LLW Repository Ltd

National Waste Programme

Workshop Note for the Record:

On-Site Decay Storage Principles

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Document history

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Issue 1	12/09/17	First issue for internal review
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Contents

1. Introduction

The National Waste Programme (NWP) is delivering a project to develop a set of practical on-site decay storage principles to support decision making in relation to the decay storage of boundary wastes. The first stage of the project was the production of a desktop review paper that presented the UK policy and the regulatory framework surrounding the storage of radioactive waste. The review also identified a number of principles relating to waste storage and decision factors that waste producers may need to consider when deciding whether decay storage is an appropriate route for their waste streams.

The second part of the project was a stakeholder workshop, which was held on 16th August 2017 at The Studio (Manchester) and was attended by a number of representatives from waste producing sites, regulators and the NDA. The aim of the workshop was to work with stakeholders to explore the site specific issues and practicalities around decay storage, which would inform the final report. A full list of delegates is provided in the Appendix 1.

This report is the note for record from the workshop capturing the key discussion points and feedback received from the stakeholders present.

The output of the workshop will be used by the COSMIC project delivery team to produce a final report that clearly identifies and defines the principles to support decision making relating to on-site decay storage.

2. Overview of the Project Purpose and Methodology

Each delegate introduced themselves and explained their role, and interest in the project. Following this, Nicole Towler (NWP Project Lead) explained the context of the project, whilst the project delivery team provided an overview of the project objectives.

Project objectives

To develop a set of practical principles to support decision-making about on-site decay storage of boundary waste. To provide information on the opportunities, and associated barriers and challenges that need to be addressed, to enable this approach to be seen to offer a credible management solution.

The methodology used during this project was also outlined to the delegates (see Section 1 which outlines the three main stages of the project), with this workshop representing the second stage of the project.

Workshop Objectives

To capture stakeholder insights on the opportunities and challenges presented by on-site decay storage.

To identify case studies that stakeholders may propose which elucidate the opportunities, challenges and uncertainties associated with on-site decay storage.

The meeting noted that certain organisations (such as Horizon) are already considering decay storage for wastes other than boundary wastes. For example, spent fuel and control rods will be decay stored before being processed for interim storage. High Level Waste (HLW) could become ILW within the decay storage period, reducing the processing of HLW. Hence, decay storage can be used as a tool for wastes other than those at the LLW/ILW boundary. The principles being developed here could provide justification for adopting decay storage as a management approach.

The proposed definition of decay storage was presented to the delegates, as the process of using time as a treatment to allow reactivity to subside, or radioactive decay of short lived radionuclides to reduce to specific activity levels, either for in-situ or containerised waste. In the context of this project, it is defined as a conscious and deliberate waste management action to access a predetermined waste route.

In the context of this project, on-site decay storage is being considered at the waste producing site. Decay storage on the Low Level Waste Repository (LLWR) site (for wastes other than those generated on the LLWR site itself) or supply chain site is excluded from this project. Other exclusions include where the pre-determined route is disposal to the Geological Disposal Facility (GDF). The group also noted that exclusions would also include Safe Stores and decay storage in the Dounreay Higher Active Waste (HAW) vaults.

In-situ decay storage was identified as being in scope. It was later clarified that retaining materials in-situ should only be defined as decay storage if there has been a clear, conscious decision to decay store and it has been specifically decided as part of that decay store process it to include an in-situ element, e.g. to reduce worker doses on retrievals. Otherwise, this is no different from in-situ management or delayed decommissioning that might arise for other reasons, in which case in-situ decay storage is not a strategy in itself but a de-facto aspect of a broader strategy.

The group noted that decay storage could be an approach to minimise risk by enabling access pre-determined waste routes. Moreover, the approach may offer flexibility, by allowing new solutions that arise during the storage period to be adopted. This may be more applicable if the storage period spans several decades where there is more opportunity for new solutions to be developed. Conditioning/treating the waste prior to decay storage may mean that they are in an incompatible form for any new treatment solutions that are developed.

However, it was also recognised that the level of risk may actually increase with increasing decay storage timescales, e.g. existing treatment facilities may become unavailable or disposal facility Waste Acceptance Criteria (WAC) may change. This was also discussed later in the meeting and it was acknowledged that as the timescales for decay storage increase, so do the uncertainties surrounding the availability of those pre-determined treatment/disposal routes.

