Nuclear Decommissioning Authority

Higher Activity Waste

Credible Options (Gate A)

February 2011

Integrated Waste Management
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Contents

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Executive Summary

The purpose of this document is to summarise the Higher Activity Wastes (HAW) Topic Strategy credible options to be taken forward by the NDA. It also highlights the importance of initiatives that deliver baseline improvements to the current reference strategy that reflect Government Policy.

The aim of the reference strategy, which will be actively pursued for the majority of the HAW inventory, ***is to achieve passive safety as soon as reasonably practicable, for longer-term storage and eventual disposal or management in near-surface facilities for HAW in Scotland. Depending on the timing of waste arisings, a period of some decades of interim storage may be required.***

The *Case for Change* section gives an overview of the current situation and highlights the following:

- For certain ILW streams in ageing facilities, particularly at Sellafield, the current strategy of a single-stage approach to risk and hazard reduction is proving difficult to implement. These raw waste storage facilities are often subject to increased Regulator scrutiny with legal requirements in place.

- In addition, some unconditioned operational wastes are held in engineered interim stores and the current plan is to retrieve and condition them into a disposable form prior to export to the Geological Disposal Facility. These wastes tend to be relatively stable material forms such as graphite and activated stainless steel components.

The case is presented for exploring alternative strategic options to the above baseline positions. In terms of developing credible options, there are two categories:

I. Alternative options in certain areas of HAW management that reduce risk against the reference strategy.

   The risk mitigation category is primarily aimed at specific high-hazard legacy wastes, *e.g.* Sellafield Ponds & Silos, where a single-step approach to retrievals and waste conditioning may prove to be very difficult or impossible in terms of managing existing facilities (asset care) and the ability to secure disposable waste products in a timely manner. Therefore the case for change in this scenario is based on overriding safety concerns and a 'two-step' progressive hazard reduction approach of waste retrievals and containerisation could be employed, with final conditioning deferred until a later date.

II. Alternative options that provide a step change in benefits against the reference strategy.

   The second category refers to waste streams where there are clear opportunities for improved long-term management. The HAW Topic Strategy will examine these opportunities in the Solid ILW and Graphite Topic Strands, where the key focus is on minimising the volume of waste. For example, *in-situ* decay storage of short lived-ILW (SL-ILW) that may include passive safety regimes for existing facilities or require building enhancements, to allow for future disposal in a suitable LLWR.

For some HAW streams, an alternative approach to disposal could be adopted especially when dealing with reactor decommissioning wastes (RDW). The case for change is based on a number of possibilities that make an alternative strategy worth exploring in detail:

- If RDW disposal can be decoupled from the main UK geological disposal programme, then this could enable earlier decommissioning of Magnox reactors than presently allowed for in the site baseline plans (which show decommissioning over the decades following 2040).

- Non-geological disposal *could* potentially provide advantages from the point of view of:

  - Overall environmental impact (including carbon footprint).

  - Cost, *e.g.* reduced ongoing running costs for Magnox sites.

  - Safety (including reducing transport if an on-site or near-site solution is pursued).

  - Decommissioning programme flexibility (as noted above), which could provide socio-economic benefits.

The aspirational outcome for this Strategy is five-fold:

- In the majority of cases, to actively pursue the current strategy and adopt UK-wide approaches to waste management.

- To support key risk and hazard reduction initiatives by enabling a flexible approach to long-term waste management.

- When considering the development of alternative strategic options, the HAW Strategy will be flexible to accommodate different timescales for Topic Strands or tactical individual waste stream area development, *e.g.* ion-exchange resins, fuel element debris.

- Where appropriate, interim storage and waste-processing facilities to be considered as NDA-wide assets rather than the current default position of 'local site only' usage.

- To support Scottish policy for HAW and explore options for near-surface disposal of certain HAW wastes, *e.g.* Reactor Decommissioning Wastes.

In summary, the HAW Topic Strategy is to convert the HAW inventory into a form that is suitable for storage and disposal, reflecting current Government policies and the principles of the Waste Hierarchy. To help address the HAW waste management lifecycle, the lower-level Topic Strands will be divided into interim storage and disposal areas that account for the major waste stream areas. Therefore, ten topic strands have been identified, which cover all the strategy-linked work streams:

HAW Topic Strand	Objective
Wet ILW – Interim storage	To ensure safe and robust interim storage arrangements of wet ILW until it has been exported to the GDF
Wet ILW – Disposal*	To ensure the safe and effective disposal of wet ILW
Solid ILW – Interim storage	To ensure safe and robust interim storage arrangements of solid ILW until it has been exported to the GDF
Solid ILW – Disposal*	To ensure the safe and effective disposal of solid ILW
Graphite – Interim storage	To ensure safe and robust interim storage arrangements of Graphite until it has been exported to the GDF

HAW Topic Strand	Objective
Graphite – Disposal*	To ensure the safe and effective disposal of Graphite
UK-owned HLW – Interim storage	To ensure safe and robust interim storage arrangements of HLW until it has been exported to the GDF
UK-owned HLW - Disposal	To ensure the safe and effective disposal of UK-Owned HLW
Overseas-owned HLW	To ensure the safe and effective disposition of HLW owned by overseas customers
Overseas-owned ILW	To ensure the safe and effective disposition of ILW owned by overseas customers

** or long-term management in near-surface facilities for wastes in Scotland*

In summary, the overall objective is to:

> ***Treat and package HAW and place it in safe, secure and suitable storage facilities until it can be disposed of, or be held in long-term storage in the case of a proportion of HAW in Scotland.***

Chapter 2 sets out all the alternative strategic options for NDA HAW. It is recognised that the reference strategy remains as the preferred approach for the majority of HAW streams. The purpose of the Strategy is to ensure the NDA is 'doing the right thing' in terms of hazard and risk reduction, environmental impact and cost from an affordability and lifetime perspective. This document describes the approach and the development of the HAW Strategy Programme that will deliver the optioneering and baseline improvement projects. The credible options have been discussed and presented to the Government's Waste Management Steering Group, Regulators, NDA SLCs and other waste owners. Engagement with broader stakeholders has been carried out at the Integrated Waste Management theme level. The main areas of strategic opportunity, which are currently being pursued, are highlighted in the second NDA Strategy, due for publication in March 2011.

At a high level, the HAW Topic Strategy considers:

- Strategic opportunities – *e.g.* alternative disposal scenarios and decay storage
- Strategic risks – a flexible approach to waste management that recognises the need for progressive risk and hazard reduction
- Baseline improvement initiatives – securing an NDA-wide approach to waste processing and storage and, where appropriate, co-ordinating with other waste producers.

Going forward the HAW Topic Strategy will be addressed on a project-by-project basis where each Strategy Project manager is responsible for preparing an NDA Strategic Business Case and achieving ultimate SMS sanction to allow for baseline change control and implementation. A Project may address a whole Topic Strand or a particular Waste Grouping(s) within a Topic Strand. The strategic framework has been established and a change control process will be used when an update is required.

Document Revision Record

Version	Stage	Record of Change	Author	Date
0.1	A	Initial version update for SAF (v0.1)	J McKinney	20/08/10
1.1	A	SAF, HAWS ToG comments. Update for WMSG issue.	J McKinney	24/09/10
2.0	A	Approved for issue	J McKinney	28/02/11

1 The Strategic Case - (Stage 0) 'Research'

1.1 Topic Background and Context

The term Higher Activity Waste (HAW) refers to all radioactive material that has no further use that falls into the following categories: vitrified High Level Waste (HLW), Intermediate Level Waste (ILW) and a relatively small volume of Low Level Waste (LLW) that is not deemed suitable for disposal at the LLWR or the LLW facility at Dounreay. HAW excludes spent fuel and nuclear materials, which are covered by the Magnox, AGR, exotics, plutonium and uranium topic strategies. This Strategy covers NDA wastes only, although it is recognised that the NDA's Radioactive Waste Management Directorate (RWMD) is accountable for the geological disposal of all HAW, except in Scotland. NDA would welcome working with other waste owners to explore co-ordinated strategies to help implement UK-wide approaches to waste management.

It is necessary to break down the Topic Strategy into lower-level Topic Strands that can focus on certain attributes relating to a combination of waste types (see section 1.5) because of the following issues:

- wide range of materials to be considered,
- differing volumes and radioactive inventories for individual NDA sites,
- near-term, medium-term and long-term timescales to be considered for waste processing,
- support to the legacy waste decommissioning and clean up programme

In addition, it is appropriate to develop the HAW Strategy beyond the credible options stage on a case-by-case strategic project basis that would follow the Strategy Management System (SMS) process[1] (see section 2.11 for further detail).

This first main section describes the reference strategy and presents the case for strategic change in areas that will mitigate key risks and help realise major opportunities. The Topic Strategy also outlines baseline improvement opportunities and introduces NDA led Strategy Development Working Teams (SDWTs).

1.1.1 Intermediate level waste

Large volumes of ILW will be generated through continuing operations and future decommissioning of NDA sites. Current estimates put existing and anticipated packaged volumes of ILW in the range of 360,000 cubic metres.[2]

ILW has radioactive waste with radioactivity levels exceeding the upper boundaries for LLW:

- Alpha emitters greater than 4 GBq/tonne.

[1] For further details on the Strategy Management System see: http://www.nda.gov.uk/strategy/developing-strategy.cfm
[2] UK National Waste Inventory 2007

- Beta/gamma emitters greater than 12 GBq/tonne.
- Waste that does not need radiological self-heating to be taken into account in the design of storage or disposal facilities.

The major components of ILW include metals and sludges, organic materials, cement and graphite. The radiological, chemical and physical forms of ILW are highly varied from large solid waste items that are relatively inert to wet sludges, which could be chemically reactive and heavily contaminated.

ILW arises from a number of operations across the nuclear fuel cycle. The following are particularly important to NDA:

- Reactor operation
- Decommissioning
- Spent fuel reprocessing
- Research facilities
- Historical waste storage practices

There are currently five different ways of storing ILW in the UK:

- The storage of untreated, *i.e.* raw waste, in historical facilities.
- The storage of treated waste that needs further treatment before longer-term storage/disposal.
- Interim storage of waste already conditioned for disposal.
- The continued interim storage of wastes in modern engineered stores that will require further conditioning before disposal.
- Interim storage of waste which is still *in situ* such as in reactor cores awaiting decommissioning.

A small proportion of LLW, some 17,000 m^3 once packaged,[3] is also included in the HAW category, as this is currently unsuitable for disposal in the LLWR or the LLW facility at Dounreay. Such LLW may consist of reactor core graphite or effluent treatment materials with high concentration of alpha activity that includes relatively high concentrations of long-lived radioisotopes.

1.1.2 High Level Waste

In the UK, HLW is defined as heat-generating highly radioactive liquor arising from the reprocessing of spent nuclear fuel from both the UK and overseas Magnox and THORP operations, and the solid vitrified product that is produced by immobilising this liquid waste.

[3] See Table 1 page 20, A Framework for Implementing Geological Disposal, Managing Radioactive Waste Safely, June 2008, Welsh Assembly, BERR, Doeni, Defra.

The intense level of radiation means that shielding is necessary to protect workers engaged in HLW operations. Sellafield is the only NDA site that stores HLW.

HLW generates significant heat from radioactive decay, which clearly needs to be taken into account when designing and operating storage and disposal facilities for this material. This heat is generated predominantly from fission products such as caesium-137 and strontium-90, as well as transuranic elements such as americium-241. The heat generating fission product component of HLW decays away within a few hundred years, whereas the transuranic elements are much longer lived.

Once vitrified, the UK HLW will be held in the Vitrified Product Store at Sellafield for 50 years or more to allow shorter lived radionuclides to decay before emplacement in a geological disposal facility. The packaged volume of HLW destined for the GDF is approximately 1,400 m^3.

1.2 Current Situation

In July 2006 CoRWM made a number of recommendations to Government, which were underpinned by a substantial stakeholder engagement programme over a three year period.[4] In June 2008 the UK, Welsh and Northern Ireland Governments published a White Paper on 'A Framework for Implementing Geological Disposal', which now establishes the long-term policy on HAW management in England and Wales.[5] In response to the CoRWM recommendations, the White Paper made the following statements that are relevant to this Topic Strategy;

- *Geological disposal is the way HAW will be managed in the long term*
- *This will be preceded by safe and secure interim storage until a geological disposal facility can receive waste. This period will include contingency planning to cover any uncertainties associated with implementation. Storage is a proven, safe and secure technology for the interim management of HAW.*
- *There will be ongoing research and development to support optimised delivery of the geological disposal programme, and the safe and secure storage of the radioactive waste in the interim.*

The Scottish Government published its Policy statement for HAW and its Post Adoption Environmental Assessment Statement in January 2011. The policy is for the long-term management of HAW in near-surface facilities.

> Therefore, the reference strategy for HAW ***is to achieve passive safety as soon as reasonably practicable, for longer-term storage and eventual disposal, or long-term management in near-surface facilities for wastes in Scotland. Depending on the timing of waste arisings a period of some decades of interim storage may be required.***

[4] CoRWM document 700, Managing our Radioactive Wastes Safely, CoRWM's recommendations to Government, July 2006.
[5] A Framework for Implementing Geological Disposal, Managing Radioactive Waste Safely, June 2008, Welsh Assembly, BERR, Doeni, Defra.

As noted in the UK HAW Interim Storage Review, the majority of HAW either exists as raw waste or is a future waste arising: *'Over the next two decades NDA sites are carrying out retrieval and treatment programmes for historical and operational wastes arising on existing facilities. By 2040, when current NDA plans anticipate that the GDF could be available, it is anticipated that the vast majority of these wastes will be in a packaged form, stored in modern interim storage facilities and ready for disposal. As of the 31st March 2008, approximately 22,000 m^3 of waste had been recovered, conditioned, packaged and placed into interim storage. This volume comprises around 44,000 individual waste packages and represents approximately 8% of the total reported ILW in the 2007 Inventory. These packages have all been issued with Final Stage Letters of Compliance (LoC).'* RWMD has instituted a rolling programme of periodic review of final stage LoCs, which is designed to ensure that endorsed waste packages are covered by safety arguments no more than 10 years old. Three such reviews have been completed to date.

