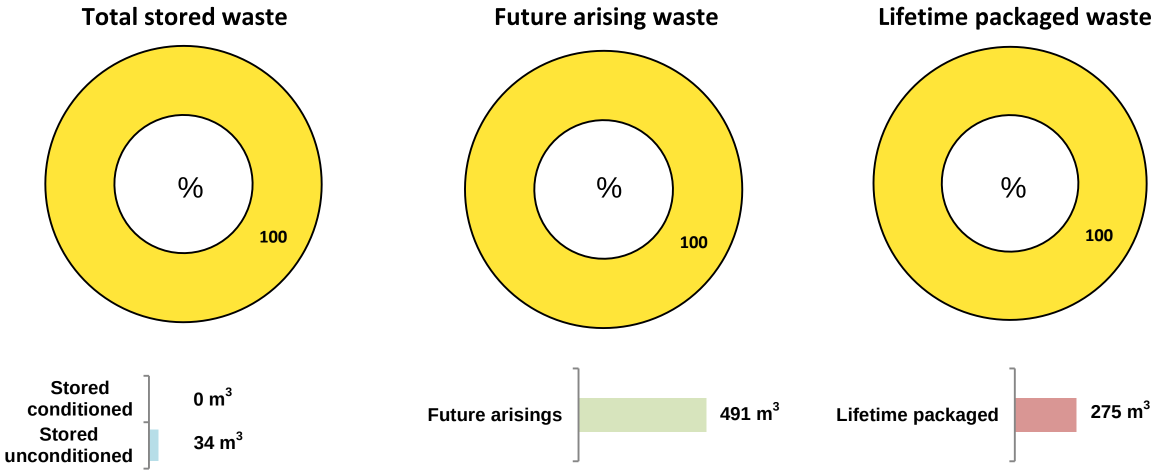



The radioactivity of the stored HAW is currently about 284,000 TBq. Radioactivity on site decreases over time as activity decays.

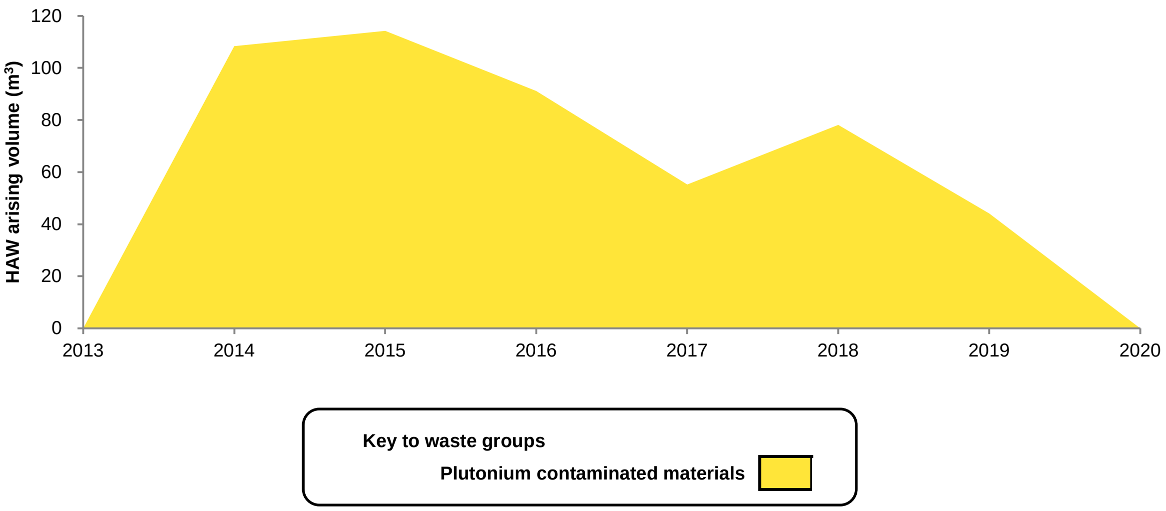
It is assumed that all HAW remains on site to be managed under Scotland's higher activity radioactive waste policy.



## LLWR Ltd (LLWR)

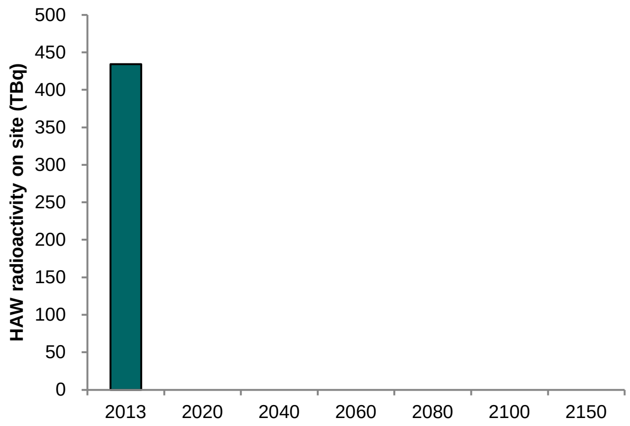



There are currently 34 $m^3$ of HAW stored on site made up of PCM. An additional 491 $m^3$ of future arisings is forecast from 2013-2020, also PCM. HAW will occupy 275 $m^3$ when it has all been packaged.




The radioactivity of the stored HAW is currently about 434 TBq. Radioactivity on site varies over time as the remaining PCM stores decommissioning waste arises, activity decays, and waste is removed from the site.

It is assumed that all HAW has left the site by 2020.