3. Plenary Discussion on Decay Storage Decision Factors and Principles

Following the discussions around the definition of decay storage, the underlying principles surrounding the storage of radioactive waste were presented, which largely focus on passive safety.

Passive Safety and Decay Storage

Manage waste in a manner that minimises the risk to the public, employees and the environment so far as is reasonably practicable throughout the anticipated period of storage.

- Passively safe storage.
- Duration of storage.
- Identified management route.

This was followed by discussion from the group who noted that the description of passive safety should be used with caution, as the requirements are normally interpreted as meaning the waste needs to be immobilised. Immobilisation of waste could reduce opportunities for alternative management routes and may foreclose options. However, containerising waste (and not necessarily conditioning/immobilising) could reduce the overall hazard and contribute to the journey towards passive safety. At several points during the meeting, the group noted that ‘passive safety is a journey’. Hence, steps towards passive safety can be made during each stage of the lifecycle without necessarily conditioning the waste and foreclosing options.

The meeting also noted that the drive of HAW management and the generation of a final wasteform as soon as practicable may be due to site programmes and the journey towards achieving interim / final end states. Conditioned waste could be stored on ‘dormant sites’ relatively easily. However, in the case of unconditioned waste, which is being stored on a ‘dormant site’, the facilities and infrastructure available to support future conditioning, handling and retrieval may not be available at the end of the storage period. Additional steps may then be required to support the journey towards passive safety, such as the re-invigoration of sites and reinstatement of facilities and infrastructure, which may be more difficult.

3.1. Waste Management Lifecycle

A schematic of the waste management lifecycle was then presented (Figure 1) and the concept of entry points was introduced. It was recognised that the decisions surrounding the implementation of decay storage may occur at a number of different points in the waste management lifecycle. For example, the waste producer may wish to consider the approach prior to waste retrieval, during characterisation, or after the waste has been packaged. The point at which a waste producer makes these considerations is referred to as the entry point.