In summary, the general approach to HAW management is:

- Prioritise the retrieval, conditioning and passive storage of HAW currently held in historical storage facilities. Application of the NDA prioritisation process focuses attention onto such relatively mobile wastes in ageing facilities thus reducing both the risk and hazard of waste materials.
- Minimise storage of HAW in raw form in line with good practice.
- Minimise the volume of ILW produced from decommissioning.
- Where possible, package HAW into a form that is compliant with NDA Generic Specifications N/104 (for ILW/LLW) and N/124 (for HLW/SF).
- Safe and secure interim storage pending availability of the GDF.
- Where appropriate, explore more innovative approaches to waste management that take into account the principles of the waste hierarchy.[6]
- As a reference position, plan to dispose of HAW into the GDF.
- Ensure transport requirements are being addressed, as part of any waste management process.
- The NDA will continue to support the Scottish Government in the implementation of its policy on the long-term management of Higher Activity Wastes. Lifetime Plans for NDA Scottish Sites will need to be reviewed to take account of Scottish HAW Policy.

However, it is noted that the full implementation of the above is proving difficult for all existing HAW due to:

- The complex nature of some poorly characterised heterogeneous waste streams.
- The condition of some raw waste storage facilities (and the need to make progress with clean-up operations).
- And/or programme deliverability, which will include affordability considerations.

[6] See http://www.nda.gov.uk/documents/upload/WNM-PP-001-The-role-of-the-waste-hierarchy-March-2008.pdf

For certain ILW streams in historical facilities at Sellafield, the current reference strategy of a single-stage approach to risk and hazard reduction is proving difficult to implement. These raw waste storage facilities are often subject to increased Regulator scrutiny with legal requirements in place. For example, in 2000 the Nuclear Installations Inspectorate (NII), the part of the Health and Safety Executive (HSE) that regulates nuclear safety, issued to BNFL (now Sellafield Limited) a number of licence instruments that required the site to carry out progressive risk and hazard reduction operations by specified dates.[7] The NDA's UK HAW Storage Review highlighted this issue by stating that *'Retrieving and conditioning wastes from historical facilities presents significant challenges due to the age of the buildings, the chemical behaviour of the wastes, physical and radiological inventory and the relatively large volumes to be considered. In the case of certain waste streams at Sellafield, disposable packages may need to be achieved in a staged approach, where the immediate priority is retrievals into better storage conditions.'*

In addition, some unconditioned operational wastes are currently being held in engineered interim stores and the current plan is to retrieve and condition it into a disposable form prior to export to the GDF. These wastes tend to be relatively stable material forms such as graphite and activated stainless steel components. Through historical practices, some conditioned wastes were produced that no longer meet requirements for geological disposal (or long-term management in near-surface facilities for wastes in Scotland) and will be repackaged for longer-term interim storage and eventual disposal. Waste such as plutonium contaminated material (PCM) are currently packaged in 200 litre drums and crates for storage or in larger drums that were used for sea dumping prior to the 1983 moratorium on sea disposal.

In 2001 the NII issued to BNFL (now Sellafield Limited) a formal programme for the reduction of liquid HLW stocks. This specification currently defines a maximum total volume of liquid HLW that can be held in storage at any time as well as a further limit for THORP derived material. The total volume limit falls progressively with time until 2015, when liquid HLW volumes are anticipated to reach a buffer volume. NDA strategy for HLW is driven by the need to ensure hazard reduction via the long-running programme of vitrification at Sellafield. The NDA supports Sellafield Limited activities to meet the NII liquid HLW reduction targets and to maximise the proportion of HLW that is stored in passively safe conditions.

The NDA is investigating appropriate disposal solutions for the UK HLW inventory. The reference case for planning purposes is that HLW will be consigned to a part of an integrated geological disposal facility that is capable of handling HLW and any spent fuel formally declared as a waste, and the much greater volume of ILW. Vitrified HLW can be safely stored in surface facilities for many years. The baseline planning assumption is that HLW would be transferred for disposal from 2075.

1.2.1 International aspects of HLW

Appropriate quantities of HLW equivalent to that derived from the reprocessing of fuel of overseas customers will be returned to the country of origin, according to agreed contractual terms and Government policy on return of waste. In addition, it is UK Government policy to enable waste substitution to take place whereby an additional radiologically equivalent quantity of UK-owned HLW will be returned to overseas customers in *lieu* of ILW and LLW resulting from reprocessing of overseas spent fuel. This policy balances the ownership of waste in radiological terms but minimises the number of waste transports required.

[7] *e.g.* Licence instrument 326a, issued by the NII in 2000, requires the bulk of the inventory to be retrieved by 2020 and the residuals to be retrieved by 2027 (for the Magnox Swarf Storage Silos at Sellafield)

The project to return HLW to overseas customers (Vitrified Residue Return) is well developed and repatriation of the waste has begun. The programme will return approximately 1,850 containers over a 10 year period.[8]

1.2.2 Interim storage of HAW

Interim storage is an essential component of the safe pre-disposal, management of HAW in England and Wales, where waste is stored according to the principles of passive safety.[9] In terms of this Topic Strategy, interim storage refers to the need for the production of waste packages that are suitable for disposal. Longer-term stores for packaged wastes have been in existence since the early 1990s and will continue to be built over the next 30 years, with operations continuing over many decades. At any one time there will be a significant difference in the age of stores and as such learning from experience and good practice experiences can be shared between the sites. Additionally the strategy is also concerned with the long-term management and performance of these packages during storage and subsequent disposal. Issues that will need to be considered include; package evolution, knowledge management and the identification of the issues and opportunities.

The Asset Management Topic Strategy will cover the asset care of legacy storage facilities. A key interface is with the Decommissioning Topic Strategy, where waste retrievals need to align to waste conditioning and longer-term storage programmes. The longer-term interim storage strategy for packaged HAW, suitable for geological disposal or long-term storage, will allow for safe and secure storage of waste packages for at least 100 years. The stores themselves will be resistant to foreseeable incidents such as seismic events and severe weather. In terms of a robust interim storage position the following will need to be considered:

- Identifying the key issues and risks associated with packaged wastes in storage and ensuring mitigating actions are in place.
- Understanding the relevant key decision points and their impact on the interim storage programme including GDF implementation and potential store replacement dates.
- Ensuring waste transport is an integral part of the interim storage programme.
- Flexible approach to waste management that can accommodate various disposal timeframes, waste volumes and packaging concepts.
- UK approach to container selection, optimising the relationship between inventory considerations, packaging efficiencies and procurement strategy.

By following this approach progress against both hazard and risk reduction can be monitored recognising its high priority status for the industry. Once conditioned wastes are placed into storage, the short term issues are minimised, compared to raw waste storage, and the longer-term performance concerns are being addressed by the sites. Furthermore, the site export schedule of waste to the GDF is not dependent on its availability and there is appropriate contingency in place that addresses any significant delay to the GDF programme.

[8] See www.sellafieldsites.com/what-we-do/featured-projects/uk-radioactive-wastes-returns-programme
[9] HSE document, Safety Assessment Principles for Nuclear Facilities, 2006 Edition, Rev 1, see paragraphs 666 – 677

The UK HAW Storage Review concluded that a different approach to interim storage would not be adopted unless there are significant delays to the availability of the GDF, *i.e.* later than 2100.[10] However, the NDA does expect contingency planning *versus* the current baseline of a 2040 availability date for the GDF. For wastes stored in Scotland, the NDA will continue to work with the Scottish Government in the implementation of its policy of *long-term management in near-surface facilities*.

The Storage Review also made recommendations on how the Site Licence Companies (SLCs) could approach longer-term storage in terms of design and store operational lives (see ***Appendix 1***).

1.2.3 Waste management lifecycle

As part of the current baseline the NDA SLCs will consider the entire waste management lifecycle. The effective use of the Waste Hierarchy is an important factor, recognising that waste is being managed at different stages of the waste management lifecycle. As part of this course, the waste producers should follow the value framework assessment process, which will include some of the following; safety, environmental impact, socio-economic impact, cost savings and affordability. Therefore, a balanced approach must be adopted that takes into consideration near and long-term risks, volume of the waste stream and single or multi-site issues, where the benefits are clearly identified. The HAW Topic Strategy considers the Waste Hierarchy an essential tool for implementing the reference strategy and in developing alternative strategic options.[11]

In terms of the approach to the waste management lifecycle, examples of good practice may include:

Avoid HAW production

There are a number of interface issues between the Higher Activity and Lower Activity Waste topics, many of which provide opportunities for optimising the approach to integrated waste management. These opportunities include:

- Through better waste characterisation it may be possible to re-categorise some of the ILW to a lower category.
- Sorting and segregation techniques could be used to separate ILW from LLW items within mixed waste streams.
- Decontamination techniques could also be used to treat waste, particularly surface-contaminated material, allowing the leftover bulk material to be treated as LLW or below; whilst secondary waste issues will need to be addressed it is also possible that the decontaminated material may have the potential to be reused or recycled.

The LLW-ILW interface is recognised as an important matter and the NDA will work closely with the SLCs and the LLWR to highlight any other opportunities for the management of waste close to this boundary. Engagement with relevant stakeholders, particularly the regulatory community, is important to pursuing these tactical options.

[10] UK Higher Activity Waste Storage Review, March 2009.
[11] NDA Draft Strategy for consultation, September 2010, see pages 39-41

Reuse/recycle

Some ILW materials may be deemed suitable for co-processing with other wastes, *e.g.* void fillers or even the possibility of converting into an encapsulant. Other materials may be decontaminated or decay stored to allow for recycle/reuse opportunities within the industry. There are also large numbers of ILW interim packages across the estate that could be reused or even recycled, *e.g.* miscellaneous boxes, 200 litre drums.

Waste volume reduction

Significant waste volume reduction may be achieved by mechanical means, *e.g.* supercompaction or by chemical conversion that separates volatile species from a non-volatile residue. For example, high temperature processing of ILW could result in a low volume concentrated wasteform that could exist as a glass or ceramic material and an off-gas waste stream, which will require some form of aerial effluent treatment. If appropriate, additional waste volume reduction may be achieved for HLW by increased waste loadings, *e.g.* more concentrated waste form.

Further waste volume optimisation may be achieved by increasing the waste packaging efficiencies by amending or creating new container designs, *e.g.* new box design for graphite wastes. In particular new container designs and waste package specifications may be worth exploring for decommissioning wastes, *e.g.* 'bigger box concept'. Furthermore, more innovative approaches to container manufacturing may result in significant costs savings, *e.g.* a major cost factor for the production of a waste container is the manufacturing process rather than the material of choice. New materials may also reduce costs or improve package performance and the effort of seeking new container materials should be encouraged, *i.e.* SLCs will have a greater choice of materials recognising the extensive timescales within the LTPs.

Chemical conversion

Chemical conversion of ILW streams will also result in more passive products especially when dealing with wastes containing relatively high concentrations of reactive metals, *e.g.* aluminium, magnesium alloys (Magnox) and uranium. The conversion of metal to its corresponding oxide may also aid long-term product performance. It should also be recognised, that licence instruments are in place for certain high hazard wastes and timescales for waste retrieval programmes must not be affected unless permission is given by the Regulators.

Storage and disposal

Adopting a standard engineering approach to store design and operations could reduce costs by avoiding duplication of effort and resource. An industry wide approach is being sought *via* NDA's Strategy Development Working Team (SDWT) on Interim Storage (see *section 2.12*). The current lifetime plan (LTP) baseline is to locate a store on the site where waste arises. However, the NDA continues to believe that it is worth exploring the options for the consolidation of waste storage, where the number of sites with stores is reduced, which would take into consideration the economies of scale, early site clearance opportunities and resulting environmental and safety impacts/benefits.[12] The UK HAW Storage Review stated that '…*the main focus of investigating storage consolidation opportunities for NDA ILW should be southern Magnox and UKAEA sites'*. It was also noted that the Review said *'There may*

[12] See NDA Draft Strategy for consultation, September 2010, pp 41

be opportunities to extend the study to include other waste owners'. Effective waste volume reduction initiatives may reduce storage requirements and will need to be considered as part of an integrated approach to HAW management.

Once wastes are conditioned and are in longer-term storage it is expected that the storage capability for a nuclear site could extend to 100 years or more if required and as a contingency, could include major store refurbishment programmes or rebuild programmes for existing facilities. Long-term performance of packaged wastes is essential in terms of continuing to meet storage, transport and disposal requirements and to minimise the need to rework packages.

Integrated approach

NDA requires its SLCs to produce IWSs for their sites.[13] These are used to help deliver decommissioning and clean-up work and are expected to identify the challenges and solutions to dealing with the waste throughout the whole lifetime of the site.

An integrated approach needs to consider the whole waste management lifecycle; from effective sorting and segregation techniques at source, appropriate waste characterisation and waste minimisation techniques for the true HAW that should be conditioned into the most optimal container design to the most appropriate storage and disposal routes. The NDA will also need to fully understand the impact of such an approach on LLW Strategy, as this overall driver will reduce HAW volumes and in turn increase volumes of LLW or VLLW. The IWS documents in turn help the NDA to identify the important issues that need to be resolved and critical facilities that need to be developed or protected. The NDA then takes an NDA-wide view to see how similar problems could be solved collectively.