# 7.0 Glossary

**Advanced gas-cooled reactor (AGR)**
A term used for the second generation of UK nuclear power plants. The fuel used in the reactor is slightly enriched uranium oxide clad in stainless steel. The coolant is carbon dioxide and the moderator is graphite.

**Becquerel (Bq)**
The standard international unit of radioactivity equal to one radioactive decay per second. Multiples of Becquerel used to define radioactivity include the Gigabecquerel (GBq) equal to 1,000,000,000Bq and the Terabecquerel (TBq) equal to 1,000,000,000,000Bq.

**CHILW**
Contact Handled Intermediate Level Waste.

**Conditioning**
Treatment of a radioactive waste material to create or assist in the creation of a wasteform that has passive safety.

**Conditioned waste volume**
The volume of the wasteform (waste plus immobilising medium) within a container.

**Container**
The vessel into which a wasteform is placed to form a waste package suitable for handling, transport, storage and disposal.

**Decommissioning**
The process whereby a nuclear facility, at the end of its economic life, is taken permanently out of service and its site made available for other purposes.

**Decontamination**
The complete or partial removal of surface radioactive contamination by a deliberate physical, chemical or biological process.

**DFR**
Dounreay Fast Reactor.

**Disposal**
In the context of solid waste, disposal is the emplacement of waste in a suitable facility without intent to retrieve it at a later date; retrieval may be possible but, if intended, the appropriate term is storage.

**DMTR**
Dounreay Materials Testing Reactor.

**FSC**
Final Site Clearance. The final stage of the decommissioning strategy for Magnox reactor stations that involves the removal of remaining structures on site including the reactors.

**Fuel element debris**
Waste arising from cladding and other items associated with the fuel.

**ILW**
Intermediate Level Waste (refer to Section 2.1).

**Interim storage**
Storage of radioactive waste before implementing a final management step, such as 'geological disposal'.

***In situ***
In the context of radioactive waste storage, refers to containment within existing engineered structures.

**HAW**
Higher Activity Waste (refer to Section 2.1).

**HLW**
High Level Waste (refer to Section 2.1).

**LAW**
Lower Activity Waste (refer to Section 2.1).

**LLW**
Low Level Waste (refer to Section 2.1).

**LLWR**
Low Level Waste Repository. The UK national facility for the near surface disposal of solid Low Level Waste, located near to the village of Drigg in Cumbria.

**$m^3$**
Cubic metres.

**MAC**
Miscellaneous activated components.

**Magnox**
An alloy of magnesium used for fuel element cladding in the first generation of UK nuclear power plants, and a generic name for this type of reactor. The reactor used natural uranium fuel, carbon dioxide coolant and graphite moderator.

**MCI**
Miscellaneous contaminated items.

**Overpacking**
A secondary or additional outer container used for the handling, transport, storage or disposal of waste packages.

**Packaged waste volume**
The packaged waste volume is the displacement volume of a container used to package a wasteform.

**Passive safety**
Providing and maintaining a safety function by minimising the need for active safety systems, monitoring or prompt human intervention. Requires radioactive wastes to be immobilised and packaged in a form that is physically and chemically stable. The package should be stored in a manner that is resistant to degradation and hazards, and which minimises the need for control and safety systems, maintenance, monitoring and human intervention.

**PCM**
Plutonium contaminated material.

**PFR**
Prototype Fast Reactor.

**Plutonium (Pu)**
A radioactive element occurring in very small quantities in uranium ores but mainly produced artificially, including for use in nuclear fuel, by neutron bombardment of uranium.

**Pressurised water reactor (PWR)**
Reactor type using ordinary water under high pressure as coolant and neutron moderator. PWRs are widely used throughout the world for electricity generation. The Sizewell B reactor in Suffolk is of this design.

**Radioactive waste**
Any material contaminated by or incorporating radioactivity above certain thresholds defined in legislation, and for which no further use is envisaged, is known as radioactive waste.

**Radioactivity**
Atoms undergoing spontaneous random disintegration, usually accompanied by the emission of radiation.

**RHILW**
Remote handled Intermediate Level Waste.

**Secondary waste**
A form and quality of waste that is a by-product from waste processing.

**Spent fuel**
Fuel that has been used (i.e. irradiated) in nuclear reactors and is no longer capable of efficient fission due to loss of fissile material.

**Supercompaction**
A term that describes the reduction in bulk volume by the application of high external force. It differs from routine compaction methods by using hydraulic equipment capable of exerting forces of 1,000-2,000 tonnes, and the original, thin-walled metal container is supercompacted along with its contents.

**Thorium (Th)**
A radioactive element occurring in very small quantities from the radioactive decay of uranium.

**Ullage**
The unfilled air space at the top of a waste package, and the amount by which a container falls short of being full.

**Uranium**
A heavy, naturally occurring and weakly radioactive element, commercially extracted from uranium ores. By nuclear fission (the nucleus splitting into two or more nuclei and releasing energy) it is used as a fuel in nuclear reactors to generate heat.

**Waste container**
The vessel into which the wasteform is placed for handling, transport, shielding, storage and/or eventual disposal: also the outer barrier protecting the wasteform from external intrusions. The waste container is a component of the waste package.

**Wasteform**
Waste in the physical and chemical form in which it will be stored/disposed. This can include any conditioning media and container furniture (i.e. in-drum mixing devices, dewatering tubes etc.) but not including the waste container itself or any added inactive capping material.

**Waste package**
The wasteform and any container(s) and internal barriers (e.g. absorbing materials and liner), as prepared in accordance with requirements for handling, transport, storage and/or disposal.