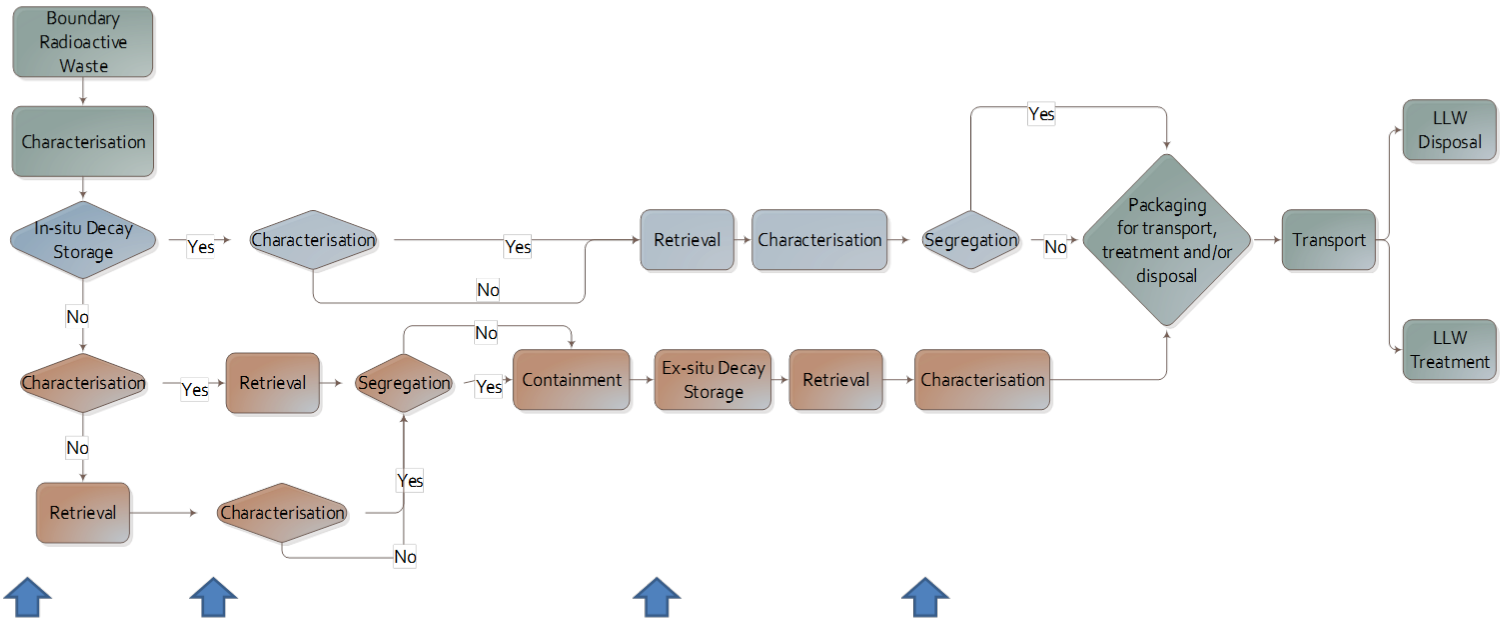

Figure 1: Waste Management Lifecycle (blue arrows denote entry points into the lifecycle)

The meeting noted that the very first characterisation step would support the strategic decision on how to manage the waste stream. For example, a waste producer may have poor knowledge on a particular waste stream, such that only strategic decisions are made and not confirmed, or underpinned, until the initial characterisation has been undertaken. In general, characterisation is required throughout the lifecycle at different levels depending upon whether strategic or more specific decisions are required.

A part of the lifecycle may include a sort and segregation step to separate short-lived and long-lived ILW. However, the meeting noted that segregation could potentially leave waste behind that is more difficult to manage. For example, the sort and segregation activities could concentrate the activity of the remaining ILW; the ILW is no longer reduced by the short-lived ILW or LLW. This could cause additional challenges to the waste producer for its management. The meeting also noted that the decision to segregate waste may actually occur first, which may then drive the rest of the project. For example, segregation could drive pre-treatment activities such as decontamination and size reduction. The meeting felt that this could be reflected in the lifecycle flowchart. Additionally, the waste management lifecycle should consider the practices of the new build community, which aims to segregate at source.

It was noted that strategic decisions do play a part in deciding whether decay storage (or any other management route) is appropriate and the outcomes of the project should acknowledge this. This is relevant to new build and all wastes which have not yet been retrieved. Conscious decisions to decay store can be made at the start of the lifecycle before waste has either been generated, or retrieved. However, it was emphasised that the project also needs to produce a set a practical decisions that waste producers could use to reach a decision on whether decay storage is a suitable route for their waste streams i.e. a practical toolkit is required to support Best Available Technique (BAT) processes. In summary, the project outputs need to address the following:

1. In what situations should I implement decay storage, or in what situations should not I consider decay storage (i.e. strategic decisions)?

2. How should I implement decay storage (i.e. practical decisions)?

Other comments and discussion in relation to the waste lifecycle flow chart include:

- Characterisation may not be undertaken straight away and there may be an ALARP case not to characterise immediately e.g. due to activity/ dose.
- The flow diagram needs to be modified to reflect that not all the stages are mandatory and the steps actually undertaken would very much depend on the waste producing site and the waste stream.

3.2. Decay Storage Requirements

The discussion then moved onto the requirements for decay storage, which are largely similar to general ‘standard’ storage requirements and focus on passive safety.

Requirements for Decay Storage

- Containment.
- Safety & security of storage.
- Passive safety.
- Multi-barrier containment.
- Storage building.
- Inspection & maintenance.
- Records and information management.
- Requirements for consignment for treatment and/or disposal.
- Storage period.

It was noted that in addition to the standard requirements surrounding passive safey, approvals should form part of the requirements. For example, the strategic approval within an organisation to implement decay storage would be required. Moreover, the decision to decay store should be reflected in the appropriate safety cases and underpinned by BAT assessments and documented within the Radioactive Waste Management Case (RWMC).

3.3. Opportunities, Challenges and Uncertainties

The opportunities, challenges and uncertainties of decay storage were then discussed amongst the group.

The benefits identified by the group during discussions are summarised in Figure 2 and largely reflect the benefits that were identified in the desktop review. The only exception was the opportunity that decay storage offers nationally. There is risk associated with the timing of GDF availability; the use of decay storage could reduce the reliance on the GDF for some wastes.