There is now Joint Regulatory Guidance on lifecycle management of HAW using Radioactive Waste Management Cases.[14] This is the overarching documentation that details the proposed lifecycle management of HAW and sets out the forward programme in safety and environmental terms. In support of the joint guidance, the first technical guidance modules were published in November 2008 for trial use including, 'Waste minimisation, characterisation and segregation' and 'Managing information relating to radioactive waste in the United Kingdom'.[15]

1.3 The Case for Change

In terms of developing credible strategic options that depart from the reference position for HAW management, there are two categories:

I. Alternative options that provide risk mitigation against the reference strategy in certain areas of HAW management.

II. Alternative options that provide a step change in benefits against the reference strategy position.

[13] See http://www.nda.gov.uk/documents/upload/WNM-PP-001-The-role-of-the-waste-hierarchy-March-2008.pdf,
[14] The management of higher activity radioactive waste on nuclear licensed sites. Part 1. The regulatory process. December 2007, HSE, EA, SEPA.
[15] See http://www.hse.gov.uk/nuclear/wastemanage.htm for further details.

Multi-site technical developments that reduce overall waste volumes, utilise existing assets, optimise future waste processing and storage or improve long-term performance are not considered as separate alternative strategic options. However, such opportunities are vital in delivering a robust reference strategy and where appropriate will follow the NDA's Strategy Management System.

The risk mitigation category is primarily aimed at specific high hazard legacy wastes, *e.g.* Sellafield Ponds & Silos, where a single step approach to retrievals and waste conditioning may prove to be very difficult or impossible in terms of managing existing facilities (asset care) and the ability to secure disposable waste products in a timely manner. Therefore the case for change in this scenario is based on initial overriding safety concerns and a progressive hazard reduction approach of waste retrievals and containerisation could be employed, with final conditioning being deferred until a later date (see Figures 1 and 2). During this deferral period continued engagement between the Regulators, SLC and NDA RWMD is required and an agreed forward programme put in place to underpin the interim state and final product form.

Within the HAW Topic Strategy this area is captured by the Wet ILW Topic Strand. For the Pile Fuel Cladding Silo Facility at Sellafield this approach is now the baseline position, where removal of waste from the silo will be into storage boxes, in an unconditioned form, pending the development and availability of a final conditioning route. For high hazard waste streams, ultimate geological disposal is UK Government Policy or in the case of wastes stored in Scotland, the long-term storage of immobilised wastes.

The second category refers to those waste streams where there are clear opportunities in terms of the long-term management. The HAW Topic Strategy will embrace these opportunities, within the Solid ILW and Graphite Topic Strands, where the key focus is on minimising the volume of waste. For example, in-situ decay storage of short lived-ILW (SL-ILW) to allow for future disposal in a suitable LLWR that may include passive safety regimes for existing facilities or major enhancements such as over buildings. This area could also consider decay storage opportunities that allow for a step-change in decommissioning approach due to a significant reduction in the level of radiation and allowing for easier plant access in the longer-term.

Figure 1 – Reference strategy for HAW management prior to final disposal

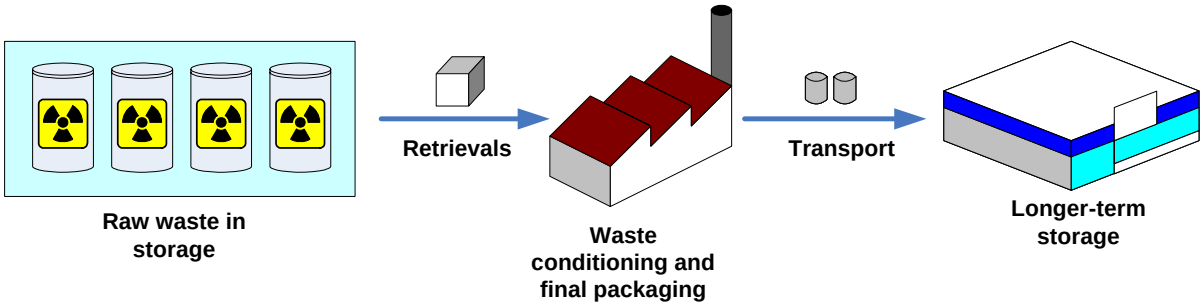
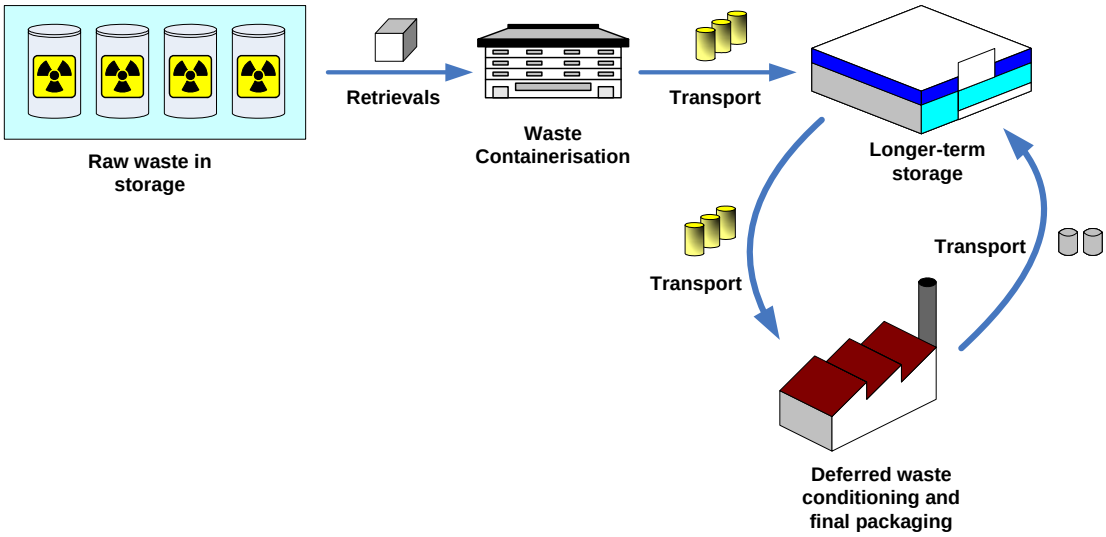


Figure 2 – Example of a containerisation strategy with deferred final waste conditioning



For some HAW streams an alternative approach to disposal could be adopted, especially when dealing with reactor decommissioning wastes (RDW), where the vast majority of material is bulk reactor graphite. The case for change is based on a number of features that make an alternative strategy worth exploring in detail:

- If RDW disposal can be decoupled from the main UK geological disposal programme then this could enable earlier decommissioning of Magnox reactors than presently allowed for in the site baseline plans (which show decommissioning over the decades following year 2040).
- Non-geological disposal could potentially provide advantages from the point of view of:
  - Overall environmental impact (including carbon footprint).
  - Cost, *e.g.* reduced ongoing running costs for Magnox sites.
  - Safety (including transportation safety if an on-site or near-site solution is pursued).
  - Decommissioning programme flexibility (as noted above), which could provide socio-economic benefits.

Keeping RDW out of the GDF could potentially reduce the volume demand on the ILW element of the facility by around one-third based on current waste packaging assumptions. Within the Governments' White Paper it was noted that alternative waste management options may be applicable to certain RDW streams and the example given was graphite reactor cores.[16] Potential approaches include, alternative GDF vault designs or disposal concepts for graphite; longer-term interim storage for SL-ILW and closer working with the

[16] See paragraph 3.16 A Framework for Implementing Geological Disposal, Managing Radioactive Waste Safely, June 2008, Welsh Assembly, BERR, Doeni, Defra.

Element 2 project for the LLWR.[17] Stakeholder engagement is an important part of the optioneering process that will include detailed discussions with the Regulators, SLCs, planning authorities and local communities that could be impacted by the options under consideration. Stakeholder engagement is an important part of successful development and implementation for new approaches to RDW long-term management.

Forward strategies for HAW may want to consider sub-categories of ILW where alpha and beta/gamma wastes are treated separately in terms of interim storage and disposal. For beta/gamma dominated wastes, decay storage may lead to step change in safety handling for short-lived species and perhaps trans-frontier shipments of beta-dominated wastes may be allowed where the concentrated waste form is returned to the waste owner and recovered 'clean' materials may be suitable for reuse or recycle. However, the impact of pursuing opportunities has to be considered from a lifecycle perspective where the value framework assessment tool needs to be applied.

For HLW there is no current requirement to move away from the baseline position of interim storage of the vitrified product followed by transport to the GDF for eventual disposal. The recent White Paper on 'A Framework for Implementing Geological Disposal' stated that:

'the UK Government sees no case for having separate facilities if one facility can be developed to provide suitable, safe containment for the Baseline Inventory. This is because the sharing of surface facilities, access tunnels, construction support and security provision could lead to significant benefits, including major cost savings and lower environmental impacts. There is no reason why this should not be technically possible, in theory, although the final decision would be made in light of the latest technical and scientific information, international best practice and site specific, safety and security assessments.'[18]

Tactics for HLW should concentrate on optimising processes especially when dealing with technical and Post Operational Clean Out wastes to ensure future decommissioning plans can proceed as expected. Another tactic to be considered is the location of the waste packaging plant for the disposal container where the current plan is to package the containers on Sellafield site. The alternative position is to locate the packaging plant at the GDF. For HLW disposal a number of alternative options could be explored, *e.g.* separate HLW disposal facility. However, the current Government position is for a co-located repository and no other strategic option will be explored unless directed otherwise.[19]

For overseas owned HLW the position is to return the waste to customers and to normally substitute the volume of overseas owned ILW with an agreed equivalent number of HLW containers. This is a commercial arrangement and no alternative strategic options will be explored.

[17] NDA is responsible for providing final disposal for NDA LLW and under the contract between NDA and LLWR Ltd. (1 April 2008) the work scope includes a key element of work ("Element 2") providing management solutions for LLW management across the NDA estate along with LLW strategy development and options studies. These activities and identified opportunities require integrated working with NDA to enable possible implementation conditional upon direction/authorisation by Ministers, BERR, Defra, Regulators and NDA.
[18] Paragraph 4.25, A Framework for Implementing Geological Disposal, Managing Radioactive Waste Safely, June 2008, Welsh Assembly, BERR, Doeni, Defra.
[19] Paragraph 4.24, A Framework for Implementing Geological Disposal, Managing Radioactive Waste Safely, June 2008, Welsh Assembly, BERR, Doeni, Defra.

1.3.1 Summary of strategic opportunities for HAW

The strategic opportunities for HAW can be summarised as follows:

- Alternative options that provide risk mitigation against the current baseline in clearly identified areas of HAW management.
- Alternative options that provide a step change in benefits against the current baseline position.

Another important aspect of the strategy is to support and improve the baseline plan by considering the following activities:

- Effective implementation of waste volume reduction initiatives.
- Optimisation of waste treatment and longer-term storage assets.
- Alternative waste packaging to support long-term performance, volume reduction and/or programme cost savings.

1.3.2 HAW Strategy Implementation

HAW Strategy development can be broken down into three broad areas:

- Realising strategic opportunities
- Mitigating strategic risks
- Baseline improvements (NDA integrated waste management solutions)

To deliver programmes of work against each of these areas the NDA will use the following mechanisms to ensure progress will be made:

- NDA Strategy Development Working Teams (SDWT)
- Site strategic specifications
- An individual NDA strategy team task

The SDWTs are NDA led projects that will underpin HAW Strategy development or integrated solutions that could lead to significant benefits. The SDWTs normally include membership from the relevant SLCs, NDA, NDA RWMD and other waste owners. The SDWTs will also seek frequent and effective engagement with the Regulators.

The site strategic specifications will be used to ensure strategic compliance and instigate projects where there is a single SLC issue (or a lead SLC has been identified). Through the site specifications the need to explore local contingency or opportunity options (or requires a strategic baseline change) will be identified.

1.4 Aspirational outcomes

In terms of strategy, HAW is a complex area due to the very wide variety of waste streams to be considered over a substantial time period, especially when GDF operational timescales and long-term storage are included. However, the description of the reference strategic aim is relatively straight forward:

"The current reference strategy for HAW is to achieve passive safety as soon as reasonably practicable, for longer-term storage and eventual disposal, or long-term management in near-surface facilities for wastes in Scotland. Depending on the timing of waste arisings a period of some decades of interim storage may be required."

The aspirational outcome for this Strategy is five-fold:

- In the majority of cases, to actively pursue the reference strategy and adopt UK-wide approaches to waste management.
- To support key risk and hazard reduction initiatives by enabling a flexible approach to long-term waste management.
- When considering the development of alternative strategic options, the HAW Strategy will be flexible to accommodate different timescales for Topic Strands or tactical individual waste stream area development, *e.g.* ion-exchange resins, fuel element debris.
- Where appropriate, interim storage and waste-processing facilities to be considered as NDA-wide assets rather than the current default position of 'local site only' usage.
- Support Scottish Government Policy for HAW and exploring options for near surface disposal of certain HAW wastes in the NDA estate, *e.g.* Reactor Decommissioning Wastes.

The main aim of the Wet ILW (potentially mobile) strategy is to effectively deal with the UK's civil nuclear waste legacy by converting raw HAW into a form that is suitable for long term storage or disposal. This Strategy would then significantly reduce both risks and hazards associated with continued raw waste storage that often rely on active management systems within ageing facilities. This is not an aspirational outcome but rather a requirement to ensure a robust long-term position is achieved for HAW.

For some historical wastes there is a necessary outcome where an initial risk reduction waste containerisation process is followed by a separate final waste conditioning step. Such an approach is being addressed on a case-by-case basis and an overall NDA-wide approach would not be appropriate due to the specific circumstances requiring attention.

The Solid ILW and Graphite strategies will explore alternative options where the aspirational outcomes include:

- To challenge and move away from the default assumption that all these materials will be transferred to the GDF by:
  - Waste characterisation and possible recategorisation.
  - Exploring alternative treatment, storage and disposal routes that will optimise the volumes of wastes being transferred to the GDF.

- To challenge the current design of the GDF and to optimise waste packaging and geological disposal scenarios for any decommissioning wastes.

However, it should be noted that ultimately some solid ILW and graphite wastes will be transferred to the GDF.

For HLW the aspirational strategic outcome is that the current baseline should be followed, where the liquid highly active liquor is converted into a safe passive form. The current planning assumption is that the vitrified HLW will be transferred to the GDF from 2075. However, this planning assumption will be challenged and the NDA will consider earlier waste transfer opportunities, which will need to fully understand any safety, environmental, disposability and cost issues.

1.5 Scope and boundaries of proposed change

HAW can be divided into four main categories of waste;

- Wet ILW
- Solid ILW
- Graphite
- HLW

In the context of the HAW Topic Strategy it is also appropriate to address waste management issues associated with interim storage and disposal. Interim storage will cover waste characterisation, processing and storage (including package performance) within long-term engineered facilities. Disposal will need to include store export scheduling, acceptance criteria for disposal facility and environmental safety case(s).

1.5.1 Wet ILW/potentially mobile wastes

Within this Topic Strategy wet ILW is defined as potentially mobile material that is stored currently in aqueous conditions or dry materials that are potentially mobile or friable. An initial assessment by NDA has shown that wet ILW accounts for approximately 30% of the total ILW inventory by packaged volume, although this figure will be subject to change.[20] Within the NDA's hazard baseline project,[21] potentially mobile has been described as:

Any material that has a form factor of gas, liquid, watery sludge and floc, other sludge, powder or loose contamination as detailed in EGR009, 'The Radiological Hazard Potential, A Progress Measure For Nuclear Clean Up'.

These materials are often heterogeneous waste streams stored in historical facilities that in some circumstances require urgent attention in terms of materials retrieval and engineering containment, in particular, Legacy Wastes on the Sellafield and Dounreay sites. The strategic drivers for wet ILW centre on hazard and time critical risk reduction and the Topic Strand is also split into two areas; interim storage and disposal. Within this Topic Strand the *'two-step*

[20] NDA UK National Waste Inventory 2007 initial analysis based on proposed HAW groupings. Will be subject to change.
[21] http://www.nda.gov.uk/documents/upload/EGG_06_Hazard_Baseline_Specification_rev_1.pdf

approach of waste retrievals and containerisation, with final conditioning being deferred until a later date' will be investigated on a case-by-case basis, as the main concerns centre on individual facilities. A third and equally important element of work will also consider NDA-wide issues including long-term package performance and tactics such as NDA-wide technical waste treatment solutions. Furthermore, these streams may contain chemically reactive species such as aluminium, Magnox and uranium. Typical wet ILW streams include the following:

- Magnox sludges
- Fuel debris
- Ion-exchange resins
- Desiccants
- Sand
- Corrosion and degradation products
- PCM
- Raffinates

Operational wastes already conditioned in storage, which contain reactive metals, will be closely monitored under this Topic Strand, *e.g.* MEP drums at Sellafield.

1.5.2 Solid ILW

Solid ILW mainly refers to wastes where long-term wasteform evolution is less of a concern when compared to wet ILW streams. Solid ILW is generally chemically benign; the raw form is relatively immobile and tends to be at the lower end of the ILW radioactive spectrum. These wastes are also more easily characterised and easier to package for interim storage and eventual disposal. Solid ILW accounts for approximately 40% of the total ILW inventory by packaged volume.[22] Sorting and segregation of these wastes should generally be straight forward, however, safety and environmental issues remain the topic priority. Typical solid ILW streams include the following:

- Concrete/rubble
- Activated steel
- Lead
- Sources
- Miscellaneous beta-gamma waste

In terms of alternative disposal options, the focus of the strategy will be on RDW.

[22] NDA UK National Waste Inventory 2007 initial analysis based on proposed HAW groupings. Will be subject to change.

1.5.3 Graphite

Within the UK there are large quantities of irradiated graphite present in advanced gas-cooled (AGR), Magnox and test/prototype reactors. There is approximately 60,000 tonnes of graphite on Magnox sites alone, where bulk graphite waste streams account for approximately 30% of the total LLW and ILW volume destined for geological disposal. [23] The present baseline strategy is reactor Safestore followed by the conditioning of the waste into a disposable form and then export to the GDF for England and Wales or long-term management in near surface facilities for wastes in Scotland. Alternative waste management solutions could substantially reduce the volume of graphitic wastes that are currently planned to go to the GDF.

Irradiated graphite contains a number of active species including ^{3}H, ^{14}C, ^{36}Cl, ^{55}Fe, ^{60}Co and ^{63}Ni. Also, a proportion of the graphite waste will be contaminated with fission products and actinides as a consequence of fuel element failures. The long-lived radionuclides ^{14}C and ^{36}Cl will be particularly significant when making a safety case for geological disposal. In contrast the short half-life radionuclide ^{3}H (12.3 years) and irradiated steel components such as pins, seals and wires (which can also be associated with some graphite waste streams), are significant for packaging, transport and storage safety cases.

The majority of the graphite will arise as a result of reactor decommissioning at NDA and EdF Energy sites, although graphite wastes also arise on sites in the form of operational wastes. Graphitic operational wastes are usually in the form of intact or fragmented reactor sleeves, struts, dowels or boats and have been stored in a number of facilities, *e.g.* solid waste vaults or silos. Operational graphite wastes may also be associated with irradiated steel items. It should be noted that certain sites have specific graphite waste management concerns. For example, with Windscale pile graphite there are concerns over possible Wigner energy release during waste conditioning and storage. This particular issue is being dealt with at the site level, although local conditioning and packaging solutions must be considered as part of the overall NDA Graphite Strategy.

The major graphite streams to be covered by this Strategy include;

- Magnox reactor graphite.
- Windscale pile graphite.
- Graphite fuel element debris at Hunterston A and Berkeley.
- AGR graphite sleeves stored at Sellafield.

It is also recognised that other smaller volume graphite waste streams will need to be dealt with, *e.g.* Dounreay reactor graphite.

1.5.4 High Level Waste

HLW has been defined in *section 1.1.2*. The HAW Strategy Topic will cover the relevant HLW areas namely:

- UK owned HLW including interim storage and disposal.

[23] NDA UK National Waste Inventory 2007 initial analysis based on proposed HAW groupings. Will be subject to change.

- Overseas owned HLW.
- HLW waste substitution of overseas owned ILW.

1.5.5 Thorium products

Within the SMS programme, thorium products will be considered within the HAW Topic Strategy, although thorium contaminated materials (TCM) are already included as these materials are already declared as wastes. Thorium products cover unirradiated and irradiated metal, oxide and nitrate materials. The volume of material within the inventory is relatively very small and is presently considered as a *nuclear material*. However, the NDA baseline position for thorium is material conditioning and packaging for disposal or long-term storage and therefore is already aligned to waste strategy.

1.5.6 Summary

In summary, the HAW Topic Strategy is to convert the HAW inventory into a form that is suitable for storage and disposal, reflecting current Government policies and the principles of the Waste Hierarchy. To help address the HAW waste management lifecycle the lower level Topic Strands will be divided into interim storage and disposal areas that account for the major waste stream areas. Therefore, ten topic strands have been identified, which cover all the strategy-linked work streams and they are:

HAW Topic Strand	Strand Objective
Wet ILW – Interim storage	To ensure safe and robust interim storage arrangements of wet ILW until it has been exported to the GDF
Wet ILW – Disposal*	To ensure the safe and effective disposal of wet ILW
Solid ILW – Interim storage	To ensure safe and robust interim storage arrangements of solid ILW until it has been exported to the GDF
Solid ILW – Disposal*	To ensure the safe and effective disposal of solid ILW
Graphite –Interim storage	To ensure safe and robust interim storage arrangements of graphite until it has been exported to the GDF
Graphite – Disposal*	To ensure the safe and effective disposal of graphite
UK owned HLW – Interim storage	To ensure safe and robust interim storage arrangements of HLW until it has been exported to the GDF
UK owned HLW - Disposal	To ensure the safe and effective disposal of UK owned HLW
Overseas owned HLW	To ensure the safe and effective disposition of overseas customers owned HLW
Overseas owned ILW	To ensure the safe and effective disposition of overseas customers owned ILW

** or long-term management in near-surface facilities for wastes in Scotland*

In summary, the overall objective is to:

Treat and package HAW and place it in safe, secure and suitable storage facilities until it can be disposed of, or be held in long-term storage in the case of a proportion of HAW in Scotland.

A summary of the process that has identified the 10 topic strands is shown in ***Appendix 2***. An overview of the proposed waste groupings for each major waste category is shown in ***Appendix 3*** and will be subject to change.

1.6 Constraints

The HAW Topic Strategy will comply with current Government policy (see *section 2.2* for further detail). Alternative disposal options only apply to RDW at this stage and will take into consideration the CoRWM recommendations and in particular recommendation 8.[24] Important strategic constraints include the following and should be taken into account throughout the SMS development programme:

- Available timescales for implementation, *e.g.* NII Licence Instruments, key programme decision points
- Affordability and overall lifecycle costs
- Planning assumptions and constraints

1.7 Interfaces with other topic strategies

The HAW Strategy will influence a number of other topic strategies. Some of these interactions are at a fundamental level and these have been termed primary interactions. Others are a secondary affect as a result of either certain options being chosen or from the introduction of additional scope into LTPs.

1.7.1 Primary Interfaces

Lower Activity Wastes (LAW)

There is a strong interaction with the LAW area, as the management approach to the low-end of ILW will be similar to LLW management. In addition, the baseline strategy for HAW is to actively explore opportunities of waste re-categorisation by decontamination, decay storage, accurate waste assessments that will lead to an overall increase in LLW volumes. It has also been noted that some LLW, *e.g.* bulk reactor graphite; is destined for the GDF although alternative treatment and disposal options are being explored. Both strategies also embrace the Waste Hierarchy.

Spent Fuel Strategy

The current baseline position for the GDF is that any spent fuel (for disposal) and HLW are being considered as part of the same disposal concept. The storage arrangements for spent fuel will need to be monitored by the HAW Topic Strategy, as similar principles will apply. Legacy fuels require close attention by both HAW and Spent Fuel Strategies. Currently, legacy metal fuels at Sellafield remain within the HAW Strategy but it may be transferred to the 'Exotics' Topic Strategy if deemed appropriate.

Transport and Logistics Strategy

Transport is an integral part of the waste management lifecycle. The availability of transport routes is an essential part of any treatment, storage and disposal routes especially when dealing with UK-wide solutions. Logistics will also allow the NDA to optimise its waste export

[24] CoRWM document 700, Managing our Radioactive Wastes Safely, CoRWM's recommendations to Government, July 2006.

scheduling (the programme for transferring waste from storage to the GDF) with respect to road and rail travel and potentially consideration of sea transport around the UK.

Decommissioning

There is a need for close working between the HAW and Decommissioning Strategies as they are both intrinsically linked. The timescales for the decommissioning of existing facilities and clean up operations have a direct impact on HAW management and the alternative strategic options that could or must be explored. Historical facilities at Sellafield are the prime example where the baseline HAW risk and hazard reduction strategy may not be possible in a single step and near-term retrieval programmes followed by deferred product encapsulation could be the preferred route. This approach is already being adopted for certain Wet ILW streams.

Asset management

This is an essential support strategy for the HAW area. Asset management programmes have a direct link *via* a number of programmes including asset care of existing raw waste storage facilities, care and maintenance programmes for longer-term interim stores and the successful implementation of the Safestore Strategy for Magnox reactors.

Research and development

The development of alternative HAW strategies will require underpinning R&D and this will be achieved *via* the SLC R&D programmes and the NDA's Direct Research Portfolio. NDA-wide baseline improvement initiatives are often supported by R&D. The HAW Topic Strategy owner is an active member of the Industry's Nuclear Waste Research Forum.

Information

Effective and robust information and knowledge management systems are necessary for the development of alternative HAW strategies or the implementation of the baseline plan. A key area is the National Inventory and the development of next generation inventory query tools. Furthermore, knowledge retention over very long timescales, *e.g.* many decades, is an essential consideration.

1.7.2 Secondary Interactions and Opportunities

Uranium and Plutonium

Some of the options under consideration may offer opportunities in terms of co-disposal of wasteforms such that other wastes or uranium could potentially be co-disposed with plutonium. Examples of this could be use of depleted uranium in the fabrication of low specification MOx or the co-disposal of plutonium in ILW waste forms as part of the encapsulation in cement options. These issues will be explored further during the decision making phase to determine whether there is benefit in pursuing this approach.

Funding

The alternative strategies could result in a significant decrease in costs when compared to the current baseline. Some strategies may be cost neutral or even result in cost increase but demonstrate clear benefits through the Value Framework process, where affordability will need to be taken account of. Ultimately the phasing of the implementation of any alternative and baseline options will be determined *via* the NDA prioritisation process, which takes cognisance of the safety and security impacts and which will show the priority of executing alternative HAW strategies against other activities and when funding is available.

Skills

Execution of these strategies will require people with a waste management skill base. The timing and execution of the required skill sets is vital to the success of the HAW management. This should be an important consideration in the funding of future work programmes. HAW management is a long-term venture where inter-generational issues, including skills retention, need to be addressed.

1.8 Key risks, issues and assumptions

The main risks, issues and key assumptions associated with the development of the HAW Topic Strategy are as follows:

1.8.1 Risks

- Unable to demonstrate to the Regulators' satisfaction the safety and environmental cases for alternatives, especially when immediate risk reduction issues are pending.
- Knowledge management and information system tools are not adequate to ensure knowledge retention and the ability to support accurate and detailed strategic optioneering and scenario planning.
- Increased prioritised funding that will result in the deferral of alternative strategic opportunities being pursued.