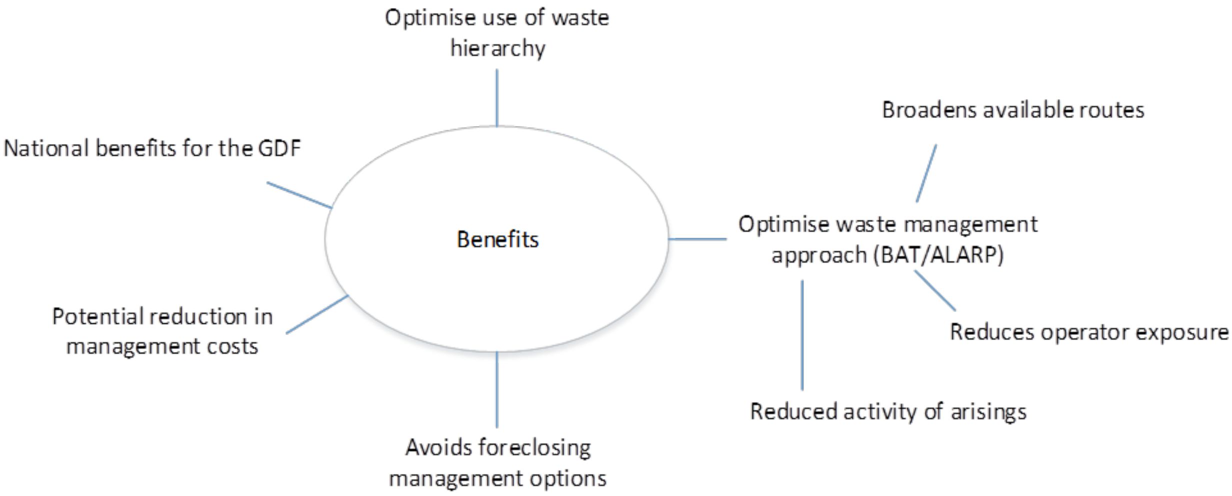

Figure 2: Potential Benefits of Decay Storage

A challenge associated with decay storage is that it may delay decommissioning programmes, preventing sites to progress to end states on currently expected timescales. Other challenges raised by the group included the availability of on-site infrastructure required to handle packages need to be considered and made available after the storage period.

The group then moved onto the uncertainties surrounding decay storage, which were identified as:

- The suitability of the characterisation.

- Availability of on-site infrastructure if the decay stored waste requires additional pre-treatment and/or conditioning prior to be consigned to its final treatment or disposal route.
- Uncertainties surrounding the Letter of Compliance (LoC) if the final treatment/disposal route is less well defined i.e. would a Final Stage LoC be granted for decay stored waste?
- Suitability of the containers used to decay store the waste e.g. would the regulators want use of durable packages to prevent future re-work? Secondary wastes would be generated from package re-work.
- Regulatory approvals for authorisation i.e. can the waste be transported off-site after the decay storage period?
- Additional treatment routes may become available during decay storage; such that storage period may be reduced.
- How does the advice or recommendations relating to decay storage fit in relation to other processes, such as Radioactive Waste Management Limited (RWM) disposability assessment? A number of participants felt that waste being decay stored should be subjected to the LoC process, particularly if the decay storage period was longer, which is associated with greater risks. For example, if a waste stream decays to LLW within a very short term period (e.g. within 5 years), then there is little risk associated with the approach; after five years, the pre-determined treatment route is highly likely to be available. However, if the decay storage period is longer (e.g. 100 years), then there may be more uncertainties surrounding the availability of the pre-determined treatment/disposal routes. In this case fall-back options would be required, which could be a dual approach that considers the GDF (via the LoC process) and LLWR disposal (providing the WAC can be met). There needs to be confidence that the LLWR WAC could be met after decay storage. If there is sufficient confidence, then the LoC process would become irrelevant.

In relation to the last point regarding existing processes, the meeting felt that the LoC process already accommodated decay storage. Moreover, the RWMC, LoC's and safety cases which cover decay storage would be periodically reviewed to ensure that the current arrangements were still appropriate. The RWMC could be used as the vehicle which explicitly states whether the waste is being decay stored and whether a LoC is being prepared for the waste stream. If there is a deviation away from the RWMC or LoC process in relation to the decay storage of waste, then it was felt that waste producers would need to make a justification for this to the regulators. The report produced as part of this project therefore needs to provide signposting to the LoC process.

3.4. Decision Factors

The decision factors that were identified during the desktop review were presented to the group which prompted some discussion. The key point raised related to timescales. The meeting felt that 100 years was probably the boundary for decay storage timescales. Beyond 100 years, the waste becomes a burden for future generations and it is highly likely that availability / capacity the national infrastructure for handling and managing the waste would be significantly different.

Current buildings are generally designed with a 100 year lifetime in mind. Hence, exceeding this timescale for decay storage could mean that new facilities need to be built to cover the storage period.