1.8.2 Issues

- The parallel implementation of UK and Scottish HAW long-term management policies. For example, Scottish Policy may result in a different approach to storage for a proportion of HAW where either a store replacement programme is required or new innovative designs for long-term storage are adopted, *e.g.* up to 300 year design lives.
- Correct level of funding to ensure the high importance areas are developed fully to enable site implementation. R&D is an essential component of this work.

1.8.3 Assumptions

- For ILW in England and Wales the planning assumption is that the GDF will be operational from 2040.
- For HLW, the planning assumption is that the GDF will be operational from 2075.
- For all HAW the Letter of Compliance will be followed by all waste producers and owners.
- Any delays to the GDF programme will not have an impact on the approach to longer-term interim storage. There will be no significant delays in the GDF programme, *e.g.* > 2100.

2 Stage A - Credible Options

The Topic Strategy for Higher Activity Wastes (HAW) needs to consider how HAW will be managed to protect people and the environment and the rate at which long-term management solutions or any interim storage state will be achieved. The HAW Topic Strategy has a number of key interfaces with other Topic Strategies where the implementation of any alternative strategic option will need to consider the overall lifecycle impact. The focus of the strategy is ultimately to support the NDA's mission of hazard reduction whilst addressing programme value and the effective application of the waste management hierarchy.

The aim of Stage A is to detail a list of approaches that can credibly deliver the objective, which is for HAW:

Treat and package HAW and place it in safe, secure and suitable storage facilities until it can be disposed of, or be held in long-term storage in the case of a proportion of HAW in Scotland.

Individual Topic Strand objectives are shown in section 1.5.6.

The UK, Welsh and Northern Ireland Government's deep geological disposal programme and the Scottish Government's policy of long-term management in near-surface facilities have provided the policy framework for the NDA's HAW Topic Strategy. Therefore all the credible options identified here comply with Government expectations. In developing the alternative HAW Topic Strategy credible options the following screening criteria were observed:

- Alternative disposal facilities only apply to Reactor Decommissioning Wastes at this stage, *i.e.* Graphite Topic Strands and certain waste streams within the Solid ILW Topic Strand.
- The requirements of the Governments' White Paper on 'A Framework for Implementing Geological Disposal'.
- Scottish Government Policy on long-term management of HAW.
- No international disposal options to be considered.
- Where appropriate, any agreed interim solutions must not foreclose future options for final waste conditioning.

Baseline improvement projects for the HAW Topic Strategy will also take into consideration the following:

- NDA's UK HAW Storage Review.
- CoRWM's Interim Storage Review.
- Government's response to CoRWM's Interim Storage Review.

As the credible options are developed in detail, a number of relevant factors will need to be taken into consideration and include:

- Regulatory frameworks.
- Financial resources and cost of implementation (of a particular HAW strategy).

- The key interfaces with other NDA Topic Strategies.
- Health, safety and environmental impact.
- Knowledge management and human resources.
- Social impacts and stakeholder involvement.
- Suitable technologies and impacts.
- Long-term uncertainties.

As already stated in section 1.5.6, the HAW Topic Strategy is broken down into 10 Topic Strands where the strategic objective refers to the reference position. HAW Topic Strategy 'credible options' are shown in ***Appendix 4***, which have been discussed and presented to the Government's Waste Management Steering Group, the Regulators, NDA SLCs and other waste owners. Further detail on each of the credible options to be pursued within each Topic Strand can be found below.

2.1 Wet ILW – Interim storage

The Wet ILW Topic Strand is mainly focussed on supporting the decommissioning and clean-up of historical facilities especially at the Sellafield site. The strategic aim is to condition all waste arisings into a final disposable form that is safe to store, safe to transport between sites and where applicable, is safe to transfer to the GDF. As well as the interim storage facilities, this Topic Strand covers the waste packaging plants (including any required buffer storage).

The strategic assumption is that the waste will be retrieved and conditioned into a form that is suitable for long-term management. A proposed solution contrary to this stated assumption is not considered as a credible option, *e.g.* long-term storage of raw ILW in ageing facilities. Any necessary raw waste storage facility enhancements will be covered by the Decommissioning and Asset Management Topic Strategies. Any pre-treatment needed within these existing facilities to aid retrieval and final decommissioning, must consider the effect on the resulting waste form and future waste conditioning processes. Any change to this strategic position will involve explicit Regulator support and NDA approval.

For certain waste streams, where the case has been justified, the SLC may adopt a progressive risk and hazard reduction approach where more than one step may be used to achieve the final conditioned waste form (see *section 1.3* for further detail). The first step will normally involve retrieved raw waste emplaced in stainless steel containment within a modern engineered facility. After a period of further storage the waste will be retrieved once more and conditioned into a final disposable form and placed back into storage. Subject to a specific safety case being made and further NDA scrutiny, the final conditioning step could be made at the end of the interim storage period immediately prior to GDF transfer.

For a small number of waste streams decay storage to allow for disposal at a LLW repository may be possible. For example, Magnox are exploring the decay storage of desiccant wastes and therefore this is included as a credible option. The length of the storage period will be dependent on the required time to allow for a waste category change and normally will have to occur within the site end date unless a strong case can be made for changing the agreed date. Otherwise, a waste transfer to another site that has an extended institutional control period may be considered.

2.2 Wet ILW - Disposal

No other alternative strategic option is to be explored for bulk wet ILW streams at this time. The reference strategy is to transfer packaged waste to the GDF or to be placed in a near surface storage facility in Scotland.

2.3 Solid ILW – interim storage

The Solid ILW Topic Strand is focussed on strategic opportunities and includes non-graphite RDW. The reference strategy for solid ILW is that waste should be conditioned into a disposable form and placed into storage. This may include the option of a deferred final conditioning step if a safety and strategic case can be made, *e.g.* Miscellaneous Beta-Gamma Wastes (MBGW) at Sellafield. For wastes arising after the GDF becomes operational the material will be packaged and transferred directly to the GDF. Some storage buffering capability will be expected as part of the strategic approach. Typical streams include Magnox Final Site Clearance (FSC) wastes, *e.g.* fuel stringer debris and activated metals, and decommissioning wastes at Sellafield.

Alternative interim storage options will explore options that will aid waste recategorisation, for example:

- ILW to LLW decay storage, or
- Support a flexible approach to decommissioning including continued *in-situ* storage or making building enhancements to allow for continued safe storage.

Building enhancements will include all the waste preparatory work to meet safety case requirements. *In-situ* storage is where building enhancements are required and the contamination is fixed within the engineered structure. For RDW in particular the NDA will seek opportunities for the decay storage of reactor steel to produce LLW products, or even recyclable metal. Decay storage opportunities will need to result in a step-change in management approach, *i.e.* remote handled to contact handled ILW or a waste management route (disposal to a LLW repository).

Solid ILW also takes account of any thorium oxide material that is in a non-dispersible form. All other thorium materials are covered within the Wet ILW Topic Strand. However, it is recognised that thorium material reuse may be possible but it would be subject to strict safeguard protocols. If NDA decided to pursue such an option it would seek approval from the appropriate authority before undertaking such work.

As well as the interim storage facilities, this Topic Strand covers the operation of waste packaging plants (including any buffer storage) and all wastes to be stored *in-situ* for a prolonged period, *e.g.* > 50 years.

2.4 Solid ILW – Disposal

The reference strategy for solid ILW is:

- to transfer all packaged wastes to the GDF, or

- for wastes stored in Scotland the packaged wastes will involve long-term near surface storage or, for a portion of the waste, it may be possible to transfer to a near-surface disposal facility assuming a safety case can be made.

As with the Graphite Topic Strand, the overall aim is to minimise the volumes of ILW destined for geological disposal by fully utilising existing or planned alternative disposal routes. The strategy will consider the waste management hierarchy and will include:

- exploring the option of decay storage, where short-lived ILW streams have been identified within the inventory;
- investigating alternative disposal options for RDW.

2.5 Graphite – Interim Storage

As described in section 1.3, the Graphite Topic Strand is of strategic significance for two main reasons:

- The large volume of wastes to be packaged.
- The opportunities for investigating alternative disposal options.

The current reference strategy for the interim storage is split into two main areas:

- Waste arising before GDF operations will be packaged into a form suitable for storage within a modern engineered facility. This may include the option of a deferred final conditioning step if a safety and strategic case can be made, *e.g.* AGR graphite sleeves at Sellafield.
- For Magnox reactors the waste will remain *in situ* until long after geological disposal is available. This *in-situ* storage position is known as the Safestore concept and is subject to a safety case being made.

Alternative strategic credible options for storage will centre on the possibility that Safestore may not prove to be the preferred option and that there is a risk that the reactors will be required to be dismantled earlier than expected and the waste arising will be packaged and placed into longer-term storage.

Within the NDA estate test reactor cores have been dismantled, *e.g.* WAGR, and the graphitic waste is in storage. Alternatively, other graphite core reactors are in the process of being dismantled, or are awaiting final dismantling. For Magnox reactors awaiting final dismantling the reference strategy for these future graphite streams is *in-situ* storage recognising that other solid ILW streams will need to be considered. RDW wastes on the Magnox sites will only be covered by this strategy during the Care & Maintenance (C&M) phase.

2.6 Graphite – disposal

In February 2011 the NDA published a summary paper on the long-term management of graphite wastes.[25] The following high level strategic options for the management of graphite have been identified:

- *Option 1 - Manage all graphite waste as ILW and ensure the geological disposal facility caters for the large volumes of material. This is the baseline option.*
- *Option 2 - Condition graphite waste to enable disposal at LLWR.*
- *Option 3 - Condition LLW and/or ILW graphite waste to remove most of the contamination and release as "exempt waste" or reuse the graphite where possible.*
- *Option 4 - Separate disposal facility (or facilities) for graphite wastes, including a near surface disposal option and may include a pre-treatment step.*

The NDA Strategy published in March 2006[26] and the current NDA business plan[27] both made a commitment to explore management and treatment options for reactor graphite waste. CoRWM's recommendation on reactor decommissioning wastes in 2006[28] and Government's response[29] (reproduced below) also recognised the need to examine alternative solutions for all wastes arising from reactor decommissioning.

CoRWM Recommendation 8:

In determining what reactor decommissioning wastes should be consigned for geological disposal, due regard should be paid to considering other available and publicly acceptable management options, including those that may arise from the low level waste review.

Government's Response:

Government accepts this recommendation. The NDA will review whether a safety case could be made for other non-geological disposal of reactor decommissioning wastes, including on-site, or near-site, disposal in order to minimise transport. In doing this it will take account of the outcome of the Government's Low Level Waste management policy review, as well as public and stakeholder views. The NDA will use the outcome of these reviews, which will be published, in developing its outline geological disposal implementation plan.

In response to all of the above statements NDA launched the Reactor Decommissioning Wastes project in 2009. This project examines the hazard reduction and potential cost or other benefit of options of alternative management of reactor decommissioning waste. This focuses on Magnox reactors in the NDA estate, but in considering the position with regard to the large waste graphite liability, also takes account of the eventual decommissioning of graphite moderated AGR reactors owned by British Energy.

[25] Reactor Decommissioning update, Summary of options for Waste Graphite, L Hughes & M Clark, February 2011, see www.nda.gov.uk
[26] http://www.nda.gov.uk/documents/loader.cfm?url=/commonspot/security/getfile.cfm&pageid=4957
[27] http://www.nda.gov.uk/loader.cfm?csModule=security/getfile&pageid=28874
[28] CoRWM document 700, Managing our Radioactive Wastes Safely, CoRWM's recommendations to Government, July 2006.
[29] http://www.defra.gov.uk/environment/radioactivity/waste/pdf/corwm-govresponse.pdf

The current strategy for graphite is to retrieve it following a period of reactor Safestore and package it for disposal in the GDF. This is still a valid option for graphite in England and Wales.

The current position is as follows:

- The baseline approach for England and Wales (geological disposal) remains in place.
- Work to date has shown that there is merit in continuing to examine alternative options using technical studies.
- The current focus is on examining the feasibility of near surface disposal of sleeve graphite at the Hunterston A site.
- NDA continues to work with the Scottish Government in support of its HAW policy.

2.7 High Level Waste – All HLW Topic Strands

The reference strategy is the only option to be followed for all four HLW Topic Strands and reflects the maturity of the programme with the interim storage strategy being implemented at Sellafield. The alternative option that may be explored in the future is the possibility of a separate HLW disposal facility. However, to explore an alternative disposal scenario would require a specific instruction. Overseas owned ILW is included in the HLW Topic Strands area, as ILW will be normally substituted with an agreed amount of vitrified HLW product based on radiological equivalence but is subject to agreed commercial arrangements. UK title to overseas owned HLW is not being considered, as the residues returns programme[30] has commenced and any change to this position would also require Government instruction.

This Topic Strand only covers the HLW vitrified product and excludes the Sellafield high-level waste plants. There is no HLW in Scotland and therefore new Scottish Policy does not apply to these Topic Strands except for small amounts of overseas owned ILW at Dounreay, which will be subject to the outcome of the joint Scottish and UK Government consultation.[31]

2.8 Baseline improvement initiatives

As already noted in *section 1.3.2*, the NDA will take a leadership role in driving significant baseline improvement initiatives that involve multiple sites or where appropriate, other waste owners. The NDA has already instigated a number of SDWTs (see section 2.11) and will continue to actively engage with key stakeholders to explore what other multi-site opportunities should be pursued.

NDA will consider waste processing and storage as a NDA-wide asset whereupon ILW movements between the sites could become normal practice and should:

- reduce the number of waste packages and storage facilities.

[30] See articles: http://www.sellafieldsites.com/news/2009-11-25/return-of-highly-active-waste--the-journey-begins- and http://www.nda.gov.uk/news/vvrprogramme.cfm
[31] See http://www.scotland.gov.uk/Publications/2010/12/03093403/0

- provide a central or regional facility for decay storage.
- where appropriate, enable early site clearance initiatives.

The SDWTs will need to take into consideration SLC activities including new storage and packaging concepts such as thick-walled cast-iron containers, *e.g.* Ministores, and the need for an accelerated Standard Waste Transport Container (SWTC) programme.

2.9 New Scottish Policy on HAW management

The Scottish Government published its Policy on HAW in January 2011.[32] The Policy is for long-term management in near-surface facilities and section 1.19 states that: *'Facilities should be located as near to the site where the waste is produced as possible. Developers will need to demonstrate how the facilities will be monitored and how waste packages, or waste, could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.'*

The following policy statements are highlighted as they relate to; disposal solutions, long-term storage and baseline improvement initiatives such as waste processing and storage consolidation opportunities:

Section 2.04.03 – *'There remains uncertainties as to how to deal with much of the waste, therefore the Scottish Government Policy at the present time is that long-term storage is still the primary long-term management option. However, recognising that there have been technological developments which enable treatment of some radioactive waste, primarily to reduce volumes, the Scottish Government Policy enables such options to be considered. Similarly, there are international examples of near-surface disposal facilities for radioactive waste that is similar to some of the waste we have in Scotland. The Scottish Government Policy is consistent with such international approaches.'*

Section 2.04.04 – *'In line with waste management principles, notably the Waste Hierarchy and the Proximity Principle, the Policy requires that the waste should be dealt with as close as possible to the site where it is produced. This means that long-term radioactive waste management facilities should be as near to those sites as practicable so that the need to transport the waste over long distances is minimal.'*

Section 2.04.22 – *'In circumstances where the waste needs to be transported for storage at a site near to but other than other than one on which it was produced, it will be for the waste producers and owners to determine, to the satisfaction of the regulators, the implications of transportation.'*

Section 2.04.30 – *'The Policy does not specify what a disposal facility should look like or how it should be constructed. It also does not specify a specific depth for near-surface as this will need to take account of the geography and geology of the location for any facility. This is consistent with the GRA approach and reflects international examples of near-surface disposal facilities. The presumption in the Policy is that a disposal facility will be as near to the surface as practicable taking account of all factors.'*

[32] Scotland's Higher Radioactive Waste Policy 2011, The Scottish Government, Edinburgh 2011, see http://www.scotland.gov.uk/Publications/2011/01/20114928/0

Scottish Government will lead the Implementation Strategy process[33] and where appropriate, the NDA will support this process including membership of the Project Board. Lifetime Plans for NDA Scottish Sites will need to be reviewed and updated to take account of Scottish HAW Policy. The alternative disposal and baseline improvement options, *e.g.* thermal treatment, decay storage and graphite management, being explored by this strategy will help to support Scottish Government Policy.

2.10 Stakeholder Engagement Plan

The reference strategy for HAW has been established for sometime *via* the extensive CoRWM programme and Government Policy related to HAW. The UK HAW Storage Review also included an initial stakeholder engagement programme on the issues and opportunities associated with the baseline position. The main purpose of this document is to present the case for alternative strategies for specific nominated waste areas, which are suitable for alternative disposal routes or storage arrangements. Engagement with key stakeholders will primarily occur through existing arrangements, *e.g*. Government and Regulator interface meetings, and broader engagement will be managed *via* the National Engagement Plan.

CoRWM is also a key stakeholder and NDA is keen to continue active engagement especially in the following areas:

- Interim Storage & HAW Topic Strategy
- R&D
- Transport

Engagement with the planning authorities will be co-ordinated *via* NuLeAF and SCORRs.

As the HAW Strategy develops it is envisaged that separate issue specific workshops will be held and involve engagement at a local or regional level. Each NDA SDWT will produce its own Stakeholder Engagement Plan and it is the responsibility of the project manager that an effective plan is in place and is being implemented.

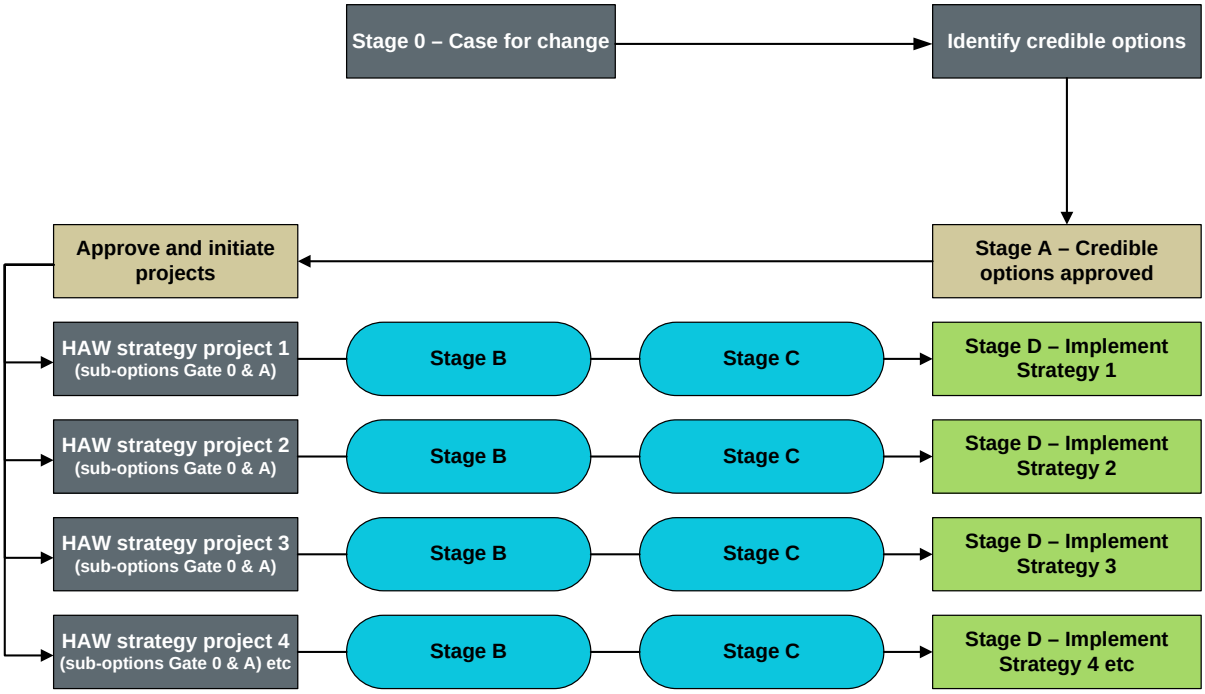
2.11 Work programme and scope

Going forward the HAW Topic Strategy will be pursued on a project-by-project basis where each Strategy Project manager is responsible for preparing a NDA Strategic Business Case and ultimate SMS sanction to allow for baseline change control and implementation. A Project may address a whole Topic Strand or a particular Waste Grouping(s) within a Topic Strand. However, the strategy need must be at the NDA level and not at a site tactical level, as this is the responsibility of the individual SLC. Likewise, a HAW Strategy Project may include a major multi-site baseline improvement initiative that requires direct input from the NDA. In might be appropriate for a project to highlight a long-list of possible options and follow the SMS process from Gate 0. To be successful each project will be given the right level of resource, and effective Regulator engagement is a prerequisite. The strategic

[33] See section 3.02, Scotland's Higher Radioactive Waste Policy 2011, The Scottish Government, Edinburgh 2011, see http://www.scotland.gov.uk/Publications/2011/01/20114928/0

framework is now established and a change control process will be used when a strategic update is required. The figure on the next page is a summary of this approach.

The NDA has initiated a number of projects that are addressing the main strategic opportunities and multi-site major baseline improvements. As already highlighted, the strategic opportunities refer to options that will mainly investigate alternative disposal routes for RDW. The NDA has also in place an Integrated Project Team (IPT, now known as SWDT) on RDW. The project will also explore decay storage opportunities for RDW, although other waste streams will be considered as part of the overall HAW Topic Strategy programme. The strategic risk areas tend to be SLC specific and will be mainly progressed *via* the individual site programmes.



HAW Strategy Project may be delivered by:

- NDA Strategy Working Team
- SLC specific project via Site Strategic Specifications
- NDA Integrated Waste Management specific task/project

The third area is baseline improvement where the NDA will take the lead in developing new waste management integrated solutions for HAW. HAW themes drawn from the 2008 Integrated Waste Strategy documents prepared by the NDA sites are summarised in the table in ***Appendix 5***.[34] The NDA is therefore exploring the possibility of developing alternative waste processing capabilities. The main focus is currently thermal treatment, which could lead to significant waste volume reductions and/or increased waste passivity. The Thermal Treatment SDWT is developing a detailed business case that is required to demonstrate the benefits of thermal treatment and is considering potential Sellafield waste streams. If

[34] NDA Theme paper, P Davies, Integrated Waste Management: an overview, December 2009

appropriate, the introduction of further business cases, which would include other waste producers, should be separate parallel activities.

A third SDWT is also in place, which was highlighted in the Government's response to CoRWM's report on Interim Storage and is covering the following issues; package performance of conditioned wastes in longer-term storage, store longevity, storage environmental conditions and store consolidation opportunities.

New SDWTs will be initiated as the HAW Topic Strategy programme matures and will contain projects investigating the credible options in detail and securing a preferred approach ready for implementation and further baseline improvement initiatives where the following criteria are met as a minimum:

- Alignment with HAW Topic Strategy objectives.
- Broad support gained from SLCs, RWMD, Regulators and Government.
- Secure Project Mandate from either NDA accountable person or if appropriate, Government.
- Secure project resources and establish key programme and stakeholder milestones as early as possible.

Appendix 1 – The approach to the interim storage of packaged wastes

Existing engineered interim stores for packaged wastes

For existing interim stores there are three main types which can be differentiated with respect to their operational design lives:

- Stores with an original design life of at least 100 years.
- Stores with an original design life of less than 100 years but capable of being extended.
- Stores with an original design life of less than 100 years and having no practicable life extension capability.

Most existing stores in the UK have a typical original design life of 50 years. During the construction of these stores the projected GDF availability date was 2012 and a 50 year design life was sufficient to allow for some changes to this date. The majority of existing interim stores are at Sellafield and the SLC has reported that there is potential to extend the operational lifetime to at least 100 years except in the case of two stores. As a consequence the current LTP covers the requirement for two new replacement stores. Some of the existing stores contain unconditioned ILW that will require additional processing before export to the GDF.

In summary, the approach for existing engineered interim stores is as follows:

- For stores with an existing original design life of 100 years or more, the site operator will need to protect the asset to ensure its longevity and ensure contingency plans are robust up to 2106 as a minimum with a clear understanding of any potential cliff-edges.
- For stores with an existing original design life of less than 100 years:
  - As a minimum the site operator must ensure that the predicted service life of the store is compliant with the declared baseline operational period, which takes into consideration required asset care programmes.
  - As a contingency, the site operator should assess if the operational life of the existing facility could be extended to 100 years or more.
  - If it is not possible to extend the operational lifetime, then the site operator should as a contingency, plan to relocate the waste to another store or plan for a new store with a design life of 100 years or more. The site operator should also consider the current planned export dates to the GDF in consultation with NDA.
  - The site operators should ensure appropriate level of scope and cost coverage within their LTPs address any risks in their storage plans, for example any increased store maintenance refurbishment costs associated with extending store lifetimes.
  - Where operational design lifetimes could be extended, the site operator will need to understand when key decisions will need to be made and factor these into their LTPs whilst monitoring progress with the GDF project.

Future interim stores

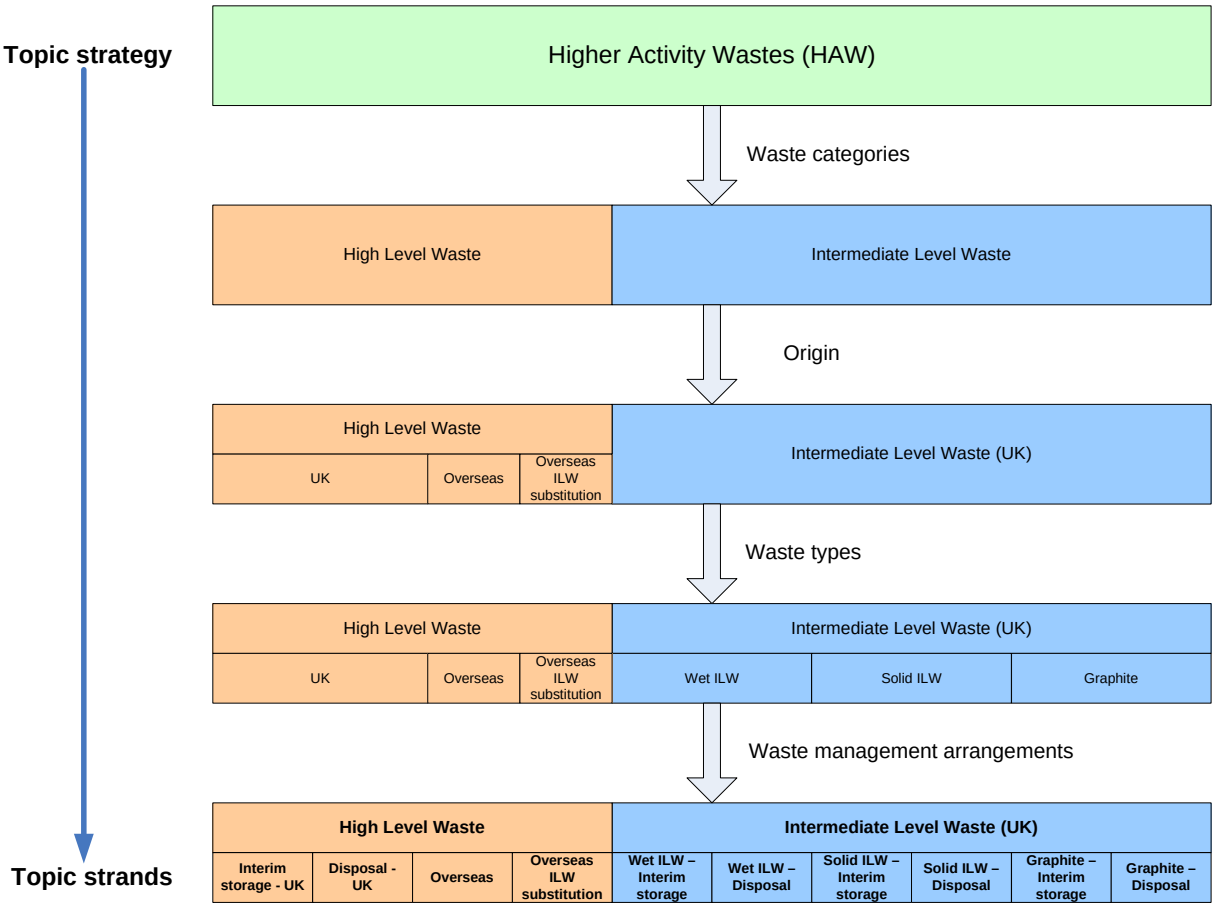
For future interim stores that are yet to be built there are two possible scenarios for operational design lives:

- Stores with a design life of 100 years or more.
- Stores with a design life of less than 100 years but capable of being extended.