Moreover, the timeframes for the availability of the intended treatment and disposal routes need to be considered. The supply chain may not be operating certain treatment routes after the decay storage period, whilst the GDF and LLWR will only operate for defined timescales, so their ability to accept waste after decay storage needs to be considered.

The meeting noted that timing is not always used in option assessments as a consideration, but does need to be factored into decision making in relation to decay storage.

The definition of what an ‘acceptable’ timescale is for decay storage is an important principle.

4. Group Work to Develop Relevant Decision Factors and Principles

The delegates were split into three different groups and were requested to consider the opportunities, challenges and uncertainties of decay storage in relation to each of the stages of the waste lifecycle. Each of the breakout groups had representatives from waste producing sites, regulators and a member of the project team. Appendix 2 lists the delegates present within each group.

Following the breakout session, one member from each breakout group gave an overview of the opportunities, challenges and uncertainties identified. The outcome of this exercise is presented in Appendix 3.

A series of discussions then followed amongst the group, with the key points including:

- The availability of characterisation capabilities could be a challenge. For example, Dounreay has previously had issues with the analysis of tritium. Characterisation is important in underpinning the decision to decay store, so having issues with this would make the justification for decay storage very difficult.
- If decay storage is implemented, it would be useful to waste producers if the documentation required to support the onward treatment or disposal following the storage period is clearly outlined. There may a risk that if waste is left in-situ during decay storage, then record and information management might not be considered as much as it would if the waste was decay stored in a dedicated storage facility (i.e. ex-situ).

- The group also discussed whether there should be a distinction between in-situ and ex-situ decay storage. It was felt that the requirements for both types of decay storage were the same. Moreover, certain members of the group felt that in-situ decay storage was not a conscious decision, or defined strategy, but more of a decommissioning programme issue.

5. Group Feedback and Project Output

The group was then invited to comment on the output of the project and identify aspects of the output that they felt would be useful to them in actual decision making. The first part of the discussion focused on the lifecycle flow charts and whether presenting the principles in terms of the waste management lifecycle would be useful. The group largely agreed that having the waste management lifecycle was useful. However, it was noted that the actual steps in the lifecycle would be very different from one site (and waste stream) to the next. Therefore, flowcharts showing the waste management lifecycle could become very complicated and prescriptive and ultimately not very useful to the waste producers. To address this problem, it was suggested that the International Atomic Energy Agency (IAEA) pre-disposal route could be referred to instead. Also, waste management lifecycle could be divided into the following three main phases:

1. Planning and strategy development: recognising earlier discussions about capturing the strategy and planning stages.
2. Implementation: this phase would incorporate the stages identified in the flowchart that was presented at the meeting e.g. characterisation (which may take place at various stages of the process), retrieval, pre-treatment, packaging, storage and consignment.
3. Treatment / Disposal.

The principles developed should be relatively generic; noting that the principles developed in this project may also be relevant to other forms of storage.

Moreover, the group felt that it would be useful to recognise the operational timescales of the GDF and Low Level Waste Repository (LLWR) in the output. These timescales may be important when the strategic decisions and planning are being undertaken at the start of the process.

The group also agreed that the project output should be a report that can be referenced, but not too lengthy or onerous to read and use. This could be achieved by stating the decay storage principles upfront in the document, with the reasoning and explanation behind each principle in an appendix. This would allow decision makers to have the important (useful) information to hand in an easy to use format, with the details provided if required. A copy of RWM’s document on the disposability assessment aims and principles [1] was handed to the project team, noting that the layout of this document could be adopted in the development of the decay storage principle report.

In relation to earlier discussions on in-situ decay storage, the group agreed that the principles should not recognise in-situ decay storage as a separate strategy as distinct from other forms of decay storage. Often deferred retrieval of waste is a decommissioning programme issue rather than a conscious waste management decision. However in-situ decay storage can be a valid part of a wider decay storage strategy if it is specifically undertaken for that reason. It was noted however that there are limited examples of in-situ decay storage.

5.1. Case Studies

Decay storage case studies will form part of the report generated through this project. Waste producers were therefore invited to propose case studies which could be incorporated into the guidance, with the following being identified:

- Dounreay tritiated steel.
- Magnox Ltd tritiated oil.
- Magnox Ltd Winfrith site: cemented drums.
- EdF Heysham site filters.
- Sellafield Ltd WAGR boxes.
- Horizon Wylfa Newydd backwash sludges.