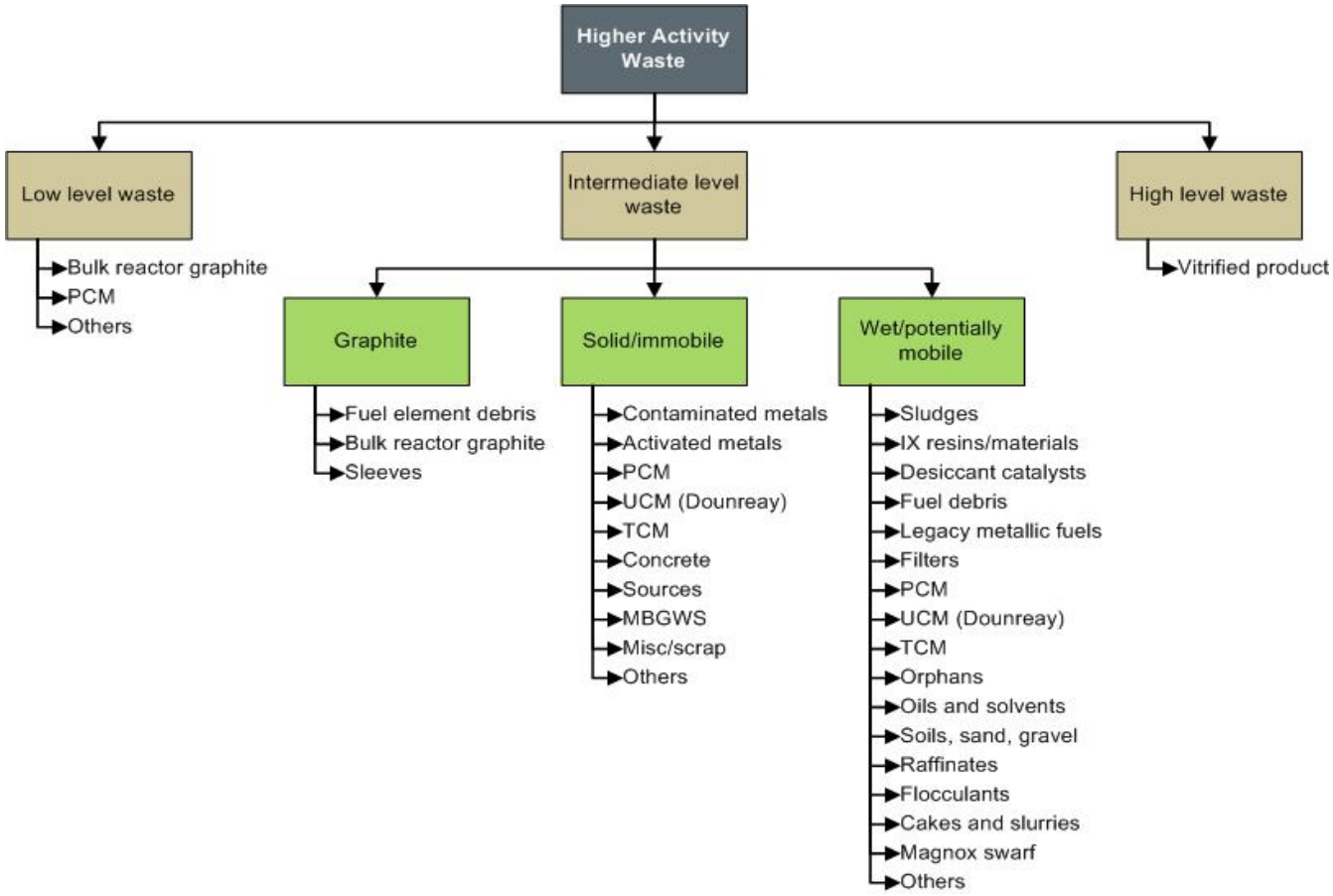
For all future stores considered within this Review there were none where the operational design life was not aligned to the operational storage period declared by the site operator. Some site operators have declared store design lives of less than 100 years to match their current baseline position and include little if any contingency against the possibility of GDF delay. In the case of British Energy ILW interim stores, the site operator has stated that due to more straight-forward storage demands and simplicity of design, the store is flexible, and the operational period could be extended to 100 years. In summary the proposed position for future interim stores is as follows:

- All new interim stores should have a design life of 100 years or more.
- The NDA will engage with Regulators and operators to investigate the need for a guidance note to site operators on the storage of radioactive wastes.
- An original operational design life of less than 100 years may be acceptable if site operators can demonstrate that in-service improvements and asset care programmes for the store will extend the operational life to 100 years or more. Anticipated additional costs must be shown as contingency planning, or:
- An original operational design life of less than 100 years may be acceptable if the design life of the store will cover a period of interim storage up to 2106, as a minimum.

Appendix 2 – Overview of waste types to be considered within each HAW topic strand



Appendix 3 – Overview of proposed waste types to be considered within each HAW topic strand (subject to change)



Appendix 4 – A summary of the reference HAW baseline and credible alternative strategic options

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
Wet ILW – Interim Storage	The Wet ILW Topic Strand considers raw waste streams that are potentially mobile and include Magnox sludge, ion-exchange resins and orphans.	Current arisings of Wet ILW are retrieved, conditioned and stored in engineered facilities and subsequently disposed of when the GDF becomes available or long-term management in near surface facilities for wastes in Scotland. Current Lifetime Plans for NDA Scottish Sites will need to be reviewed to take account of Scottish HAW Policy. Historical raw wastes and historical packaged wastes will be retrieved from ageing facilities and packaged into a disposable form and transferred to an engineered interim store. The timing of retrievals and waste treatment of the historical wastes is based on the NDA Lifetime Plans. As a contingency all sites must consider the impact of a delay in the GDF programme. To help with this contingency planning all new interim stores will have a design life of 100 years or more with appropriate care & maintenance programmes in place.	The Governments' White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that geological disposal; '*will be preceded by safe and secure interim storage until a geological disposal facility can receive waste. This period will include contingency planning to cover any uncertainties associated with implementation. Storage is a proven, safe and secure technology for the interim management of higher activity radioactive waste.*' UK HAW Storage Review (2009); section 4.2.6 - The NDA's Waste Storage Optimisation study is relevant to the industry's future waste storage planning. The main points can be summarised as: NDA should continue to encourage the development and realisation of waste minimisation, alternative waste packaging and decay storage opportunities to help reduce the overall NDA liability, *i.e.* reduce the overall number of ILW packages (and potentially	• Where near-term safety considerations require relatively early solutions, ILW could be containerised in a raw, or part raw form, and undergo final conditioning prior to disposal.	Unique challenges for Sellafield Legacy Wastes. Command 2919 (1995) – where safety is overriding then the initial risk reduction processes can be supported. UK HAW Storage Review (2009); section 1.4.3 – 'In line with Government policy the default approach is to achieve disposable products, without the need for future re-packaging. The asset management of these historical facilities is vital in enabling the wastes to be safely retrieved and processed while ensuring protection of the environment. However, in some cases, disposable packages may only be achieved in a staged approach, where the immediate priority is near term environmental risk and hazard reduction.'
				• Decay storage of suitable waste streams and allow for disposal as LAW.	UK HAW Storage Review (2009); section 2.3 – All sites should consider separately those ILW materials that may be suitable for decay storage and ultimate disposal at a LLWR. CoRWM recommendations, full report (ref 700), July 2006 – Annex 3 inventory listed that decay

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
			ILW interim stores), and thus increase storage flexibility. The main focus of investigating storage consolidation opportunities for NDA ILW should be southern Magnox and UKAEA sites. Stakeholder engagement is a key consideration and should be applied to any proposals to transfer wastes between sites. Any storage optimisation process solution will involve the transport of waste from one location to another and transport must be seen as a key enabler. There may be opportunities to extend the study to include other waste owners for example, it may be reasonable to consider a single ILW store for co-generation BE/NDA sites.		storage/decontamination could lead to a reduction of 19,000 m^3 of ILW.

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
Wet ILW – Disposal	The wet ILW Topic Strand considers raw waste streams that are chemically reactive and/or mobile and include Magnox sludge, ion-exchange resins and orphans.	The reference strategy is to transfer the conditioned waste to the GDF in line with the site export schedule. RWMD are in the process of producing a Disposal System Specification. In Scotland the Policy is for long-term management of waste in near-surface facilities. Current Lifetime Plans for NDA Scottish Sites will need to be reviewed to take account of Scottish HAW Policy.	The Government's White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that; *'Geological disposal is the way higher activity radioactive waste will be managed in the long-term'*. The Scottish Government's HAW Policy[35] on its Higher Radioactive Waste Policy states that: *'Facilities should be located as near to the site where the waste is produced as possible. Developers will need to demonstrate how the facilities will be monitored and how waste packages, or waste, could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.' The* Policy states in section 2.04.03 that: *'There remains uncertainties as to how to deal with much of the waste, therefore the Scottish Government Policy at the present time is that long-term storage is still the primary long-term management option*.' See section 2 relating to treatment and long-term	• No alternative options for the disposal of such wastes to be explored at this time.	

[35] Scotland's Higher Radioactive Waste Policy 2011, The Scottish Government, Edinburgh 2011, see http://www.scotland.gov.uk/Publications/2011/01/20114928/0

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
			storage.		
Solid ILW – Interim storage	The solid ILW Topic Strand mainly considers large volume waste streams during decommissioning and final site clearance operations and excludes bulk reactor graphite.	The current strategy is for individual sites to ensure that their waste storage arrangements meet the current export timescales to the GDF or long-term management in near-surface facilities for wastes in Scotland. Current Lifetime Plans for NDA Scottish Sites will need to be reviewed to take account of Scottish HAW Policy. As a contingency all sites must consider the impact of a delay	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that geological disposal; '*will be preceded by safe and secure interim storage until a geological disposal facility can receive waste. This period will include contingency planning to cover any uncertainties associated with implementation. Storage is a proven, safe and secure technology for the interim management of higher activity*	• Containerise solid ILW and defer conditioning.	Stage D/Stage E for existing streams in longer term storage, *e.g.* AGR graphite sleeves & MBGW in storage at Sellafield. For new wastes this position could be difficult to justify unless overall benefits are proven and supported by the Regulators.

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
		in the GDF programme. To help with this contingency planning all new interim stores will have a design life of 100 years or more with appropriate care & maintenance programmes in place. Some ILW will remain in the raw form and will be conditioned prior to disposal.	*radioactive waste.*' UK HAW Storage Review (2009); section 4.2.6 - The NDA's Waste Storage Optimisation study is relevant to the industry's future waste storage planning. The main points can be summarised as: NDA should continue to encourage the development and realisation of waste minimisation, alternative waste packaging and decay storage opportunities to help reduce the overall NDA liability, *i.e.* reduce the overall number of ILW packages (and potentially ILW interim stores), and thus increase storage flexibility. The main focus of investigating storage consolidation opportunities for NDA ILW should be southern Magnox and UKAEA sites. Stakeholder engagement is a key consideration and should be applied to any proposals to transfer wastes between sites. Any storage optimisation process solution will involve the transport of waste from one location to another and transport must be seen as a key enabler. There may be opportunities to extend the study to include other waste owners for	• An *in-situ* storage concept may also be considered for other nuclear facilities that supported GDF planning contingencies or decay storage opportunities, *e.g.* building *in-situ* waste storage following POCO.	CoRWM report to Government on 'Interim Storage of HAW and the management of Spent Fuels, Plutonium and Uranium', March 2009, stated that 'too few sites have contingency plans' where the 2040 available date for the GDF is a planning assumption only. Some buildings across the estate hold ILW in-situ and will be decommissioned after 2040 and require no interim storage of the packaged wastes. What will happen if the GDF is delayed? UK HAW Storage Review (2009); section 2.3 – All sites should consider separately those ILW materials that may be suitable for decay storage and ultimate disposal at a LLWR. CoRWM recommendations, full report (ref 700), July 2006 – Annex 3 inventory listed that decay storage/ decontamination could lead to a reduction of 19,000 m3 of ILW. UK HAW Storage Review (2009); section 2.4.2 – '*The Scottish Government policy is for near surface, near site long term storage for these wastes. The NDA is working with the Scottish Government as it develops its policy and the options and issues identified in this report will be considered in that process.*'
				• Interim storage of decommissioning wastes, which are currently	CoRWM report to Government on 'Interim Storage of HAW and the management of Spent Fuels,