The project team will draft an outline for the case studies and then contact the relevant organisations for input.

[1] RWM Disposability Assessment Aims and Principles, RW60, Revision 2, August 2015

Appendix 1: Organisations attending the Workshop

Organisation
NDA
RWM
EA
ONR
SEPA
Magnox
SL
EDF Energy
DSRL
HORIZON NUCLEAR POWER
NuGeneration
NSG
NSG
Quintessa
Quintessa
LLWR (Waste Services & National Programme Office)

Appendix 2: Break Out Groups

Group 1
NDA
ONR
Magnox
LLWR (NPO)
Quintessa
Group 2
RWM
EA
NuGeneration
Sellafield
LLWR (Waste Services)
NSG
Group 3
SEPA
DSRL
EDF Energy
HORIZON NUCLEAR POWER
LLWR (NPO)
NSG

Appendix 3: Summary of Findings from Group Sessions

The opportunities, challenges and uncertainties are summarised below.

Table 1: Summary of the Opportunities, Challenges and Uncertainties Identified in the Group Sessions

Stage	Opportunities	Challenges	Uncertainties
Point at which ex-situ and in-situ decay storage decision is made	• In-situ decay storage avoids handling ILW. • The dose associated with in-situ decay stored waste would be lower when retrieved. • In-situ decay storage may provide a cost saving since a separate external store not required. • In-situ decay storage should minimise the amount of external storage space required on-site. • Keeping waste in-situ may mean that other decommissioning works can progress.	• In-situ decay storage could be jeopardised by degrading facility. • Cost associated with maintaining facility during storage period. • Characterisation of waste in-situ may be difficult due to difficulties in accessing the waste. • In-situ decay will impact on decommissioning timescales. • Loss of knowledge and SQEP personnel.	• Does the approach fit in with the strategic objectives of the site? E.g. is the facility due to be decommissioned within the decay storage period? • May limit opportunities for decommissioning. • Availability of treatment routes at the end of the decay period is uncertain. The supply chain may not provide services. • A LoC may not be required providing no fall-back option is needed? • What is the approval process for decay storage?
Waste retrieval	• Retrieving waste that has been decay stored in-situ would be easier owing to lower category (avoids remote handling and minimises dose to operators). • Leaving waste in-situ would provide more time for sites to plan and prepare. • Retrieval of waste for ex-situ storage would result in improved storage conditions. Waste would be packaged upon retrieval, creating a safer state. • Retrieving waste for ex-situ storage would allow the facility to be decommissioned.	• Ex-situ stored waste would potentially be handled twice (once during retrieval and again during packaging). • Waste retrieved for ex-situ storage would have to be handled as ILW (greater complexity). There would essentially be a dose penalty from retrieving waste early.	• Decay storage may not offer any benefits to the waste producer if the waste has to be passed through an existing ILW processing route once retrieved.

Stage	Opportunities	Challenges	Uncertainties
Characterisation	• Easier to characterise retrieved waste (ex-situ storage). • More confidence in the characterisation of ex-situ waste. • Characterisation of retrieved waste allows ILW that isn't suitable for decay storage to be identified.	• Potentially more difficult to characterise in-situ waste, potentially less confidence in characterisation and more risk.	
Sort and segregation	• Retrieving waste for ex-situ storage makes sort and segregation easier. • Waste retrieved after decay storage (in-situ) would be handled at a lower category (lower dose), so ALARP.	• Discrete items would need further consideration. • Sort and segregation may result in a concentration of problematic components of the stream.	
Containerisation and packaging	• Packages generated from waste that has been decayed in-situ would be better understood (waste unlikely to evolve further). Waste could be packaged for treatment/disposal with more confidence. • Alternative disposal options e.g. near surface could be available.	• Waste that is packaged for decay storage (ex-situ) would need to be packaged to cover all uncertainties resulting in an over-engineered package. • More robust packages would also be required for waste stored ex-situ. • Risk that packages generated long before the treatment/disposal date (e.g. for ex-situ storage) would need to be re-worked at a later date. • The storage facility used for ex-situ stored wastes would need to be shielded.	• Uncertainties in future treatment routes, again resulting in over-engineered packages e.g. changes to WAC and regulations.
Decay Store	• Waste producers with multiple sites may wish to consolidate decay storage packages on one site. This could result in a consistency in packaging if a single facility is employed.	• Adequate storage capacity would be required for waste stored ex-situ. • Resources to support the storage facility would be required throughout the entire decay storage period. • Cost of storage facilities for ex-situ waste. • Cost of care, maintenance and inspection	• Uncertainty whether waste producers could actually transport decay store packages to a centralised storage facility if they wished to consolidate. • Trade-off between the costs associated with the storage period (dependent on time) vs GDF disposal. There may be very