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
			example, it may be reasonable to consider a single ILW store for co-generation BE/NDA sites.	assumed to be processed and directly transferred to the GDF. Could include raw waste transfer and conditioning at GDF for certain waste streams.	Plutonium and Uranium', March 2009, stated that 'too few sites have contingency plans' where the 2040 available date for the GDF is a planning assumption only. Some buildings across the estate hold ILW in-situ and will be decommissioned after 2040 and require no interim storage of the packaged wastes. What will happen if the GDF is delayed? Options need to be explored. This alternative option could also support the development of Scottish Policy with respect to the long-term storage of HAW.
Solid ILW - Disposal	The solid ILW Topic Strand mainly considers large volume waste streams during decommissioning and final site clearance operations and excludes bulk reactor graphite.	Conditioned waste in storage will be transferred to the GDF in line with the NDA's site export schedule. RWMD are in the process of producing a Disposal System Specification. Most ILW arising after 2040 will be conditioned into a disposable form and then transferred directly to the GDF. In Scotland the Policy is for long-term management of wastes in near-surface facilities. Current Lifetime Plans for NDA Scottish Sites will need to be reviewed to take	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that; *'Geological disposal is the way higher activity radioactive waste will be managed in the long-term'*. In Scotland the Policy is for long-term management of waste in near-surface facilities Scottish Government's HAW Policy[36] on its Higher Radioactive Waste Policy states that: *'Facilities should be located as near to the site where the waste is produced as possible. Developers will*	• Condition solid ILW for near surface disposal including the possibility of on-site disposal, regional disposal facility or a single centralised disposal facility.	ILW reactor decommissioning wastes (RDW) were specifically highlighted in 2006 by CoRWM, Recommendation 8, which stated; *'In determining what reactor decommissioning wastes should be consigned for geological disposal due regard should be paid to considering other available and publicly acceptable management options, including those that may arise from the low level waste review'*. The NDA is therefore considering the possibility of alternative management options for reactor decommissioning wastes, which will have a significant input into the developing strategy for

[36] Scotland's Higher Radioactive Waste Policy 2011, The Scottish Government, Edinburgh 2011, see http://www.scotland.gov.uk/Publications/2011/01/20114928/0

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
		account of Scottish HAW Policy.	*need to demonstrate how the facilities will be monitored and how waste packages, or waste, could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.'*		HAW.
				• Decay storage of suitable waste streams and allow for disposal as LAW or Exempt.	UK HAW Storage Review (2009); section 2.3 – All sites should consider separately those ILW materials that may be suitable for decay storage and ultimate disposal at a LLWR. CoRWM recommendations, full report (ref 700), July 2006 – Annex 3 inventory listed that decay storage/decontamination could lead to a reduction of 19,000 m3 of ILW. This alternative option could also support Scottish Policy with respect to the long-term storage of Higher Activity Wastes.
				• In-situ disposal – 'entombment'	Can only apply to RDW at this stage Option not to be pursued for non-RDW streams - Government Policy for wastes in England and Wales is geological disposal.
Graphite – Interim Storage	The future decommissioning of Graphite cores from Magnox nuclear reactors will result in the single largest volume waste stream in the UK inventory. The reactor cores are mainly made up of interlocking	The Safestore concept is the current strategy for the interim storage of graphite reactors. Bulk reactor graphite will not arise as a waste until the latter end of this century and beyond.	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that geological disposal; '*will be preceded by safe and secure interim storage until a geological*	• Storage of conditioned bulk reactor graphite pending disposal to GDF. • Storage of unconditioned graphite (deferred final conditioning).	CoRWM report to Government on 'Interim Storage of HAW and the management of Spent Fuels, Plutonium and Uranium', March 2009, stated that 'too few sites have contingency plans' where the 2040 available date for the GDF is

Topic Strand	Raw Waste Description	Current position	Reference documents	Alternative credible options	Reason for possible baseline change
	graphite blocks. Graphite Fuel Element Debris, Pile Graphite and AGR graphite sleeves are also considered as part of this Topic Strand.	For graphite waste arisings before 2040, the material may be retrieved, conditioned into a disposable form or in some acceptable cases, retrieved and containerised with deferred conditioning. Actual waste management arrangements will be site or waste stream specific.	*disposal facility can receive waste. This period will include contingency planning to cover any uncertainties associated with implementation. Storage is a proven, safe and secure technology for the interim management of higher activity radioactive waste.*' In support of this current strategy for graphite waste management the following opportunities could be explored: • Reduced Care & Maintenance period for Safestore concept. • Extended Safestore period for Magnox reactors in support of Scottish Policy.		a planning assumption only. Some buildings across the estate hold ILW in-situ and will be decommissioned after 2040 and require no interim storage of the packaged wastes. What will happen if the GDF is delayed? For example, explore the possibility of unencapsulated FED graphite products for interim storage and disposal following the LoC process. Regulatory acceptance is a key requirement throughout. These alternative options could support Scottish Policy with respect to the long-term storage of Higher Activity Wastes.
Graphite - Disposal	The future decommissioning of Graphite cores from Magnox nuclear reactors will result in the single largest volume waste stream in the UK inventory. The reactor cores are essentially made up of interlocking graphite blocks. Graphite Fuel Element Debris, Pile Graphite and AGR	The waste treatment and disposal of reactor graphite is seen as a key enabler for the Magnox decommissioning programme. Before disposal the core reactor graphite waste will be conditioned into a disposable form and then transferred directly to the GDF. RWMD are in the process of producing a Disposal System	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that; *'Geological disposal is the way higher activity radioactive waste will be managed in the long-term'*. In Scotland the Policy is for long-term management of waste in near-surface	An alternative long-term waste management solution to the current reference position for bulk reactor graphite is being sought where the following opportunities will be explored: • Condition graphite waste to enable disposal at LLWR. • Condition LLW and/or ILW graphite waste to remove	2006 NDA Strategy and Business Plans stated that NDA will explore alternative waste management options for graphite. NDA Reactor Decommissioning Wastes Workshop, 2/3 May 2006. NDA presentation at IAEA conference March 2007 stated these alternative options. The Government's White Paper 'A Framework for Implementing

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	graphite sleeves are also considered as part of this Topic Strand.	Specification. The impact of relatively large inventories of long-lived radioisotopes C-14 and Cl-36 will also need to be considered as part of any programme. In Scotland the Policy is for long-term management of wastes in near-surface facilities. Current Lifetime Plans for NDA Scottish Sites will need to be reviewed to take account of Scottish HAW Policy.	facilities. Scottish Government's HAW Policy[37] on its Higher Radioactive Waste Policy states that: *'Facilities should be located as near to the site where the waste is produced as possible. Developers will need to demonstrate how the facilities will be monitored and how waste packages, or waste, could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.'*	most of the contamination and release as "exempt waste" or reuse the graphite where possible. • Separate disposal facility (or facilities) for graphite wastes, including a near surface disposal option and may include a pre-treatment step.	Geological Disposal', June 2008, stated in para 3.16 that *'In practice, there may also be some types of waste – for example, the graphite cores from Magnox nuclear reactors – where alternative management options could alter the inventory of waste destined for geological disposal.'* Some of these alternative options could support Scottish Policy with respect to near-surface long-term management of HAW.
UK owned HLW - disposal	HLW arises as a consequence of reprocessing and is a by-product resulting from the separation of uranium & plutonium from the fission products. HLW only arises at Sellafield.	The current strategy is to package the vitrified HLW for disposal and then transfer to the GDF from 2075.	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that; *'Geological disposal is the way higher activity radioactive waste will be managed in the long-term'*. The UK Government currently sees no case for having more than one facility if it can be avoided and if one facility can be developed to provide suitable containment for the whole waste inventory.	• No alternative options for the disposal of such wastes to be explored. If deemed appropriate, alternative GDF options could be explored in the future and examples may include: • Following a period of interim storage conditioned HLW is disposed of to a separate HLW/SF GDF. • Following a period of interim storage conditioned HLW is disposed of to a separate glass waste form GDF.	Alternative options are not being explored at this stage. Current work is generic and will help technical underpinning.

[37] Scotland's Higher Radioactive Waste Policy 2011, The Scottish Government, Edinburgh 2011, see http://www.scotland.gov.uk/Publications/2011/01/20114928/0

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UK owned HLW – interim storage	HLW arises as a consequence of reprocessing and is a by-product resulting from the separation of uranium & plutonium from the fission products. HLW only arises at Sellafield.	The strategy for HLW is to convert all the liquid waste into a vitrified glass product, which is suitable for interim storage, for at least 50 years, and ultimate disposal. Any new store should have a design life of 100 years or more.	The White Paper 'A Framework for Implementing Geological Disposal', June 2008, stated that geological disposal; '*will be preceded by safe and secure interim storage until a geological disposal facility can receive waste. This period will include contingency planning to cover any uncertainties associated with implementation. Storage is a proven, safe and secure technology for the interim management of higher activity radioactive waste.*'	• No other options to be considered.	
Overseas owned HLW	HLW arises as a consequence of reprocessing and is a by-product resulting from the separation of uranium & plutonium from the fission products. HLW only arises at Sellafield.	Sellafield undertakes reprocessing for a number of overseas customers. The current strategy is to return HLW vitrified products to customers, as specified in the reprocessing contracts.[38]	DTI statement of the UK Government and devolved administrations' policy on Intermediate Level Waste Substitution, December 2004 stated that '*Government policy remains that the wastes resulting from the reprocessing of overseas spent fuel should be returned to the country of origin, and the HLW should be returned as soon as practicable after vitrification.'*	• No other options to be considered at this stage. This is a commercial arrangement that is being implemented. UK title to HLW is a possible option and is not being considered.	
Overseas owned ILW	Some ILW arises as a consequence of reprocessing and is a by-product resulting	Sellafield undertakes reprocessing for a number of overseas customers. The	DTI statement of the UK Government and devolved administrations' policy on	• No other options to be considered at this stage for Sellafield customers.	

[38] See articles: http://www.sellafieldsites.com/news/2009-11-25/return-of-highly-active-waste--the-journey-begins- and http://www.nda.gov.uk/news/vvrprogramme.cfm

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	from the separation of uranium & plutonium from the fission products.	current strategy is to enact ILW substitution whereby additional equivalent amounts of HLW vitrified products are returned to customers *in lieu* of ILW, as specified in the reprocessing contracts. Other overseas owned ILW will be subject to agreed commercial arrangements.	Intermediate Level Waste Substitution, December 2004 stated that '*Government policy remains that the wastes resulting from the reprocessing of overseas spent fuel should be returned to the country of origin, and the HLW should be returned as soon as practicable after vitrification. It [the Government] accepts that, for ILW (and as now for LLW), this policy can be implemented by waste substitution arrangements that ensure broad environmental neutrality for the UK.'* Joint Scottish and UK Government consultation, December 2010, on a proposed policy of radioactive waste substitution for the radioactive waste arising from historic fuel reprocessing contracts with overseas customers at Dounreay.[39]	ILW returns not deemed appropriate for the majority of materials as different packaging concepts adopted by different countries and waste substitution is an accepted position. Other options may be considered but will proceed on a case-by-case basis and will be subject to commercial and policy arrangements. As well as HLW substitution, the other options is as follows: • Return of ILW to customer UK title to overseas owned ILW	

[39] See .http://www.scotland.gov.uk/Publications/2010/12/03093403/0

Appendix 5 – HAW themes from site integrated waste strategies

Issue	NDA commentary
Optimise treatment of ILW Opportunity to minimise the quantity of ILW sent to geological disposal by application of segregation, treatment technologies and enhanced immobilisation; opportunity for increased use of dissolution of fuel element debris.	These issues can be addressed by individual SLCs to optimise their own waste management. We are supportive of innovations, and will assist SLCs for example in their interactions with Regulators. (See also Multi-site synergy below)
Efficient waste storage Opportunity to consolidate ILW storage rather than have waste stores at each site	We regard the distributed arrangement of waste storage to be appropriate, and currently have no plans to consolidate waste storage nationally. Previous work has shown that there are opportunities for some shared storage capacity at southern sites, and supports the SLCs in investigating the opportunity. Local stakeholders will have interest in transport movements and the concept of shared facilities.
Multi-site synergy Opportunity to have a single NDA-wide or multi-site treatment programmes for certain types of ILW (e.g. ion exchange resins); opportunity for NDA to lead on engagement/consultation for multi-site waste management opportunities.	We are investigating multi-site/national waste treatment opportunities and are keen to develop this opportunity, supporting the Magnox South 'wet waste' project. We will also take a wider view of such opportunities and engage with Regulators, Government Departments and stakeholders as they develop. We will investigate the business case for a national thermal waste treatment capability.
Transport enabler. The need to have transport safety cases and authorisations to handle any proposed waste transfers, e.g. for consolidated storage	The point is accepted by NDA. The Transport and Logistics Topic Strategy will consider this issue.
Skills Opportunity to have teams skilled in individual waste treatment or handling operations operating across multiple sites, rather than developing teams to handle each task at each site	We will investigate covering this opportunity via a 'Best Practice Forum' or similar institution.

Issue	NDA commentary
Knowledge Opportunity to improve sharing of experience and best practice in waste management between operators and sites. Better visibility of strategic and multi-site initiatives. Better sharing of historical development work.	We will investigate covering this opportunity via a 'Best Practice Forum' or similar institution. This issue will also feature in the NDA Knowledge Management Topic Strategy.
Graphite The need for research and development into suitable waste forms for reactor graphite; the need for a UK-wide graphite management programme	NDA is directly involved in the EU Carbowaste programme on treatment and disposal of irradiated graphite and supports Magnox South programme on graphite waste forms.*
Waste information Opportunity for enhanced waste information management; possible extension of the use of the Waste Accountancy Template	NDA is running an initiative to: simplify production of the UK inventory; foster common practice on waste information amongst waste owners; and provide a central UK system for information on waste held in interim storage.