Stage	Opportunities	Challenges	Uncertainties
		associated with waste stored in-situ.	little benefit in decay storing if the storage period extends beyond the date of GDF availability.
Document and Transport	• Waste that is packaged close to the consignment date (for example, in-situ stored waste) may have better records as they are generated just before consignment. Hence, the consignor could have a clearer understanding of what needs to be recorded.	• Adequate management would be required to ensure that waste records are available during and after decay storage. • Risk that valuable knowledge would be lost during decay storage, which could impact on the quality of the records. • Waste that has been containerised during storage period (ex-situ) may need further treatment/conditioning prior to being transported off-site. This would result in double handling.	• Uncertainty in the level and scope of information that is required following the period of decay storage. Records may need to be stored for long periods of time. • Transport regulations after the storage period may have changed, hence, packages generated several decades earlier may no longer be compliant.
Disposal and treatment	• Decay stored waste that can be treated or disposed in the LLWR preserves space in the GDF. • Decay stored waste that is treated could preserve space in the LLWR vaults.		• Are the intended treatment/disposal routes still available? • Is there space within the relevant disposal vaults after several decades (up to 100 years) of storage? • Does the waste meet the WAC? • Would treatment of the waste prevent other waste producers consigning their wastes to the same treatment facility? E.g. noting that incineration of tritiated oil may cause the treatment facility to exceed its discharge limits for several years, preventing other parts of the estate from progressing their programmes.

Key points from discussion session

The key points from the discussions held during the group session include:

- Before the decision to decay store in-situ or ex-situ, the waste producer would need to consider:
    - Has the waste been generated yet?
    - Does the waste need to be retrieved?
    - Does the facility where the waste originates from need to be decommissioned?
- SAP RW5, RSMDP11 states that the waste should be made passively safe and disposable as soon as practicable. There are guiding principles surrounding this requirement. However, this principle could also be used to make a case for decay storage. The benefit being that deferring waste handling/processing would reduce operator dose and prevents foreclosing options.
- The key driver for decay storage is characterisation and the extent of information available and the confidence associate with it. There may be a requirement to have a hold point after the initial characterisation step to reassess the risks and benefits associated with decay storage.
- The timeframe for decay storage is also important and whether the timeframes required are feasible. Hence, a principle associated with decision making should be:

  '*Define what an 'acceptable' timescale for decay storage is*.'

- The potential benefits of decay storage need to be balanced against the risks and uncertainties. A waste producer may set out with the premise of generating a disposable package as soon as reasonably practicable. However, any deviation to this would need to demonstrate that there were tangible benefits.
- The risks associated with decay storage may increase with time. For example, if the storage duration extends beyond the site lifetime, then the risk increases. Hence, another principle may include:

  'Is there sufficient benefit that outweighs the risks associated with decay storage?'

- When the strategic decisions are being made, it would be necessary to engage with the providers of treatment and disposal services to understand the availability of treatment options and disposability implications. Hence, a principle to consider at the strategy and planning phase could include:

  '*Engage with representatives from the supply chain to determine the availability of treatment and disposal options and any issues associated with disposability*.'

- It is the responsibility of the senior strategists and decision makers to have confidence that the lifecycle has been considered.
- The risks and benefits that were initially identified should be re-assessed to ensure the strategy remains sound.

- The RWMC could be used to capture the risks and uncertainties. Likewise, the site risk register could capture the risks associated with the decay storage management of waste streams. This could be made available to the NDA, allowing the risks to be aggregated nationally.
- It could be that a LoC equivalent is required to cover alternative treatment/disposal routes. It was acknowledged disposability could be threatened due to the unacceptable evolution of waste. The RWM guidance for non-encapsulated waste may be a useful guide for waste producers wishing to decay store unconditioned waste ex-situ and for making the case for decaying storing waste.
- There needs to be an opportunity for LLWR to assess the disposability of the candidate wastes against the Environment Safety Case of the disposal site.
- The group agreed that different time horizons may drive different decisions. The graphic below illustrates how the risk associated with decay storage may change over time.